

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property

Organization

International Bureau

(43) International Publication Date

26 October 2017 (26.10.2017)



(10) International Publication Number

WO 2017/181276 A2

(51) International Patent Classification:

A01H 5/00 (2006.01) A01H 1/02 (2006.01)

A01H 1/00 (2006.01) A01H 5/10 (2006.01)

(21) International Application Number:

PCT/CA2017/050474

(22) International Filing Date:

18 April 2017 (18.04.2017)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

62/326,111 22 April 2016 (22.04.2016) US

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(81) Designated States (unless otherwise indicated, for every

kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every

kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

- with declaration under Article 17(2)(a); without abstract; title not checked by the International Searching Authority
- with (an) indication(s) in relation to deposited biological material furnished under Rule 13bis separately from the description (Rules 13bis.4(d)(i) and 48.2(a)(viii))

(54) Title: BRASSICA CARINATA CULTIVARS AGR044-312D AND AGR044-3A22

(57) Abstract:



WO 2017/181276 A2

Brassica carinata* cultivars AGR044-312D and AGR044-3A22*[0001] 1. FIELD**

[0002] The invention is in the field of *Brassica carinata* breeding (i.e. Ethiopian mustard breeding), specifically relating to the inbred *Brassica carinata* cultivar designated *Brassica carinata* AGR044-312D and *Brassica carinata* AGR044-3A22.

[0003] 2. BACKGROUND

[0004] *Brassica carinata* is a member of the Brassicaceae (formerly Cruciferae) family, commonly known as the mustard family. In Canada, *Brassica carinata* is commonly known as carinata, Ethiopian mustard or Abyssinian mustard. It is also referred to as gomenzer (Getinet 1996).

[0005] The genus *Brassica* is a member of the tribe Brassiceae in the mustard family (Brassicaceae; Warwick et al. 2009). In addition to *B. carinata*, the *Brassica* genus includes several economically important oilseed crop species: *B. juncea* (L.) Czern. (brown mustard), *B. napus* L. (rape, Argentine canola), *B. nigra* (L.) W.D.J. Koch (black mustard), and *B. rapa* L. (field mustard, Polish canola). The genus *Brassica* also includes *B. oleracea* L. food crops, including cabbage, broccoli, cauliflower, Brussels sprouts, kohlrabi and kale.

[0006] The six *Brassica* species are closely related genetically, as described in the Triangle of U (U 1935). *Brassica carinata* is an amphidiploid (BBCC, 2n=34) thought to be derived from interspecific hybridization of the diploid species *B. nigra* L. (BB, 2n=16) and *B. oleracea* L. (CC, 2n=18; Prakash et al. 2012). The native range of *Brassica carinata* comprises the central highland region of Ethiopia. All of the naturally occurring carinata in these regions is cultivated; there do not appear to be wild populations

[0007] *Brassica carinata* is an herbaceous annual with a determinate growth habit (Zanetti et al. 2013). Carinata plants have an erect, upright bearing, averaging 1.4 m in height. Plants are highly branching, with well-developed and aggressive tap root systems (Barro and Martín 1999).

[0008] Seeds are globose, 1-1.5 mm in diameter and finely reticulated (Mnzava and Schippers 2004). They vary from yellow to yellow-brown to brown in colour (Getinet 1987; Rahman and Tahir 2010). The seeds are rich in oil, containing 37-44% depending on the cultivar and growing conditions, and the seed protein content is high, at 25-30% expressed as seed dry weight (Pan et al, 2012)

[0009] In Spain and Italy, seed oil is used for biofuel (Bouaid et al. 2005; Cardone et al. 2002, 2003; Gasol et al. 2007, 2009) and as a bio-industrial feedstock with many uses (i.e., in lubricants, paints, cosmetics, plastics). In North America, carinata has been assessed as a biofuel feedstock (Blackshaw et al. 2011), and crude oil produced from *B. carinata* seed has been used for the production of green bio-diesel and bio-jet fuel. In October 2012, experimental aviation flights by the National Research Council of Canada using the world's first 100% bio-jet fuel were successful ("ReadiJet 100% biofuels flight - one of 2012's 25 most important scientific events", Popular Science Magazine, 2012(12).

[0010] Carinata is grown as a cover crop to reduce soil erosion and herbicide use, and promote water conservation in orchards (Alcántara et al. 2011); it can be plowed into the soil for use as a green manure soil amendment, or as a bio-fumigant (Lazzarini et al; Pane et al. 2013). Carinata plants also have utility in heavy metal phytoremediation (Mourato et al 2015). Also, carinata seed meal can be used as a high protein animal feed when mixed with other protein sources fed to beef cattle (Schulmeister et al, 2015)

[0011] (A) *Brassica carinata* Breeding

[0012] Carinata breeding has focused on the improvement of seed quality traits, agronomic performance (e.g., early maturity, higher yield) and disease resistance. Carinata varieties optimized for production of feedstock for biofuels (i.e. biodiesel, bio-jet fuel), bio-industrial uses such as for manufacturing of bio-plastics (Newson et al, 2014, Impallomeni et al. 2011), lubricants (Zannetti et al; 2006) and specialty fatty acids such as 5, 13-docosadienoic acid, 5-eicosenoic acid (Jadhav et al. 2005), eicosapentaenoic acid (Cheng et al. 2009) and nervonic acid (Taylor et al 2010) have been developed. In some cases, modification of the seed oil profile has involved the use of transgenic technologies to introduce specific genes encoding enzymes of the fatty acid biosynthesis pathways (Taylor 2010).

[0013] Breeding to improve carinata seed quality has led to development of lines with lower meal glucosinolate content with potential for use as a protein rich additive for additive in animal diets (Xin and Yu 2014; Getinet et al. 1997; Márquez-Lema et al. 2006, 2008). Carinata bred for very high levels of glucosinolates in seed meal is of use in biofumigation (Márquez-Lema et al. 2009).

[0014] Critical to the development and breeding of any crop is the ability to make use of genetic and phenotypic diversity. For a newly developing crop such as carinata, it is necessary to be able to obtain a sufficient pool of genetic material to identify genetic backgrounds more adapted to target geographies (i.e. a better starting point), as well as variation for traits of interest. This allows for crossing or other modifications to be done, to identify genetic combinations superior to the types already tested. Thus, an important initial objective is the collection and characterization of as large of a collection of genetic backgrounds as possible, for each target geography.

[0015] Characterization of accessions or breeding lines of carinata generally takes place in the field in the geography of interest, where phenotypic data collected is generally more reflective of actual performance that would be realized by a seed producer. Traits collected focus on those that would be of agronomic or economic benefit in the crop. Examples of traits characterized in a carinata breeding program are early plant vigor, plant height, branching habit, days to flower, silique density, flower petal color, pod size, reaction to heat and water stress, disease susceptibility, shatter tolerance, etc.

[0016] Breeding nurseries are often the first cycle of evaluation of new material, whether from sources external to the breeding program, or new genetic combinations generated within the breeding program. Generally, nurseries utilize single or paired rows with frequent checks (i.e. the best available commercial germplasm for a specified geography), to evaluate overall agronomic potential as well as specific traits of the experimental material. For material that is somewhat heterogeneous but displays traits of interest, often multiple single plants will be self-pollinated, and carried forward to the next breeding cycle. In this way, multiple streams of inbred parents are in simultaneous development each year. These inbred lines can be yield tested to become an open-pollinated (OP) variety if sufficiently improving on the checks; however, the more usual scenario is they are used as parents in crossing or as parents in hybrid testing. When inbred lines are developed in this way as a result of a planned cross, this is referred to as pedigree breeding. In the case that they are developed from a collection or accession, it is usually referred to as inbred line development. Self-pollination is also done in completely inbred lines to preserve a pure seed supply of those lines that may warrant further testing.

[0017] Crossing of inbred lines, by sexual hybridization, is typically done manually in controlled conditions. The selection of parents of these crosses is critical to the effectiveness of a breeding program. Parental lines are selected based on breeding priorities and the unique combination of traits available in potential crossing parents. Often, two or three rounds of crossing are needed to accumulate beneficial alleles into a single genetic background. This includes evaluating offspring of a cross, selecting the most desirable inbred lines as future parents, and making the next round of parental selection based on priority targets.

[0018] **Doubled Haploid (DH) Technology:** DH technology allows for the generation of completely homozygous lines, which are a combination of genes of the parental lines, in a single generation. This accelerates the process of inbred line development dramatically; as the process from seeding of parental lines to obtaining seed for a resulting inbred population from those parents will generally take about 18 months. To achieve a highly homozygous line using traditional self-pollination generally will take five or six growth cycles; which in the case of carinata would represent three years or six growth cycles, with two cycles completed per year. In this technique, using appropriate in vitro conditions, haploid microspores from an F1 plant can be induced to differentiate into diploid embryos and subsequently plantlets. This technique typically relies on a percentage of regenerated plants to undergo spontaneous doubling (usually in the range of 20 to 60% of plants, depending on a number of factors), whereas the remaining plants will remain haploid and sterile. To increase the efficiency of space used for seed increase, such as in the greenhouse or field, a flow cytometer is used to distinguish at an early stage the chromosome content “n” or “2n” of each plant. Thus, the sterile plants can be discarded at an early stage.

[0019] **Molecular Markers:** A breeding program can make use of marker assisted breeding (MAB) to accelerate the successful outcome of a breeding project. This allows the identification of lines carrying a trait of interest in the laboratory, while other lines not containing a marker of interest can then be discarded at an early stage. This increases the efficiency of a program, as the lines being evaluated in the field have a greater probability of meeting seed quality or other criteria. MAB relies on the existence of a dense set of genetic markers for the species of interest. Genetic markers are the unique sequences that may be found in allelic forms of genes, distinguishing one allele from another. Like genes themselves they can be transmitted to progeny in a Mendelian fashion and can thus be used to follow the movement of specific alleles from parents to progeny. There are several types of genetic markers in common use, including:

- i. **Restriction fragment length polymorphisms (RFLP):** where a mutation may create or eliminate a restriction site, creating restriction fragments of unique size. These are detected by electrophoresis and transfer onto membranes (Southern blotting) followed by hybridization with specific labeled probes;
- ii. **Random Amplified Polymorphic DNA (RAPD):** where a single primer is used to PCR amplify random segments of genomic DNA, sequence polymorphisms which diminish the primers ability to hybridize at a locus will cause the disappearance of specific bands, polymorphisms which result in improved hybridization can result in new amplified bands;
- iii. **Amplified Fragment Length Polymorphism (AFLP):** where genomic DNA is digested with a pair of restriction enzymes, one rare cutting and the other frequent cutting. Fragments are then annealed to synthetic adaptors and then PCR carried out using primers complementary to the adaptor sequence and

adjacent restriction sites. The PCR products can be separated by gel or capillary electrophoresis and the pattern of bands produced constitutes a unique fingerprint for a particular genotype;

iv. **Simple Sequence Repeats (SSRs):** repeat sequences called microsatellites (from 2 nt to 6 nt in length) are found randomly distributed in plant genomes. The copy numbers of these repeats at their sites of occurrence can vary greatly and constitutes a source of considerable allelic polymorphism. Primers homologous with regions that flank known microsatellite-containing regions are used to amplify the genomic DNA and the variation in size of the polymorphic products can be used to demonstrate the local allelic variations;

v. **Single Nucleotide Polymorphism (SNP):** are single base changes, deletions or insertions that can occur in coding noncoding or intergenic DNA. These can be detected in a number of ways, for example by NGS sequencing, differential hybridization etc.

[0020] The most useful markers are those that are co-dominant – they allow a researcher to distinguish whether the plant is homozygous, heterozygous or null for a particular marker. The utility of a marker is also increased if it can be detected using very little DNA and if the methodology of detection is relatively simple, sensitive and reproducible. Allelic markers are also more valuable if their presence is linked to the expression of a particular phenotypic trait and molecular markers that co-segregated with alleles that are linked to quantitative trait loci (QTL) afford the opportunity to use these markers in marker assisted breeding.

[0021] **Wide Crossing (interspecific Crossing):** In some instances, a trait may not reside within the species of interest. In that case, it may be possible to transfer the trait via interspecific or wide crossing. The methodology for performing the cross is similar to that described for within-species crosses described above. However, unlike intraspecific crosses, the likelihood of the cross producing viable seed is very low and thus represents a formidable challenge to the success of this technique. In order to overcome this potential block, embryo rescue techniques are often employed to recover viable offspring from the cross. Essentially this relies on the progeny surviving until the embryogenic stage at which point it can be dissected from the silique and placed into artificial growth medium. Under appropriate conditions the cultured embryo can survive and be induced to differentiate into a plantlet, which can be grown into a mature plant. Successive rounds of embryo rescue may be needed until inbred progeny, or backcross-derived progeny, are stable and can produce fertile offspring without intervention. Often molecular markers, where available, are used to trace a specific allele from a related species into an adapted background in the target species, using repeated cycles of backcrossing.

[0022] **Hybrid Cultivar Testing:** Brassica species have been shown to display significant levels of heterosis, or hybrid vigor. Most of the *B. napus* varieties available today are hybrid varieties. It is very probable that similar levels of heterosis for seed yield and vigorous plant development can be exploited in *B. carinata*. This breeding technique may allow the crop to achieve yield potentials, which would allow the resulting biofuels to be more price competitive with traditional petroleum. However, not much research has been done to date on testing hybrid combinations of *carinata*. Thus, there may be a large forum for exploiting heterosis in this crop and increasing productivity on farm, as well as profitability to producers.

[0023] In order to produce and test hybrid combinations, some form of pollination control system must be employed. The most widely used pollination control system to achieve this in Brassica species is the method of Ogura (1968) based on male cytoplasmic sterility. In cytoplasmic male sterile (cms) plants, a mitochondrial gene mutation interferes with the flowers ability to produce viable pollen but does not affect the functionality of the flower's female components. Because the mutation is within the mitochondrial genome, it is transmitted maternally through the cytoplasm. The Ogura cms trait is derived from a Japanese radish variety and has been successfully transferred to *Brassica juncea* and *B. napus* through interspecific crossing. While the mitochondrial gene mutation eliminates the ability of the cms variety to self-pollinate, it does not interfere with its ability to outcross via pollination from non-cms varieties and thus produce F₁ seed. However, the resulting hybrid F₁ produced in such a cross would be male sterile, as this trait is maternally transmitted. The cms phenotype in the F₁ can be overcome by the expression of a nuclear genome encoded restorer (Rf) gene in the male variety used in the cross to produce the F₁. The nuclear Rf gene of radish has also been successfully introgressed in *Brassica napus* (ref) and *Brassica juncea* (ref) varieties. More recently, both the CMS and Rf traits have been developed and are being validated in *B. carinata*. The development of a set of genetically diverse cms and Rf lines in *carinata* will allow the testing of a large number of combinations for the first time in this Brassica species.

[0024] In a hypothetical production scheme based on the Ogura CMS system the following steps are carried out:

- i. Based on genetic diversity and groupings, key morphological traits, and agronomic potential, female (A-lines) carrying the cms trait, and male (R-lines) carrying the restorer gene, are developed;
- ii. Test hybrids are produced and evaluated typically in replicated small plot trials, for evaluation of yield potential and other characteristics;
- iii. Patterns of heterosis between parental "pools" are identified, combinations using these pools are tested more extensively;
- iv. Specific combinations are also selected for potential commercial release as a new variety;
- v. Parental seed is increased for commercial production scheme of best hybrid variety. In order to do so, a maintainer (B-line) of the cms parent is also necessary for seed increase.

[0025] **Mutagenesis:** Another method of creating genetic variation, and capturing beneficial changes in a heritable fashion, is through mutagenesis breeding. This method is often carried out via chemical means or ionizing radiation, and is typically focused either on a microspore or on a whole seed level. In Brassica breeding, some common forms of mutagens used have been chemical agents such as Ethyl methanesulfonate (EMS) or N-ethyl-N-nitrosourea (ENU), high levels of ionizing (x- ray or gamma) irradiation or exposure to UV light. EMS produces random point mutations via low frequency methylation of guanine residues in genomic DNA. This results in altered Watson-Crick base pairing such that the affected base pairing is converted from G-C to A-T. ENU is also an alkylating agent that preferentially modifies thymine residues converting A-T to G-C. Ionizing radiation may affect DNA in many ways but more often than not the mutations are double strand breaks leading to deletions and frameshift mutations that are frequently inactivating.

[0026] To carry out this technique, seedlings or microspores are exposed to the mutagenic agent and the surviving fraction are allowed to develop into mature plants. In some cases, the mutagenized plantlets or embryos (in the case of microspore mutagenesis) may be exposed to selection in order to enrich for a particular phenotype. For example, mutagenesis has been used to develop plants that are

resistant to the actions of specific herbicides; in this instance the developing plantlets or microspores can be grown in vitro in the presence of the herbicide(s) of interest in order to select for those plants with the appropriate mutations conferring resistance. The advantage of the microspore mutagenesis of the seed approach is that the resultant DH plants can be used to derive pure and homozygous plant lines, where all induced mutations, whether dominant or recessive, would be expressed. Mutagenesis has been used to develop brassica varieties with resistance to various herbicides, altered seed oil profiles and increased tolerance to disease and abiotic stress.

[0027] **Genetic Transformation:** In instances where unique and valuable traits are known to be available in distant plant or in non-plant species that cannot be transferred to *Brassica carinata* via classical breeding, and where the genes for those traits have been cloned, a breeding program may resort to genetic transformation techniques to stably transfer those genes into this species. Transfer of cloned genetic elements into *B. carinata* have been achieved via a number of means, including PEG mediated DNA uptake into protoplasts (Johnson, C M. et al. 1989), electroporation into protoplasts (Fromm, M et al 1985), ballistic infiltration using DNA coated microprojectiles (Finer, J. et al 1999), Agrobacteria-based vector infiltration (Babic et al, 1997), infection using plant virus based vectors (Gleba et al 2014). Aside from having the genes of interest in cloned form, the other requirements include having the genes cloned into a suitable vector to allow for their propagation in an appropriate bacterial system as well as their packaging, in appropriate viral and agrobacterial strains to allow for their infectious route of transfer. Once transferred they would also require appropriate plant based promoters, enhancers and terminators to allow for the correct temporal and tissue specific pattern of expression for the heterologous gene. Finally, in order to select those rare events where the heterologous gene expression unit has been successfully transferred into the plant genome, a selectable marker may be introduced, either physically linked to the heterologous gene of interest or co-transformed with the gene of interest at a suitable ratio so as to favor co-insertion.

[0028] The selectable marker may consist of a gene that can confer resistance to a particular herbicide or antibiotic that would otherwise kill the plant, or a gene that may confer a growth advantage, a gene that may alter a response to plant hormones, or may express a fluorescent protein that can allow transformed cells to be easily visualized. Examples of selectable markers based on conferring resistance to antibiotics, successfully used in brassica transformation are the NPTII gene (Bevan, 1984; Datta et al, 1992, encoding an enzyme conferring resistance to the antibiotic kanamycin and the HPT gene encoding an enzyme conferring resistance to the antibiotic Hygromycin (Rothstein et al, 1987). Examples of selection markers based on conferring tolerance to herbicides and successfully used in brassica transformation are the BAR (Thompson et al, 1987) and PAT (Wohlleben et al, 1988) gene products which confer resistance to glufosinate (bialaphos) or L-PPT and the AHAS gene product conferring resistance to imidazolinones (Miki et al. 1990). Other plant selectable markers have been developed whose actions are not based on conferring resistance to toxic compounds per se but instead allow survival in the presence of nutrients not normally metabolized by the wildtype organism.

[0029] Transformation cannot only be used to introduce heterologous genes into the genome of *carinata* plants, it can also be used to introduce DNA constructs that are designed to modulate the expression of endogenous genes. Genes encoding antisense RNA or RNAi sequences (Tang and Galil, 2004) can be used to interfere or knock down the expression of endogenous genes to extremely low

levels, simulating the effect of a null mutation at the endogenous locus. This of course relies on the continuous stable expression of the antisense or RNAi to be effective. In amphidiploid brassica species such as *napus*, *juncea* and *carinata* multiple copies of genes from the contributing ancestral species may create a high level of functional redundancy such that a single mutation in one of the homologues may not be sufficient to confer a phenotype. However, by using an RNAi or antisense approach, where the interfering RNA is derived from conserved sequences, one may conceivably be capable of targeting all of the expressed homologues and achieving a functional knockdown effect.

[0030] More recently several novel approaches have been developed which offer the ability to manipulate the plant genome in a targeted way. Collectively known as gene editing technology, (Petolino et al, 2010; Sauer et al 2014, Woo et al, 2015) the technologies share several important similarities:

- i. They offer the ability to introduce small or large gene deletions in the plant genome by means of targeted double strand breaks at precise genomic locations
- ii. They allow for the insertion of small inactivating mutations into specific genes of interest
- iii. They permit the replacement of an entire gene or gene segment by a modified counterpart
- iv. They allow for the insertion of a heterologous gene in a specific genomic location which may represent a preferred site for regulated gene expression. (i.e. downstream of a known endogenous promoter/enhancer)

[0031] As is evident by the examples cited and to those skilled in the art, there are numerous methods available to the *carinata* breeder to assemble a unique collection of traits into a singular cultivar. The skill lies in the ability of the breeder to select for the combination of traits through successive generations, and ultimately obtaining a unique, homogeneous and homozygous cultivar breeding true for the selected combination of traits, a necessary requirement for commercial crop production.

[0032] 3. SUMMARY

[0033] According to the present invention, there are provided novel *Brassica carinata* varieties designated *Brassica carinata* AGR044-312D and AGR044-3A22. This invention thus relates to the seeds of the AGR044-312D and AGR044-3A22 varieties, to plants of the AGR044-312D and AGR044-3A22 varieties, methods for producing a *Brassica carinata* plant produced by self- crossing of AGR044-312D or AGR044-3A22 or outcrossing said varieties with other *Brassica carinata* lines as well as producing DH varieties from F1 of said crosses, methods for producing a *Brassica carinata* plant by outcrossing the AGR044-312D and AGR044-3A22 with other brassica species, such as *Brassica napus*, *Brassica juncea*, *Brassica oleracea*, *Brassica rapa*, *Brassica nigra*, followed by backcrossing with AGR044-312D and AGR044-3A22 as well as producing DH varieties from said interspecific crosses. The invention also relates to the use of the AGR044-312D and AGR044-3A22 varieties as a background for chemical and/ or radiation induced mutagenesis or for targeted gene editing, for modulation of traits via RNA interference or antisense RNA expression or for introduction of traits via genetic transformation. The invention may also encompass the use of the AGR044-312D and AGR044-3A22 line in a hybrid variety production scheme as described above.

[0034] In the embodiments described below, “essentially all of the physiological and morphological characteristics” can mean, for example, the quantitative physiological and morphological characteristics described in Tables 1 and 3-7 for AGR044-3A22 or in Tables 1, 2, and 4-14 for AGR044-312D when grown in the same location under the same environmental conditions, as determined at the 5% significance level.

[0035] In the embodiments described below, “essentially all of the physiological and morphological characteristics” can also mean the quantitative physiological and morphological characteristics described in Tables 1, 3 and 5-7 for AGR044-3A22 or in Tables 1, 2, 5-10, and 12-14 for AGR044-312D when grown in the same location under the same environmental conditions, as determined at the 5% significance level.

[0036] In particular embodiments, there is provided:

1. A seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015.
2. A plant of *Brassica carinata* cultivar AGR044-312D, or a part thereof, produced from the seed of embodiment 1.
3. The plant part of embodiment 2, wherein the plant part is an ovule, a leaf, pollen, a seed, an embryo a root, a root tip, a pod, a flower, a stalk, a cell, or a protoplast.
4. The plant part of embodiment 3, wherein the plant part is pollen.
5. The plant part of embodiment 3, wherein the plant part is an ovule.
6. A *Brassica carinata* plant, or parts thereof, having essentially all of the physiological and morphological characteristics of the plant of embodiment 2 when grown in the same location under the same environmental conditions.
7. A tissue culture of protoplasts or regenerable cells of the plant, or part thereof, of embodiment 2.
8. The tissue culture according to embodiment 7, wherein the protoplasts or regenerable cells are produced from a tissue selected from the group consisting of leaves, pollen, embryos, roots, root tips, pods, flowers, ovules, and stalks.
9. A *Brassica carinata* plant regenerated from the tissue culture of embodiment 7 or 8, wherein the plant has essentially all of the morphological and physiological characteristics of cultivar AGR044-312D, the seed of which has been deposited under ATCC Accession number PTA-123015, when grown in the same location under the same environmental conditions.
10. A regenerated *Brassica carinata* plant having essentially all of the physiological and morphological characteristics of the cultivar AGR044-312D when grown in the same location under the same environmental conditions, the regenerated plant having been produced using a

tissue culture, wherein the tissue culture is produced from the plant or part thereof of embodiment 2.

11. A method for producing *Brassica carinata* seed comprising crossing *Brassica carinata* plants and harvesting the resulting *Brassica carinata* seed, wherein at least one *Brassica carinata* plant is the plant of embodiment 2.

12. A *Brassica carinata* seed produced by the method of embodiment 11.

13. A method for producing a first generation (F1) hybrid *Brassica carinata* seed comprising crossing the plant of embodiment 2 with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid carinata seed, and wherein the plant of embodiment 2 is either a female parent or a male parent.

14. The method of embodiment 13 wherein the plant of embodiment 2 is the female parent.

15. The method of embodiment 13 wherein the plant of embodiment 2 is the male parent.

16. An F1 hybrid seed produced by the method of any one of embodiments 13 to 15.

17. An F1 hybrid plant grown from the F1 hybrid seed produced by the method of any one of embodiments 13 to 15.

18. A method for producing a Doubled Haploidy variety comprising:

- (a) isolating a flower bud of the F1 plant of embodiment 17;
- (b) dissecting out a haploid microspore;
- (c) placing the haploid microspore in culture;
- (d) inducing the microspore to differentiate into an embryo and subsequently into a plantlet;
- (e) identifying whether the plantlet contains a diploid chromosome number, wherein the diploid chromosome number occurred through chromosome doubling; and
- (f) continuing to grow the plantlet if it contains a diploid chromosome number.

19. The method of embodiment 18 further comprising inducing chromosome doubling by chemical or physical means.

20. A plant, or part thereof, or seed of a Doubled Haploidy variety produced by the method of embodiment 18 or 19.

21. A method of producing a *Brassica carinata* variety produced from the plant of embodiment 2, wherein the *Brassica carinata* variety comprises a desired trait, the method comprising the steps of:

- (a) crossing a plant of cultivar AGR044-312D with another *Brassica carinata* variety comprising the desired trait;

- (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait;
- (c) backcrossing the selected progeny plants that have the desired trait with plants of cultivar AGR044-312D to produce backcross progeny seed; and
- (d) growing the resultant backcross progeny seed and selecting backcross progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-312D.

22. The method of embodiment 21, wherein steps (c) and (d) are repeated until the *Brassica carinata* variety produced from cultivar AGR044-312D has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions.

23. The method of embodiment 21 or 22, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

24. The method of embodiment 23, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

25. A plant, or part thereof, or seed of a *Brassica carinata* variety produced by the method of any one of embodiments 22 to 24.

26. A method of producing a *Brassica carinata* variety produced from the plant of embodiment 2, wherein the *Brassica carinata* variety comprises a desired trait, the method comprising introducing a DNA construct conferring the desired trait into a plant of cultivar AGR044-312D.

27. The method of embodiment 26, wherein the DNA construct is introduced using polyethylene glycol (PEG) mediated DNA uptake, electroporation, ballistic infiltration using DNA coated microprojectiles (gene gun), an Agrobacteria infiltration based vector, or a plant virus based vector.

28. The method of embodiment 26 or 27, wherein the DNA construct comprises a transgene.

29. The method of embodiment 26 or 27, wherein the DNA construct comprises an RNAi construct.

30. The method of any one of embodiments 26 to 29, wherein the *Brassica carinata* variety comprises the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-312D, when grown in the same location under the same environmental conditions.

31. The method of any one of embodiments 26 to 30, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

32. The method of embodiment 31, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

33. A plant, or part thereof, or seed of a *Brassica carinata* variety produced by the method of any one of embodiments 26 to 32.

34. A method of producing a *Brassica carinata* variety produced from the plant of embodiment 2, wherein the *Brassica carinata* variety comprises a desired trait, the method comprising the steps of:

- (a) crossing a plant of cultivar AGR044-312D with another *Brassica carinata* variety comprising the desired trait;
- (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait;
- (c) selfing the progeny plants that have the desired trait to produce further progeny seed; and
- (d) growing the further progeny seed and selecting further progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-312D.

35. The method of embodiment 34, wherein steps (c) and (d) are repeated until the *Brassica carinata* variety produced from cultivar AGR044-312D has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions.

36. The method of embodiment 34 or 35, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

37. The method of embodiment 36, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

38. A plant, or part thereof, or seed of a *Brassica carinata* variety produced by the method of any one of embodiments 34 to 37.

39. A method of producing a *Brassica carinata* variety produced from the plant of embodiment 2, wherein the *Brassica carinata* variety comprises a new trait, the method

comprising exposing seedlings or microspores to a mutagenic agent and allowing the surviving fraction to develop into mature plants.

40. The method of embodiment 39, wherein the mutagenic agent is ethyl methanesulfonate, N-ethyl-N-nitrosourea, or x-ray, gamma or ultraviolet radiation.

41. A plant, or part thereof, or seed of a *Brassica carinata* variety produced by the method of embodiment 39 or 40.

42. A method of producing a carinata variety produced from the plant of embodiment 2, wherein the carinata variety comprises a desired trait, the method comprising:

- (a) crossing a plant of cultivar AGR044-312D with a plant of another Brassicaceae species comprising the desired trait;
- (b) using embryo rescue techniques to recover viable F1 plants from the cross or growing F1 seeds to produce F1 plants;
- (c) selfing the F1 plants that have the desired trait and carinata character;
- (d) using embryo rescue techniques to recover viable F2 plants or growing F2 seeds to produce F2 plants;
- (e) selfing the F2 plants that have the desired trait and carinata character;
- (f) using embryo rescue techniques to recover viable F3 plants or growing F3 seeds to produce progeny plants;
- (g) selfing the progeny plants that have the desired trait and carinata character to produce further progeny plants; and
- (h) selecting the progeny plants with the desired trait and carinata character to produce the carinata variety produced from cultivar AGR044-312D.

43. The method of embodiment 42, wherein steps (g) and (h) are repeated until the carinata variety produced from cultivar AGR044-312D has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions.

44. The method of embodiment 42 or 43, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

45. The method of embodiment 44, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

46. A plant, or part thereof, or seed of a progeny carinata variety produced by the method of any one of embodiments 42 to 45.

47. A method of producing a commercial plant product, the method comprising growing the plant of embodiment 2 to produce a commercial crop, and producing said commercial plant product from the commercial crop.
48. The method of embodiment 47, wherein the commercial plant product comprises oil, meal, or protein isolate.
49. A commercial plant product produced by the method of embodiment 47 or 48.
50. Oil, meal, or protein isolate produced by the method of embodiment 48.
51. Crushed, non-viable seed of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015.
52. A cell of a seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015.
53. A cell of a plant of *Brassica carinata* cultivar AGR044-312D, or a part thereof, produced from the seed defined in embodiment 52.
54. A protoplast of a plant of *Brassica carinata* cultivar AGR044-312D, or a part thereof, produced from the seed defined in embodiment 52.
55. The cell of embodiment 53, wherein the plant part is an ovule, a leaf, pollen, a seed, an embryo a root, a root tip, a pod, a flower, or a stalk.
56. The cell of embodiment 55, wherein the plant part is pollen.
57. The cell of embodiment 55, wherein the plant part is an ovule.
58. A cell of a *Brassica carinata* plant, or parts thereof, having essentially all of the physiological and morphological characteristics of the plant defined in embodiment 53 when grown in the same location under the same environmental conditions.
59. A tissue culture of protoplasts or regenerable cells of the plant, or part thereof, defined in embodiment 53.
60. The tissue culture according to embodiment 59, wherein the protoplasts or regenerable cells are produced from a tissue selected from the group consisting of leaves, pollen, embryos, roots, root tips, pods, flowers, ovules, and stalks.
61. A cell of a *Brassica carinata* plant regenerated from the tissue culture of embodiment 59 or 60, wherein said plant has essentially all of the morphological and physiological

characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions.

62. A cell of a regenerated *Brassica carinata* plant having essentially all of the physiological and morphological characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions, the regenerated plant having been produced using a tissue culture, wherein the tissue culture is produced from the plant or part thereof defined in embodiment 53.

63. Use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce seed, wherein the seed is produced by self-fertilization or cross-fertilization.

64. Use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015 to produce an F1 hybrid *Brassica carinata* seed, wherein the plant is either a female parent or a male parent in a cross-fertilization.

65. The use of embodiment 64 wherein the plant is the female parent.

66. The use of embodiment 64 wherein the plant is the male parent.

67. A cell of an F1 hybrid plant grown from the F1 hybrid seed produced by the use according to any one of embodiments 64 to 66.

68. A cell of an F1 hybrid plant grown from F1 hybrid seed produced by a method comprising crossing a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid *carinata* seed.

69. Use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a Doubled Haploidy variety.

70. Use of embodiment 69, wherein chromosome doubling is introduced by chemical or physical means.

71. A cell of a Doubled Haploidy variety produced from *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015.

72. Use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a *Brassica carinata* variety comprising a desired trait,

73. The use of embodiment 72, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

74. The use of embodiment 73, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

75. A cell of a plant of a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety is produced by a method comprising the steps of:

- (a) crossing a plant of cultivar AGR044-312D with another *Brassica carinata* variety comprising the desired trait;
- (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait;
- (c) backcrossing the selected progeny plants that have the desired trait with plants of cultivar AGR044-312D to produce backcross progeny plants; and
- (d) growing the resultant backcross progeny seed and selecting backcross progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-312D.

76. The cell of embodiment 75, wherein the method to produce the *Brassica carinata* variety further comprises repeating steps (c) and (d) until the *Brassica carinata* variety produced from cultivar AGR044-312D has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions.

77. The cell of embodiment 75 or 76, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

78. The cell of embodiment 77, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

79. Use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a *Brassica carinata* variety comprising a desired trait, wherein the desired trait is conferred by a DNA construct.

80. The use of embodiment 79, wherein the DNA construct is introduced using polyethylene glycol (PEG) mediated DNA uptake, electroporation, ballistic infiltration using DNA coated

microprojectiles (gene gun), an Agrobacteria infiltration based vector, or a plant virus based vector.

81. The use of embodiment 79 or 80, wherein the DNA construct comprises a transgene.

82. The use of embodiment 79 or 80, wherein the DNA construct comprises an RNAi construct.

83. The use of any one of embodiments 79 to 82, wherein the *Brassica carinata* variety comprises the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions.

84. The use of any one of embodiments 79 to 83, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

85. The use of embodiment 84, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

86. A cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-312D, the seed of which has been deposited under ATCC Accession number PTA-123015, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety was produced by a method comprising introducing a DNA construct conferring the desired trait into a plant of cultivar AGR044-312D.

87. The cell of embodiment 86, wherein the DNA construct is introduced using polyethylene glycol (PEG) mediated DNA uptake, electroporation, ballistic infiltration using DNA coated microprojectiles (gene gun), an Agrobacteria infiltration based vector, or a plant virus based vector.

88. The cell of embodiment 86 or 87, wherein the DNA construct comprises a transgene.

89. The cell of embodiment 86 or 87, wherein the DNA construct comprises an RNAi construct.

90. The cell of any one of embodiments 86 to 89, wherein the *Brassica carinata* variety comprises the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions.

91. The cell of any one of embodiments 86 to 90, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

92. The cell of embodiment 91, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

93. A cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-312D, the seed of which has been deposited under ATCC Accession number PTA-123015, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety was produced by a method comprising the steps of:

- (a) crossing a plant of cultivar AGR044-312D with a plant of another *Brassica carinata* variety comprising the desired trait;
- (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait;
- (c) selfing the progeny plants that have the desired trait to produce further progeny plants; and
- (d) growing the resultant further progeny plants and selecting further progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-312D.

94. The cell of embodiment 93, wherein steps (c) and (d) are repeated until the *Brassica carinata* variety produced from cultivar AGR044-312D has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions.

95. The cell of embodiment 93 or 94, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

96. The cell of embodiment 95, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

97. Use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a *Brassica carinata* variety comprising a new trait, wherein the new trait is introduced by exposing seedlings or microspores to a mutagenic agent.

98. The use of embodiment 97, wherein the mutagenic agent is ethyl methanesulfonate, N-ethyl-N-nitrosourea, or x-ray, gamma or ultraviolet radiation.

99. A cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, wherein the *Brassica carinata* variety comprises a new trait, and wherein the *Brassica carinata* variety is produced by a method comprising exposing seedlings or microspores to a mutagenic agent and allowing the surviving fraction to develop into mature plants.
100. The cell of embodiment 99, wherein the mutagenic agent is ethyl methanesulfonate, N-ethyl-N-nitrosourea, or x-ray, gamma or ultraviolet radiation.
101. Use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a carinata variety comprising a desired trait, wherein the desired trait is introduced by crossing a plant of cultivar AGR044-312D with a plant of another Brassicaceae species comprising the desired trait.
102. The use of embodiment 101, wherein the carinata variety produced from cultivar AGR044-312D has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions.
103. The use of embodiment 101 or 102, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.
104. The use of embodiment 103, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.
105. A cell of a plant of a carinata variety comprising a desired trait, wherein the carinata variety is produced by a method comprising:
- crossing a plant of cultivar AGR044-312D with a plant of another Brassicaceae species comprising the desired trait;
 - using embryo rescue techniques to recover viable F1 plants from the cross or growing F1 seeds to produce F1 plants;
 - selfing the F1 plants that have the desired trait and carinata character;
 - using embryo rescue techniques to recover viable F2 plants or growing F2 seeds to produce F2 plants;
 - selfing the F2 plants that have the desired trait and carinata character;
 - using embryo rescue techniques to recover viable F3 plants or growing F3 seeds to produce progeny plants;
 - selfing the progeny plants that have the desired trait and carinata character to produce further progeny plants; and
 - selecting the progeny plants with the desired trait and carinata character to produce the carinata variety produced from cultivar AGR044-312D.

106. The cell of embodiment 105, wherein steps (g) and (h) are repeated until the carinata variety produced from cultivar AGR044-312D has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions.

107. The method of embodiment 105 or 106, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

108. The method of embodiment 107, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

109. Use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a commercial crop.

110. Use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a commercial plant product.

111. The use of embodiment 110, wherein the commercial plant product comprises oil, meal, or protein isolate.

112. A plant, or part thereof, whose genotype has greater than 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98% or 99% of the single nucleotide polymorphisms and indel markers of Tables 19 to 35 in common with AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015.

113. The plant part of embodiment 112, wherein the plant part is an ovule, a leaf, pollen, a seed, an embryo a root, a root tip, a pod, a flower, a stalk, a cell, or a protoplast.

114. A seed whose genotype has greater than 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98% or 99% of the single nucleotide polymorphisms and indel markers of Tables 19 to 35 in common with AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015.

115. A cell of a plant, or part thereof, whose genotype has greater than 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98% or 99% of the single nucleotide polymorphisms and indel markers of Tables 19 to 35 in common with AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015.

116. The cell of embodiment 115, wherein the plant part is an ovule, a leaf, pollen, a seed, an embryo a root, a root tip, a pod, a flower, a stalk, a cell, or a protoplast.

117. A cell of a seed whose genotype has greater than 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98% or 99% of the single nucleotide polymorphisms and indel markers of Tables 19 to 35 in common with AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015.
118. A seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014.
119. A plant of *Brassica carinata* cultivar AGR044-3A22, or a part thereof, produced from the seed of embodiment 118.
120. The plant part of embodiment 119, wherein the plant part is an ovule, a leaf, pollen, a seed, an embryo a root, a root tip, a pod, a flower, a stalk, a cell, or a protoplast.
121. The plant part of embodiment 120, wherein the plant part is pollen.
122. The plant part of embodiment 120, wherein the plant part is an ovule.
123. A *Brassica carinata* plant, or parts thereof, having essentially all of the physiological and morphological characteristics of the plant of embodiment 119 when grown in the same location under the same environmental conditions.
124. A tissue culture of protoplasts or regenerable cells of the plant, or part thereof, of embodiment 119.
125. The tissue culture according to embodiment 124, wherein the protoplasts or regenerable cells are produced from a tissue selected from the group consisting of leaves, pollen, embryos, roots, root tips, pods, flowers, ovules, and stalks.
126. A *Brassica carinata* plant regenerated from the tissue culture of embodiment 124 or 125, wherein the plant has essentially all of the morphological and physiological characteristics of cultivar AGR044-3A22, the seed of which has been deposited under ATCC Accession number PTA-123014, when grown in the same location under the same environmental conditions.
127. A regenerated *Brassica carinata* plant having essentially all of the physiological and morphological characteristics of the cultivar AGR044-3A22 when grown in the same location under the same environmental conditions, the regenerated plant having been produced using a tissue culture, wherein the tissue culture is produced from the plant or part thereof of embodiment 119.
128. A method for producing *Brassica carinata* seed comprising crossing *Brassica carinata* plants and harvesting the resulting *Brassica carinata* seed, wherein at least one *Brassica carinata* plant is the plant of embodiment 119.
129. A *Brassica carinata* seed produced by the method of embodiment 128.

130. A method for producing a first generation (F1) hybrid *Brassica carinata* seed comprising crossing the plant of embodiment 119 with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid carinata seed, and wherein the plant of embodiment 119 is either a female parent or a male parent.

131. The method of embodiment 130 wherein the plant of embodiment 119 is the female parent.

132. The method of embodiment 130 wherein the plant of embodiment 119 is the male parent.

133. An F1 hybrid seed produced by the method of any one of embodiments 130 to 132.

134. An F1 hybrid plant grown from the F1 hybrid seed produced by the method of any one of embodiments 130 to 132.

135. A method for producing a Doubled Haploidy variety comprising:

- (a) isolating a flower bud of the F1 plant of embodiment 134;
- (b) dissecting out a haploid microspore;
- (c) placing the haploid microspore in culture;
- (d) inducing the microspore to differentiate into an embryo and subsequently into a plantlet;
- (e) identifying whether the plantlet contains a diploid chromosome number, wherein the diploid chromosome number occurred through chromosome doubling; and
- (f) continuing to grow the plantlet if it contains a diploid chromosome number.

136. The method of embodiment 135 further comprising inducing chromosome doubling by chemical or physical means.

137. A plant, or part thereof, or seed of a Doubled Haploidy variety produced by the method of embodiment 135 to 136.

138. A method of producing a *Brassica carinata* variety produced from the plant of embodiment 119, wherein the *Brassica carinata* variety comprises a desired trait, the method comprising the steps of:

- (a) crossing a plant of cultivar AGR044-3A22 with another *Brassica carinata* variety comprising the desired trait;
- (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait;
- (c) backcrossing the selected progeny plants that have the desired trait with plants of cultivar AGR044-3A22 to produce backcross progeny seed; and
- (d) growing the resultant backcross progeny seed and selecting backcross progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-3A22.

139. The method of embodiment 138, wherein steps (c) and (d) are repeated until the *Brassica carinata* variety produced from cultivar AGR044-3A22 has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions.

140. The method of embodiment 138 or 139, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

141. The method of embodiment 140, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

142. A plant, or part thereof, or seed of a *Brassica carinata* variety produced by the method of any one of embodiments 138 to 141.

143. A method of producing a *Brassica carinata* variety produced from the plant of embodiment 119, wherein the *Brassica carinata* variety comprises a desired trait, the method comprising introducing a DNA construct conferring the desired trait into a plant of cultivar AGR044-3A22.

144. The method of embodiment 143, wherein the DNA construct is introduced using polyethylene glycol (PEG) mediated DNA uptake, electroporation, ballistic infiltration using DNA coated microprojectiles (gene gun), an Agrobacteria infiltration based vector, or a plant virus based vector.

145. The method of embodiment 143 or 144, wherein the DNA construct comprises a transgene.

146. The method of embodiment 143 or 144, wherein the DNA construct comprises an RNAi construct.

147. The method of any one of embodiments 143 to 146, wherein the *Brassica carinata* variety comprises the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22, when grown in the same location under the same environmental conditions.

148. The method of any one of embodiments 143 to 147, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

149. The method of embodiment 148, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

150. A plant, or part thereof, or seed of a *Brassica carinata* variety produced by the method of any one of embodiments 143 to 149.

151. A method of producing a *Brassica carinata* variety produced from the plant of embodiment 119, wherein the *Brassica carinata* variety comprises a desired trait, the method comprising the steps of:

- (a) crossing a plant of cultivar AGR044-3A22 with another *Brassica carinata* variety comprising the desired trait;
- (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait;
- (c) selfing the progeny plants that have the desired trait to produce further progeny seed; and
- (d) growing the further progeny seed and selecting further progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-3A22.

152. The method of embodiment 151, wherein steps (c) and (d) are repeated until the *Brassica carinata* variety produced from cultivar AGR044-3A22 has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions.

153. The method of embodiment 151 or 152, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

154. The method of embodiment 153, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

155. A plant, or part thereof, or seed of a *Brassica carinata* variety produced by the method of any one of embodiments 151 to 154.

156. A method of producing a *Brassica carinata* variety produced from the plant of embodiment 119, wherein the *Brassica carinata* variety comprises a new trait, the method comprising exposing seedlings or microspores to a mutagenic agent and allowing the surviving fraction to develop into mature plants.

157. The method of embodiment 156, wherein the mutagenic agent is ethyl methanesulfonate, N-ethyl-N-nitrosourea, or x-ray, gamma or ultraviolet radiation.

158. A plant, or part thereof, or seed of a *Brassica carinata* variety produced by the method of embodiment 156 or 157.

159. A method of producing a carinata variety produced from the plant of embodiment 119, wherein the carinata variety comprises a desired trait, the method comprising:

- (a) crossing a plant of cultivar AGR044-3A22 with a plant of another Brassicaceae species comprising the desired trait;
- (b) using embryo rescue techniques to recover viable F1 plants from the cross or growing F1 seeds to produce F1 plants;
- (c) selfing the F1 plants that have the desired trait and carinata character;
- (d) using embryo rescue techniques to recover viable F2 plants or growing F2 seeds to produce F2 plants;
- (e) selfing the F2 plants that have the desired trait and carinata character;
- (f) using embryo rescue techniques to recover viable F3 plants or growing F3 seeds to produce progeny plants;
- (g) selfing the progeny plants that have the desired trait and carinata character to produce further progeny plants; and
- (h) selecting the progeny plants with the desired trait and carinata character to produce the carinata variety produced from cultivar AGR044-3A22.

160. The method of embodiment 159, wherein steps (g) and (h) are repeated until the carinata variety produced from cultivar AGR044-3A22 has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions.

161. The method of embodiment 159 or 160, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

162. The method of embodiment 161, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

163. A plant, or part thereof, or seed of a progeny carinata variety produced by the method of any one of embodiments 159 to 162.

164. A method of producing a commercial plant product, the method comprising growing the plant of embodiment 119 to produce a commercial crop, and producing said commercial plant product from the commercial crop.

165. The method of embodiment 164, wherein the commercial plant product comprises oil, meal, or protein isolate.

166. A commercial plant product produced by the method of embodiment 164 or 165.

167. Oil, meal, or protein isolate produced by the method of embodiment 165.

168. Crushed, non-viable seed of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014.
169. A cell of a seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014.
170. A cell of a plant of *Brassica carinata* cultivar AGR044-3A22, or a part thereof, produced from the seed defined in embodiment 169.
171. A protoplast of a plant of *Brassica carinata* cultivar AGR044-3A22, or a part thereof, produced from the seed defined in embodiment 169.
172. The cell of embodiment 170, wherein the plant part is an ovule, a leaf, pollen, a seed, an embryo a root, a root tip, a pod, a flower, or a stalk.
173. The cell of embodiment 172, wherein the plant part is pollen.
174. The cell of embodiment 172, wherein the plant part is an ovule.
175. A cell of a *Brassica carinata* plant, or parts thereof, having essentially all of the physiological and morphological characteristics of the plant defined in embodiment 170 when grown in the same location under the same environmental conditions.
176. A tissue culture of protoplasts or regenerable cells of the plant, or part thereof, defined in embodiment 170.
177. The tissue culture according to embodiment 176, wherein the protoplasts or regenerable cells are produced from a tissue selected from the group consisting of leaves, pollen, embryos, roots, root tips, pods, flowers, ovules, and stalks.
178. A cell of a *Brassica carinata* plant regenerated from the tissue culture of embodiment 176 or 177, wherein said plant has essentially all of the morphological and physiological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions.
179. A cell of a regenerated *Brassica carinata* plant having essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions, the regenerated plant having been produced using a tissue culture, wherein the tissue culture is produced from the plant or part thereof defined in embodiment 170.

180. Use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce seed, wherein the seed is produced by self-fertilization or cross-fertilization.

181. Use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014 to produce an F1 hybrid *Brassica carinata* seed, wherein the plant is either a female parent or a male parent in a cross-fertilization.

182. The use of embodiment 181 wherein the plant is the female parent.

183. The use of embodiment 181 wherein the plant is the male parent.

184. A cell of an F1 hybrid plant grown from the F1 hybrid seed produced by the use according to any one of embodiments 181 to 183.

185. A cell of an F1 hybrid plant grown from F1 hybrid seed produced by a method comprising crossing a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid *carinata* seed.

186. Use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce a Doubled Haploidy variety.

187. Use of embodiment 186, wherein chromosome doubling is introduced by chemical or physical means.

188. A cell of a Doubled Haploidy variety produced from *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014.

189. Use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce a *Brassica carinata* variety comprising a desired trait.

190. The use of embodiment 189, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

191. The use of embodiment 190, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

192. A cell of a plant of a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety is produced by a method comprising the steps of:

- (a) crossing a plant of cultivar AGR044-3A22 with another *Brassica carinata* variety comprising the desired trait;
- (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait;
- (c) backcrossing the selected progeny plants that have the desired trait with plants of cultivar AGR044-3A22 to produce backcross progeny plants; and
- (d) growing the resultant backcross progeny seed and selecting backcross progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-3A22.

193. The cell of embodiment 192, wherein the method to produce the *Brassica carinata* variety further comprises repeating steps (c) and (d) until the *Brassica carinata* variety produced from cultivar AGR044-3A22 has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions.

194. The cell of embodiment 192 or 193, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

195. The cell of embodiment 194, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

196. Use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce a *Brassica carinata* variety comprising a desired trait, wherein the desired trait is conferred by a DNA construct.

197. The use of embodiment 196, wherein the DNA construct is introduced using polyethylene glycol (PEG) mediated DNA uptake, electroporation, ballistic infiltration using DNA coated microprojectiles (gene gun), an *Agrobacteria* infiltration based vector, or a plant virus based vector.

198. The use of embodiment 196 or 197, wherein the DNA construct comprises a transgene.

199. The use of embodiment 196 or 197, wherein the DNA construct comprises an RNAi construct.

200. The use of any one of embodiments 196 to 199, wherein the *Brassica carinata* variety comprises the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions.

201. The use of any one of embodiments 196 to 200, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

202. The use of embodiment 201, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

203. A cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-3A22, the seed of which has been deposited under ATCC Accession number PTA-123014, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety was produced by a method comprising introducing a DNA construct conferring the desired trait into a plant of cultivar AGR044-3A22.

204. The cell of embodiment 203, wherein the DNA construct is introduced using polyethylene glycol (PEG) mediated DNA uptake, electroporation, ballistic infiltration using DNA coated microprojectiles (gene gun), an Agrobacteria infiltration based vector, or a plant virus based vector.

205. The cell of embodiment 203 or 204, wherein the DNA construct comprises a transgene.

206. The cell of embodiment 203 or 204, wherein the DNA construct comprises an RNAi construct.

207. The cell of any one of embodiments 203 to 206, wherein the *Brassica carinata* variety comprises the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions.

208. The cell of any one of embodiments 203 to 207, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

209. The cell of embodiment 208, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

210. A cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-3A22, the seed of which has been deposited under ATCC Accession number PTA-123014, wherein the

Brassica carinata variety comprises a desired trait, and wherein the *Brassica carinata* variety was produced by a method comprising the steps of:

- (a) crossing a plant of cultivar AGR044-3A22 with a plant of another *Brassica carinata* variety comprising the desired trait;
- (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait;
- (c) selfing the progeny plants that have the desired trait to produce further progeny plants; and
- (d) growing the resultant further progeny plants and selecting further progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-3A22.

211. The cell of embodiment 210, wherein steps (c) and (d) are repeated until the *Brassica carinata* variety produced from cultivar AGR044-3A22 has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions.

212. The cell of embodiment 210 or 211, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

213. The cell of embodiment 212, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

214. Use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce a *Brassica carinata* variety comprising a new trait, wherein the new trait is introduced by exposing seedlings or microspores to a mutagenic agent.

215. The use of embodiment 214, wherein the mutagenic agent is ethyl methanesulfonate, N-ethyl-N-nitrosourea, or x-ray, gamma or ultraviolet radiation.

216. A cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, wherein the *Brassica carinata* variety comprises a new trait, and wherein the *Brassica carinata* variety is produced by a method comprising exposing seedlings or microspores to a mutagenic agent and allowing the surviving fraction to develop into mature plants.

217. The cell of embodiment 216, wherein the mutagenic agent is ethyl methanesulfonate, N-ethyl-N-nitrosourea, or x-ray, gamma or ultraviolet radiation.

218. Use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce

a carinata variety comprising a desired trait, wherein the desired trait is introduced by crossing a plant of cultivar AGR044-3A22 with a plant of another Brassicaceae species comprising the desired trait.

219. The use of embodiment 218, wherein the carinata variety produced from cultivar AGR044-3A22 has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions.

220. The use of embodiment 218 or 219, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

221. The use of embodiment 220, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

222. A cell of a plant of a carinata variety comprising a desired trait, wherein the carinata variety is produced by a method comprising:

- (a) crossing a plant of cultivar AGR044-3A22 with a plant of another Brassicaceae species comprising the desired trait;
- (b) using embryo rescue techniques to recover viable F1 plants from the cross or growing F1 seeds to produce F1 plants;
- (c) selfing the F1 plants that have the desired trait and carinata character;
- (d) using embryo rescue techniques to recover viable F2 plants or growing F2 seeds to produce F2 plants;
- (e) selfing the F2 plants that have the desired trait and carinata character;
- (f) using embryo rescue techniques to recover viable F3 plants or growing F3 seeds to produce progeny plants;
- (g) selfing the progeny plants that have the desired trait and carinata character to produce further progeny plants; and
- (h) selecting the progeny plants with the desired trait and carinata character to produce the carinata variety produced from cultivar AGR044-3A22.

223. The cell of embodiment 222, wherein steps (g) and (h) are repeated until the carinata variety produced from cultivar AGR044-3A22 has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions.

224. The method of embodiment 222 or 223, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

225. The method of embodiment 224, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

226. Use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce a commercial crop.

227. Use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce a commercial plant product.

228. The use of embodiment 227, wherein the commercial plant product comprises oil, meal, or protein isolate.

229. A plant, or part thereof, whose genotype has greater than 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98% or 99% of the single nucleotide polymorphisms and indel markers of Tables 19 to 35 in common with AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014.

230. The plant part of embodiment 229, wherein the plant part is an ovule, a leaf, pollen, a seed, an embryo a root, a root tip, a pod, a flower, a stalk, a cell, or a protoplast.

231. A seed whose genotype has greater than 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98% or 99% of the single nucleotide polymorphisms and indel markers of Tables 19 to 35 in common with AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014.

232. A cell of a plant, or part thereof, whose genotype has greater than 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98% or 99% of the single nucleotide polymorphisms and indel markers of Tables 19 to 35 in common with AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014.

233. The cell of embodiment 232, wherein the plant part is an ovule, a leaf, pollen, a seed, an embryo a root, a root tip, a pod, a flower, a stalk, a cell, or a protoplast.

234. A cell of a seed whose genotype has greater than 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98% or 99% of the single nucleotide polymorphisms and indel markers of Tables 19 to 35 in common with AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014.

[0037] 4. EVALUATION CRITERIA

[0038] In the description and tables which follow a number of terms are used. In order to aid in a clear and consistent understanding of the specification the following definitions and/or explanations of the assessment of the evaluation criteria are provided.

[0039] **Type.** Type refers to whether the new cultivar is considered to be primarily a Spring or Winter type of *Brassica carinata*.

[0040] **Ploidy.** Ploidy refers to whether the number of chromosomes exhibited by the cultivar is diploid or tetraploid.

[0041] **Leaf Anthocyanin Coloration.** The presence or absence of leaf anthocyanin coloration and the degree thereof if present are observed when the plant has reached the 9 to 11 leaf-stage.

[0042] **Time of Flowering.** A determination is made of the number of days when at least 50 percent of the plants have one or more open buds on a terminal raceme in the year of sowing.

[0043] **Plant Height.** The overall plant height at the end of flowering is observed (mean of 50).

[0044] **Flower Petal Coloration.** The coloration of open exposed petals on the first day of flowering is observed.

[0045] **Pod Anthocyanin Coloration.** The presence or absence at maturity of silique anthocyanin coloration, and the degree thereof if present are observed.

[0046] **Silique attitude (Pod Habit).** The typical manner in which the silique are borne on the plant at maturity is observed.

[0047] **Maturity.** The number of days from planting to maturity is observed with maturity being defined as the plant stage when pods with seed color change, occurring from green to brown or black, on the bottom third of the pod bearing area of the main stem.

[0048] **Seeds Per Pod.** The average number of seeds per pod is observed (mean of 50).

[0049] **Seed Size.** The weight in grams of 1,000 typical seeds is determined at maturity while such seeds exhibit a moisture content of approximately 5 to 6 percent by weight.

[0050] **Seed Coat Color.** The seed coat color of typical mature seeds is observed.

[0051] **NIR analysis:** Near infrared spectroscopy screening is a non-destructive method that allows one to determine the NIR absorption spectra of intact samples of material such as plant seed. Once the absorption spectra of the sample is determined, it can be used to determine the sample's content of compounds such as protein, oil, fatty acids, glucosinolates and others. This is done by comparing the spectra to those of calibrated samples. Calibration was developed in-house by correlating the NIR spectra with experimentally-measured seed quality parameters of over 700 diverse carinata lines. These lines comprise a highly-diverse range of oil contents, profiles, glucosinolate levels, seed colours, etc. and have been collected from regions all around the world.

[0052] **Oil Content:** The typical percentage by weight oil present in the mature whole dried seeds is determined by Near Infrared Spectroscopy (NIR).

[0053] **Protein Content:** The typical percentage by weight of protein in the oil free meal of the mature whole dried seeds is determined by NIR analysis.

[0054] **Fatty Acid Content:** The typical percentages by weight of fatty acids present in the endogenously formed oil of the mature whole dried seeds are determined by NIR analysis. Seed oil of *Brassica carinata* and other brassica oilseeds, are comprised largely of mono and poly unsaturated fatty acids ranging from 18 to 22 carbons in chain length. Of the monounsaturated fatty acids, one finds predominantly oleic acid, (C18.1), gondoic acid (C20.1) erucic acid (C22.1). Of the polyunsaturated fatty acids, one finds predominantly Linoleic (C18.2) and Linolenic (C18.3). The remaining fraction is comprised of saturated fatty acids (SATS), including Lauric (C12.0), Myristic acid (C14.0), Palmitic acid (C16) and Stearic acid (C18.0).

[0055] **Glucosinolate Content.** The total aliphatic glucosinolate content of the meal of the seeds is determined by NIR and is expressed as micromoles per gram seed weight.

[0056] **Resistance to Shattering.** Resistance to silique shattering is observed at seed maturity and is expressed on a scale of 1 (poor) to 5 (excellent).

[0057] **Resistant to Lodging.** Resistance to lodging at maturity and is expressed on a scale of 1 (weak) to 5 (strong).

[0058] **Frost Tolerance (Spring Type Only).** The ability of young plants to withstand late spring frosts at a typical growing area is evaluated and is expressed on a scale of 1 (poor) to 5 (excellent).

[0059] **Disease Resistance:** Resistant to various diseases is evaluated and is expressed on a scale of 0 (not tested), 1 (susceptible), 2 (low resistance), 3 (moderate resistance), or 4 (high resistance).

[0060] **Herbicide Resistance:** Resistance to various herbicides when applied at standard recommended application rates is expressed on a scale of 1 (resistant), 2 (tolerant), or 3 (susceptible).

[0061] 5. DETAILED DESCRIPTION

[0062] AGR044-312D and AGR044-3A22 are inbred *Brassica carinata* varieties that have been selected on the basis of improved yield relative to existing commercial *carinata* varieties (eg A110 and A120). Other improvements relative to existing commercial *carinata* varieties may include: reduced levels of seed glucosinolate, improved disease resistance, reduced tendency to lodging and pod shatter.

[0063] In some embodiments, the present invention provides methods, uses, and compositions of matter related to the cells, seeds, plants or parts thereof, derivative seeds, and derivative plants of *Brassica carinata* cultivars AGR044-312D and AGR044-3A22.

[0064] In the embodiments described below, “essentially all of the physiological and morphological characteristics” can mean, for example, the quantitative physiological and morphological characteristics described in Tables 1 and 3-7 for AGR044-3A22 or in Tables 1, 2, and 14 for AGR044-312D when grown in the same location under the same environmental conditions, as determined at the 5% significance level.

[0065] In the embodiments described below, “essentially all of the physiological and morphological characteristics” can also mean the quantitative physiological and morphological characteristics described in Tables 1, 3, and 5-7 for AGR044-3A22 or in Tables 1, 2, 5-10, and 12-14 for AGR044-312D when grown in the same location under the same environmental conditions, as determined at the 5% significance level.

[0066] **5.1 AGR044-312D**

[0067] **5.1.1 Seeds, plants, plant parts and cells**

[0068] In one embodiment, the invention provides a seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015.

[0069] In another embodiment, the invention provides a plant of *Brassica carinata* cultivar AGR044-312D, or a part thereof, produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015.

[0070] In another embodiment, the invention provides a plant part of *Brassica carinata* cultivar AGR044-312D, or a part thereof, produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, wherein the plant part is an ovule, a leaf, pollen, a seed, an embryo a root, a root tip, a pod, a flower, a stalk, a cell, or a protoplast.

[0071] In another embodiment, the invention provides a plant part of *Brassica carinata* cultivar AGR044-312D, or a part thereof, produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, wherein the plant part is pollen.

[0072] In another embodiment, the invention provides a plant part of *Brassica carinata* cultivar AGR044-312D, or a part thereof, produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, wherein the plant part is an ovule.

[0073] In another embodiment, the invention provides a *Brassica carinata* plant, or a part thereof, having essentially all of the physiological and morphological characteristics of a plant of *Brassica*

carinata cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, when grown in the same location under the same environmental conditions.

[0074] In another embodiment, the invention provides a cell of a seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015.

[0075] In another embodiment, the invention provides a cell of a plant of *Brassica carinata* cultivar AGR044-312D, or a part thereof, produced from a seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015.

[0076] In another embodiment, the invention provides a protoplast of a plant of *Brassica carinata* cultivar AGR044-312D, or a part thereof, produced from a seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015.

[0077] In another embodiment, the invention provides a cell of a plant of *Brassica carinata* cultivar AGR044-312D, or a part thereof, produced from a seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, wherein the plant part is an ovule, a leaf, pollen, a seed, an embryo a root, a root tip, a pod, a flower, or a stalk.

[0078] In another embodiment, the invention provides a cell of a plant of *Brassica carinata* cultivar AGR044-312D, or a part thereof, produced from a seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, wherein the plant part is pollen.

[0079] In another embodiment, the invention provides a cell of a plant of *Brassica carinata* cultivar AGR044-312D, or a part thereof, produced from a seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, wherein the plant part is an ovule.

[0080] In another embodiment, the invention provides a cell of a *Brassica carinata* plant, or parts thereof, having essentially all of the physiological and morphological characteristics of a plant of *Brassica carinata* cultivar AGR044-312D produced from a seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, when grown in the same location under the same environmental conditions.

[0081] **5.1.2 Tissue cultures and regenerated plants**

[0082] In another embodiment, the invention provides a tissue culture of protoplasts or regenerable cells of a plant of *Brassica carinata* cultivar AGR044-312D, or a part thereof, produced from the seed of

Brassica carinata cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015.

[0083] In another embodiment, the invention provides a tissue culture of protoplasts or regenerable cells of a plant of *Brassica carinata* cultivar AGR044-312D, or a part thereof, produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, wherein the protoplasts or regenerable cells are produced from a tissue selected from the group consisting of leaves, pollen, embryos, roots, root tips, pods, flowers, ovules, and stalks.

[0084] In another embodiment, the invention provides a *Brassica carinata* plant regenerated from a tissue culture of protoplasts or regenerable cells of a plant of *Brassica carinata* cultivar AGR044-312D, or a part thereof, produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, wherein the plant has essentially all of the morphological and physiological characteristics of cultivar AGR044-312D, the seed of which has been deposited under ATCC Accession number PTA-123015, when grown in the same location under the same environmental conditions.

[0085] In another embodiment, the invention provides a *Brassica carinata* plant regenerated from a tissue culture of protoplasts or regenerable cells of a plant of *Brassica carinata* cultivar AGR044-312D, or a part thereof, produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, wherein the protoplasts or regenerable cells are produced from a tissue selected from the group consisting of leaves, pollen, embryos, roots, root tips, pods, flowers, ovules, and stalks, wherein the plant has essentially all of the morphological and physiological characteristics of cultivar AGR044-312D, the seed of which has been deposited under ATCC Accession number PTA-123015, when grown in the same location under the same environmental conditions.

[0086] In another embodiment, the invention provides a regenerated *Brassica carinata* plant having essentially all of the physiological and morphological characteristics of the cultivar AGR044-312D when grown in the same location under the same environmental conditions, the regenerated plant having been produced using a tissue culture, wherein the tissue culture is produced from a plant of *Brassica carinata* cultivar AGR044-312D, or a part thereof, produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015.

[0087] In another embodiment, the invention provides a cell of a *Brassica carinata* plant regenerated from a tissue culture of protoplasts or regenerable cells of a plant of *Brassica carinata* cultivar AGR044-312D, or a part thereof, produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, wherein the plant has essentially all of the morphological and physiological characteristics of cultivar AGR044-312D, the seed of which has been deposited under ATCC Accession number PTA-123015, when grown in the same location under the same environmental conditions.

[0088] In another embodiment, the invention provides a cell of a *Brassica carinata* plant regenerated from a tissue culture of protoplasts or regenerable cells of a plant of *Brassica carinata* cultivar AGR044-312D, or a part thereof, produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, wherein the protoplasts or regenerable cells are produced from a tissue selected from the group consisting of leaves, pollen, embryos, roots, root tips, pods, flowers, ovules, and stalks, wherein the plant has essentially all of the morphological and physiological characteristics of cultivar AGR044-312D, the seed of which has been deposited under ATCC Accession number PTA-123015, when grown in the same location under the same environmental conditions.

[0089] In another embodiment, the invention provides a cell of a regenerated *Brassica carinata* plant having essentially all of the physiological and morphological characteristics of the cultivar AGR044-312D when grown in the same location under the same environmental conditions, the regenerated plant having been produced using a tissue culture, wherein the tissue culture is produced from a plant of *Brassica carinata* cultivar AGR044-312D, or a part thereof, produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015.

[0090] 5.1.3 Methods of crossing and uses for crossing *Brassica carinata* plants, and the cells and seeds produced therefrom

[0091] In another embodiment, the invention provides a method for producing *Brassica carinata* seed comprising crossing *Brassica carinata* plants and harvesting the resulting *Brassica carinata* seed, wherein at least one *Brassica carinata* plant is a plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015.

[0092] In another embodiment, the invention provides a *Brassica carinata* seed produced by a method for producing *Brassica carinata* seed comprising crossing *Brassica carinata* plants and harvesting the resulting *Brassica carinata* seed, wherein at least one *Brassica carinata* plant is a plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015.

[0093] In another embodiment, the invention provides a cell of a *Brassica carinata* seed produced by a method for producing *Brassica carinata* seed comprising crossing *Brassica carinata* plants and harvesting the resulting *Brassica carinata* seed, wherein at least one *Brassica carinata* plant is a plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015.

[0094] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession

number PTA-123015, to produce seed, wherein the seed is produced by self-fertilization or cross-fertilization.

[0095] 5.1.4 Methods of and uses for producing an F1 hybrid *Brassica carinata* seed, and the cells, seeds and plants produced therefrom

[0096] In another embodiment, the invention provides a method for producing a first generation (F1) hybrid *Brassica carinata* seed comprising crossing a plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid carinata seed, and wherein the plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D is either a female parent or a male parent.

[0097] In another embodiment, the invention provides a method for producing a first generation (F1) hybrid *Brassica carinata* seed comprising crossing a plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid carinata seed, and wherein the plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D is the female parent.

[0098] In another embodiment, the invention provides a method for producing a first generation (F1) hybrid *Brassica carinata* seed comprising crossing a plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid carinata seed, and wherein the plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D is the male parent.

[0099] In another embodiment, the invention provides an F1 hybrid seed produced by a method comprising crossing a plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid carinata seed, and wherein the plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D is either a female parent or a male parent.

[0100] In another embodiment, the invention provides an F1 hybrid seed produced by a method comprising crossing a plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid carinata seed, and wherein the plant of *Brassica carinata* cultivar

AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D is the female parent.

[0101] In another embodiment, the invention provides an F1 hybrid seed produced by a method comprising crossing a plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid carinata seed, and wherein the plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D is the male parent.

[0102] In another embodiment, the invention provides an F1 hybrid plant grown from an F1 hybrid seed produced by a method comprising crossing a plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid carinata seed, and wherein the plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D is either a female parent or a male parent.

[0103] In another embodiment, the invention provides an F1 hybrid plant grown from an F1 hybrid seed produced by a method comprising crossing a plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid carinata seed, and wherein the plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D is the female parent.

[0104] In another embodiment, the invention provides an F1 hybrid plant grown from an F1 hybrid seed produced by a method comprising crossing a plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid carinata seed, and wherein the plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D is the male parent.

[0105] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015 to produce an F1 hybrid *Brassica carinata* seed, wherein the plant is either a female parent or a male parent in a cross-fertilization.

[0106] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015 to produce an F1 hybrid *Brassica carinata* seed, wherein the plant is the female parent.

[0107] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015 to produce an F1 hybrid *Brassica carinata* seed, wherein the plant is the male parent.

[0108] In another embodiment, the invention provides a cell of an F1 hybrid plant grown from the F1 hybrid seed produced by any of the above uses.

[0109] In another embodiment, the invention provides a cell of an F1 hybrid plant grown from F1 hybrid seed produced by a method comprising crossing a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid *carinata* seed.

[0110] 5.1.5 Methods of and uses for producing a Doubled Haploidy variety, and the cells, seeds, and plants produced therefrom

[0111] In another embodiment, the invention provides a method for producing a Doubled Haploidy variety comprising: (a) isolating a flower bud of an F1 hybrid plant grown from an F1 hybrid seed produced by a method comprising crossing a plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid *carinata* seed, and wherein the plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D is either a female parent or a male parent; (b) dissecting out a haploid microspore; (c) placing the haploid microspore in culture; (d) inducing the microspore to differentiate into an embryo and subsequently into a plantlet; (e) identifying whether the plantlet contains a diploid chromosome number, wherein the diploid chromosome number occurred through chromosome doubling; and (f) continuing to grow the plantlet if it contains a diploid chromosome number.

[0112] In another embodiment, the invention provides a method for producing a Doubled Haploidy variety comprising: (a) isolating a flower bud of an F1 hybrid plant grown from an F1 hybrid seed produced by a method comprising crossing a plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid *carinata* seed, and wherein the plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D is the female parent; (b) dissecting out a haploid microspore; (c) placing the haploid microspore in culture; (d) inducing the microspore to differentiate into an embryo and subsequently into a plantlet; (e) identifying whether the plantlet contains a diploid chromosome number, wherein the diploid chromosome number occurred through chromosome doubling; and (f) continuing to grow the plantlet if it contains a diploid chromosome number.

[0113] In another embodiment, the invention provides a method for producing a Doubled Haploidy variety comprising: (a) isolating a flower bud of an F1 hybrid plant grown from an F1 hybrid seed produced by a method comprising crossing a plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid carinata seed, and wherein the plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D is the male parent; (b) dissecting out a haploid microspore; (c) placing the haploid microspore in culture; (d) inducing the microspore to differentiate into an embryo and subsequently into a plantlet; (e) identifying whether the plantlet contains a diploid chromosome number, wherein the diploid chromosome number occurred through chromosome doubling; and (f) continuing to grow the plantlet if it contains a diploid chromosome number.

[0114] In another embodiment, the invention provides a method for producing a Doubled Haploidy variety comprising: (a) isolating a flower bud of an F1 hybrid plant grown from an F1 hybrid seed produced by a method comprising crossing a plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid carinata seed, and wherein the plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D is either a female parent or a male parent; (b) dissecting out a haploid microspore; (c) placing the haploid microspore in culture; (d) inducing the microspore to differentiate into an embryo and subsequently into a plantlet; (e) identifying whether the plantlet contains a diploid chromosome number, wherein the diploid chromosome number occurred through chromosome doubling; and (f) continuing to grow the plantlet if it contains a diploid chromosome number; wherein the method further comprises inducing chromosome doubling by chemical or physical means.

[0115] In another embodiment, the invention provides a method for producing a Doubled Haploidy variety comprising: (a) isolating a flower bud of an F1 hybrid plant grown from an F1 hybrid seed produced by a method comprising crossing a plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid carinata seed, and wherein the plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D is the female parent; (b) dissecting out a haploid microspore; (c) placing the haploid microspore in culture; (d) inducing the microspore to differentiate into an embryo and subsequently into a plantlet; (e) identifying whether the plantlet contains a diploid chromosome number, wherein the diploid chromosome number occurred through chromosome doubling; and (f) continuing to grow the plantlet if it contains a diploid chromosome number; wherein the method further comprises inducing chromosome doubling by chemical or physical means.

[0116] In another embodiment, the invention provides a method for producing a Doubled Haploidy variety comprising: (a) isolating a flower bud of an F1 hybrid plant grown from an F1 hybrid seed

produced by a method comprising crossing a plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid *carinata* seed, and wherein the plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D is the male parent; (b) dissecting out a haploid microspore; (c) placing the haploid microspore in culture; (d) inducing the microspore to differentiate into an embryo and subsequently into a plantlet; (e) identifying whether the plantlet contains a diploid chromosome number, wherein the diploid chromosome number occurred through chromosome doubling; and (f) continuing to grow the plantlet if it contains a diploid chromosome number; wherein the method further comprises inducing chromosome doubling by chemical or physical means.

[0117] In another embodiment, the invention provides a plant, or part thereof, or seed of a Doubled Haploidy variety produced by any of the above methods.

[0118] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015 to produce a Doubled Haploidy variety.

[0119] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015 to produce a Doubled Haploidy variety, wherein chromosome doubling is introduced by chemical or physical means.

[0120] In another embodiment, the invention provides a cell of a Doubled Haploidy variety produced from *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015.

[0121] In another embodiment, the invention provides use of a plant of a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a Doubled Haploidy variety.

[0122] In another embodiment, the invention provides use of a plant of a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a Doubled Haploidy variety, wherein chromosome doubling is introduced by chemical or physical means.

[0123] **5.1.6 Desired traits**

[0124] In one aspect, the present invention includes the introduction of a desired trait into *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, to produce a *Brassica carinata* variety comprising the desired trait.

[0125] Examples of potential desired traits include

- a. cytoplasmic male sterility, CMS restorer traits,
- b. biotic and abiotic stress resistance such as disease resistance, fungal resistance, pest resistance, drought tolerance, and frost tolerance,
- c. agronomic traits such as increased pod shatter resistance, improved harvestability, improved nutrient usage efficiency, seed colour seed size, seed pod size, seed pod architecture, seed pod fill. earlier and more uniform time to flowering, earlier maturity, extent of branching, flower colour and density, and plant height,
- d. altered metabolism (increased seed oil, increased seed protein, altered seed oil or fatty acid profile, reduced seed content of glucosinolates and other antinutritionals),
- e. improved performance: improved oil per unit area, improved grain per unit area,
- f. herbicide tolerance including tolerance to glyphosate, glufosinate, imidazolinones and auxin analogues such as 2,4-D and dicamba.

[0126] **5.1.7 Methods of and uses for introducing a desired trait by crossing and backcrossing, and the cells, seeds and plants produced therefrom**

[0127] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from a plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, and wherein the *Brassica carinata* variety comprises a desired trait, the method comprising the steps of: (a) crossing a plant of cultivar AGR044-312D with another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) backcrossing the selected progeny plants that have the desired trait with plants of cultivar AGR044-312D to produce backcross progeny seed; and (d) growing the resultant backcross progeny seed and selecting backcross progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-312D.

[0128] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from a plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, and wherein the *Brassica carinata* variety comprises a desired trait, the method comprising the steps of: (a) crossing a plant of cultivar AGR044-312D with another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) backcrossing the selected progeny plants that have the desired trait with plants of cultivar AGR044-312D to produce backcross progeny seed; and (d) growing the resultant backcross progeny seed and selecting backcross progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-312D; wherein steps (c) and (d) are repeated until the *Brassica carinata* variety produced from cultivar AGR044-312D has the desired trait and essentially all of the physiological and

morphological characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions.

[0129] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from a plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, and wherein the *Brassica carinata* variety comprises a desired trait, the method comprising the steps of: (a) crossing a plant of cultivar AGR044-312D with another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) backcrossing the selected progeny plants that have the desired trait with plants of cultivar AGR044-312D to produce backcross progeny seed; and (d) growing the resultant backcross progeny seed and selecting backcross progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-312D; and wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0130] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from a plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, and wherein the *Brassica carinata* variety comprises a desired trait, the method comprising the steps of: (a) crossing a plant of cultivar AGR044-312D with another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) backcrossing the selected progeny plants that have the desired trait with plants of cultivar AGR044-312D to produce backcross progeny seed; and (d) growing the resultant backcross progeny seed and selecting backcross progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-312D; wherein steps (c) and (d) are repeated until the *Brassica carinata* variety produced from cultivar AGR044-312D has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions; and wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0131] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from a plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, and wherein the *Brassica carinata* variety comprises a desired trait, the method comprising the steps of: (a) crossing a plant of cultivar AGR044-312D with another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) backcrossing the selected progeny plants that have the desired trait with plants of cultivar AGR044-312D to produce backcross progeny seed; and (d) growing the resultant backcross progeny seed and selecting backcross progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from

cultivar AGR044-312D; and wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, auxin analogues such as 2,4-D and dicamba.

[0132] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from a plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, and wherein the *Brassica carinata* variety comprises a desired trait, the method comprising the steps of: (a) crossing a plant of cultivar AGR044-312D with another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) backcrossing the selected progeny plants that have the desired trait with plants of cultivar AGR044-312D to produce backcross progeny seed; and (d) growing the resultant backcross progeny seed and selecting backcross progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-312D; wherein steps (c) and (d) are repeated until the *Brassica carinata* variety produced from cultivar AGR044-312D has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions; and wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, auxin analogues such as 2,4-D and dicamba.

[0133] In another embodiment, the invention provides a plant, or part thereof, or seed of a *Brassica carinata* variety produced by any of the above methods.

[0134] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a *Brassica carinata* variety comprising a desired trait.

[0135] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a *Brassica carinata* variety comprising a desired trait, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0136] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a *Brassica carinata* variety comprising a desired trait, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

[0137] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, wherein the *Brassica carinata* variety

comprises a desired trait, and wherein the *Brassica carinata* variety is produced by a method comprising the steps of: (a) crossing a plant of cultivar AGR044-312D with another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) backcrossing the selected progeny plants that have the desired trait with plants of cultivar AGR044-312D to produce backcross progeny plants; and (d) growing the resultant backcross progeny seed and selecting backcross progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-312D.

[0138] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, wherein the variety comprises a desired trait, and wherein the *Brassica carinata* variety is produced by a method comprising the steps of: (a) crossing a plant of cultivar AGR044-312D with another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) backcrossing the selected progeny plants that have the desired trait with plants of cultivar AGR044-312D to produce backcross progeny plants; and (d) growing the resultant backcross progeny seed and selecting backcross progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-312D; wherein the method to produce the *Brassica carinata* variety further comprises repeating steps (c) and (d) until the *Brassica carinata* variety produced from cultivar AGR044-312D has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions.

[0139] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety is produced by a method comprising the steps of: (a) crossing a plant of cultivar AGR044-312D with another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) backcrossing the selected progeny plants that have the desired trait with plants of cultivar AGR044-312D to produce backcross progeny plants; and (d) growing the resultant backcross progeny seed and selecting backcross progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-312D; wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0140] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety is produced by a method comprising the steps of: (a) crossing a plant of cultivar AGR044-312D with another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) backcrossing the selected progeny plants that have the desired trait with plants of cultivar AGR044-312D to produce backcross progeny plants; and (d) growing the

resultant backcross progeny seed and selecting backcross progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-312D; wherein the method to produce the *Brassica carinata* variety further comprises repeating steps (c) and (d) until the *Brassica carinata* variety produced from cultivar AGR044-312D has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions, and wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0141] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety is produced by a method comprising the steps of: (a) crossing a plant of cultivar AGR044-312D with another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) backcrossing the selected progeny plants that have the desired trait with plants of cultivar AGR044-312D to produce backcross progeny plants; and (d) growing the resultant backcross progeny seed and selecting backcross progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-312D, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

[0142] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety is produced by a method comprising the steps of: (a) crossing a plant of cultivar AGR044-312D with another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) backcrossing the selected progeny plants that have the desired trait with plants of cultivar AGR044-312D to produce backcross progeny plants; and (d) growing the resultant backcross progeny seed and selecting backcross progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-312D; wherein the method to produce the *Brassica carinata* variety further comprises repeating steps (c) and (d) until the *Brassica carinata* variety produced from cultivar AGR044-312D has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

[0143] **5.1.8 DNA constructs**

[0144] In one aspect, the present invention includes the introduction of a desired trait into *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, to produce a *Brassica carinata* variety comprising the desired trait, wherein the desired trait is conferred by a DNA construct.

[0145] The DNA construct can be introduced by a variety of methods, including by using polyethylene glycol (PEG) mediated DNA uptake, electroporation, ballistic infiltration using DNA coated microprojectiles (gene gun), an Agrobacteria infiltration based vector, or a plant virus based vector.

[0146] The DNA construct can comprise any type of DNA, including a transgene or a DNA construct that is designed to modulate the expression of endogenous genes.

[0147] Examples of transgenes that could be incorporated include, but are not limited to, the following group: *Crambe abbyssinica* FAE1, *Teesdalia nodulicans* FAE1, *Cardamine graeca* FAE1 *Brassica napus* DGAT, *Tropaeolum majus* DGAT, Yeast SLC1

[0148] DNA constructs that are designed to modulate the expression of endogenous genes include, but are not limited to the following group: *Brassica carinata* Myb28, Myb29, FAD2 and FAD3 antisense RNA or RNAi sequences, which can be used to interfere or knock down the expression of endogenous genes to extremely low levels, simulating the effect of a null mutation at the endogenous locus. As discussed above, because *Brassica carinata* is amphidiploid, it can have multiple copies of genes from the contributing ancestral species that may create a high level of functional redundancy. As such, a single mutation in one of the homologues may not be sufficient to confer a phenotype. By using RNAi or an antisense approach, one may conceivably be capable of targeting all of the expressed homologues and achieving a functional knockdown effect. Such approaches require the RNAi or antisense RNA to be stably expressed.

[0149] **5.1.9 Methods of and uses for introducing a desired trait using DNA constructs, and the cells, seeds and plants produced therefrom**

[0150] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, and wherein the *Brassica carinata* variety comprises a desired trait, the method comprising introducing a DNA construct conferring the desired trait into a plant of cultivar AGR044-312D.

[0151] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, wherein the *Brassica carinata* variety comprises a desired trait, the method comprising introducing a DNA construct conferring the desired trait into a plant of cultivar AGR044-312D, and wherein the DNA construct is introduced using polyethylene glycol (PEG) mediated DNA uptake, electroporation, ballistic infiltration using DNA coated microprojectiles (gene gun), an Agrobacteria infiltration based vector, or a plant virus based vector.

[0152] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, wherein the *Brassica carinata* variety comprises a desired trait, the method comprising introducing a DNA construct conferring the desired trait into a plant of cultivar AGR044-312D, and wherein the DNA construct comprises a transgene.

[0153] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, wherein the *Brassica carinata* variety comprises a desired trait, the method comprising introducing a DNA construct conferring the desired trait into a plant of cultivar AGR044-312D, wherein the DNA construct is introduced using polyethylene glycol (PEG) mediated DNA uptake, electroporation, ballistic infiltration using DNA coated microprojectiles (gene gun), an Agrobacteria infiltration based vector, or a plant virus based vector, and wherein the DNA construct comprises a transgene.

[0154] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, wherein the *Brassica carinata* variety comprises a desired trait, the method comprising introducing a DNA construct conferring the desired trait into a plant of cultivar AGR044-312D, and wherein the DNA construct comprises an RNAi construct.

[0155] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, wherein the *Brassica carinata* variety comprises a desired trait, the method comprising introducing a DNA construct conferring the desired trait into a plant of cultivar AGR044-312D, wherein the DNA construct is introduced using polyethylene glycol (PEG) mediated DNA uptake, electroporation, ballistic infiltration using DNA coated microprojectiles (gene gun), an Agrobacteria infiltration based vector, or a plant virus based vector, and wherein the DNA construct comprises an RNAi construct.

[0156] In another embodiment, the invention provides any one of the above methods, wherein the *Brassica carinata* variety comprises the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-312D, when grown in the same location under the same environmental conditions.

[0157] In another embodiment, the invention provides any one of the above methods, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0158] In another embodiment, the invention provides any one of the above methods, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not

limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

[0159] In another embodiment, the invention provides a plant, or part thereof, or seed of a *Brassica carinata* variety produced by any one of the above methods.

[0160] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a *Brassica carinata* variety comprising a desired trait, wherein the desired trait is conferred by a DNA construct.

[0161] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a *Brassica carinata* variety comprising a desired trait, wherein the desired trait is conferred by a DNA construct, wherein the DNA construct is introduced using polyethylene glycol (PEG) mediated DNA uptake, electroporation, ballistic infiltration using DNA coated microprojectiles (gene gun), an Agrobacteria infiltration based vector, or a plant virus based vector.

[0162] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a *Brassica carinata* variety comprising a desired trait, wherein the desired trait is conferred by a DNA construct, and wherein the DNA construct comprises a transgene.

[0163] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a *Brassica carinata* variety comprising a desired trait, wherein the desired trait is conferred by a DNA construct, wherein the DNA construct is introduced using polyethylene glycol (PEG) mediated DNA uptake, electroporation, ballistic infiltration using DNA coated microprojectiles (gene gun), an Agrobacteria infiltration based vector, or a plant virus based vector, and wherein the DNA construct comprises a transgene.

[0164] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a *Brassica carinata* variety comprising a desired trait, wherein the desired trait is conferred by a DNA construct, and wherein the DNA construct comprises an RNAi construct.

[0165] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a *Brassica carinata* variety comprising a desired trait, wherein the desired trait is conferred by a DNA construct, wherein the DNA construct is introduced using polyethylene glycol (PEG) mediated DNA uptake, electroporation, ballistic infiltration using DNA coated microprojectiles (gene gun), an Agrobacteria infiltration based vector, or a plant virus based vector, and wherein the DNA construct comprises an RNAi construct.

[0166] In another embodiment, the invention provides any of the above uses, wherein the *Brassica carinata* variety comprises the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions.

[0167] In another embodiment, the invention provides any of the above uses, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0168] In another embodiment, the invention provides any of the above uses, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

[0169] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-312D, the seed of which has been deposited under ATCC Accession number PTA-123015, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety was produced by a method comprising introducing a DNA construct conferring the desired trait into a plant of cultivar AGR044-312D.

[0170] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-312D, the seed of which has been deposited under ATCC Accession number PTA-123015, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety was produced by a method comprising introducing a DNA construct conferring the desired trait into a plant of cultivar AGR044-312D, wherein the DNA construct is introduced using polyethylene glycol (PEG) mediated DNA uptake, electroporation, ballistic infiltration using DNA coated microprojectiles (gene gun), an Agrobacteria infiltration based vector, or a plant virus based vector.

[0171] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-312D, the seed of which has been deposited under ATCC Accession number PTA-123015, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety was produced by a method comprising introducing a DNA construct conferring the desired trait into a plant of cultivar AGR044-312D, and wherein the DNA construct comprises a transgene.

[0172] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-312D, the seed of which has been deposited under ATCC Accession number PTA-123015, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety was produced by a method comprising introducing a DNA construct conferring the desired trait into a plant of cultivar AGR044-312D, wherein the DNA construct is introduced using polyethylene glycol (PEG) mediated DNA uptake, electroporation, ballistic infiltration using DNA coated microprojectiles (gene gun), an Agrobacteria infiltration based vector, or a plant virus based vector, and wherein the DNA construct comprises a transgene.

[0173] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-312D, the seed of which has been deposited under ATCC Accession number PTA-123015, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety was produced by a method comprising introducing a DNA construct conferring the desired trait into a plant of cultivar AGR044-312D, and wherein the DNA construct comprises an RNAi construct.

[0174] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-312D, the seed of which has been deposited under ATCC Accession number PTA-123015, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety was produced by a method comprising introducing a DNA construct conferring the desired trait into a plant of cultivar AGR044-312D, wherein the DNA construct is introduced using polyethylene glycol (PEG) mediated DNA uptake, electroporation, ballistic infiltration using DNA coated microprojectiles (gene gun), an Agrobacteria infiltration based vector, or a plant virus based vector, and wherein the DNA construct comprises an RNAi construct.

[0175] In another embodiment, the invention provides any of the above cells, wherein the *Brassica carinata* variety comprises the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions.

[0176] In another embodiment, the invention provides any of the above cells, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0177] In another embodiment, the invention provides any of the above cells, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

[0178] 5.1.10 Methods of and uses for introducing a desired trait by an initial cross and then pedigree selection, and cells, plants and seeds produced therefrom

[0179] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, and wherein the *Brassica carinata* variety comprises a desired trait, the method comprising the steps of: (a) crossing a plant of cultivar AGR044-312D with another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) selfing the progeny plants that have the desired trait to produce further progeny seed; and (d) growing the further progeny seed and selecting further progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-312D.

[0180] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, and wherein the *Brassica carinata* variety comprises a desired trait, the method comprising the steps of: (a) crossing a plant of cultivar AGR044-312D with another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) selfing the progeny plants that have the desired trait to produce further progeny seed; and (d) growing the further progeny seed and selecting further progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-312D; wherein steps (c) and (d) are repeated until the *Brassica carinata* variety produced from cultivar AGR044-312D has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions.

[0181] In another embodiment, the invention provides any one of the above methods wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0182] In another embodiment, the invention provides any one of the above methods, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

[0183] In another embodiment, the invention provides a plant, or part thereof, or seed of a *Brassica carinata* variety produced by any one of the above methods.

[0184] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-312D, the seed of which has been deposited under ATCC Accession number PTA-123015, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety was produced by a method comprising the steps of: (a) crossing a plant of cultivar AGR044-312D with a plant of another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) selfing the progeny plants that have the desired trait to produce further progeny plants; and (d) growing the resultant further progeny plants and selecting further progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-312D.

[0185] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-312D, the seed of which has been deposited under ATCC Accession number PTA-123015, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety was produced by a method comprising the steps of: (a) crossing a plant of cultivar AGR044-312D with a plant of another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) selfing the progeny plants that have the desired trait to produce further progeny plants; and (d) growing the resultant further progeny plants and selecting further progeny plants that have the desired

trait to produce the *Brassica carinata* variety produced from cultivar AGR044-312D; wherein steps (c) and (d) are repeated until the *Brassica carinata* variety produced from cultivar AGR044-312D has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions.

[0186] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-312D, the seed of which has been deposited under ATCC Accession number PTA-123015, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety was produced by a method comprising the steps of: (a) crossing a plant of cultivar AGR044-312D with a plant of another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) selfing the progeny plants that have the desired trait to produce further progeny plants; and (d) growing the resultant further progeny plants and selecting further progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-312D; wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0187] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-312D, the seed of which has been deposited under ATCC Accession number PTA-123015, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety was produced by a method comprising the steps of: (a) crossing a plant of cultivar AGR044-312D with a plant of another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) selfing the progeny plants that have the desired trait to produce further progeny plants; and (d) growing the resultant further progeny plants and selecting further progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-312D; wherein steps (c) and (d) are repeated until the *Brassica carinata* variety produced from cultivar AGR044-312D has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions, and wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0188] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-312D, the seed of which has been deposited under ATCC Accession number PTA-123015, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety was produced by a method comprising the steps of: (a) crossing a plant of cultivar AGR044-312D with a plant of another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) selfing the progeny plants that have the desired trait to produce further progeny plants; and (d) growing the resultant further progeny plants and selecting further progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-312D; wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

[0189] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-312D, the seed of which has been deposited under ATCC Accession number PTA-123015, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety was produced by a method comprising the steps of: (a) crossing a plant of cultivar AGR044-312D with a plant of another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) selfing the progeny plants that have the desired trait to produce further progeny plants; and (d) growing the resultant further progeny plants and selecting further progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-312D; wherein steps (c) and (d) are repeated until the *Brassica carinata* variety produced from cultivar AGR044-312D has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions; and wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

[0190] **5.1.11 Mutagenesis**

[0191] In one aspect, the present invention includes the introduction of a desired trait into *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, to produce a *Brassica carinata* variety comprising the desired trait, wherein the desired trait is introduced by mutagenesis.

[0192] Any means of mutagenesis can potentially be used, including the mutagenic agents ethyl methanesulfonate, N-ethyl-N-nitrosourea, ionizing radiation such as x-ray or gamma, or ultraviolet radiation.

[0193] The mutagenization can be of a variety of parts of the plants, including a seed, seedling, or microspore. Mutagenized microspores can then be used to generate doubled haploid plants (see above). Seedlings or microspores are exposed to the mutagenic agent and then the surviving fraction are allowed to develop into mature plants. In some cases, the mutagenized plantlets or embryos (in the case of microspore mutagenesis) may be exposed to selection in order to enrich for a particular phenotype. This technique can be used to develop varieties with a desired trait, such as resistance to a herbicide, an altered seed oil profile, increased tolerance to disease, or abiotic stress.

[0194] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, and wherein the *Brassica carinata* variety comprises a desired trait, the method comprising exposing seedlings or microspores to a mutagenic agent and allowing the surviving fraction to develop into mature plants.

[0195] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, and wherein the *Brassica carinata* variety comprises a desired trait, the method comprising exposing seedlings or microspores to a mutagenic agent and allowing the surviving fraction to develop into mature plants, and wherein the mutagenic agent is ethyl methanesulfonate, N-ethyl-N-nitrosourea, ionizing radiation such as x-ray or gamma, or ultraviolet radiation.

[0196] In another embodiment, the invention provides a plant, or part thereof, or seed of a *Brassica carinata* variety produced by any of the above methods.

[0197] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a *Brassica carinata* variety comprising a desired trait, wherein the desired trait is introduced by exposing seedlings or microspores to a mutagenic agent.

[0198] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a *Brassica carinata* variety comprising a desired trait, wherein the desired trait is introduced by exposing seedlings or microspores to a mutagenic agent, and wherein the mutagenic agent is ethyl methanesulfonate, N-ethyl-N-nitrosourea, ionizing radiation such as x-ray or gamma, or ultraviolet radiation.

[0199] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety is produced by a method comprising exposing seedlings or microspores to a mutagenic agent and allowing the surviving fraction to develop into mature plants.

[0200] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety is produced by a method comprising exposing seedlings or microspores to a mutagenic agent and allowing the surviving fraction to develop into mature plants, wherein the mutagenic agent is ethyl methanesulfonate, N-ethyl-N-nitrosourea, ionizing radiation such as x-ray or gamma, or ultraviolet radiation.

[0201] **5.1.12 Methods of or uses for producing a carinata variety by outcrossing (interspecific or wide crossing), and cells, plants, seeds produced therefrom**

[0202] Where no *Brassica carinata* variety has a specific desired trait, outcrossing (interspecific or wide crossing) can be used where the trait is found in another Brassicaceae species, such as, for example, *Brassica napus*, *Brassica juncea*, *Brassica oleracea*, *Brassica rapa*, or *Brassica nigra*.

[0203] In another embodiment, the invention provides a method of producing a carinata variety produced from *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, and wherein the carinata variety comprises a desired trait, the method comprising: (a) crossing a plant of cultivar AGR044-312D with a plant of another Brassicaceae species comprising the desired trait; (b) using embryo rescue techniques to recover viable F1 plants from the cross or growing F1 seeds to produce F1 plants; (c) selfing the F1 plants that have the desired trait and carinata character; (d) using embryo rescue techniques to recover viable F2 plants or growing F2 seeds to produce F2 plants; (e) selfing the F2 plants that have the desired trait and carinata character; (f) using embryo rescue techniques to recover viable F3 plants or growing F3 seeds to produce progeny plants; (g) selfing the progeny plants that have the desired trait and carinata character to produce further progeny plants; and (h) selecting the progeny plants with the desired trait and carinata character to produce the carinata variety produced from cultivar AGR044-312D.

[0204] In another embodiment, the invention provides a method of producing a carinata variety produced from *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, and wherein the carinata variety comprises a desired trait, the method comprising: (a) crossing a plant of cultivar AGR044-312D with a plant of another Brassicaceae species comprising the desired trait; (b) using embryo rescue techniques to recover viable F1 plants from the cross or growing F1 seeds to produce F1 plants; (c) selfing the F1 plants that have the desired trait and carinata character; (d) using embryo rescue techniques to recover viable F2 plants or growing F2 seeds to produce F2 plants; (e) selfing the F2 plants that have the desired trait and carinata character; (f) using embryo rescue techniques to recover viable F3 plants or growing F3 seeds to produce progeny plants; (g) selfing the progeny plants that have the desired trait and carinata character to produce further progeny plants; and (h) selecting the progeny plants with the desired trait and carinata character to produce the carinata variety produced from cultivar AGR044-312D; wherein steps (g) and (h) are repeated until the carinata variety produced from cultivar AGR044-312D has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions.

[0205] In another embodiment, the invention provides any of the above methods, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0206] In another embodiment, the invention provides any of the above methods, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

[0207] In another embodiment, the invention provides any of the above methods, wherein the method further comprises producing a doubled haploidy variety from the carinata variety.

[0208] In another embodiment, the invention provides a plant, or part thereof, or seed of a carinata variety produced by any of the above methods.

[0209] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a carinata variety comprising a desired trait, wherein the desired trait is introduced by crossing a plant of cultivar AGR044-312D with a plant of another Brassicaceae species comprising the desired trait.

[0210] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a carinata variety comprising a desired trait, wherein the desired trait is introduced by crossing a plant of cultivar AGR044-312D with a plant of another Brassicaceae species comprising the desired trait, and wherein the carinata variety produced from cultivar AGR044-312D has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions.

[0211] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a carinata variety comprising a desired trait, wherein the desired trait is introduced by crossing a plant of cultivar AGR044-312D with a plant of another Brassicaceae species comprising the desired trait, and wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0212] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a carinata variety comprising a desired trait, wherein the desired trait is introduced by crossing a plant of cultivar AGR044-312D with a plant of another Brassicaceae species comprising the desired trait, and wherein the carinata variety produced from cultivar AGR044-312D has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions, and wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0213] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a carinata variety comprising a desired trait, wherein the desired trait is introduced by crossing a plant of cultivar AGR044-312D with a plant of another Brassicaceae species comprising the desired trait, and wherein the desired trait is herbicide tolerance and the tolerance is

conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

[0214] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a carinata variety comprising a desired trait, wherein the desired trait is introduced by crossing a plant of cultivar AGR044-312D with a plant of another Brassicaceae species comprising the desired trait, and wherein the carinata variety produced from cultivar AGR044-312D has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions, and wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

[0215] In another embodiment, the invention provides a cell of a plant of a carinata variety comprising a desired trait, wherein the carinata variety is produced by a method comprising: (a) crossing a plant of cultivar AGR044-312D with a plant of another Brassicaceae species comprising the desired trait; (b) using embryo rescue techniques to recover viable F1 plants from the cross or growing F1 seeds to produce F1 plants; (c) selfing the F1 plants that have the desired trait and carinata character; (d) using embryo rescue techniques to recover viable F2 plants or growing F2 seeds to produce F2 plants; (e) selfing the F2 plants that have the desired trait and carinata character; (f) using embryo rescue techniques to recover viable F3 plants or growing F3 seeds to produce progeny plants; (g) selfing the progeny plants that have the desired trait and carinata character to produce further progeny plants; and (h) selecting the progeny plants with the desired trait and carinata character to produce the carinata variety produced from cultivar AGR044-312D.

[0216] In another embodiment, the invention provides a cell of a plant of a carinata variety comprising a desired trait, wherein the carinata variety is produced by a method comprising: (a) crossing a plant of cultivar AGR044-312D with a plant of another Brassicaceae species comprising the desired trait; (b) using embryo rescue techniques to recover viable F1 plants from the cross or growing F1 seeds to produce F1 plants; (c) selfing the F1 plants that have the desired trait and carinata character; (d) using embryo rescue techniques to recover viable F2 plants or growing F2 seeds to produce F2 plants; (e) selfing the F2 plants that have the desired trait and carinata character; (f) using embryo rescue techniques to recover viable F3 plants or growing F3 seeds to produce progeny plants; (g) selfing the progeny plants that have the desired trait and carinata character to produce further progeny plants; and (h) selecting the progeny plants with the desired trait and carinata character to produce the carinata variety produced from cultivar AGR044-312D; wherein steps (g) and (h) are repeated until the carinata variety produced from cultivar AGR044-312D has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions.

[0217] In another embodiment, the invention provides a cell of a plant of a carinata variety comprising a desired trait, wherein the carinata variety is produced by a method comprising: (a) crossing a plant of

cultivar AGR044-312D with a plant of another Brassicaceae species comprising the desired trait; (b) using embryo rescue techniques to recover viable F1 plants from the cross or growing F1 seeds to produce F1 plants; (c) selfing the F1 plants that have the desired trait and carinata character; (d) using embryo rescue techniques to recover viable F2 plants or growing F2 seeds to produce F2 plants; (e) selfing the F2 plants that have the desired trait and carinata character; (f) using embryo rescue techniques to recover viable F3 plants or growing F3 seeds to produce progeny plants; (g) selfing the progeny plants that have the desired trait and carinata character to produce further progeny plants; and (h) selecting the progeny plants with the desired trait and carinata character to produce the carinata variety produced from cultivar AGR044-312D; wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0218] In another embodiment, the invention provides a cell of a plant of a carinata variety comprising a desired trait, wherein the carinata variety is produced by a method comprising: (a) crossing a plant of cultivar AGR044-312D with a plant of another Brassicaceae species comprising the desired trait; (b) using embryo rescue techniques to recover viable F1 plants from the cross or growing F1 seeds to produce F1 plants; (c) selfing the F1 plants that have the desired trait and carinata character; (d) using embryo rescue techniques to recover viable F2 plants or growing F2 seeds to produce F2 plants; (e) selfing the F2 plants that have the desired trait and carinata character; (f) using embryo rescue techniques to recover viable F3 plants or growing F3 seeds to produce progeny plants; (g) selfing the progeny plants that have the desired trait and carinata character to produce further progeny plants; and (h) selecting the progeny plants with the desired trait and carinata character to produce the carinata variety produced from cultivar AGR044-312D; wherein steps (g) and (h) are repeated until the carinata variety produced from cultivar AGR044-312D has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions, and wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0219] In another embodiment, the invention provides a cell of a plant of a carinata variety comprising a desired trait, wherein the carinata variety is produced by a method comprising: (a) crossing a plant of cultivar AGR044-312D with a plant of another Brassicaceae species comprising the desired trait; (b) using embryo rescue techniques to recover viable F1 plants from the cross or growing F1 seeds to produce F1 plants; (c) selfing the F1 plants that have the desired trait and carinata character; (d) using embryo rescue techniques to recover viable F2 plants or growing F2 seeds to produce F2 plants; (e) selfing the F2 plants that have the desired trait and carinata character; (f) using embryo rescue techniques to recover viable F3 plants or growing F3 seeds to produce progeny plants; (g) selfing the progeny plants that have the desired trait and carinata character to produce further progeny plants; and (h) selecting the progeny plants with the desired trait and carinata character to produce the carinata variety produced from cultivar AGR044-312D; wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

[0220] In another embodiment, the invention provides a cell of a plant of a carinata variety comprising a desired trait, wherein the carinata variety is produced by a method comprising: (a) crossing a plant of cultivar AGR044-312D with a plant of another Brassicaceae species comprising the desired trait; (b) using embryo rescue techniques to recover viable F1 plants from the cross or growing F1 seeds to produce F1 plants; (c) selfing the F1 plants that have the desired trait and carinata character; (d) using embryo rescue techniques to recover viable F2 plants or growing F2 seeds to produce F2 plants; (e) selfing the F2 plants that have the desired trait and carinata character; (f) using embryo rescue techniques to recover viable F3 plants or growing F3 seeds to produce progeny plants; (g) selfing the progeny plants that have the desired trait and carinata character to produce further progeny plants; and (h) selecting the progeny plants with the desired trait and carinata character to produce the carinata variety produced from cultivar AGR044-312D; wherein steps (g) and (h) are repeated until the carinata variety produced from cultivar AGR044-312D has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions, and wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

[0221] **5.1.13 Commercial crops and commercial plant products**

[0222] In another embodiment, the invention provides a method of producing a commercial plant product, the method comprising growing a plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, to produce a commercial crop, and producing said commercial plant product from the commercial crop.

[0223] In another embodiment, the invention provides a method of producing a commercial plant product, the method comprising growing a plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, to produce a commercial crop, and producing said commercial plant product from the commercial crop, wherein the commercial plant product comprises oil, meal or protein isolate.

[0224] In another embodiment, the invention provides a method of producing a commercial plant product, the method comprising growing a plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, to produce a commercial crop, and producing said commercial plant product from the commercial crop, wherein the commercial plant product comprises a biofumigant.

[0225] In another embodiment, the invention provides a commercial plant product produced by a method comprising growing a plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has

been deposited under ATCC Accession number PTA-123015, to produce a commercial crop, and producing said commercial plant product from the commercial crop.

[0226] In another embodiment, the invention provides a commercial plant product produced by a method comprising growing a plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, to produce a commercial crop, and producing said commercial plant product from the commercial crop, wherein the commercial plant product comprises oil, meal, or protein isolate.

[0227] In another embodiment, the invention provides oil, meal, or protein isolate produced by a method comprising growing a plant of *Brassica carinata* cultivar AGR044-312D produced from the seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015, to produce a commercial crop, and producing the oil, meal, or protein isolate from the commercial crop.

[0228] In another embodiment, the invention provides crushed, non-viable seed of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015.

[0229] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a commercial crop.

[0230] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a commercial plant product.

[0231] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a commercial plant product, wherein the commercial plant product comprises oil, meal, or protein isolate.

[0232] In another embodiment, the invention provides crushed, non-viable seed of a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015.

[0233] In another embodiment, the invention provides use of a plant of a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a commercial crop.

[0234] In another embodiment, the invention provides use of a plant of a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a commercial plant product.

[0235] In another embodiment, the invention provides use of a plant of a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, to produce a commercial plant product, wherein the commercial plant product comprises oil, meal, or protein isolate.

[0236] **5.2 AGR044-3A22**

[0237] **5.2.1 Seeds, plants, plant parts and cells**

[0238] In one embodiment, the invention provides a seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014.

[0239] In another embodiment, the invention provides a plant of *Brassica carinata* cultivar AGR044-3A22, or a part thereof, produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014.

[0240] In another embodiment, the invention provides a plant part of *Brassica carinata* cultivar AGR044-3A22, or a part thereof, produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, wherein the plant part is an ovule, a leaf, pollen, a seed, an embryo a root, a root tip, a pod, a flower, a stalk, a cell, or a protoplast.

[0241] In another embodiment, the invention provides a plant part of *Brassica carinata* cultivar AGR044-3A22, or a part thereof, produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, wherein the plant part is pollen.

[0242] In another embodiment, the invention provides a plant part of *Brassica carinata* cultivar AGR044-3A22, or a part thereof, produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, wherein the plant part is an ovule.

[0243] In another embodiment, the invention provides a *Brassica carinata* plant, or a part thereof, having essentially all of the physiological and morphological characteristics of a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, when grown in the same location under the same environmental conditions.

[0244] In another embodiment, the invention provides a cell of a seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014.

[0245] In another embodiment, the invention provides a cell of a plant of *Brassica carinata* cultivar AGR044-3A22, or a part thereof, produced from a seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014.

[0246] In another embodiment, the invention provides a protoplast of a plant of *Brassica carinata* cultivar AGR044-3A22, or a part thereof, produced from a seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014.

[0247] In another embodiment, the invention provides a cell of a plant of *Brassica carinata* cultivar AGR044-3A22, or a part thereof, produced from a seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, wherein the plant part is an ovule, a leaf, pollen, a seed, an embryo a root, a root tip, a pod, a flower, or a stalk.

[0248] In another embodiment, the invention provides a cell of a plant of *Brassica carinata* cultivar AGR044-3A22, or a part thereof, produced from a seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, wherein the plant part is pollen.

[0249] In another embodiment, the invention provides a cell of a plant of *Brassica carinata* cultivar AGR044-3A22, or a part thereof, produced from a seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, wherein the plant part is an ovule.

[0250] In another embodiment, the invention provides a cell of a *Brassica carinata* plant, or parts thereof, having essentially all of the physiological and morphological characteristics of a plant of *Brassica carinata* cultivar AGR044-3A22 produced from a seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, when grown in the same location under the same environmental conditions.

[0251] **5.2.2 Tissue cultures and regenerated plants**

[0252] In another embodiment, the invention provides a tissue culture of protoplasts or regenerable cells of a plant of *Brassica carinata* cultivar AGR044-3A22, or a part thereof, produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014.

[0253] In another embodiment, the invention provides a tissue culture of protoplasts or regenerable cells of a plant of *Brassica carinata* cultivar AGR044-3A22, or a part thereof, produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has

been deposited under ATCC Accession number PTA-123014, wherein the protoplasts or regenerable cells are produced from a tissue selected from the group consisting of leaves, pollen, embryos, roots, root tips, pods, flowers, ovules, and stalks.

[0254] In another embodiment, the invention provides a *Brassica carinata* plant regenerated from a tissue culture of protoplasts or regenerable cells of a plant of *Brassica carinata* cultivar AGR044-3A22, or a part thereof, produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, wherein the plant has essentially all of the morphological and physiological characteristics of cultivar AGR044-3A22, the seed of which has been deposited under ATCC Accession number PTA-123014, when grown in the same location under the same environmental conditions.

[0255] In another embodiment, the invention provides a *Brassica carinata* plant regenerated from a tissue culture of protoplasts or regenerable cells of a plant of *Brassica carinata* cultivar AGR044-3A22, or a part thereof, produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, wherein the protoplasts or regenerable cells are produced from a tissue selected from the group consisting of leaves, pollen, embryos, roots, root tips, pods, flowers, ovules, and stalks, wherein the plant has essentially all of the morphological and physiological characteristics of cultivar AGR044-3A22, the seed of which has been deposited under ATCC Accession number PTA-123014, when grown in the same location under the same environmental conditions.

[0256] In another embodiment, the invention provides a regenerated *Brassica carinata* plant having essentially all of the physiological and morphological characteristics of the cultivar AGR044-3A22 when grown in the same location under the same environmental conditions, the regenerated plant having been produced using a tissue culture, wherein the tissue culture is produced from a plant of *Brassica carinata* cultivar AGR044-3A22, or a part thereof, produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014.

[0257] In another embodiment, the invention provides a cell of a *Brassica carinata* plant regenerated from a tissue culture of protoplasts or regenerable cells of a plant of *Brassica carinata* cultivar AGR044-3A22, or a part thereof, produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, wherein the plant has essentially all of the morphological and physiological characteristics of cultivar AGR044-3A22, the seed of which has been deposited under ATCC Accession number PTA-123014, when grown in the same location under the same environmental conditions.

[0258] In another embodiment, the invention provides a cell of a *Brassica carinata* plant regenerated from a tissue culture of protoplasts or regenerable cells of a plant of *Brassica carinata* cultivar AGR044-3A22, or a part thereof, produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, wherein the protoplasts or regenerable cells are produced from a tissue selected from the group consisting of leaves, pollen, embryos, roots, root tips, pods, flowers, ovules, and stalks, wherein

the plant has essentially all of the morphological and physiological characteristics of cultivar AGR044-3A22, the seed of which has been deposited under ATCC Accession number PTA-123014, when grown in the same location under the same environmental conditions.

[0259] In another embodiment, the invention provides a cell of a regenerated *Brassica carinata* plant having essentially all of the physiological and morphological characteristics of the cultivar AGR044-3A22 when grown in the same location under the same environmental conditions, the regenerated plant having been produced using a tissue culture, wherein the tissue culture is produced from a plant of *Brassica carinata* cultivar AGR044-3A22, or a part thereof, produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014.

[0260] 5.2.3 Methods of crossing and uses for crossing *Brassica carinata* plants, and the cells and seeds produced therefrom

[0261] In another embodiment, the invention provides a method for producing *Brassica carinata* seed comprising crossing *Brassica carinata* plants and harvesting the resulting *Brassica carinata* seed, wherein at least one *Brassica carinata* plant is a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014.

[0262] In another embodiment, the invention provides a *Brassica carinata* seed produced by a method for producing *Brassica carinata* seed comprising crossing *Brassica carinata* plants and harvesting the resulting *Brassica carinata* seed, wherein at least one *Brassica carinata* plant is a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014.

[0263] In another embodiment, the invention provides a cell of a *Brassica carinata* seed produced by a method for producing *Brassica carinata* seed comprising crossing *Brassica carinata* plants and harvesting the resulting *Brassica carinata* seed, wherein at least one *Brassica carinata* plant is a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014.

[0264] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce seed, wherein the seed is produced by self-fertilization or cross-fertilization.

[0265] 5.2.4 Methods of and uses for producing an F1 hybrid *Brassica carinata* seed, and the cells, seeds and plants produced therefrom

[0266] In another embodiment, the invention provides a method for producing a first generation (F1) hybrid *Brassica carinata* seed comprising crossing a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid carinata seed, and wherein the plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22 is either a female parent or a male parent.

[0267] In another embodiment, the invention provides a method for producing a first generation (F1) hybrid *Brassica carinata* seed comprising crossing a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid carinata seed, and wherein the plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22 is the female parent.

[0268] In another embodiment, the invention provides a method for producing a first generation (F1) hybrid *Brassica carinata* seed comprising crossing a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid carinata seed, and wherein the plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22 is the male parent.

[0269] In another embodiment, the invention provides an F1 hybrid seed produced by a method comprising crossing a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid carinata seed, and wherein the plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22 is either a female parent or a male parent.

[0270] In another embodiment, the invention provides an F1 hybrid seed produced by a method comprising crossing a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid carinata seed, and wherein the plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22 is the female parent.

[0271] In another embodiment, the invention provides an F1 hybrid seed produced by a method comprising crossing a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has

been deposited under ATCC Accession number PTA-123014, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid carinata seed, and wherein the plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22 is the male parent.

[0272] In another embodiment, the invention provides an F1 hybrid plant grown from an F1 hybrid seed produced by a method comprising crossing a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid carinata seed, and wherein the plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22 is either a female parent or a male parent.

[0273] In another embodiment, the invention provides an F1 hybrid plant grown from an F1 hybrid seed produced by a method comprising crossing a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid carinata seed, and wherein the plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22 is the female parent.

[0274] In another embodiment, the invention provides an F1 hybrid plant grown from an F1 hybrid seed produced by a method comprising crossing a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid carinata seed, and wherein the plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22 is the male parent.

[0275] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014 to produce an F1 hybrid *Brassica carinata* seed, wherein the plant is either a female parent or a male parent in a cross-fertilization.

[0276] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014 to produce an F1 hybrid *Brassica carinata* seed, wherein the plant is the female parent.

[0277] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014 to produce an F1 hybrid *Brassica carinata* seed, wherein the plant is the male parent.

[0278] In another embodiment, the invention provides a cell of an F1 hybrid plant grown from the F1 hybrid seed produced by any of the above uses.

[0279] In another embodiment, the invention provides a cell of an F1 hybrid plant grown from F1 hybrid seed produced by a method comprising crossing a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid carinata seed.

[0280] 5.2.5 Methods of and uses for producing a Doubled Haploidy variety, and the cells, seeds, and plants produced therefrom

[0281] In another embodiment, the invention provides a method for producing a Doubled Haploidy variety comprising: (a) isolating a flower bud of an F1 hybrid plant grown from an F1 hybrid seed produced by a method comprising crossing a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid carinata seed, and wherein the plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22 is either a female parent or a male parent; (b) dissecting out a haploid microspore; (c) placing the haploid microspore in culture; (d) inducing the microspore to differentiate into an embryo and subsequently into a plantlet; (e) identifying whether the plantlet contains a diploid chromosome number, wherein the diploid chromosome number occurred through chromosome doubling; and (f) continuing to grow the plantlet if it contains a diploid chromosome number.

[0282] In another embodiment, the invention provides a method for producing a Doubled Haploidy variety comprising: (a) isolating a flower bud of an F1 hybrid plant grown from an F1 hybrid seed produced by a method comprising crossing a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid carinata seed, and wherein the plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22 is the female parent; (b) dissecting out a haploid microspore; (c) placing the haploid microspore in culture; (d) inducing the microspore to differentiate into an embryo and subsequently into a plantlet; (e) identifying whether the plantlet contains a diploid chromosome number, wherein the diploid chromosome number occurred through chromosome doubling; and (f) continuing to grow the plantlet if it contains a diploid chromosome number.

[0283] In another embodiment, the invention provides a method for producing a Doubled Haploidy variety comprising: (a) isolating a flower bud of an F1 hybrid plant grown from an F1 hybrid seed produced by a method comprising crossing a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, with a different *Brassica*

carinata plant and harvesting the resultant F1 hybrid *carinata* seed, and wherein the plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22 is the male parent; (b) dissecting out a haploid microspore; (c) placing the haploid microspore in culture; (d) inducing the microspore to differentiate into an embryo and subsequently into a plantlet; (e) identifying whether the plantlet contains a diploid chromosome number, wherein the diploid chromosome number occurred through chromosome doubling; and (f) continuing to grow the plantlet if it contains a diploid chromosome number.

[0284] In another embodiment, the invention provides a method for producing a Doubled Haploidy variety comprising: (a) isolating a flower bud of an F1 hybrid plant grown from an F1 hybrid seed produced by a method comprising crossing a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid *carinata* seed, and wherein the plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22 is either a female parent or a male parent; (b) dissecting out a haploid microspore; (c) placing the haploid microspore in culture; (d) inducing the microspore to differentiate into an embryo and subsequently into a plantlet; (e) identifying whether the plantlet contains a diploid chromosome number, wherein the diploid chromosome number occurred through chromosome doubling; and (f) continuing to grow the plantlet if it contains a diploid chromosome number; wherein the method further comprises inducing chromosome doubling by chemical or physical means.

[0285] In another embodiment, the invention provides a method for producing a Doubled Haploidy variety comprising: (a) isolating a flower bud of an F1 hybrid plant grown from an F1 hybrid seed produced by a method comprising crossing a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid *carinata* seed, and wherein the plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22 is the female parent; (b) dissecting out a haploid microspore; (c) placing the haploid microspore in culture; (d) inducing the microspore to differentiate into an embryo and subsequently into a plantlet; (e) identifying whether the plantlet contains a diploid chromosome number, wherein the diploid chromosome number occurred through chromosome doubling; and (f) continuing to grow the plantlet if it contains a diploid chromosome number; wherein the method further comprises inducing chromosome doubling by chemical or physical means.

[0286] In another embodiment, the invention provides a method for producing a Doubled Haploidy variety comprising: (a) isolating a flower bud of an F1 hybrid plant grown from an F1 hybrid seed produced by a method comprising crossing a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid *carinata* seed, and wherein the plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22 is the male parent; (b) dissecting out a haploid microspore; (c) placing the haploid

microspore in culture; (d) inducing the microspore to differentiate into an embryo and subsequently into a plantlet; (e) identifying whether the plantlet contains a diploid chromosome number, wherein the diploid chromosome number occurred through chromosome doubling; and (f) continuing to grow the plantlet if it contains a diploid chromosome number; wherein the method further comprises inducing chromosome doubling by chemical or physical means.

[0287] In another embodiment, the invention provides a plant, or part thereof, or seed of a Doubled Haploidy variety produced by any of the above methods.

[0288] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014 to produce a Doubled Haploidy variety.

[0289] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014 to produce a Doubled Haploidy variety, wherein chromosome doubling is introduced by chemical or physical means.

[0290] In another embodiment, the invention provides a cell of a Doubled Haploidy variety produced from *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014.

[0291] In another embodiment, the invention provides use of a plant of a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce a Doubled Haploidy variety.

[0292] In another embodiment, the invention provides use of a plant of a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce a Doubled Haploidy variety, wherein chromosome doubling is introduced by chemical or physical means.

[0293] **5.2.6 Desired traits**

[0294] In one aspect, the present invention includes the introduction of a desired trait into *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, to produce a *Brassica carinata* variety comprising the desired trait.

[0295] Examples of potential desired traits include:

- a. cytoplasmic male sterility, CMS restorer traits,
- b. biotic and abiotic stress resistance such as disease resistance, fungal resistance, pest resistance, drought tolerance, and frost tolerance,
- c. agronomic traits such as increased pod shatter resistance, improved harvestability, improved nutrient usage efficiency, seed colour seed size, seed pod size, seed pod architecture, seed

pod fill. earlier and more uniform time to flowering , earlier maturity, extent of branching, flower colour and density, and plant height,

- d. altered metabolism (increased seed oil, increased seed protein, altered seed oil or fatty acid profile, reduced seed content of glucosinolates and other antinutritionals),
- e. improved performance: improved oil per unit area, improved grain per unit area,
- f. herbicide tolerance including tolerance to glyphosate, glufosinate, imidazolinones and auxin analogues such as 2,4-D and dicamba.

[0296] 5.2.7 Methods of and uses for introducing a desired trait by crossing and backcrossing, and the cells, seeds and plants produced therefrom

[0297] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, and wherein the *Brassica carinata* variety comprises a desired trait, the method comprising the steps of: (a) crossing a plant of cultivar AGR044-3A22 with another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) backcrossing the selected progeny plants that have the desired trait with plants of cultivar AGR044-3A22 to produce backcross progeny seed; and (d) growing the resultant backcross progeny seed and selecting backcross progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-3A22.

[0298] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, and wherein the *Brassica carinata* variety comprises a desired trait, the method comprising the steps of: (a) crossing a plant of cultivar AGR044-3A22 with another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) backcrossing the selected progeny plants that have the desired trait with plants of cultivar AGR044-3A22 to produce backcross progeny seed; and (d) growing the resultant backcross progeny seed and selecting backcross progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-3A22; wherein steps (c) and (d) are repeated until the *Brassica carinata* variety produced from cultivar AGR044-3A22 has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions.

[0299] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, and wherein the *Brassica carinata* variety comprises a desired trait, the method comprising the steps of: (a) crossing a plant of cultivar AGR044-3A22 with another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1

hybrid seed and selecting one or more progeny plants that have the desired trait; (c) backcrossing the selected progeny plants that have the desired trait with plants of cultivar AGR044-3A22 to produce backcross progeny seed; and (d) growing the resultant backcross progeny seed and selecting backcross progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-3A22; and wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0300] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, and wherein the *Brassica carinata* variety comprises a desired trait, the method comprising the steps of: (a) crossing a plant of cultivar AGR044-3A22 with another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) backcrossing the selected progeny plants that have the desired trait with plants of cultivar AGR044-3A22 to produce backcross progeny seed; and (d) growing the resultant backcross progeny seed and selecting backcross progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-3A22; wherein steps (c) and (d) are repeated until the *Brassica carinata* variety produced from cultivar AGR044-3A22 has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions; and wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0301] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, and wherein the *Brassica carinata* variety comprises a desired trait, the method comprising the steps of: (a) crossing a plant of cultivar AGR044-3A22 with another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) backcrossing the selected progeny plants that have the desired trait with plants of cultivar AGR044-3A22 to produce backcross progeny seed; and (d) growing the resultant backcross progeny seed and selecting backcross progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-3A22; and wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

[0302] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, and wherein the *Brassica carinata* variety comprises a desired trait, the method comprising the steps of: (a) crossing a plant of cultivar AGR044-

3A22 with another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) backcrossing the selected progeny plants that have the desired trait with plants of cultivar AGR044-3A22 to produce backcross progeny seed; and (d) growing the resultant backcross progeny seed and selecting backcross progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-3A22; wherein steps (c) and (d) are repeated until the *Brassica carinata* variety produced from cultivar AGR044-3A22 has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions; and wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

[0303] In another embodiment, the invention provides a plant, or part thereof, or seed of a *Brassica carinata* variety produced by any of the above methods.

[0304] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce a *Brassica carinata* variety comprising a desired trait.

[0305] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce a *Brassica carinata* variety comprising a desired trait, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0306] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce a *Brassica carinata* variety comprising a desired trait, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

[0307] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety is produced by a method comprising the steps of: (a) crossing a plant of cultivar AGR044-3A22 with another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) backcrossing the selected progeny plants that have the desired trait with plants of cultivar AGR044-3A22 to produce backcross progeny plants; and (d) growing the resultant backcross progeny seed and selecting backcross progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-3A22.

[0308] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, wherein the variety comprises a desired trait, and wherein the *Brassica carinata* variety is produced by a method comprising the steps of: (a) crossing a plant of cultivar AGR044-3A22 with another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) backcrossing the selected progeny plants that have the desired trait with plants of cultivar AGR044-3A22 to produce backcross progeny plants; and (d) growing the resultant backcross progeny seed and selecting backcross progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-3A22; wherein the method to produce the *Brassica carinata* variety further comprises repeating steps (c) and (d) until the *Brassica carinata* variety produced from cultivar AGR044-3A22 has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions.

[0309] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety is produced by a method comprising the steps of: (a) crossing a plant of cultivar AGR044-3A22 with another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) backcrossing the selected progeny plants that have the desired trait with plants of cultivar AGR044-3A22 to produce backcross progeny plants; and (d) growing the resultant backcross progeny seed and selecting backcross progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-3A22; wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0310] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety is produced by a method comprising the steps of: (a) crossing a plant of cultivar AGR044-3A22 with another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) backcrossing the selected progeny plants that have the desired trait with plants of cultivar AGR044-3A22 to produce backcross progeny plants; and (d) growing the resultant backcross progeny seed and selecting backcross progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-3A22; wherein the method to produce the *Brassica carinata* variety further comprises repeating steps (c) and (d) until the *Brassica carinata* variety produced from cultivar AGR044-3A22 has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions, and wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0311] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety is produced by a method comprising the steps of: (a) crossing a plant of cultivar AGR044-3A22 with another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) backcrossing the selected progeny plants that have the desired trait with plants of cultivar AGR044-3A22 to produce backcross progeny plants; and (d) growing the resultant backcross progeny seed and selecting backcross progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-3A22, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

[0312] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety is produced by a method comprising the steps of: (a) crossing a plant of cultivar AGR044-3A22 with another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) backcrossing the selected progeny plants that have the desired trait with plants of cultivar AGR044-3A22 to produce backcross progeny plants; and (d) growing the resultant backcross progeny seed and selecting backcross progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-3A22; wherein the method to produce the *Brassica carinata* variety further comprises repeating steps (c) and (d) until the *Brassica carinata* variety produced from cultivar AGR044-3A22 has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

[0313] 5.2.8 DNA constructs

[0314] In one aspect, the present invention includes the introduction of a desired trait into *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, to produce a *Brassica carinata* variety comprising the desired trait, wherein the desired trait is conferred by a DNA construct.

[0315] The DNA construct can be introduced by a variety of methods, including by using polyethylene glycol (PEG) mediated DNA uptake, electroporation, ballistic infiltration using DNA coated microprojectiles (gene gun), an Agrobacteria infiltration based vector, or a plant virus based vector.

[0316] The DNA construct can comprise any type of DNA, including a transgene or a DNA construct that is designed to modulate the expression of endogenous genes.

[0317] Examples of transgenes that could be incorporated can include, but are not limited to, the following: *Crambe abyssinica* FAE1, *Teesdalia nodulicans* FAE1, *Cardamine graeca* FAE1 *Brassica napus* DGAT, *Tropaeolum majus* DGAT, *Yeast* SLC1

[0318] DNA constructs that are designed to modulate the expression of endogenous genes may include, but are not limited to the following group: *Brassica carinata* Myb28, Myb29, FAD2 and FAD3 antisense RNA or RNAi sequences, which can be used to interfere or knock down the expression of endogenous genes to extremely low levels, simulating the effect of a null mutation at the endogenous locus. As discussed above, because *Brassica carinata* is amphidiploid, it can have multiple copies of genes from the contributing ancestral species that may create a high level of functional redundancy. As such, a single mutation in one of the homologues may not be sufficient to confer a phenotype. By using RNAi or an antisense approach, one may conceivably be capable of targeting all of the expressed homologues and achieving a functional knockdown effect. Such approaches require the RNAi or antisense RNA to be stably expressed.

[0319] **5.2.9 Methods of and uses for introducing a desired trait using DNA constructs, and the cells, seeds and plants produced therefrom**

[0320] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, and wherein the *Brassica carinata* variety comprises a desired trait, the method comprising introducing a DNA construct conferring the desired trait into a plant of cultivar AGR044-3A22.

[0321] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, wherein the *Brassica carinata* variety comprises a desired trait, the method comprising introducing a DNA construct conferring the desired trait into a plant of cultivar AGR044-3A22, and wherein the DNA construct is introduced using polyethylene glycol (PEG) mediated DNA uptake, electroporation, ballistic infiltration using DNA coated microprojectiles (gene gun), an *Agrobacteria* infiltration based vector, or a plant virus based vector.

[0322] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, wherein the *Brassica carinata* variety comprises a desired trait, the method comprising introducing a DNA construct conferring the desired trait into a plant of cultivar AGR044-3A22, and wherein the DNA construct comprises a transgene.

[0323] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, wherein the *Brassica carinata* variety comprises a desired trait, the method comprising introducing a DNA construct conferring the desired trait into a plant of cultivar AGR044-3A22, wherein the DNA construct is introduced using polyethylene glycol (PEG) mediated DNA uptake, electroporation, ballistic infiltration using DNA coated microprojectiles (gene gun), an Agrobacteria infiltration based vector, or a plant virus based vector, and wherein the DNA construct comprises a transgene.

[0324] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, wherein the *Brassica carinata* variety comprises a desired trait, the method comprising introducing a DNA construct conferring the desired trait into a plant of cultivar AGR044-3A22, and wherein the DNA construct comprises an RNAi construct.

[0325] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, wherein the *Brassica carinata* variety comprises a desired trait, the method comprising introducing a DNA construct conferring the desired trait into a plant of cultivar AGR044-3A22, wherein the DNA construct is introduced using polyethylene glycol (PEG) mediated DNA uptake, electroporation, ballistic infiltration using DNA coated microprojectiles (gene gun), an Agrobacteria infiltration based vector, or a plant virus based vector, and wherein the DNA construct comprises an RNAi construct.

[0326] In another embodiment, the invention provides any one of the above methods, wherein the *Brassica carinata* variety comprises the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22, when grown in the same location under the same environmental conditions.

[0327] In another embodiment, the invention provides any one of the above methods, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0328] In another embodiment, the invention provides any one of the above methods, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

[0329] In another embodiment, the invention provides a plant, or part thereof, or seed of a *Brassica carinata* variety produced by any one of the above methods.

[0330] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession

number PTA-123014, to produce a *Brassica carinata* variety comprising a desired trait, wherein the desired trait is conferred by a DNA construct.

[0331] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce a *Brassica carinata* variety comprising a desired trait, wherein the desired trait is conferred by a DNA construct, wherein the DNA construct is introduced using polyethylene glycol (PEG) mediated DNA uptake, electroporation, ballistic infiltration using DNA coated microprojectiles (gene gun), an Agrobacteria infiltration based vector, or a plant virus based vector.

[0332] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce a *Brassica carinata* variety comprising a desired trait, wherein the desired trait is conferred by a DNA construct, and wherein the DNA construct comprises a transgene.

[0333] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce a *Brassica carinata* variety comprising a desired trait, wherein the desired trait is conferred by a DNA construct, wherein the DNA construct is introduced using polyethylene glycol (PEG) mediated DNA uptake, electroporation, ballistic infiltration using DNA coated microprojectiles (gene gun), an Agrobacteria infiltration based vector, or a plant virus based vector, and wherein the DNA construct comprises a transgene.

[0334] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce a *Brassica carinata* variety comprising a desired trait, wherein the desired trait is conferred by a DNA construct, and wherein the DNA construct comprises an RNAi construct.

[0335] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce a *Brassica carinata* variety comprising a desired trait, wherein the desired trait is conferred by a DNA construct, wherein the DNA construct is introduced using polyethylene glycol (PEG) mediated DNA uptake, electroporation, ballistic infiltration using DNA coated microprojectiles (gene gun), an Agrobacteria infiltration based vector, or a plant virus based vector, and wherein the DNA construct comprises an RNAi construct.

[0336] In another embodiment, the invention provides any of the above uses, wherein the *Brassica carinata* variety comprises the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions.

[0337] In another embodiment, the invention provides any of the above uses, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0338] In another embodiment, the invention provides any of the above uses, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

[0339] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-3A22, the seed of which has been deposited under ATCC Accession number PTA-123014, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety was produced by a method comprising introducing a DNA construct conferring the desired trait into a plant of cultivar AGR044-3A22.

[0340] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-3A22, the seed of which has been deposited under ATCC Accession number PTA-123014, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety was produced by a method comprising introducing a DNA construct conferring the desired trait into a plant of cultivar AGR044-3A22, wherein the DNA construct is introduced using polyethylene glycol (PEG) mediated DNA uptake, electroporation, ballistic infiltration using DNA coated microprojectiles (gene gun), an Agrobacteria infiltration based vector, or a plant virus based vector.

[0341] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-3A22, the seed of which has been deposited under ATCC Accession number PTA-123014, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety was produced by a method comprising introducing a DNA construct conferring the desired trait into a plant of cultivar AGR044-3A22, and wherein the DNA construct comprises a transgene.

[0342] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-3A22, the seed of which has been deposited under ATCC Accession number PTA-123014, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety was produced by a method comprising introducing a DNA construct conferring the desired trait into a plant of cultivar AGR044-3A22, wherein the DNA construct is introduced using polyethylene glycol (PEG) mediated DNA uptake, electroporation, ballistic infiltration using DNA coated microprojectiles (gene gun), an Agrobacteria infiltration based vector, or a plant virus based vector, and wherein the DNA construct comprises a transgene.

[0343] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-3A22, the seed of which has been deposited under ATCC Accession number PTA-123014, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety was produced by a method comprising introducing a DNA construct conferring

the desired trait into a plant of cultivar AGR044-3A22, and wherein the DNA construct comprises an RNAi construct.

[0344] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-3A22, the seed of which has been deposited under ATCC Accession number PTA-123014, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety was produced by a method comprising introducing a DNA construct conferring the desired trait into a plant of cultivar AGR044-3A22, wherein the DNA construct is introduced using polyethylene glycol (PEG) mediated DNA uptake, electroporation, ballistic infiltration using DNA coated microprojectiles (gene gun), an Agrobacteria infiltration based vector, or a plant virus based vector, and wherein the DNA construct comprises an RNAi construct.

[0345] In another embodiment, the invention provides any of the above cells, wherein the *Brassica carinata* variety comprises the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions.

[0346] In another embodiment, the invention provides any of the above cells, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0347] In another embodiment, the invention provides any of the above cells, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

[0348] 5.2.10 Methods of and uses for introducing a desired trait by an initial cross and then pedigree selection, and cells, plants and seeds produced therefrom

[0349] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, and wherein the *Brassica carinata* variety comprises a desired trait, the method comprising the steps of: (a) crossing a plant of cultivar AGR044-3A22 with another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) selfing the progeny plants that have the desired trait to produce further progeny seed; and (d) growing the further progeny seed and selecting further progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-3A22.

[0350] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, and wherein the *Brassica carinata* variety comprises a desired trait, the method comprising the steps of: (a) crossing a plant of cultivar

AGR044-3A22 with another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) selfing the progeny plants that have the desired trait to produce further progeny seed; and (d) growing the further progeny seed and selecting further progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-3A22; wherein steps (c) and (d) are repeated until the *Brassica carinata* variety produced from cultivar AGR044-3A22 has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions.

[0351] In another embodiment, the invention provides any one of the above methods wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0352] In another embodiment, the invention provides any one of the above methods, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

[0353] In another embodiment, the invention provides a plant, or part thereof, or seed of a *Brassica carinata* variety produced by any one of the above methods.

[0354] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-3A22, the seed of which has been deposited under ATCC Accession number PTA-123014, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety was produced by a method comprising the steps of: (a) crossing a plant of cultivar AGR044-3A22 with a plant of another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) selfing the progeny plants that have the desired trait to produce further progeny plants; and (d) growing the resultant further progeny plants and selecting further progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-3A22.

[0355] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-3A22, the seed of which has been deposited under ATCC Accession number PTA-123014, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety was produced by a method comprising the steps of: (a) crossing a plant of cultivar AGR044-3A22 with a plant of another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) selfing the progeny plants that have the desired trait to produce further progeny plants; and (d) growing the resultant further progeny plants and selecting further progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-3A22; wherein steps (c) and (d) are repeated until the *Brassica carinata* variety produced from cultivar AGR044-3A22 has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions.

[0356] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-3A22, the seed of which has been deposited under ATCC Accession number PTA-123014, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety was produced by a method comprising the steps of: (a) crossing a plant of cultivar AGR044-3A22 with a plant of another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) selfing the progeny plants that have the desired trait to produce further progeny plants; and (d) growing the resultant further progeny plants and selecting further progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-3A22; wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0357] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-3A22, the seed of which has been deposited under ATCC Accession number PTA-123014, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety was produced by a method comprising the steps of: (a) crossing a plant of cultivar AGR044-3A22 with a plant of another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) selfing the progeny plants that have the desired trait to produce further progeny plants; and (d) growing the resultant further progeny plants and selecting further progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-3A22; wherein steps (c) and (d) are repeated until the *Brassica carinata* variety produced from cultivar AGR044-3A22 has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions, and wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0358] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-3A22, the seed of which has been deposited under ATCC Accession number PTA-123014, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety was produced by a method comprising the steps of: (a) crossing a plant of cultivar AGR044-3A22 with a plant of another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) selfing the progeny plants that have the desired trait to produce further progeny plants; and (d) growing the resultant further progeny plants and selecting further progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-3A22; wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

[0359] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-3A22, the seed of which has been deposited under ATCC Accession number PTA-123014, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety was produced by a method comprising the steps of: (a) crossing a plant of

cultivar AGR044-3A22 with a plant of another *Brassica carinata* variety comprising the desired trait; (b) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait; (c) selfing the progeny plants that have the desired trait to produce further progeny plants; and (d) growing the resultant further progeny plants and selecting further progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-3A22; wherein steps (c) and (d) are repeated until the *Brassica carinata* variety produced from cultivar AGR044-3A22 has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions; and wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

[0360] **5.2.11 Mutagenesis**

[0361] In one aspect, the present invention includes the introduction of a desired trait into *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, to produce a *Brassica carinata* variety comprising the desired trait, wherein the desired trait is introduced by mutagenesis.

[0362] Any means of mutagenesis can potentially be used, including the mutagenic agents ethyl methanesulfonate, N-ethyl-N-nitrosourea, ionizing radiation such as x-ray or gamma, or ultraviolet radiation.

[0363] The mutagenization can be of a variety of parts of the plants, including a seed, seedling, or microspore. Mutagenized microspores can then be used to generate doubled haploid plants (see above). Seedlings or microspores are exposed to the mutagenic agent and then the surviving fraction are allowed to develop into mature plants. In some cases, the mutagenized plantlets or embryos (in the case of microspore mutagenesis) may be exposed to selection in order to enrich for a particular phenotype. This technique can be used to develop varieties with a desired trait, such as resistance to a herbicide, an altered seed oil profile, increased tolerance to disease, or abiotic stress.

[0364] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, and wherein the *Brassica carinata* variety comprises a desired trait, the method comprising exposing seedlings or microspores to a mutagenic agent and allowing the surviving fraction to develop into mature plants.

[0365] In another embodiment, the invention provides a method of producing a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, and wherein the *Brassica carinata* variety comprises a desired trait, the method comprising exposing seedlings or microspores to a mutagenic agent and allowing the surviving fraction to develop into mature plants, and wherein the

mutagenic agent is ethyl methanesulfonate, N-ethyl-N-nitrosourea, ionizing radiation such as x-ray or gamma, or ultraviolet radiation.

[0366] In another embodiment, the invention provides a plant, or part thereof, or seed of a *Brassica carinata* variety produced by any of the above methods.

[0367] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce a *Brassica carinata* variety comprising a desired trait, wherein the desired trait is introduced by exposing seedlings or microspores to a mutagenic agent.

[0368] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce a *Brassica carinata* variety comprising a desired trait, wherein the desired trait is introduced by exposing seedlings or microspores to a mutagenic agent, and wherein the mutagenic agent is ethyl methanesulfonate, N-ethyl-N-nitrosourea, ionizing radiation such as x-ray or gamma, or ultraviolet radiation.

[0369] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety is produced by a method comprising exposing seedlings or microspores to a mutagenic agent and allowing the surviving fraction to develop into mature plants.

[0370] In another embodiment, the invention provides a cell of a plant of a *Brassica carinata* variety produced from cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, wherein the *Brassica carinata* variety comprises a desired trait, and wherein the *Brassica carinata* variety is produced by a method comprising exposing seedlings or microspores to a mutagenic agent and allowing the surviving fraction to develop into mature plants, wherein the mutagenic agent is ethyl methanesulfonate, N-ethyl-N-nitrosourea, ionizing radiation such as x-ray or gamma, or ultraviolet radiation.

[0371] 5.2.12 Methods of or uses for producing a carinata variety by outcrossing (interspecific or wide crossing), and cells, plants, seeds produced therefrom

[0372] Where no *Brassica carinata* variety has a specific desired trait, outcrossing (interspecific or wide crossing) can be used where the trait is found in another Brassicaceae species, such as, for example, *Brassica napus*, *Brassica juncea*, *Brassica oleracea*, *Brassica rapa*, or *Brassica nigra*.

[0373] In another embodiment, the invention provides a method of producing a carinata variety produced from *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, and wherein the carinata variety comprises a desired trait, the method comprising: (a) crossing a plant of cultivar AGR044-3A22 with a

plant of another Brassicaceae species comprising the desired trait; (b) using embryo rescue techniques to recover viable F1 plants from the cross or growing F1 seeds to produce F1 plants; (c) selfing the F1 plants that have the desired trait and carinata character; (d) using embryo rescue techniques to recover viable F2 plants or growing F2 seeds to produce F2 plants; (e) selfing the F2 plants that have the desired trait and carinata character; (f) using embryo rescue techniques to recover viable F3 plants or growing F3 seeds to produce progeny plants; (g) selfing the progeny plants that have the desired trait and carinata character to produce further progeny plants; and (h) selecting the progeny plants with the desired trait and carinata character to produce the carinata variety produced from cultivar AGR044-3A22.

[0374] In another embodiment, the invention provides a method of producing a carinata variety produced from *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, and wherein the carinata variety comprises a desired trait, the method comprising: (a) crossing a plant of cultivar AGR044-3A22 with a plant of another Brassicaceae species comprising the desired trait; (b) using embryo rescue techniques to recover viable F1 plants from the cross or growing F1 seeds to produce F1 plants; (c) selfing the F1 plants that have the desired trait and carinata character; (d) using embryo rescue techniques to recover viable F2 plants or growing F2 seeds to produce F2 plants; (e) selfing the F2 plants that have the desired trait and carinata character; (f) using embryo rescue techniques to recover viable F3 plants or growing F3 seeds to produce progeny plants; (g) selfing the progeny plants that have the desired trait and carinata character to produce further progeny plants; and (h) selecting the progeny plants with the desired trait and carinata character to produce the carinata variety produced from cultivar AGR044-3A22; wherein steps (g) and (h) are repeated until the carinata variety produced from cultivar AGR044-3A22 has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions.

[0375] In another embodiment, the invention provides any of the above methods, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0376] In another embodiment, the invention provides any of the above methods, wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

[0377] In another embodiment, the invention provides any of the above methods, wherein the method further comprises producing a doubled haploidy variety from the carinata variety.

[0378] In another embodiment, the invention provides a plant, or part thereof, or seed of a carinata variety produced by any of the above methods.

[0379] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce a carinata variety comprising a desired trait, wherein the desired trait

is introduced by crossing a plant of cultivar AGR044-3A22 with a plant of another Brassicaceae species comprising the desired trait.

[0380] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce a carinata variety comprising a desired trait, wherein the desired trait is introduced by crossing a plant of cultivar AGR044-3A22 with a plant of another Brassicaceae species comprising the desired trait, and wherein the carinata variety produced from cultivar AGR044-3A22 has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions.

[0381] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce a carinata variety comprising a desired trait, wherein the desired trait is introduced by crossing a plant of cultivar AGR044-3A22 with a plant of another Brassicaceae species comprising the desired trait, and wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0382] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce a carinata variety comprising a desired trait, wherein the desired trait is introduced by crossing a plant of cultivar AGR044-3A22 with a plant of another Brassicaceae species comprising the desired trait, and wherein the carinata variety produced from cultivar AGR044-3A22 has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions, and wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0383] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce a carinata variety comprising a desired trait, wherein the desired trait is introduced by crossing a plant of cultivar AGR044-3A22 with a plant of another Brassicaceae species comprising the desired trait, and wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

[0384] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce a carinata variety comprising a desired trait, wherein the desired trait is introduced by crossing a plant of cultivar AGR044-3A22 with a plant of another Brassicaceae species comprising the desired trait, and wherein the carinata variety produced from cultivar AGR044-3A22 has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions, and wherein

the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

[0385] In another embodiment, the invention provides a cell of a plant of a carinata variety comprising a desired trait, wherein the carinata variety is produced by a method comprising: (a) crossing a plant of cultivar AGR044-3A22 with a plant of another Brassicaceae species comprising the desired trait; (b) using embryo rescue techniques to recover viable F1 plants from the cross or growing F1 seeds to produce F1 plants; (c) selfing the F1 plants that have the desired trait and carinata character; (d) using embryo rescue techniques to recover viable F2 plants or growing F2 seeds to produce F2 plants; (e) selfing the F2 plants that have the desired trait and carinata character; (f) using embryo rescue techniques to recover viable F3 plants or growing F3 seeds to produce progeny plants; (g) selfing the progeny plants that have the desired trait and carinata character to produce further progeny plants; and (h) selecting the progeny plants with the desired trait and carinata character to produce the carinata variety produced from cultivar AGR044-3A22.

[0386] In another embodiment, the invention provides a cell of a plant of a carinata variety comprising a desired trait, wherein the carinata variety is produced by a method comprising: (a) crossing a plant of cultivar AGR044-3A22 with a plant of another Brassicaceae species comprising the desired trait; (b) using embryo rescue techniques to recover viable F1 plants from the cross or growing F1 seeds to produce F1 plants; (c) selfing the F1 plants that have the desired trait and carinata character; (d) using embryo rescue techniques to recover viable F2 plants or growing F2 seeds to produce F2 plants; (e) selfing the F2 plants that have the desired trait and carinata character; (f) using embryo rescue techniques to recover viable F3 plants or growing F3 seeds to produce progeny plants; (g) selfing the progeny plants that have the desired trait and carinata character to produce further progeny plants; and (h) selecting the progeny plants with the desired trait and carinata character to produce the carinata variety produced from cultivar AGR044-3A22; wherein steps (g) and (h) are repeated until the carinata variety produced from cultivar AGR044-3A22 has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions.

[0387] In another embodiment, the invention provides a cell of a plant of a carinata variety comprising a desired trait, wherein the carinata variety is produced by a method comprising: (a) crossing a plant of cultivar AGR044-3A22 with a plant of another Brassicaceae species comprising the desired trait; (b) using embryo rescue techniques to recover viable F1 plants from the cross or growing F1 seeds to produce F1 plants; (c) selfing the F1 plants that have the desired trait and carinata character; (d) using embryo rescue techniques to recover viable F2 plants or growing F2 seeds to produce F2 plants; (e) selfing the F2 plants that have the desired trait and carinata character; (f) using embryo rescue techniques to recover viable F3 plants or growing F3 seeds to produce progeny plants; (g) selfing the progeny plants that have the desired trait and carinata character to produce further progeny plants; and (h) selecting the progeny plants with the desired trait and carinata character to produce the carinata variety produced from cultivar AGR044-3A22; wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0388] In another embodiment, the invention provides a cell of a plant of a carinata variety comprising a desired trait, wherein the carinata variety is produced by a method comprising: (a) crossing a plant of cultivar AGR044-3A22 with a plant of another Brassicaceae species comprising the desired trait; (b) using embryo rescue techniques to recover viable F1 plants from the cross or growing F1 seeds to produce F1 plants; (c) selfing the F1 plants that have the desired trait and carinata character; (d) using embryo rescue techniques to recover viable F2 plants or growing F2 seeds to produce F2 plants; (e) selfing the F2 plants that have the desired trait and carinata character; (f) using embryo rescue techniques to recover viable F3 plants or growing F3 seeds to produce progeny plants; (g) selfing the progeny plants that have the desired trait and carinata character to produce further progeny plants; and (h) selecting the progeny plants with the desired trait and carinata character to produce the carinata variety produced from cultivar AGR044-3A22; wherein steps (g) and (h) are repeated until the carinata variety produced from cultivar AGR044-3A22 has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions, and wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.

[0389] In another embodiment, the invention provides a cell of a plant of a carinata variety comprising a desired trait, wherein the carinata variety is produced by a method comprising: (a) crossing a plant of cultivar AGR044-3A22 with a plant of another Brassicaceae species comprising the desired trait; (b) using embryo rescue techniques to recover viable F1 plants from the cross or growing F1 seeds to produce F1 plants; (c) selfing the F1 plants that have the desired trait and carinata character; (d) using embryo rescue techniques to recover viable F2 plants or growing F2 seeds to produce F2 plants; (e) selfing the F2 plants that have the desired trait and carinata character; (f) using embryo rescue techniques to recover viable F3 plants or growing F3 seeds to produce progeny plants; (g) selfing the progeny plants that have the desired trait and carinata character to produce further progeny plants; and (h) selecting the progeny plants with the desired trait and carinata character to produce the carinata variety produced from cultivar AGR044-3A22; wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

[0390] In another embodiment, the invention provides a cell of a plant of a carinata variety comprising a desired trait, wherein the carinata variety is produced by a method comprising: (a) crossing a plant of cultivar AGR044-3A22 with a plant of another Brassicaceae species comprising the desired trait; (b) using embryo rescue techniques to recover viable F1 plants from the cross or growing F1 seeds to produce F1 plants; (c) selfing the F1 plants that have the desired trait and carinata character; (d) using embryo rescue techniques to recover viable F2 plants or growing F2 seeds to produce F2 plants; (e) selfing the F2 plants that have the desired trait and carinata character; (f) using embryo rescue techniques to recover viable F3 plants or growing F3 seeds to produce progeny plants; (g) selfing the progeny plants that have the desired trait and carinata character to produce further progeny plants; and (h) selecting the progeny plants with the desired trait and carinata character to produce the carinata variety produced from cultivar AGR044-3A22; wherein steps (g) and (h) are repeated until the carinata variety produced from cultivar AGR044-3A22 has the desired trait and essentially all of the physiological

and morphological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions, and wherein the desired trait is herbicide tolerance and the tolerance is conferred to a herbicide selected from but not limited to the group consisting of glyphosate, glufosinate, imidazolinones, and auxin analogues such as 2,4-D and dicamba.

[0391] **5.2.13 Commercial crops and commercial plant products**

[0392] In another embodiment, the invention provides a method of producing a commercial plant product, the method comprising growing a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, to produce a commercial crop, and producing said commercial plant product from the commercial crop.

[0393] In another embodiment, the invention provides a method of producing a commercial plant product, the method comprising growing a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, to produce a commercial crop, and producing said commercial plant product from the commercial crop, wherein the commercial plant product comprises oil, meal, or protein isolate.

[0394] In another embodiment, the invention provides a method of producing a commercial plant product, the method comprising growing a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, to produce a commercial crop, and producing said commercial plant product from the commercial crop, wherein the commercial plant product comprises a biofumigant.

[0395] In another embodiment, the invention provides a commercial plant product produced by a method comprising growing a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, to produce a commercial crop, and producing said commercial plant product from the commercial crop.

[0396] In another embodiment, the invention provides a commercial plant product produced by a method comprising growing a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014, to produce a commercial crop, and producing said commercial plant product from the commercial crop, wherein the commercial plant product comprises oil, meal, or protein isolate.

[0397] In another embodiment, the invention provides oil, meal, or protein isolate produced by a method comprising growing a plant of *Brassica carinata* cultivar AGR044-3A22 produced from the seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has

been deposited under ATCC Accession number PTA-123014, to produce a commercial crop, and producing the oil, meal, or protein isolate from the commercial crop.

[0398] In another embodiment, the invention provides crushed, non-viable seed of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014.

[0399] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce a commercial crop.

[0400] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce a commercial plant product.

[0401] In another embodiment, the invention provides use of a plant of *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce a commercial plant product, wherein the commercial plant product comprises oil, meal, or protein isolate.

[0402] In another embodiment, the invention provides crushed, non-viable seed of a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014.

[0403] In another embodiment, the invention provides use of a plant of a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce a commercial crop.

[0404] In another embodiment, the invention provides use of a plant of a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce a commercial plant product.

[0405] In another embodiment, the invention provides use of a plant of a *Brassica carinata* variety produced from *Brassica carinata* cultivar AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, to produce a commercial plant product, wherein the commercial plant product comprises oil, meal, or protein isolate.

[0406] **5.3 Characteristics of AGR044-312D and AGR044-3A22**

[0407] **Example 1: AGR044-312D and AGR044-3A22 yield performance in North Dakota , South Dakota and Saskatchewan**

[0408] Yield trials were carried out for AGR044-312D at Winner, South Dakota; Hettinger, North Dakota; Moosomin, SK; and Vanguard, SK during the summer of 2015 in small plots using a three

replicate randomized complete block design. These tests including 312D were designated “PYT A”. This same experimental design was used for yield trials including AGR044-3A22, and data for two reliable sites was collected at Winner, South Dakota and Tioga, North Dakota. Yields were calculated from the mean of replicate plots of the test variety and expressed as a percentage of the mean yield of the check varieties in the same trial (A110 and A120, the current commercial varieties, were used as checks).

[0409] Table 1 records seed yield relative to the A110 check in yield testing in 2015. In the Hettinger trial, AGR044-312D yielded substantially higher than both of the commercial carinata check varieties; while in the Winner trial this variety yielded more than the A110 commercial check but not A120. In both Moosomin and Vanguard, AGR044-312D yielded lower than both A110 and A120. It should be noted that 312D has been tested as an improved variety for more southern geographies such as in the Southeast U.S. or South America. Therefore, yield data for AGR044-312D in these northern sites is not necessarily indicative of the full yield potential of this variety. For AGR044-3A22 in Tioga, yields substantially exceed both check lines, while at the Winner trial this variety yielded more than the A110 but not A120.

Table 1: AGR044-312D and -3A22 yields relative to checks in North Dakota, South Dakota and Saskatchewan yield trials (2015)

Traits	Trials	Carinata variety			
		312D	3A22	A120	A110
Yield as % of A110 (Hettinger, ND)	Prelim A	136	n.d.	118	100
Yield as % of A110 (Winner, SD)		109	n.d.	113	100
Yield as % of A110 (Moosomin SK)		86	n.d.	103	100
Yield as % of A110 (Vanguard, SK)		84	n.d.	97	100
Yield as % of A110 (Winner, SD)	Prelim B	n.d.	105	106	100
Yield as % of A110 (Tioga, SD)		n.d.	133	118	100
Yield as % of A110 (Vanguard, SK)		n.d.	n.d.	108	100

[0410] **Example 2: AGR044-312D and AGR044-3A22 agronomic traits in North Dakota, South Dakota and Saskatchewan testing**

[0411] Observations were made of various distinguishing traits leaf, flower and silique colouration, plant height, as well as agronomic traits such as days to flower (DTF), days to maturity (DTM). Table 2 summarizes these observations for the AGR044-312D variety and Table 3 for the AGR044-3A22 variety.

Table 2: AGR044- 312D Unique plant traits (North Dakota, South Dakota and Saskatchewan, 2015)

Trait	AGR044-312D	A120	A110
Moosomin - Flower Petal colour	yellow (<10% white)	yellow	yellow
Vanguard – Flower Petal colour	yellow (<10% white)	yellow	yellow
Hettinger - DTF	54	54	54
Moosomin - DTF	50	53	52
Vanguard - DTF	58	58	62
Vanguard - DTM	112	112	117
Moosomin - DTM	97	100	99
Tioga Maturity rating (taken Aug 10; rating 1 to 10, 10 being complete maturity)	8.7	6.7	6.3
Vanguard - Canopy height (cm)	93	109	106
Hettinger - Height (cm)	106	130	133
Leaf colouration at bolting	Dark green	Bluish green	Bluish green
Incidence of purple silique coloration (due to anthocyanin)	Medium to high	low	low

Table 3: AGR044-3A22 Unique plant traits (North Dakota, South Dakota and Saskatchewan, 2015)

Trait	AGR044-3A22	A120	A110
Winner - Flower Petal colour	yellow (<5% white)	yellow	yellow
Tioga – Flower Petal colour	yellow (<5% white)	yellow	yellow
Winner - DTF	55	56	56
Tioga Maturity rating (taken Aug 10; rating 1 to 10, 10 being complete maturity)	7.0	4.7	6.7
Leaf colouration at bolting	Green	Bluish green	Bluish green
Incidence of purple silique coloration (due to anthocyanin)	Very low level	Low level mostly in leaf axil area	Low level mostly in leaf axil area

[0412] **Example 3: Seed quality characteristics of AGR044-312D and AGR044-3A22 in 2015 testing (North Dakota, South Dakota and Saskatchewan)**

[0413] Seed samples from each plot in the 2015 preliminary trial sites were used for seed quality data analysis. Seed quality estimates were obtained for AGR044-312D at Winner, South Dakota; Moosomin, SK; and Vanguard, SK; and for AGR044-3A22 at Winner, SD and Tioga, ND

[0414] Seed oil, GSL (glucosinolate) content, protein content and fatty acid profile were determined by NIR analysis on a FOSS XDS™ Rapid Content Analyser fitted with an auto sampling unit. For NIR analysis, a minimum of 5 g of seed sample (cleaned and dried to approximately 5% moisture) was placed in a ring cup, tracking code recorded, and sample spectra collected at 0.5 nm increments, over the range of 400-2500 nm. Calibration was developed in-house by correlating the NIR spectra with experimentally-measured seed quality parameters of a diverse set of carinata experimental lines, representing as wide a spectrum of seed quality characteristics as could be found in this species (diverse range of oil contents, profiles, glucosinolate levels, seed colours, etc.). NIR values for oil content (% of whole seed) were validated using data obtained from NMR analysis of samples on an Oxford MARAN Ultra benchtop NMR system. NIR determination of seed Fatty-acid profile (and derived statistics, such as % SATS and % LCFA) was calibrated using Gas Chromatography of the Fatty-Acid Methyl Esters (FAMES) using the protocol described by Taylor et al. (1992). NIR based glucosinolate determination was calibrated using Canadian Grains Commission data, a combination of the ISO 9167 method and their own NIR measurements. For calibration, seed samples were analyzed using our NIR instrument, the spectra collected and the experimental values recorded. The data set was then subjected to mathematical modeling to refine the spectra and the WinISI software package was used to determine the spectral regions most predictive of the desired parameters. Points providing >99.99% correlation with the experimental values (determined as described above) were selected from the spectral curve and used to develop the predictive equation.

[0415] Least square means of replicate seed oil and GSL content data were calculated and their standard errors compared via REML analysis to determine whether seed quality differences between tested carinata varieties were significant. Values not sharing a group letter (Tables 4 and 5) were significantly different at $P < 0.05$, using the Student comparison of LS Mean method. All statistical analysis was performed using the JMP statistical analysis software (SAS)

[0416] **Seed oil content:** As can be seen in Table 4, the mean oil content of AGR044-312D was consistently 3 -4 % lower than those of the check varieties A120 and A110 in three groups of yield trials carried out in N. Dakota, S. Dakota and Saskatchewan during the summer of 2015. The variety AGR044-3A22, was closer in oil content to the check lines. For this variety, comparison of the means using REML test showed no significant differences between AGR044-3A22, A120 and A110.

[0417] **Glucosinolate content:** As can be seen in Table 5, the varieties AGR044-312D and AGR044-3A22 clearly demonstrated a significantly lower seed GSL content relative to A110 and A120 seed. For AGR044-312D, decreases in GSL content of 18-23% relative to A110 and 19-28% relative to A120 were observed. For AGR044-3A22, decreases in GSL content of 27% relative to A110 and 32% relative to A120 were observed.

Table 4: Seed quality versus check lines; oil content of AGR044-312D and AGR044-3A22 compared with check lines in 2015 yield testing (North Dakota, South Dakota and Saskatchewan, 2015)

Trial	No. sites	Name	Oil % (LS Mean)	Std Error	Group
PYT A	3	AAC A110	43.2	0.6	ABC
PYT A	3	AAC A120	43.1	0.6	ABC
PYT A	3	AGR044-312D	39.5	0.5	GHIJ
PYT B	2	AAC A110	44.6	0.6	ABCD
PYT B	2	AAC A120	43.5	0.6	DEFGH
PYT B	2	AGR044-3A22	44.4	0.7	ABCDEF

Table 5: Seed quality versus check lines; seed Glucosinolate content of AGR044-312D and AGR044-3A22 compared with check lines in 2015 yield testing (North Dakota, South Dakota and Saskatchewan)

Trial	No. sites	Name	GSL ($\mu\text{mol/g}$) (LS Mean)	Std Error	Group
PYT A	3	AAC A110	92.9	3.4	FGHI
PYT A	3	AAC A120	91.2	3.4	FGH
PYT A	3	AGR044-312D	73.9	3.1	AB
PYT B	2	AAC A110	77.9	3.7	IJKL
PYT B	2	AAC A120	83.4	3.7	KL
PYT B	2	AGR044-3A22	57.1	4.5	AC

[0418] **Protein:** Brassica carinata seed is known to contain appreciable levels of protein. When oil is extracted from the seed in commercial crushing operations, the remaining meal fraction can in itself be a valuable co-product, serving as a source of protein for use in animal feed applications. Therefore, in any assessment of new carinata varieties for commercial potential, seed protein content is an important consideration. Table 6 compares the protein contents of AGR044-312D and AGR044-3A22 with those of check lines A110 and A120 in seed harvested from 2015 field trials. The least square means estimate of AGR044-312D and AGR044-3A22 whole seed protein values was 26 to 27%; and for the checks it was 28 to 29% (Table 6).

Table 6: Seed quality versus check lines; seed protein content of AGR044-312D and AGR044-3A22 compared with check lines in 2015 yield testing (North Dakota, South Dakota and Saskatchewan)

Trial	No. sites	Name	% Protein (LS Mean)	Std Error	Group
PYT A	3	AAC A110	28.4	0.6	CDE
PYT A	3	AAC A120	27.9	0.6	CDEF
PYT A	3	AGR044-312D	26.9	0.5	FG
PYT B	2	AAC A110	28.1	0.6	BCDEFG
PYT B	2	AAC A120	29.0	0.6	BC
PYT B	2	AGR044-3A22	25.9	0.8	IJKL

[0419] **Fatty acid profile:** The composition of carinata oil makes it suitable as an industrial feedstock in a number of biofuel manufacturing applications (see for example Gesch et al 2015, Wagid et al 2015). In particular, high levels of long and very long chain monounsaturated fatty acid content and a low proportion of saturated fatty acids are key definers of the current carinata profile and significant divergence from this profile in new carinata varieties would be problematic. Table 7 shows the fatty acid profile of AGR044-312D, AGR044-3A22 and the A110 and A120 check lines from grain harvested from 2015 trials carried out in North Dakota, South Dakota and Saskatchewan. As can be seen, the VLCFA erucic acid (C22:1) proportion in oil of both AGR044-312D and AGR044-3A22 falls very close to those of the commercial check lines in all trials. Similarly, the levels of saturated fatty acids in both AGR044-312D and AGR044-3A22 oil are close to those of the check varieties. The composition of the other main fatty acid constituents of AGR044-312D and AGR044-3A22 also do not deviate substantially from those of their check line counterparts. This it is expected that the physical properties of the AGR044-312D and AGR044-3A22 oil that are dependant on fatty acid composition should not differ greatly from those of the check lines.

Table 7: Fatty acid profile of oil from grain harvested in North Dakota, South Dakota and Saskatchewan trials (2015)

Site	Name	SATS	SD	C18.1	SD	C18.2	SD	C18.3	SD	C20.1	SD	C22.1	SD
Moosomin, SK	AAC A110	6.03	0.18	8.13	0.95	14.97	0.64	14.67	0.27	8.75	0.59	40.39	0.64
Moosomin, SK	AAC A120	6.27	0.13	8.25	0.72	15.69	0.78	13.99	0.36	9.12	0.35	38.55	1.07
Moosomin, SK	AGR044-312D	6.11	0.08	10.14	1.21	16.31	0.30	12.91	0.14	9.42	0.26	41.46	0.70
Vanguard, SK	AAC A110	6.41	0.24	13.83	1.21	16.09	1.12	13.39	0.67	10.04	0.28	34.90	2.23
Vanguard, SK	AAC A120	6.24	0.13	13.26	1.36	15.70	0.42	12.99	0.39	10.43	0.43	36.77	1.23
Vanguard, SK	AGR044-312D	6.31	0.10	13.58	1.20	15.94	0.62	12.50	0.56	10.64	0.17	37.63	0.84
Winner, SD	AAC A110	5.90	0.11	13.16	0.92	17.24	0.84	12.42	0.20	8.90	0.44	38.72	1.06
Winner, SD	AAC A120	6.08	0.05	14.10	0.87	17.32	0.70	11.59	0.31	9.60	0.39	38.32	0.22
Winner, SD	AGR044-312D	6.36	0.10	16.33	1.06	19.13	0.45	9.81	0.16	9.19	0.27	37.87	0.82
Tioga, ND	AAC A120	6.30	0.11	13.42	1.66	17.51	0.74	12.99	0.74	7.91	0.74	39.19	0.74
Tioga, ND	AAC A110	6.23	0.05	10.49	1.76	15.89	0.74	13.51	0.74	8.80	0.74	39.77	0.74
Tioga, ND	AGR044-3A22	6.30	0.05	11.66	1.46	17.00	0.74	12.74	0.74	9.49	0.74	38.08	0.74
Winner, SD	AAC A120	6.29	0.25	14.68	0.91	19.36	0.74	11.17	0.74	8.32	0.74	36.76	0.74
Winner, SD	AAC A110	6.27	0.02	13.39	3.05	18.44	0.74	11.77	0.74	8.66	0.74	37.92	0.74
Winner, SD	AGR044-3A22	6.10	0.06	14.76	0.61	18.20	0.74	11.30	0.74	10.15	0.74	36.26	0.74

[0420] Example 4: AGR044-312D yield performance in Florida

[0421] Two small plot yield trials were carried out in Quincy, FL during the winter of 2014- 2015 comprising 20 entries and had four replications per entry in a randomized complete block design. The sites differ in that one field contained no traces of residual Cadre Herbicide (a commonly used herbicide in the southeastern United States, but whose residue might be of concern to potential carinata growers), while the other was on a piece that did have carry over of residual Cadre herbicide from previous crops. Seed yield estimates were calculated from the least square means of replicated plots estimated in kg per hectare and/or bushel per acre. Least square mean values and their standard errors were compared via REML analysis (using student method of LS mean comparison) to determine whether differences were significant. Values that do not share a group letter are significantly different at $P < 0.05$. All statistical analysis was performed using the JMP statistical analysis software (SAS).

[0422] As can be seen in Table 8, yields of AGR044-312D were significantly higher than checks in both the Cadre residue and no residue sites. The entry AGR044-312D Improved on A120 yields by 123% and A110 by 126% in the no residue site and likewise improved on A120 by 109% and A110 by 112% in cadre residue containing site. There did not appear to be a large difference between the site with Cadre residue and the no cadre site.

Table 8: AGR044-312D yields relative to checks in Quincy FL yield trials (Winter 2014-2015)

Site	Variety	Yield (bu/ac)	Yield (kg/ha)	Std Error	Group
No Residue	AGR044-312D	65.1	3647	112	A
No Residue	AAC A120	53.1	2975	85	CDE
No Residue	AAC A110	51.6	2888	177	DEF
Cadre Residue	AGR044-312D	70.7	3958	55	-
Cadre Residue	AAC A120	64.6	3619	125	-
Cadre Residue	AAC A110	62.9	3520	94	-

[0423] Example 5: AGR044-312D Agronomic traits in Florida

[0424] **Frost tolerance:** In Florida, carinata is grown as a winter cover crop, seeded optimally in November. As such it is exposed to a period where frost is a persistent risk. Evidence has indicated that carinata is quite frost tolerant when exposed in early spring / late fall in its more northerly ranges and commercial varieties are assessed on their ability to recover after frost damage. Due to the fact that short periods of hard frost are an annual risk for carinata's use as a winter grown crop, assessing frost tolerance characteristics in new varieties is an important breeding consideration. In the 2014-15 Florida yield trials, two consecutive nights reaching -9°C provided good frost pressure to evaluate differences in yield trial entries. Frost tolerance was assessed on all plots at the two sites one, two, and three weeks following these hard frost events. This was done by determining the relative amount of damaged or dead plants in each plot, where 1 represents no damage and 10 represents all plants being killed. Table 9 illustrates post-frost ratings for AGR044-312D and the two check varieties, at each of the three time periods following the hard frost event. More freeze damage occurred at the No Residual site than the Cadre residual site. No major differences, positive or negative, were noted in these trials between 312D and the check varieties.

Table 9: Frost tolerance tolerance of AGR044-312D compared with checks in Quincy, FL, 2014-15**No Residual - More freeze damage**

Name	1 wk	2 wks	3 wks
AAC A110	8	7	7
AAC A120	9	8	7
AGR044-312D	9	8	7

Cadre residual - Less freeze damage

Name	1 wk	2 wks	3 wks
AGR044-312D	9	5	4
AAC A110	9	5	4
AAC A120	9	6	5

Ratings: 1-10, indicating % damage. 1 = no damage; 10 = dead (ratings taken weekly after freeze event)

[0425] **Maturity ratings:** Days to maturity is an important factor in selection of new varieties. In Florida, as a winter cover crop, it is important that carinata matures and is harvested early enough to allow for timely seeding of the spring cash crops, such as peanuts, soybean, sesame, etc. Days to flowering is typically correlated with days to maturity, as earlier flowering and completion of flowering allows for earlier seed maturation. Accordingly, days to flowering and days to maturity were evaluated for AGR044-312D in relation to the check lines A110 and A120. At the no residue site, mean days to flowering occurred significantly earlier for the check lines than for AGR044-312D (by 2.5 days). Mean days to maturity for A110 occurred 1.8 days earlier than AGR044-312D while mean days to maturity for A120 occurred 3.3 days earlier than AGR044-312D, the latter difference being significant. It is not clear whether fertility would affect the maturity ratings. Thus, in the winter of 2014-15, 312D matured slightly later than the check varieties.

Table 10: Maturity ratings at the No Residue site in 2014-15 Quincy, FL yield trials

Days to flowering			Days to maturity		
Name	DTF	Group	Name	DTM	Group
AAC A120	109.8	B	AAC A120	170.0	A
AAC A110	109.8	B	AAC A110	171.5	ABC
AGR044-312D	112.3	CD	AGR044-312D	173.3	BCD

[0426] Example 6: AGR044-312D seed quality data from Quincy Florida (2014-2015)

[0427] Seed harvested from the 2014- 2015 Florida yield trial sites were used for seed quality analysis using the same methodology as described in earlier examples

[0428] **Oil content:** As can be seen in Table 11, the mean oil content of the AGR044-312D seed was slightly lower compared to those of the check-lines A110 and A120, however this difference was not statistically significant.

Table 11: Seed quality versus check lines for oil content of 312D in 2014-15 Quincy, FL yield testing – Least Square Mean of two sites

Name	Oil % (LS Mean)	Std Error	Group
AAC A110	46.0	0.4	ABC
AAC A120	45.2	0.5	ABCD
AGR044-312D	44.1	0.4	BCDE

[0429] **GSL content:** Similar to what was observed in the North Dakota, South Dakota and Saskatchewan trials, GSL content of AGR044-312D seed harvested from Florida trials (Table 12) showed a significant reduction relative to check lines A110 and A120 (in the order of a 40% reduction).

Table 12: Seed quality versus check lines for glucosinolate content of AGR044- 312D in 2014-15 Quincy, FL yield testing – Least Square Mean of two sites

Name	GSL (μmol/g) (LS Mean)	Std Error	Group
AAC A110	86.5	2.6	G
AAC A120	87.3	3.1	G
AGR044-312D	51.5	1.8	A

[0430] **Seed protein content:** Table 13 compares the protein contents of AGR044-312D with those of check lines A110 and A120 in seed harvested from the 2014-2015 Florida field trials. At both sites in 2014-15 Quincy, FL yield testing, the AGR044-312D line had approximately 2% lower protein content on a whole seed basis than the check varieties.

Table 13: Seed protein levels of A110, A120 and AGR044-312D expressed as percentage of seed weight from 2014-15 Quincy, FL yield testing

Sample	Name	Protein (%)	St Dev
Quincy, Cadre residue	AAC A110	29.3	0.9
Quincy, Cadre residue	AAC A120	29.7	0.8
Quincy, Cadre residue	AGR044-312D	27.5	0.7
Sample	Name	Protein (%)	St Dev
Quincy, No herbicide residue	AAC A110	27.7	1.1
Quincy, No herbicide residue	AAC A120	27.3	0.9
Quincy, No herbicide residue	AGR044-312D	25.0	1.1

[0431] **Fatty Acid Profile:** Table 14 shows the fatty acid profile of AGR044-312D and check lines A110 and A120 from grain harvested from 2014- 2015 Florida trials. Similar to that of the North Dakota, South Dakota and Saskatchewan trials, the VLCFA erucic acid (C22:1) proportion in AGR044-312D oil falls very close to those of the commercial check lines in these trials, and likewise levels of saturated fatty acid (SATS) of AGR044-312D oil are close to those of the check lines. The relative proportions of the other main fatty acid constituents of AGR044-312D oil do not deviate substantially from those of the check line counterparts. Thus, it is expected that the physical properties of AGR044-312D oil that are influenced by fatty acid composition should not differ greatly from those of the check lines.

Table 14: Fatty acid profiles of AGR044-312D, A120 and A110 oil, as determined by NIR analysis, from 2014-15 Quincy, FL yield testing

Sample	Name	SATS	sd	C18.1	sd	C18.2	sd	C18.3	sd	C20.1	sd	C22.1	sd
Quincy, Cadre residue	AAC A110	6.3	0.1	11.1	1.0	15.5	0.7	13.8	0.4	8.2	0.3	39.6	1.0
Quincy, Cadre residue	AAC A120	6.3	0.1	11.9	1.2	15.8	0.4	13.4	0.4	8.4	0.3	39.1	1.1
Quincy, Cadre residue	AGR044-312D	6.4	0.1	14.1	0.3	17.7	0.7	12.0	0.2	7.8	0.3	38.4	0.8
Quincy, No herbicide residue	AAC A110	6.3	0.1	10.4	0.7	15.5	0.6	13.7	0.3	8.2	0.7	40.3	0.5
Quincy, No herbicide residue	AAC A120	6.5	0.1	10.9	0.8	15.8	0.2	13.2	0.2	8.3	0.2	39.8	0.2
Quincy, No herbicide residue	AGR044-312D	6.4	0.1	12.8	0.7	16.5	0.2	12.0	0.3	8.7	0.1	40.4	1.0

[0432] Example 7: Preparation of DNA from *Brassica carinata* A110, A120, AGR044-312D and AGR044-3A22 leaf tissue

[0433] Approximately 50-100 mg leaf tissues was sampled from *Brassica carinata* plants and placed into a sterile 1.5 ml microfuge tube on ice using forceps sterilized by dipping in 70% ethanol or 2% solution of sodium hypochlorite (NaClO) and wiping off between samples to avoid possible cross contamination. The tubes were then sealed with Parafilm and a fine-tipped forceps was used to make approximately 2-4 small holes in the Parafilm seal. The samples were then placed at -80°C overnight (minimally greater than 12 hours).

[0434] After the -80°C incubation, the samples were loaded directly from -80°C into freeze drying apparatus and lyophilized for a minimum of 42 hours. Following the lyophilization, the parafilm seals were removed from the tubes and replaced with the tube lids. At this point samples could be stored at -20°C for up to two weeks before processing for extraction of DNA.

[0435] To extract genomic DNA from the lyophilized samples two 3 mm glass beads (Sigma or any general suppliers) were placed into each tube. Tubes were then capped and loaded on a bead beater and processed twice for 30 s each time. Tubes were then centrifuged briefly to collect contents at the bottom and 500 µl of extraction buffer (2% CTAB, 100 mM Tris, pH 8, 20 mM EDTA, 1.4M NaCl ; before use beta-mercaptoethanol was added at ratio of 4 µl/ml of extraction buffer) was added to each sample tube and mixed by inversion, ensuring that all the lyophilized powder was solubilized, then placed at 65°C for 1 h. 500 µl of chloroform was then added and to each sample then content of the tubes was mixed by inversion for 5 minutes. Sample tubes were then centrifuged for 10 min at 13,000 RPM and then 400 µl of aqueous supernatant phase was transferred to new tubes containing 250 µl of isopropanol, mixed by inversion and incubated at room temperature for 10 minutes to overnight. DNA pellets were collected by centrifugation at 13,000 rpm for 15 min. Pellets were washed 2X by addition of 250 µl of 70% followed by centrifugation at 13000RPM for 1 min and removal of supernatant. After the completion of the second wash, the tubes were briefly centrifuged to collect any residual liquid , and the last drops of wash was removed with a micropipettor. The DNA pellets were dried at room temperature for 5 minutes, and then resuspended in 50 µl 0.1 x TE (for PCR) or 1 x TE (for other downstream work) containing 1 µl of RNase A (10mg/ml). Genomic DNA (gDNA) was quantified by picogreen fluorescence using the Quanti-IT DS DNA assay kit (Invitrogen) according to the manufacturers instructions and sample concentrations were normalized to 20 ng/µl.

[0436] Example 8: GBS library generation and QC from DNA from *Brassica carinata* A110, A120, AGR044-312D and AGR044-3A22

[0437] GBS libraries were generated essentially as described (Poland et al. 2012). Briefly, 10 µl of DNA (20 ng/µl) was double digested with restriction enzymes *Pst*I (*Pst*I-HF, NEB, Cat.# R3140) and *Msp*I (NEB, Cat.# R0106) by incubating at 37°C for 2 hrs, then 65°C for 20 min. Digested DNA was ligated to adapters by adding 5 µl of Adapters (0.02 µM Adapter 1 = 0.1 pmol, 3 µM Adapter 2 = 15 pmol) and 15 µl ligation mix (2 µl NEB Buffer 4, 4 µl ATP (10mM), 0.5 µl T4 DNA ligase (200 U)), and 8.5 µl H₂O. The reaction was incubated at 22°C for 2 h, and then 65°C for 20 min. Five µl from each sample ligation was pooled into a single tube and cleaned on a Qiagen column (QIAquick PCR Purification Kit (Qiagen, Cat#: 28106)). Eight PCR reactions were made for each library: 10 µl DNA (digested library), 5 µl Taq 5 X Master Mix (NEB,

Cat# M0285S), and 8 µl H₂O. PCR was run following this program: 95°C, 30 s.; 16 cycles of 95°C, 30 s, 62°C, 30 s, and 68°C for 30 s; followed by extension at 72°C for 5 min. The 8 PCR reactions were pooled and cleaned using QIAquick PCR Purification Kit following the manufacturer's directions and resuspended in 30 µl 1X TE buffer (pH 8.0) with addition of 1 µl of RNase A (10 mg/µl). Prior to sequencing the GBS library was checked for quality on Agilent 2100 Bioanalyzer using the Agilent DNA 1000 Kit (Cat: 5067-1504) to ensure that a majority DNA fragments ranged from 150-250 bp in size.

[0438] Example 9: GS library sequence analysis

[0439] The libraries were multiplexed at 96-fold and sequenced as 100 bp paired-end reads on an Illumina HiSeq2000TM according to the manufacturer's instructions. The raw sequence data were then de-multiplexed into the 96 individual samples). The software package Trimmomatic (<http://www.usadellab.org/cms/?page=trimmomatic>) was used to remove short sequences, adapter sequences, trim leading and trailing low quality regions and scan the read to cut bases when the average quality per base dropped below the threshold. Duplicate reads were then removed.

[0440] Cleaned sequence reads were aligned to the reference genome *B. nigra* (B) and *B. oleracea* (C) using Bowtie2 (Langmead and Salzberg S, 2012). The parameters were set as : --local --sensitive --phred33 --minins 0 --maxins 1000 --no-mixed --no-discordant --dovetail -k 50 --score-min L,0,0.8. The best hit from any multi-mapped reads were then selected. SNPs were called using the genome analysis toolkit (GATK) using an UnifiedGenotyper (Mackenna et al. 2010). Of the raw SNPs, high quality SNPs were selected using the following criteria: minor allele frequency (MAF) >0.05, missing data in less than 30% of the lines, heterozygosity of ≤ 0.1, and read depth of ≥4.

[0441] Example 10: Comparison of polymorphic SNPs (determined by GBS) found in A110, A120, AGR044-312D and AGR044-3A22 varieties

[0442] A GBS approach (genotype by sequencing) was used to identify a set of allelic markers that can be used to identify *Brassica carinata* varieties AGR044-312D and AGR044-3A22. The allelic markers are mainly single nucleotide polymorphisms (SNPs), but there are also some indel (insertion/deletion) markers. Varieties A110 and A120 were used as controls.

[0443] In Tables 16, 17 and 18 the positions of SNP (and Indel) mutations determined by GBS that are polymorphic among the A110, A120, AGR044-312D and AGR044-3A22 lines are tabulated and mapped to *Brassica carinata* chromosomes. Table 15 shows examples of contiguous chromosomal regions containing SNPS/indels that are common among AGR044-312D and AGR044-3A22, Table 16 shows examples of contiguous chromosomal regions containing multiple SNPS/INDELS unique for AGR044-312D, and Table 17 shows examples of contiguous chromosomal regions containing multiple SNPS/INDELS unique for AGR044-3A22. The data provides a demonstration at the molecular level of the distinctiveness of the AGR044-312D and AGR044-3A22 varieties relative to current commercial carinata varieties.

[0444] Tables 18 through 34 each represent one of the *Brassica carinata* chromosomes. There are 17 chromosomes in total: eight B chromosomes, and 9 C chromosomes.

Table 15: Examples of regions on *Brassica carinata* chromosome 1, 3, 6 and 11 with shared markers for two members of the AGR044 family

SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
B1_34061998	A/C	1	34061998	CC	CC	AA	AA
B1_34062026	A/T	1	34062026	TT	TT	AA	AA
B1_34062030	A/T	1	34062030	TT	TT	AA	AA
B1_34062032	T/A	1	34062032	AA	AA	TT	TT
B1_34316809	G/C	1	34316809	CC	CC	GG	GG
B1_34465544	T/G	1	34465544	GG	TT	TT	TT
B1_34465574	T/C	1	34465574	CC	CC	TT	TT
B1_36734256	G/C	1	36734256	CC	CC	GG	GG
B1_36734421	T/C	1	36734421	CC	CC	TT	TT
B1_36734436	C/T	1	36734436	TT	TT	CC	CC
B1_36734454	A/G	1	36734454	GG	GG	AA	AA
B1_36734457	G/T	1	36734457	TT	TT	GG	GG

SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
B3_3570723	A/C	3	3570723	CC	CC	AA	AA
B3_3731442	G/A	3	3731442	GG	GG	AA	AA
B3_3731489	C/T	3	3731489	CC	CC	TT	TT
B3_3731493	T/C	3	3731493	TT	TT	CC	CC
B3_3731499	C/T	3	3731499	CC	CC	TT	TT
B3_3731508	A/C	3	3731508	AA	AA	CC	CC
B3_4200470	T/A	3	4200470	TT	TT	AA	AA
B3_4200528	C/T	3	4200528	CC	CC	TT	TT
B3_4200558	T/C	3	4200558	TT	TT	CC	CC

SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
B6_18195799	G/T	6	18195799	GG	GG	TT	TT
B6_18737656	T/A	6	18737656	TT	TT	AA	AA
B6_18910126	A/G	6	18910126	AA	AA	GG	GG
B6_18961665	C/A	6	18961665	CC	CC	AA	AA
B6_18961721	A/G	6	18961721	AA	AA	GG	GG
B6_18961731	G/A	6	18961731	GG	GG	AA	AA
B6_19031097	C/A	6	19031097	CC	CC	AA	AA
B6_19090688	-/+	6	19090688	--	--	++	++
B6_19107834	A/G	6	19107834	AA	AA	GG	GG
B6_19107886	G/C	6	19107886	GG	GG	CC	CC
B6_19107923	A/G	6	19107923	AA	AA	GG	GG
B6_19143187	A/C	6	19143187	AA	AA	CC	CC
B6_19387905	G/T	6	19387905	GG	GG	TT	TT
B6_19689358	A/G	6	19689358	AA	AA	GG	GG
B6_19933516	T/C	6	19933516	TT	TT	CC	CC
B6_19933631	G/A	6	19933631	GG	AG	AA	AA
B6_20015515	A/G	6	20015515	AA	AA	GG	GG
B6_20015538	G/A	6	20015538	GG	GG	AA	AA
B6_20015615	A/C	6	20015615	AA	AA	CC	CC
B6_20015622	C/T	6	20015622	CC	CC	TT	TT
B6_20015695	+/-	6	20015695	++	++	--	--
B6_20015752	C/T	6	20015752	CC	CC	TT	TT

SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
C3_25957548	G/A	11	25957548	GG	GG	AA	AA
C3_25957577	C/G	11	25957577	CC	CC	GG	GG
C3_25957598	A/G	11	25957598	AA	AA	GG	GG
C3_27064045	C/T	11	27064045	CC	TT	CC	CC
C3_29046232	T/G	11	29046232	TT	TT	GG	GG
C3_29046278	G/A	11	29046278	GG	GG	AA	AA
C3_29046307	G/T	11	29046307	GG	GG	TT	TT
C3_29046388	C/T	11	29046388	CC	CC	TT	TT
C3_29046395	A/C	11	29046395	AA	AA	CC	CC
C3_29754400	A/C	11	29754400	AA	AA	CC	CC

Table 16: Examples of regions on *Brassica carinata* chromosome 1, 3, 6 and 11 with markers unique for AGR044-312D

SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
B1_4594828	G/C	1	4594828	CC	CC	GG	CC
B1_4594851	G/T	1	4594851	TT	TT	GG	TT
B1_4594858	G/A	1	4594858	AA	AA	GG	AA
B1_4594968	C/T	1	4594968	TT	TT	CC	TT
B1_4594984	G/A	1	4594984	AA	AA	GG	AA
B1_4649762	T/G	1	4649762	TT	TT	GG	TT
B1_4649824	-/+	1	4649824	--	--	++	--
B1_4649855	A/G	1	4649855	GG	GG	AA	GG
B1_4649900	C/T	1	4649900	CC	CC	TT	CC
B1_4912639	G/T	1	4912639	GG	GG	TT	GG
B1_4912708	G/C	1	4912708	GG	GG	CC	GG
B1_4912822	A/C	1	4912822	AA	AA	CC	AA
B1_4913370	C/G	1	4913370	CC	CC	GG	CC
B1_4913468	G/A	1	4913468	GG	GG	AA	GG
B1_5079804	C/T	1	5079804	CC	CC	TT	CC
B1_5079805	T/G	1	5079805	TT	TT	GG	TT
SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
B3_28641082	A/G	3	28641082	AA	AA	GG	AA
B3_28641288	A/G	3	28641288	AA	AA	GG	AA
B3_28641315	A/G	3	28641315	AA	AA	GG	AA
B3_29578734	T/G	3	29578734	GG	TT	TT	GG
B3_30636951	A/G	3	30636951	AA	AA	GG	AA
B3_30636977	C/T	3	30636977	CC	CC	TT	CC
B3_30636986	A/G	3	30636986	AA	AA	GG	AA
B3_30637010	T/G	3	30637010	TT	TT	GG	TT
B3_30873236	T/C	3	30873236	TT	TT	CC	TT
B3_30903011	G/A	3	30903011	GG	GG	AA	GG
B3_30903084	G/C	3	30903084	GG	GG	CC	GG
SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
B6_4063534	G/A	6	4063534	GG	GG	AA	GG
B6_4063555	A/G	6	4063555	AA	AA	GG	AA
B6_4063597	G/A	6	4063597	GG	GG	AA	GG
B6_4063598	C/T	6	4063598	CC	CC	TT	CC
B6_4063624	A/G	6	4063624	GG	GG	AA	GG
B6_4067659	T/G	6	4067659	GG	GG	TT	GG
B6_4067682	A/G	6	4067682	GG	GG	AA	GG
B6_4067692	C/T	6	4067692	TT	TT	CC	TT
B6_4067710	G/A	6	4067710	AA	AA	GG	AA
B6_4067734	G/A	6	4067734	AA	AA	GG	AA
B6_4067755	T/C	6	4067755	CC	CC	TT	CC
B6_4067767	C/T	6	4067767	TT	TT	CC	TT
B6_4067773	C/T	6	4067773	TT	TT	CC	TT
B6_4067788	G/A	6	4067788	AA	AA	GG	AA
B6_4097407	G/A	6	4097407	AA	AA	GG	AA
B6_4097455	T/C	6	4097455	CC	CC	TT	CC
B6_4751128	G/A	6	4751128	AA	AA	GG	AA
B6_4751324	G/A	6	4751324	AA	AA	GG	AA
B6_4792541	A/G	6	4792541	AA	AA	GG	AA
SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
C3_6598198	A/G	11	6598198	AA	AA	GG	AA
C3_6598262	G/A	11	6598262	GG	GG	AA	GG
C3_6598266	-/+	11	6598266	--	--	++	--
C3_6598271	+/-	11	6598271	++	++	--	++
C3_6598277	A/C	11	6598277	AA	AA	CC	AA
C3_6598278	C/T	11	6598278	CC	CC	TT	CC
C3_6598287	T/A	11	6598287	TT	TT	AA	TT
C3_6598295	G/A	11	6598295	GG	GG	AA	GG
C3_6598309	A/C	11	6598309	AA	AA	CC	AA
C3_6604144	T/C	11	6604144	TT	TT	CC	TT
C3_6604205	C/T	11	6604205	CC	CC	TT	CC
C3_6604298	-/+	11	6604298	--	--	++	--

Table 17: Examples of regions on *Brassica carinata* chromosome 1, 2, 5, 8, 9 and 12 with markers unique for AGR044-3A22

SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
B1_37913522	A/G	1	37913522	AA	AA	AA	GG
B1_37916594	+/-	1	37916594	++	++	++	-
B1_37916596	A/G	1	37916596	AA	AA	AA	GG
B1_37916597	A/C	1	37916597	AA	AA	AA	CC
B1_37916614	G/T	1	37916614	GG	GG	GG	TT
B1_37916616	C/T	1	37916616	CC	CC	CC	TT
B1_37916631	A/C	1	37916631	AA	AA	AA	CC
B1_37916634	C/T	1	37916634	CC	CC	CC	TT
B1_37916653	G/A	1	37916653	GG	GG	GG	AA
B1_37916656	A/C	1	37916656	AA	AA	AA	CC
B1_37916659	G/A	1	37916659	GG	GG	GG	AA
SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
B2_32183433	G/T	2	32183433	GG	TT	GG	TT
B2_33093633	T/C	2	33093633	TT	TT	TT	CC
B2_33093639	C/T	2	33093639	CC	CC	CC	TT
B2_33093717	C/T	2	33093717	CC	CC	CC	TT
B2_33093724	C/T	2	33093724	CC	CC	CC	TT
B2_33093732	A/G	2	33093732	AA	AA	AA	GG
B2_33093758	G/A	2	33093758	GG	GG	GG	AA
B2_33093782	A/G	2	33093782	AA	AA	AA	GG
SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
B5_1985401	C/T	5	1985401	CC	CC	CC	TT
B5_2048942	G/C	5	2048942	GG	GG	GG	CC
B5_2143463	C/A	5	2143463	CC	CC	CC	AA
B5_2484395	G/T	5	2484395	GG	GG	GG	TT
B5_2484401	A/T	5	2484401	AA	AA	AA	TT
B5_2484428	T/C	5	2484428	TT	TT	TT	CC
B5_2484431	C/T	5	2484431	CC	CC	CC	TT
B5_2484560	C/G	5	2484560	CC	CC	CC	GG
B5_2484562	G/A	5	2484562	GG	GG	GG	AA
B5_2484563	-/+	5	2484563	--	--	--	++
B5_2484571	A/G	5	2484571	AA	AA	AA	GG
B5_2484602	C/T	5	2484602	CC	CC	CC	TT
SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
B8_49616122	T/C	8	49616122	TT	TT	TT	CC
B8_49616208	C/T	8	49616208	CC	CC	CC	TT
B8_49831698	G/A	8	49831698	GG	GG	GG	AA
B8_49831746	-/+	8	49831746	--	--	--	++
B8_49831749	T/G	8	49831749	TT	TT	TT	GG
B8_49831895	C/T	8	49831895	CC	CC	CC	TT
B8_49900066	G/A	8	49900066	GG	GG	GG	AA
B8_49900202	+/-	8	49900202	++	++	++	-
B8_49900244	A/C	8	49900244	AA	AA	AA	CC
B8_49900247	A/G	8	49900247	AA	AA	AA	GG
SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
C1_33744223	A/G	9	33744223	AA	AA	AA	GG
C1_33744234	C/T	9	33744234	CC	CC	CC	TT
C1_33744240	C/A	9	33744240	CC	CC	CC	AA
C1_33744303	G/A	9	33744303	GG	GG	GG	AA
C1_33795936	A/C	9	33795936	AA	AA	AA	CC
C1_33796068	C/T	9	33796068	CC	CC	CC	TT
C1_35710691	G/T	9	35710691	GG	GG	GG	TT
C1_35835246	G/A	9	35835246	GG	GG	GG	AA
SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
C4_37868619	C/A	12	37868619	CC	CC	CC	AA
C4_37868763	G/A	12	37868763	GG	GG	GG	AA
C4_37868766	G/T	12	37868766	GG	GG	GG	TT
C4_37985818	C/T	12	37985818	CC	CC	CC	TT
C4_38052425	T/C	12	38052425	TT	TT	TT	CC
C4_38052612	G/C	12	38052612	GG	GG	GG	CC
C4_38114258	G/A	12	38114258	GG	GG	GG	AA
C4_38135264	G/A	12	38135264	GG	GG	GG	AA
C4_38135266	C/A	12	38135266	CC	CC	CC	AA
C4_38135330	A/G	12	38135330	AA	AA	AA	GG
C4_38135333	T/C	12	38135333	TT	TT	TT	CC
C4_38149116	C/T	12	38149116	CC	CC	CC	TT
C4_38149201	T/C	12	38149201	TT	TT	TT	CC
C4_38748104	C/T	12	38748104	TT	TT	TT	CC

Table 18: SNP and indel markers on carinata chromosome B1.

SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
B1_424519	C/T	1	424519	TT	CC	CC	CC
B1_436508	G/A	1	436508	AA	GG	GG	GG
B1_436529	G/A	1	436529	AA	GG	GG	GG
B1_436575	A/C	1	436575	CC	AA	AA	AA
B1_436613	C/T	1	436613	TT	CC	CC	CC
B1_448688	T/A	1	448688	TT	TT	TT	AA
B1_785446	G/C	1	785446	CC	CC	GG	GG
B1_1900515	-/+	1	1900515	--	++	--	--
B1_1900565	-/+	1	1900565	--	++	--	--
B1_2517033	G/A	1	2517033	GG	GG	AA	GG
B1_2517034	T/C	1	2517034	TT	TT	CC	TT
B1_2517052	T/C	1	2517052	TT	TT	CC	TT
B1_2517075	T/A	1	2517075	TT	TT	AA	TT
B1_2517079	A/G	1	2517079	AA	AA	GG	AA
B1_2517153	C/T	1	2517153	CC	CC	TT	CC
B1_2517168	A/G	1	2517168	AA	AA	GG	AA
B1_3935356	A/G	1	3935356	GG	GG	AA	GG
B1_3935384	A/G	1	3935384	GG	GG	AA	GG
B1_3935514	C/G	1	3935514	GG	GG	CC	GG
B1_4345933	A/C	1	4345933	AA	CC	AA	CC
B1_4345950	C/G	1	4345950	CC	GG	CC	GG
B1_4345955	G/A	1	4345955	AA	AA	GG	AA
B1_4346000	C/T	1	4346000	CC	TT	CC	TT
B1_4346010	C/G	1	4346010	CC	GG	CC	GG
B1_4594828	G/C	1	4594828	CC	CC	GG	CC
B1_4594851	G/T	1	4594851	TT	TT	GG	TT
B1_4594858	G/A	1	4594858	AA	AA	GG	AA
B1_4594968	C/T	1	4594968	TT	TT	CC	TT
B1_4594984	G/A	1	4594984	AA	AA	GG	AA
B1_4649762	T/G	1	4649762	TT	TT	GG	TT
B1_4649824	-/+	1	4649824	--	--	++	--
B1_4649855	A/G	1	4649855	GG	GG	AA	GG
B1_4649900	C/T	1	4649900	CC	CC	TT	CC
B1_4912639	G/T	1	4912639	GG	GG	TT	GG
B1_4912708	G/C	1	4912708	GG	GG	CC	GG
B1_4912822	A/C	1	4912822	AA	AA	CC	AA

B1_4913370	C/G	1	4913370	CC	CC	GG	CC
B1_4913468	G/A	1	4913468	GG	GG	AA	GG
B1_5079804	C/T	1	5079804	CC	CC	TT	CC
B1_5079805	T/G	1	5079805	TT	TT	GG	TT
B1_5205202	+/-	1	5205202	--	++	++	++
B1_5263885	A/G	1	5263885	AA	GG	GG	GG
B1_5433567	A/T	1	5433567	TT	TT	AA	TT
B1_5433574	A/T	1	5433574	AA	AA	TT	AA
B1_5433575	C/G/T	1	5433575	GG	GG	TT	GG
B1_5433576	A/T	1	5433576	TT	TT	AA	TT
B1_5433601	C/T	1	5433601	TT	TT	CC	TT
B1_5433606	G/A	1	5433606	AA	AA	GG	AA
B1_6091439	T/C	1	6091439	TT	TT	CC	CC
B1_6113949	C/T	1	6113949	TT	TT	CC	TT
B1_6113967	A/T	1	6113967	AA	AA	TT	AA
B1_6113973	C/T	1	6113973	CC	CC	TT	CC
B1_6113982	T/C	1	6113982	CC	CC	TT	CC
B1_6113994	G/C	1	6113994	CC	CC	GG	CC
B1_6219642	G/C	1	6219642	GG	CC	CC	CC
B1_6226291	T/C	1	6226291	CT	CC	CC	CC
B1_6226329	A/C	1	6226329	AC	CC	CC	CC
B1_6266950	T/C	1	6266950	TT	CC	CC	CC
B1_7196923	A/T	1	7196923	AA	AA	TT	AA
B1_7375544	G/A	1	7375544	GG	GG	AA	GG
B1_7375562	G/A	1	7375562	GG	GG	AA	GG
B1_7375570	T/G	1	7375570	TT	TT	GG	TT
B1_7375574	T/C	1	7375574	TT	TT	CC	TT
B1_7375619	C/T	1	7375619	CC	CC	TT	CC
B1_7375694	T/C	1	7375694	TT	TT	CC	TT
B1_7385056	A/G	1	7385056	AG	AA	AA	AA
B1_7385080	G/T	1	7385080	GT	GG	GG	GG
B1_7385107	G/T	1	7385107	GG	GG	TT	GG
B1_8098708	T/C	1	8098708	TT	CC	CC	CC
B1_8098839	G/A	1	8098839	GG	AA	AA	AA
B1_8099096	T/C	1	8099096	TT	CC	CC	CC
B1_8497566	A/C	1	8497566	AC	AA	CC	AA
B1_8497593	C/T	1	8497593	CT	CC	TT	CC
B1_8617833	C/T	1	8617833	TT	CC	CC	CC
B1_8657230	C/T	1	8657230	CT	CC	CC	CC

B1_8657231	C/A	1	8657231	AC	CC	CC	CC
B1_8657252	A/T	1	8657252	AT	AA	AA	AA
B1_8657264	+/-	1	8657264	-+	++	++	++
B1_8657287	T/A	1	8657287	AT	TT	TT	TT
B1_8796643	T/C	1	8796643	CC	TT	TT	TT
B1_8938410	A/G	1	8938410	GG	AA	GG	GG
B1_9040408	T/A	1	9040408	TT	TT	AA	TT
B1_9076501	T/G	1	9076501	TT	TT	GG	TT
B1_9903740	G/C	1	9903740	CC	CC	GG	GG
B1_9903773	C/T	1	9903773	TT	TT	CC	CC
B1_11358777	A/G	1	11358777	AA	AA	GG	AA
B1_11358794	T/G	1	11358794	TT	TT	GG	TT
B1_11358803	T/C	1	11358803	TT	TT	CC	TT
B1_11358810	C/T	1	11358810	CC	CC	TT	CC
B1_11358815	G/A	1	11358815	GG	GG	AA	GG
B1_11358848	G/A	1	11358848	GG	GG	AA	GG
B1_11358852	A/G	1	11358852	AA	AA	GG	AA
B1_11358853	C/T	1	11358853	CC	CC	TT	CC
B1_11358895	A/T	1	11358895	AA	AA	TT	AA
B1_11451599	G/C	1	11451599	GG	GG	CC	GG
B1_11451607	G/A	1	11451607	GG	GG	AA	GG
B1_12593164	C/T	1	12593164	CC	TT	TT	TT
B1_12689423	A/T	1	12689423	TT	AA	AA	AA
B1_13625960	A/G	1	13625960	AA	GG	GG	GG
B1_13633115	A/T	1	13633115	AA	TT	TT	TT
B1_13633146	A/G	1	13633146	AA	GG	GG	GG
B1_13633153	C/T	1	13633153	CC	TT	TT	TT
B1_13633167	G/T	1	13633167	GG	TT	TT	TT
B1_13633169	A/G	1	13633169	AA	GG	GG	GG
B1_13867050	A/G	1	13867050	AA	AA	GG	AA
B1_13867158	C/T	1	13867158	CC	CC	TT	CC
B1_13934008	T/A	1	13934008	TT	TT	AA	TT
B1_13934047	T/A	1	13934047	TT	TT	AA	TT
B1_13941235	G/T	1	13941235	GG	GG	TT	GG
B1_14344065	+/-	1	14344065	--	--	++	++
B1_14621432	A/T	1	14621432	AA	AA	TT	AA
B1_15171944	T/C	1	15171944	TT	CC	TT	CC
B1_15171975	+/-	1	15171975	++	--	++	--
B1_15171977	+/-	1	15171977	++	--	++	--

B1_15171978	+/-	1	15171978	++	--	++	--
B1_15519937	A/G	1	15519937	AA	AA	GG	AA
B1_15684572	C/T	1	15684572	CC	CC	TT	CC
B1_15684590	+/-	1	15684590	++	++	--	++
B1_15684592	+/-	1	15684592	++	++	--	++
B1_15684600	+/-	1	15684600	++	++	--	++
B1_15684746	C/G	1	15684746	CC	CC	GG	CC
B1_15697210	C/T	1	15697210	CC	CC	TT	CC
B1_15718053	A/T	1	15718053	AA	AA	TT	AA
B1_15827845	A/T	1	15827845	AA	AA	TT	AA
B1_15828085	-/+	1	15828085	--	--	++	--
B1_16017282	T/C	1	16017282	TT	CC	TT	CC
B1_16152353	C/T	1	16152353	CC	TT	CC	TT
B1_16152360	G/A	1	16152360	GG	AA	GG	AA
B1_16152370	A/G	1	16152370	AA	GG	AA	GG
B1_16152374	C/A	1	16152374	CC	AA	CC	AA
B1_16152375	G/A	1	16152375	GG	AA	GG	AA
B1_16152413	G/C	1	16152413	GG	CC	GG	CC
B1_16152447	T/A	1	16152447	TT	AA	TT	AA
B1_16152448	T/G	1	16152448	TT	GG	TT	GG
B1_16285720	G/T	1	16285720	GG	GG	GG	TT
B1_16285732	T/G	1	16285732	TT	TT	TT	GG
B1_16285738	G/A	1	16285738	GG	GG	GG	AA
B1_18583848	G/T	1	18583848	GT	GG	GG	GG
B1_18583885	A/C	1	18583885	AC	AA	AA	AA
B1_22802512	C/T	1	22802512	CC	CC	TT	TT
B1_23003189	C/A	1	23003189	CC	CC	AA	CC
B1_33983139	+/-	1	33983139	--	++	++	--
B1_34061998	A/C	1	34061998	CC	CC	AA	AA
B1_34062026	A/T	1	34062026	TT	TT	AA	AA
B1_34062030	A/T	1	34062030	TT	TT	AA	AA
B1_34062032	T/A	1	34062032	AA	AA	TT	TT
B1_34316809	G/C	1	34316809	CC	CC	GG	GG
B1_34465544	T/G	1	34465544	GG	TT	TT	TT
B1_34465574	T/C	1	34465574	CC	CC	TT	TT
B1_36734256	G/C	1	36734256	CC	CC	GG	GG
B1_36734421	T/C	1	36734421	CC	CC	TT	TT
B1_36734436	C/T	1	36734436	TT	TT	CC	CC
B1_36734454	A/G	1	36734454	GG	GG	AA	AA

B1_36734457	G/T	1	36734457	TT	TT	GG	GG
B1_36989449	A/G	1	36989449	AA	AA	AA	GG
B1_36989614	C/T	1	36989614	CC	CC	CC	TT
B1_37008771	C/T	1	37008771	CC	TT	CC	CC
B1_37235018	G/T	1	37235018	GG	GG	TT	GG
B1_37235020	G/T	1	37235020	GG	GG	TT	GG
B1_37235037	C/T	1	37235037	CC	CC	TT	CC
B1_37235248	T/G	1	37235248	TT	TT	GG	TT
B1_37235251	C/T	1	37235251	CC	CC	TT	CC
B1_37235289	A/T	1	37235289	AA	AA	TT	AA
B1_37235761	C/G	1	37235761	GG	GG	CC	GG
B1_37388943	A/G	1	37388943	GG	GG	AA	AA
B1_37388973	T/A	1	37388973	AA	AA	TT	TT
B1_37877639	T/C	1	37877639	TT	TT	CC	TT
B1_37913522	A/G	1	37913522	AA	AA	AA	GG
B1_37916594	+/-	1	37916594	++	++	++	--
B1_37916596	A/G	1	37916596	AA	AA	AA	GG
B1_37916597	A/C	1	37916597	AA	AA	AA	CC
B1_37916614	G/T	1	37916614	GG	GG	GG	TT
B1_37916616	C/T	1	37916616	CC	CC	CC	TT
B1_37916631	A/C	1	37916631	AA	AA	AA	CC
B1_37916634	C/T	1	37916634	CC	CC	CC	TT
B1_37916653	G/A	1	37916653	GG	GG	GG	AA
B1_37916656	A/C	1	37916656	AA	AA	AA	CC
B1_37916659	G/A	1	37916659	GG	GG	GG	AA
B1_37922785	+/-	1	37922785	--	++	--	++
B1_38841681	T/G	1	38841681	TT	GG	TT	TT
B1_38968377	A/T	1	38968377	AA	AA	AA	TT
B1_38968533	A/C	1	38968533	CC	AA	AA	CC
B1_38968534	T/A	1	38968534	AA	AA	TT	AA
B1_39055759	G/A	1	39055759	GG	GG	AA	GG
B1_39178523	C/G	1	39178523	GG	GG	CC	GG
B1_39178745	C/T	1	39178745	TT	TT	CC	TT
B1_39179533	T/A	1	39179533	AA	AA	TT	AA
B1_39179568	C/T	1	39179568	TT	TT	CC	TT
B1_39179623	T/A	1	39179623	AA	AA	TT	AA
B1_39179626	T/C	1	39179626	CC	CC	TT	CC
B1_39184869	A/T	1	39184869	TT	TT	AA	TT
B1_39184879	T/G	1	39184879	GG	GG	TT	GG

B1_39184901	T/C	1	39184901	CC	CC	TT	CC
B1_39184910	T/C	1	39184910	CC	CC	TT	CC
B1_39184921	C/T	1	39184921	TT	TT	CC	TT
B1_39415871	+/-	1	39415871	++	++	--	++
B1_39415872	+/-	1	39415872	++	++	--	++
B1_39415876	-/+	1	39415876	--	--	++	--
B1_39415930	G/C	1	39415930	GG	GG	CC	GG
B1_39574365	C/T	1	39574365	CC	CC	CC	TT
B1_39574372	A/G	1	39574372	AA	AA	AA	GG
B1_39574582	C/G	1	39574582	CC	CC	CC	GG
B1_39574602	T/C	1	39574602	TT	TT	TT	CC
B1_39682794	T/C	1	39682794	TT	TT	CC	TT
B1_39683005	C/G	1	39683005	CC	CC	GG	CC
B1_39704139	A/T	1	39704139	TT	TT	TT	AA
B1_39704142	A/G	1	39704142	GG	GG	GG	AA
B1_39704156	A/G	1	39704156	GG	GG	GG	AA
B1_40778920	+/-	1	40778920	++	++	++	++
B1_41330761	T/C	1	41330761	CC	CC	CC	TT
B1_41330901	A/G	1	41330901	GG	AA	GG	GG
B1_41330908	T/A	1	41330908	AA	AA	AA	TT
B1_41989952	A/G	1	41989952	AA	AA	GG	AA

Table 19: SNP and indel markers on carinata chromosome B2.

SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
B2_744598	T/C	2	744598	CC	CC	TT	TT
B2_744610	A/G	2	744610	GG	GG	AA	AA
B2_809186	C/T	2	809186	TT	TT	CC	CC
B2_809192	C/A	2	809192	AA	AA	CC	CC
B2_809209	-/+	2	809209	++	++	--	--
B2_1543020	A/C	2	1543020	CC	AA	AA	AA
B2_1543035	T/C	2	1543035	CC	TT	TT	TT
B2_1543041	C/T	2	1543041	TT	CC	CC	CC
B2_1543134	G/A	2	1543134	AA	GG	GG	GG
B2_1543142	C/A	2	1543142	AA	CC	CC	CC
B2_1614473	-/A+/T	2	1614473	AA	AA	--	--
B2_1614476	T/-/G/+	2	1614476	--	--	TT	TT
B2_2046346	A/G	2	2046346	GG	GG	AA	AA

B2_2046354	A/G	2	2046354	GG	GG	AA	AA
B2_2046467	T/C	2	2046467	CC	CC	TT	TT
B2_2095931	A/G	2	2095931	GG	GG	AA	AA
B2_2490513	A/G	2	2490513	GG	AA	AA	AA
B2_2685089	A/G	2	2685089	GG	GG	AA	AA
B2_2685159	A/G	2	2685159	GG	GG	AA	AA
B2_2685171	-/+A	2	2685171	++	++	--	--
B2_2685171	A/G	2	2685171	GG	GG	AA	AA
B2_2685177	+/-	2	2685177	--	--	++	++
B2_2817238	C/T	2	2817238	CC	TT	TT	TT
B2_2817245	C/G	2	2817245	GG	CC	CC	CC
B2_2817306	A/T	2	2817306	AA	TT	TT	TT
B2_2817345	+/-	2	2817345	++	--	--	--
B2_2817349	+/-	2	2817349	--	++	++	++
B2_2869441	C/G	2	2869441	GG	CC	GG	GG
B2_5613898	T/C	2	5613898	TT	TT	CC	TT
B2_5705108	C/T	2	5705108	CC	CC	TT	TT
B2_5705132	C/T	2	5705132	CC	CC	TT	TT
B2_5705250	G/A	2	5705250	GG	GG	AA	AA
B2_5705300	G/C	2	5705300	GG	GG	CC	CC
B2_5705318	A/G	2	5705318	AA	AA	GG	AA
B2_8647348	A/G	2	8647348	GG	GG	AA	AA
B2_17033118	A/G	2	17033118	AA	AA	GG	GG
B2_17253174	A/G	2	17253174	GG	AA	GG	AA
B2_21926129	C/T	2	21926129	CC	CC	TT	CC
B2_21926133	A/G	2	21926133	GG	AA	GG	AA
B2_25376864	A/G	2	25376864	GG	GG	AA	AA
B2_25376941	A/T	2	25376941	TT	TT	AA	AA
B2_25376948	T/A	2	25376948	AA	AA	TT	TT
B2_25376953	-/+	2	25376953	++	++	--	--
B2_25433916	T/C	2	25433916	TT	TT	CC	CC
B2_25607162	T/C	2	25607162	CC	CC	TT	TT
B2_25607173	T/G	2	25607173	GG	GG	TT	TT
B2_25607176	T/A	2	25607176	AA	AA	TT	TT
B2_25607251	T/A	2	25607251	AA	AA	TT	TT
B2_25614867	A/C	2	25614867	AA	AA	CC	CC
B2_25614886	C/T	2	25614886	CC	CC	TT	TT
B2_25844297	+/-	2	25844297	--	++	++	++
B2_26402164	A/T	2	26402164	TT	AA	AA	AA
B2_26402171	C/A	2	26402171	CC	CC	AA	CC
B2_27092960	+/-	2	27092960	--	++	++	++

B2_27718601	C/T	2	27718601	TT	CC	CC	CC
B2_27718638	C/T	2	27718638	TT	CC	CC	CC
B2_28002506	G/T	2	28002506	TT	GG	GG	GG
B2_30578322	A/G	2	30578322	GG	AA	GG	AA
B2_30578333	A/T	2	30578333	TT	AA	TT	AA
B2_30578361	+/-	2	30578361	--	++	++	--
B2_30589836	A/G	2	30589836	AA	GG	AA	AA
B2_30589837	T/A	2	30589837	TT	AA	TT	TT
B2_30589907	A/T	2	30589907	AA	TT	AA	AA
B2_30716778	+/-	2	30716778	--	++	--	--
B2_30894547	C/T	2	30894547	CC	CC	TT	TT
B2_31283579	C/G	2	31283579	GG	CC	CC	CC
B2_31788221	C/T	2	31788221	CC	CC	TT	CC
B2_31926404	A/C	2	31926404	CC	CC	AA	AA
B2_31926458	T/C	2	31926458	CC	CC	TT	TT
B2_31989632	C/T	2	31989632	TT	TT	CC	CC
B2_32076325	G/A	2	32076325	GG	GG	AA	GG
B2_32076356	A/G	2	32076356	AA	AA	GG	AA
B2_32076508	G/C	2	32076508	GG	GG	CC	GG
B2_32076509	A/T	2	32076509	AA	AA	TT	AA
B2_32076561	A/G	2	32076561	AA	AA	GG	AA
B2_32076577	T/C	2	32076577	TT	TT	CC	TT
B2_32183288	G/A	2	32183288	GG	AA	GG	AA
B2_32183294	A/G	2	32183294	AA	GG	AA	GG
B2_32183433	G/T	2	32183433	GG	TT	GG	TT
B2_33093633	T/C	2	33093633	TT	TT	TT	CC
B2_33093639	C/T	2	33093639	CC	CC	CC	TT
B2_33093717	C/T	2	33093717	CC	CC	CC	TT
B2_33093724	C/T	2	33093724	CC	CC	CC	TT
B2_33093732	A/G	2	33093732	AA	AA	AA	GG
B2_33093768	G/A	2	33093768	GG	GG	GG	AA
B2_33093782	A/G	2	33093782	AA	AA	AA	GG
B2_33889056	C/T	2	33889056	CC	TT	CC	CC
B2_33889059	G/A	2	33889059	GG	AA	GG	GG
B2_35073237	+/-	2	35073237	--	++	++	--
B2_35134541	G/A	2	35134541	GG	AA	AA	AA
B2_35146912	G/A	2	35146912	GG	AA	AA	AA
B2_35146915	G/T	2	35146915	GG	TT	TT	TT
B2_35147035	G/C	2	35147035	GG	GG	CC	GG
B2_35147036	T/C	2	35147036	TT	TT	CC	TT
B2_35147037	G/T	2	35147037	GG	GG	TT	GG

B2_35147038	G/A	2	35147038	GG	GG	AA	GG
B2_35147040	G/C	2	35147040	GG	GG	CC	GG
B2_35147075	T/A	2	35147075	TT	TT	AA	TT
B2_35147077	C/A	2	35147077	CC	CC	AA	CC
B2_35314554	A/T	2	35314554	TT	AA	TT	TT
B2_35314563	T/G	2	35314563	GG	TT	GG	GG
B2_35314717	C/T	2	35314717	CC	CC	TT	TT
B2_35314729	A/G	2	35314729	AA	AA	GG	GG
B2_35906658	A/C	2	35906658	AA	AA	CC	AA
B2_35906661	A/G	2	35906661	AA	AA	GG	AA
B2_35906832	G/C	2	35906832	GG	GG	CC	GG
B2_36131519	T/C	2	36131519	TT	TT	CC	CC
B2_36297563	C/T	2	36297563	CC	TT	TT	CC
B2_36341182	A/G	2	36341182	GG	GG	AA	GG
B2_36845065	T/C	2	36845065	CC	TT	TT	TT
B2_36845091	G/A	2	36845091	GG	AA	GG	GG
B2_36845212	C/G	2	36845212	CC	CC	GG	CC
B2_36845223	A/T	2	36845223	AA	TT	AA	AA
B2_36845252	T/G	2	36845252	GG	TT	TT	TT
B2_36848565	A/C	2	36848565	AA	CC	AA	AA
B2_36849003	C/A	2	36849003	CC	CC	AA	CC
B2_36849004	A/G	2	36849004	AA	AA	GG	AA
B2_36849006	T/C	2	36849006	TT	TT	CC	TT
B2_36849009	A/G	2	36849009	AA	AA	GG	AA
B2_37088988	G/A	2	37088988	GG	AA	GG	AA
B2_37089079	C/A	2	37089079	CC	AA	CC	CC
B2_37089144	C/A	2	37089144	CC	AA	CC	CC
B2_37089168	C/A	2	37089168	CC	AA	CC	CC
B2_37089203	T/A	2	37089203	TT	AA	TT	TT
B2_37196101	+/-	2	37196101	++	--	--	--
B2_37196102	C/T	2	37196102	CC	TT	TT	TT
B2_37196129	C/T	2	37196129	CC	TT	TT	TT
B2_37596308	T/C	2	37596308	CC	TT	TT	TT
B2_37596432	G/C	2	37596432	CC	GG	GG	GG
B2_37605168	T/G	2	37605168	GG	TT	TT	TT
B2_37605365	T/G	2	37605365	TT	TT	GG	GG
B2_38148274	C/T	2	38148274	CC	TT	CC	CC
B2_38148299	T/C	2	38148299	TT	CC	TT	TT
B2_38195542	T/G	2	38195542	GG	TT	TT	TT
B2_38195545	C/A	2	38195545	AA	CC	CC	CC
B2_38195584	G/C	2	38195584	CC	GG	GG	GG

B2_38195588	T/C	2	38195588	CC	TT	TT	TT
B2_38994537	T/A	2	38994537	AA	TT	TT	TT
B2_38994583	T/G	2	38994583	GG	TT	TT	TT
B2_39085736	C/T	2	39085736	CC	TT	CC	CC
B2_39182584	A/C	2	39182584	CC	AA	AA	AA
B2_39182692	C/G	2	39182692	GG	CC	CC	CC
B2_39182694	G/T	2	39182694	TT	GG	GG	GG
B2_39182696	G/T	2	39182696	TT	GG	GG	GG
B2_39182697	G/A	2	39182697	AA	GG	GG	GG
B2_39182700	T/C	2	39182700	CC	TT	TT	TT
B2_39182701	C/A	2	39182701	AA	CC	CC	CC
B2_39182721	C/T	2	39182721	TT	CC	CC	CC
B2_39182729	T/C	2	39182729	CC	TT	TT	TT
B2_39186529	A/C	2	39186529	CC	AA	AA	AA
B2_39186576	T/C	2	39186576	CC	TT	TT	TT
B2_39186628	G/A	2	39186628	AA	GG	GG	GG
B2_39832793	A/G	2	39832793	GG	GG	GG	AA
B2_39832817	G/A	2	39832817	AA	AA	GG	GG
B2_39838840	G/C	2	39838840	CC	CC	GG	GG
B2_39838847	+/-	2	39838847	--	--	++	++
B2_39843974	G/A	2	39843974	AA	AA	GG	GG
B2_39843986	C/T	2	39843986	CC	CC	TT	TT
B2_39924831	C/T	2	39924831	CC	CC	TT	TT
B2_39924852	G/A	2	39924852	GG	GG	AA	AA
B2_39934892	T/C	2	39934892	TT	TT	CC	CC
B2_40636742	+/-	2	40636742	--	++	++	--
B2_41185174	+/-	2	41185174	++	++	--	++
B2_41185187	T/C	2	41185187	TT	TT	CC	TT
B2_41185350	G/A	2	41185350	GG	GG	AA	GG
B2_41435165	T/A	2	41435165	TT	TT	AA	AA
B2_41435202	A/C	2	41435202	AA	AA	CC	CC
B2_41435204	G/C	2	41435204	GG	GG	CC	CC
B2_41435206	T/A	2	41435206	TT	TT	AA	AA
B2_41438344	C/T	2	41438344	CC	CC	TT	TT
B2_41438375	C/T	2	41438375	CC	CC	TT	TT
B2_41438383	G/A	2	41438383	GG	GG	AA	AA
B2_41438420	C/T	2	41438420	CC	CC	TT	TT
B2_41438443	G/C	2	41438443	GG	GG	CC	CC
B2_41438444	G/C	2	41438444	GG	GG	CC	CC
B2_41438445	A/T	2	41438445	AA	AA	TT	TT
B2_41438507	A/T	2	41438507	AA	AA	TT	TT

B2_41704942	T/C	2	41704942	TT	TT	CC	CC
B2_41704954	C/T	2	41704954	CC	CC	TT	TT
B2_41704957	C/G	2	41704957	CC	CC	GG	GG
B2_41704981	T/G	2	41704981	TT	TT	GG	GG
B2_41704996	A/C	2	41704996	AA	AA	CC	CC
B2_41704999	A/C	2	41704999	AA	AA	CC	CC
B2_41705005	G/C	2	41705005	GG	GG	CC	CC
B2_41900188	A/G	2	41900188	AA	AA	GG	AA
B2_41900299	C/T	2	41900299	TT	TT	CC	CC
B2_41900304	C/T	2	41900304	TT	TT	CC	CC
B2_41900305	A/G	2	41900305	GG	GG	AA	AA
B2_41900319	A/G	2	41900319	GG	GG	AA	AA
B2_41900327	-/+	2	41900327	++	++	--	--
B2_41900330	-/+	2	41900330	++	++	--	--
B2_41900338	A/G	2	41900338	GG	GG	AA	AA
B2_41900439	A/G	2	41900439	GG	GG	AA	AA
B2_41900441	T/C	2	41900441	CC	CC	TT	TT
B2_41900480	C/T	2	41900480	TT	TT	CC	CC
B2_41900496	G/A	2	41900496	AA	AA	GG	GG
B2_41930864	-/+	2	41930864	++	++	--	--
B2_42627565	T/C	2	42627565	TT	TT	CC	TT
B2_42897201	C/T	2	42897201	TT	CC	CC	CC
B2_42897211	+/-	2	42897211	--	++	++	++
B2_42897214	A/C	2	42897214	CC	AA	AA	AA
B2_42897226	G/A	2	42897226	AA	GG	GG	GG
B2_42897273	C/T	2	42897273	TT	CC	CC	CC
B2_42897274	A/C	2	42897274	CC	AA	AA	AA
B2_42897275	T/C	2	42897275	CC	TT	TT	TT
B2_42897281	T/C	2	42897281	CC	TT	TT	TT
B2_42897282	G/A	2	42897282	AA	GG	GG	GG
B2_42939943	A/T	2	42939943	TT	AA	AA	AA
B2_43112370	C/G	2	43112370	CC	GG	CC	GG
B2_43112519	C/T	2	43112519	CC	TT	CC	TT
B2_43164140	T/C	2	43164140	TT	TT	TT	CC
B2_43168208	T/G	2	43168208	TT	TT	TT	GG
B2_43255370	T/C	2	43255370	TT	CC	TT	TT
B2_43298937	G/A	2	43298937	AA	GG	GG	GG
B2_43298961	C/T	2	43298961	TT	CC	CC	CC
B2_43298963	A/G	2	43298963	GG	AA	AA	AA
B2_43299009	T/C	2	43299009	CC	TT	TT	TT
B2_43299053	G/T	2	43299053	TT	GG	GG	GG

B2_43536933	-/+	2	43536933	++	++	--	++
B2_43537125	C/A	2	43537125	CC	CC	AA	CC
B2_43756448	-/+	2	43756448	--	--	++	--
B2_43756451	A/G	2	43756451	AA	GG	AA	GG
B2_43756484	T/C	2	43756484	TT	TT	CC	TT
B2_43756508	T/C	2	43756508	TT	TT	CC	CC
B2_43756580	C/T	2	43756580	CC	CC	TT	CC
B2_43925481	A/C/G	2	43925481	AA	CC	AA	AA
B2_43925514	G/A	2	43925514	GG	AA	GG	GG
B2_43925565	C/A	2	43925565	CC	AA	CC	CC
B2_44395214	G/A	2	44395214	GG	AA	AA	AA
B2_44445324	T/A	2	44445324	TT	TT	TT	AA
B2_44951868	A/T	2	44951868	TT	TT	AA	AA
B2_44951873	T/A	2	44951873	AA	AA	TT	TT
B2_44951876	T/A	2	44951876	AA	AA	TT	TT
B2_44952207	A/T	2	44952207	TT	TT	AA	AA
B2_44952232	C/T	2	44952232	TT	TT	CC	CC
B2_44952318	-/+	2	44952318	--	++	--	--
B2_44952352	G/C	2	44952352	GG	CC	GG	GG
B2_45019981	T/C	2	45019981	TT	CC	TT	TT
B2_45019990	T/C	2	45019990	TT	CC	TT	TT
B2_45139358	C/T	2	45139358	CC	CC	CC	TT
B2_45139370	A/G	2	45139370	GG	AA	AA	GG
B2_45139421	T/G	2	45139421	TT	TT	TT	GG
B2_45584234	T/A	2	45584234	TT	AA	TT	TT
B2_45797405	G/T	2	45797405	GT	GG	GG	GG
B2_45797469	A/G	2	45797469	AG	GG	AA	GG
B2_45797535	A/G	2	45797535	AG	GG	AA	GG
B2_45797548	C/T	2	45797548	CT	TT	CC	TT
B2_45797561	A/T	2	45797561	AT	TT	AA	TT
B2_46124179	G/A	2	46124179	AA	GG	GG	GG
B2_46152800	C/T	2	46152800	CC	TT	CC	CC
B2_46152828	A/G	2	46152828	AA	GG	AA	AA
B2_46482001	C/T	2	46482001	TT	CC	CC	CC
B2_46482055	G/A	2	46482055	AA	GG	GG	GG
B2_46664691	T/A	2	46664691	TT	TT	TT	AA
B2_46664714	G/C	2	46664714	GG	GG	GG	CC
B2_46664891	C/T	2	46664891	CC	CC	CC	TT
B2_46735650	-/+	2	46735650	++	--	--	++
B2_46741860	G/C	2	46741860	CC	GG	GG	CC
B2_46741887	T/G	2	46741887	GG	TT	TT	GG

B2_46985529	A/T	2	46985529	TT	AA	AA	AA
B2_46985577	T/C	2	46985577	CC	TT	TT	TT
B2_46985611	A/C	2	46985611	CC	AA	AA	AA
B2_46999719	T/G	2	46999719	GG	TT	TT	TT
B2_47083570	A/G	2	47083570	GG	AA	GG	AA
B2_47083593	T/C	2	47083593	CC	TT	CC	TT
B2_47153449	C/A	2	47153449	CC	CC	CC	AA
B2_47153491	G/A	2	47153491	GG	GG	GG	AA
B2_47509345	C/T	2	47509345	CC	CC	TT	CC
B2_48740610	T/A	2	48740610	AA	AA	TT	TT
B2_48740639	A/C	2	48740639	CC	CC	AA	AA
B2_49872143	T/C	2	49872143	TT	TT	CC	TT
B2_49872220	T/A	2	49872220	TT	TT	AA	TT
B2_49872271	G/C	2	49872271	GG	GG	CC	GG
B2_51345834	C/T	2	51345834	CC	CC	CC	TT
B2_51345868	C/T	2	51345868	CC	CC	CC	TT
B2_51345870	A/G	2	51345870	AA	AA	AA	GG
B2_51365120	G/A	2	51365120	GG	GG	GG	AA
B2_51365137	+/-	2	51365137	++	++	++	--
B2_51444825	T/C	2	51444825	TT	TT	TT	CC
B2_51534879	T/C	2	51534879	TT	CC	TT	TT

Table 20: SNP and indel markers on carinata chromosome B3.

SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
B3_96030	+/-	3	96030	--	++	++	++
B3_497571	T/A	3	497571	AA	TT	AA	AA
B3_917312	T/C	3	917312	TT	TT	CC	CC
B3_949180	G/A	3	949180	GG	AA	GG	GG
B3_1052397	T/C	3	1052397	CC	TT	TT	TT
B3_1328525	G/C	3	1328525	CC	CC	GG	GG
B3_1672312	A/C	3	1672312	AA	CC	AA	AA
B3_1672330	C/T	3	1672330	CC	TT	CC	CC
B3_1672333	G/A	3	1672333	GG	AA	GG	GG
B3_1672391	T/C	3	1672391	TT	CC	TT	TT
B3_1672405	A/G	3	1672405	AA	GG	AA	AA
B3_2118561	T/G	3	2118561	GG	TT	TT	TT
B3_2118587	A/G	3	2118587	GG	AA	AA	AA
B3_2118742	C/T	3	2118742	TT	CC	CC	CC

B3_2494869	G/A	3	2494869	GG	GG	AA	AA
B3_2494890	G/A	3	2494890	GG	GG	AA	AA
B3_2804073	T/C	3	2804073	TT	CC	TT	TT
B3_2804085	C/T	3	2804085	CC	TT	CC	CC
B3_2804115	T/C	3	2804115	TT	TT	CC	CC
B3_2804118	A/G	3	2804118	AA	AA	GG	GG
B3_2804130	T/C	3	2804130	TT	TT	CC	CC
B3_2804145	G/T	3	2804145	GG	TT	GG	GG
B3_2804148	G/A	3	2804148	AA	GG	GG	GG
B3_2804163	G/A	3	2804163	AA	GG	GG	GG
B3_2864742	A/G	3	2864742	AA	AA	GG	GG
B3_2864811	C/A	3	2864811	CC	CC	AA	AA
B3_3070053	G/A	3	3070053	GG	GG	AA	AA
B3_3188238	+/-	3	3188238	++	--	++	++
B3_3188251	T/C	3	3188251	TT	CC	TT	TT
B3_3188252	+/-	3	3188252	++	--	++	++
B3_3188286	C/T	3	3188286	CC	TT	CC	CC
B3_3253668	+/-	3	3253668	--	++	--	--
B3_3304470	-/+	3	3304470	--	++	--	--
B3_3304557	T/C	3	3304557	CC	TT	TT	TT
B3_3381623	G/C	3	3381623	GG	GG	CC	CC
B3_3381644	A/G	3	3381644	AA	AA	GG	GG
B3_3381650	T/G	3	3381650	TT	TT	GG	GG
B3_3381686	A/G	3	3381686	AA	AA	GG	GG
B3_3381693	A/G	3	3381693	AA	AA	GG	GG
B3_3381706	T/G	3	3381706	TT	TT	GG	GG
B3_3421459	A/G	3	3421459	GG	AA	AA	AA
B3_3421463	C/T	3	3421463	TT	CC	CC	CC
B3_3421583	G/T	3	3421583	TT	GG	GG	GG
B3_3421605	C/T	3	3421605	TT	CC	CC	CC
B3_3421638	C/A	3	3421638	AA	CC	CC	CC
B3_3547083	G/A	3	3547083	AA	GG	GG	GG
B3_3547098	C/A	3	3547098	AA	CC	CC	CC
B3_3547135	G/A	3	3547135	AA	GG	GG	GG
B3_3547206	A/G	3	3547206	GG	AA	AA	AA
B3_3551663	G/A	3	3551663	GG	AA	GG	GG
B3_3551750	T/A	3	3551750	TT	AA	TT	TT
B3_3551915	G/T	3	3551915	GG	TT	GG	GG
B3_3551919	G/A	3	3551919	GG	AA	GG	GG
B3_3551975	T/C	3	3551975	TT	CC	TT	TT
B3_3564741	C/G	3	3564741	CC	GG	CC	CC

B3_3564747	G/A	3	3564747	GG	AA	GG	GG
B3_3570723	A/C	3	3570723	CC	CC	AA	AA
B3_3731442	G/A	3	3731442	GG	GG	AA	AA
B3_3731489	C/T	3	3731489	CC	CC	TT	TT
B3_3731493	T/C	3	3731493	TT	TT	CC	CC
B3_3731499	C/T	3	3731499	CC	CC	TT	TT
B3_3731508	A/C	3	3731508	AA	AA	CC	CC
B3_4200470	T/A	3	4200470	TT	TT	AA	AA
B3_4200528	C/T	3	4200528	CC	CC	TT	TT
B3_4200558	T/C	3	4200558	TT	TT	CC	CC
B3_4273336	+/-	3	4273336	--	++	--	--
B3_4542443	C/A	3	4542443	AA	CC	CC	CC
B3_4981971	C/A	3	4981971	AA	CC	AA	AA
B3_5010464	A/T	3	5010464	AA	AA	TT	TT
B3_5010515	A/G	3	5010515	AA	AA	GG	GG
B3_5010525	T/G	3	5010525	TT	TT	GG	GG
B3_5010526	G/T	3	5010526	GG	GG	TT	TT
B3_5225938	A/G	3	5225938	GG	AA	AA	AA
B3_5225962	C/T	3	5225962	TT	CC	CC	CC
B3_5225968	A/T	3	5225968	TT	AA	AA	AA
B3_5225992	-/+	3	5225992	++	--	--	--
B3_5343538	-/+	3	5343538	++	--	--	--
B3_5343541	C/T	3	5343541	TT	CC	CC	CC
B3_5343559	T/C	3	5343559	CC	TT	TT	TT
B3_5343562	T/C	3	5343562	CC	TT	TT	TT
B3_5343579	G/A	3	5343579	AA	GG	GG	GG
B3_5343585	G/A	3	5343585	AA	GG	GG	GG
B3_5343633	T/G	3	5343633	GG	TT	TT	TT
B3_5343643	C/T	3	5343643	TT	CC	CC	CC
B3_6790711	G/A	3	6790711	GG	GG	AA	AG
B3_6790728	-/+	3	6790728	--	--	++	++
B3_6790733	C/T	3	6790733	CC	CC	TT	CT
B3_6995373	-/+	3	6995373	--	--	++	++
B3_6995388	G/A	3	6995388	GG	GG	AA	AA
B3_8129537	+/-	3	8129537	--	-+	++	++
B3_9105106	A/G	3	9105106	GG	AA	AA	AA
B3_10562264	T/G	3	10562264	GG	TT	TT	TT
B3_10562288	-/+	3	10562288	++	--	--	--
B3_10562291	T/G	3	10562291	GG	TT	TT	TT
B3_10587725	A/G	3	10587725	GG	GG	AA	GG
B3_10587730	+/-	3	10587730	--	--	++	--

B3_10587732	A/G	3	10587732	AA	AA	GG	AA
B3_10587924	C/T	3	10587924	TT	TT	CC	TT
B3_10794776	G/C	3	10794776	GG	GG	CC	GG
B3_10794966	A/G	3	10794966	AA	AA	GG	AA
B3_10794984	G/A	3	10794984	GG	GG	AA	AA
B3_11821666	T/A	3	11821666	AA	TT	TT	TT
B3_11881808	+/-	3	11881808	--	++	++	++
B3_11881837	C/A	3	11881837	AA	CC	CC	CC
B3_11881925	C/G	3	11881925	GG	CC	CC	CC
B3_11881931	G/A	3	11881931	AA	GG	GG	GG
B3_11952635	T/A	3	11952635	TT	AA	TT	AA
B3_11952747	T/A	3	11952747	TT	AA	TT	AA
B3_11962347	C/T	3	11962347	CC	TT	CC	TT
B3_11962350	T/G	3	11962350	TT	GG	TT	GG
B3_11962353	C/A	3	11962353	CC	AA	CC	AA
B3_12302228	C/T	3	12302228	TT	CC	CC	CC
B3_12624798	A/T	3	12624798	AA	AT	AA	TT
B3_12717198	T/C	3	12717198	CC	TT	TT	TT
B3_12717260	T/C	3	12717260	CC	TT	TT	TT
B3_12717275	C/T	3	12717275	TT	CC	CC	CC
B3_12717293	A/G	3	12717293	GG	AA	AA	AA
B3_13065542	C/T	3	13065542	TT	CC	CC	CC
B3_13088838	G/A	3	13088838	AG	GG	GG	GG
B3_13088922	G/A	3	13088922	AG	GG	GG	GG
B3_13088951	G/T	3	13088951	GT	GG	GG	GG
B3_13101374	+/-	3	13101374	++	--	++	++
B3_13101450	A/G	3	13101450	AA	GG	AA	AA
B3_13123469	+/-	3	13123469	--	++	++	++
B3_13123489	C/T	3	13123489	TT	CC	CC	CC
B3_13123505	T/C	3	13123505	CC	TT	TT	TT
B3_13123516	C/A	3	13123516	AA	CC	CC	CC
B3_13738924	A/C	3	13738924	AA	AA	CC	AA
B3_13739100	C/T	3	13739100	CC	CC	TT	CC
B3_13739124	C/T	3	13739124	CC	CC	TT	CC
B3_14481530	G/T	3	14481530	GG	GT	GG	GG
B3_14481545	A/T	3	14481545	AA	AT	AA	AA
B3_14491306	A/G	3	14491306	AA	AG	AA	AA
B3_15347180	A/G	3	15347180	AA	AA	GG	GG
B3_15429126	T/C	3	15429126	TT	TT	CC	TT
B3_16244765	G/A	3	16244765	GG	AG	AA	GG
B3_16501177	C/T	3	16501177	CC	CC	TT	TT

B3_16501191	G/A	3	16501191	GG	GG	AA	AA
B3_16501192	A/T	3	16501192	AA	AA	TT	TT
B3_16501243	A/G	3	16501243	AA	AA	GG	GG
B3_16501246	A/G	3	16501246	AA	AA	GG	GG
B3_16677881	T/G	3	16677881	GG	GT	TT	GG
B3_16677883	G/T	3	16677883	TT	GT	GG	TT
B3_17062482	T/C	3	17062482	TT	TT	TT	CT
B3_18547409	A/G	3	18547409	AA	GG	AA	GG
B3_18718974	A/C	3	18718974	AA	CC	AA	AA
B3_18836852	T/G	3	18836852	GG	TT	GG	GG
B3_18836873	C/T	3	18836873	CC	CC	TT	TT
B3_18836883	A/T	3	18836883	AA	AA	TT	TT
B3_18836995	-/+	3	18836995	--	--	++	++
B3_18836996	-/+	3	18836996	--	--	++	++
B3_18837013	T/C	3	18837013	CC	TT	CC	CC
B3_18837018	A/C	3	18837018	AA	AA	CC	CC
B3_19124739	G/C	3	19124739	GG	CC	GG	GG
B3_19124742	A/G	3	19124742	AA	GG	AA	AA
B3_19124743	+/-	3	19124743	++	--	++	++
B3_19124847	A/G	3	19124847	AA	GG	AA	AA
B3_19124870	C/T	3	19124870	CC	TT	CC	CC
B3_19124897	G/A	3	19124897	GG	AA	GG	GG
B3_19130886	T/A	3	19130886	AA	TT	AA	AA
B3_19130910	T/A	3	19130910	AA	TT	AA	AA
B3_19130961	T/C	3	19130961	CC	TT	CC	CC
B3_19978214	A/G	3	19978214	AA	GG	GG	GG
B3_19978353	G/A	3	19978353	GG	GG	AG	GG
B3_20127326	G/T	3	20127326	GG	TT	GG	GG
B3_22492905	G/C	3	22492905	CC	GG	CC	CC
B3_22541095	G/C	3	22541095	CC	GG	CC	CC
B3_22541096	G/C	3	22541096	CC	GG	CC	CC
B3_22541138	G/A	3	22541138	AA	GG	AA	AA
B3_22541202	C/T	3	22541202	TT	CC	TT	TT
B3_22541223	G/A	3	22541223	AA	GG	AA	AA
B3_23610585	T/C	3	23610585	TT	CC	TT	TT
B3_23610676	T/C	3	23610676	TT	CC	TT	TT
B3_23610680	+/-	3	23610680	--	++	--	--
B3_23835994	-/+	3	23835994	--	--	++	++
B3_23836017	A/G	3	23836017	AA	AA	GG	GG
B3_23836019	G/A	3	23836019	GG	GG	AA	AA
B3_23836169	G/A	3	23836169	GG	GG	AA	AA

B3_24012257	+/-	3	24012257	--	++	++	++
B3_26904173	T/C	3	26904173	TT	CC	TT	TT
B3_26904209	+/-	3	26904209	++	--	++	++
B3_26904210	G/C	3	26904210	GG	CC	GG	GG
B3_26904210	+/-/G/C	3	26904210	++	--	++	++
B3_26904211	+/-	3	26904211	++	--	++	++
B3_26904235	+/-	3	26904235	++	--	++	++
B3_26904236	+/-	3	26904236	++	--	++	++
B3_27244575	T/C	3	27244575	CC	TT	CC	CC
B3_27380725	T/C	3	27380725	CC	TT	CC	CC
B3_27380744	C/A	3	27380744	AA	CC	AA	AA
B3_27381123	+/-	3	27381123	--	++	--	--
B3_27428548	T/C	3	27428548	CC	TT	CC	CC
B3_27556078	+/-	3	27556078	--	--	--	++
B3_27556087	+/-	3	27556087	--	++	--	--
B3_27786577	C/T	3	27786577	CC	CC	TT	TT
B3_27795547	A/G	3	27795547	GG	AA	GG	GG
B3_27795548	G/T	3	27795548	TT	GG	TT	TT
B3_28452841	-/+	3	28452841	--	++	--	++
B3_28632155	+/-	3	28632155	--	--	++	++
B3_28641082	A/G	3	28641082	AA	AA	GG	AA
B3_28641288	A/G	3	28641288	AA	AA	GG	AA
B3_28641315	A/G	3	28641315	AA	AA	GG	AA
B3_29578734	T/G	3	29578734	GG	TT	TT	GG
B3_30636951	A/G	3	30636951	AA	AA	GG	AA
B3_30636977	C/T	3	30636977	CC	CC	TT	CC
B3_30636986	A/G	3	30636986	AA	AA	GG	AA
B3_30637010	T/G	3	30637010	TT	TT	GG	TT
B3_30873236	T/C	3	30873236	TT	TT	CC	TT
B3_30903011	G/A	3	30903011	GG	GG	AA	GG
B3_30903084	G/C	3	30903084	GG	GG	CC	GG
B3_31949735	A/G	3	31949735	AA	AA	AA	GG
B3_32536648	C/T	3	32536648	TT	CC	CC	TT
B3_32753593	G/A	3	32753593	GG	AA	GG	GG
B3_32831672	+/-	3	32831672	--	--	++	++
B3_33499765	G/A	3	33499765	GG	AA	GG	GG
B3_36439867	G/A	3	36439867	GG	AA	GG	GG
B3_37825487	T/C	3	37825487	TT	TT	CC	TT
B3_40289368	+/-	3	40289368	--	++	++	--
B3_42213222	+/-	3	42213222	--	++	++	++
B3_44283940	G/A	3	44283940	AA	GG	GG	GG

B3_45408330	A/G	3	45408330	GG	AA	AA	GG
B3_45408546	G/T	3	45408546	TT	GG	GG	TT
B3_45408581	C/T	3	45408581	TT	CC	CC	TT
B3_45462102	T/C	3	45462102	CC	TT	TT	CC
B3_45462655	C/T	3	45462655	CC	CC	CC	TT
B3_45915537	+/-	3	45915537	--	++	++	--

Table 21: SNP and indel markers on carinata chromosome B4.

SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
B4_951266	G/A	4	951266	AA	GG	GG	GG
B4_1078147	-/+	4	1078147	--	--	++	--
B4_1078153	C/G	4	1078153	CC	CC	GG	CC
B4_1078162	C/T	4	1078162	CC	CC	TT	CC
B4_1078293	A/G	4	1078293	AA	AA	GG	AA
B4_1078305	T/C	4	1078305	TT	TT	CC	TT
B4_1078318	A/G	4	1078318	AA	AA	GG	AA
B4_1078338	T/C	4	1078338	TT	TT	CC	TT
B4_1206121	C/T	4	1206121	CC	CC	TT	CC
B4_1206132	C/T	4	1206132	CC	CC	TT	CC
B4_1276400	T/A	4	1276400	AA	AA	TT	AA
B4_1276407	T/G	4	1276407	GG	GG	TT	GG
B4_3801068	C/T	4	3801068	CC	CC	TT	CC
B4_3801082	T/A	4	3801082	TT	TT	AA	TT
B4_3801100	T/A	4	3801100	TT	TT	AA	TT
B4_3801144	-/+	4	3801144	--	--	++	--
B4_4119791	T/C	4	4119791	TT	TT	CC	TT
B4_4119809	T/A	4	4119809	TT	TT	AA	TT
B4_4119818	A/C	4	4119818	AA	AA	CC	AA
B4_4120205	T/G	4	4120205	TT	TT	GG	TT
B4_4120210	T/G	4	4120210	TT	TT	GG	TT
B4_4120379	G/A	4	4120379	GG	GG	AA	GG
B4_4395231	T/C	4	4395231	TT	TT	CC	TT
B4_4395257	G/A	4	4395257	GG	GG	AA	GG
B4_4395302	G/A	4	4395302	GG	GG	AA	GG
B4_4395320	C/T	4	4395320	CC	CC	TT	CC
B4_4395331	A/G	4	4395331	AA	AA	GG	AA
B4_4395334	G/A	4	4395334	GG	GG	AA	GG
B4_5084478	T/C	4	5084478	TT	TT	CC	TT

B4_6273931	A/G	4	6273931	AA	AA	GG	AA
B4_6273942	C/T	4	6273942	CC	CC	TT	CC
B4_6273945	A/C	4	6273945	AA	AA	CC	AA
B4_6273954	-/+	4	6273954	--	--	++	--
B4_6273958	T/C	4	6273958	TT	TT	CC	TT
B4_6273964	A/G	4	6273964	AA	AA	GG	AA
B4_6274002	C/T	4	6274002	CC	CC	TT	CC
B4_6464630	A/G	4	6464630	AA	AA	GG	AA
B4_6464661	-/+	4	6464661	--	--	++	--
B4_6464706	A/C	4	6464706	AA	AA	CC	AA
B4_6464774	C/G	4	6464774	CC	CC	GG	CC
B4_6464783	T/A	4	6464783	TT	TT	AA	TT
B4_6464785	+/-	4	6464785	++	++	--	++
B4_6464789	+/-	4	6464789	++	++	--	++
B4_7096712	+/-	4	7096712	--	++	++	++
B4_7678055	C/A	4	7678055	AA	AA	CC	AA
B4_7678082	G/A	4	7678082	AA	AA	GG	AA
B4_7678130	C/A	4	7678130	AA	AA	CC	AA
B4_7878224	G/T	4	7878224	TT	TT	GG	TT
B4_7878260	C/G	4	7878260	GG	GG	CC	GG
B4_7878263	G/A	4	7878263	AA	AA	GG	AA
B4_7878453	G/A	4	7878453	AA	AA	GG	AA
B4_7878497	A/G	4	7878497	GG	GG	AA	GG
B4_8034824	T/G	4	8034824	TT	TT	GG	TT
B4_8034841	C/T	4	8034841	CC	CC	TT	CC
B4_8034865	G/T	4	8034865	GG	GG	TT	GG
B4_8034876	T/C	4	8034876	TT	TT	CC	TT
B4_8040373	A/G	4	8040373	AA	AA	GG	AA
B4_8040374	C/T	4	8040374	CC	CC	TT	CC
B4_8040386	T/C	4	8040386	TT	TT	CC	TT
B4_8040417	G/A	4	8040417	GG	GG	AA	GG
B4_8645443	T/C	4	8645443	TT	TT	CC	TT
B4_8645469	C/T	4	8645469	CC	CC	TT	CC
B4_8645500	T/C	4	8645500	TT	TT	CC	TT
B4_8645505	C/A	4	8645505	CC	CC	AA	CC
B4_8645522	T/C	4	8645522	TT	TT	CC	TT
B4_8645588	A/G	4	8645588	AA	AA	GG	AA
B4_8779280	G/A	4	8779280	GG	GG	AA	GG
B4_8779305	C/G	4	8779305	CC	CC	GG	CC
B4_8779316	G/A	4	8779316	GG	GG	AA	GG
B4_8779341	C/A	4	8779341	CC	CC	AA	CC

B4_8779359	C/G	4	8779359	CC	CC	GG	CC
B4_8779383	T/G	4	8779383	TT	TT	GG	TT
B4_9274073	-/+	4	9274073	++	++	--	++
B4_9274116	G/C	4	9274116	CC	CC	GG	CC
B4_9303364	G/T	4	9303364	TT	TT	GG	TT
B4_9314848	A/G	4	9314848	GG	GG	AA	GG
B4_9505302	G/A	4	9505302	AA	AA	GG	AA
B4_9505309	T/C	4	9505309	CC	CC	TT	CC
B4_9505319	G/A	4	9505319	AA	AA	GG	AA
B4_10778612	G/A	4	10778612	AA	AA	GG	GG
B4_11728606	C/A	4	11728606	AA	AA	CC	AA
B4_11728615	-/+	4	11728615	++	++	--	++
B4_12040572	A/G	4	12040572	GG	GG	AA	GG
B4_12040676	-/+	4	12040676	++	++	--	++
B4_12955219	A/G	4	12955219	GG	GG	GG	AA
B4_12955381	C/T	4	12955381	TT	TT	TT	CC
B4_12955382	A/G	4	12955382	GG	GG	GG	AA
B4_12955385	C/G	4	12955385	GG	GG	GG	CC
B4_12955390	T/A	4	12955390	AA	AA	AA	TT
B4_12955395	G/C	4	12955395	CC	CC	CC	GG
B4_12955401	G/A	4	12955401	AA	AA	AA	GG
B4_12955406	T/G	4	12955406	GG	GG	GG	TT
B4_12955414	T/C	4	12955414	CC	CC	CC	TT
B4_13032550	G/A	4	13032550	GG	GG	GG	AA
B4_13032579	A/G	4	13032579	AA	AA	AA	GG
B4_13032615	A/T	4	13032615	AA	AA	AA	TT
B4_13032617	-/+	4	13032617	--	--	--	++
B4_13032624	-/+	4	13032624	--	--	--	++
B4_13032630	+/-	4	13032630	++	++	++	--
B4_13367056	+/-	4	13367056	--	--	++	++
B4_14997272	T/C	4	14997272	TT	TT	TT	CC
B4_14997312	G/C	4	14997312	GG	GG	GG	CC
B4_15035777	C/T	4	15035777	CT	CC	CC	CC
B4_15035778	T/A	4	15035778	AT	TT	TT	TT
B4_15035815	T/A	4	15035815	AT	TT	TT	TT
B4_15035822	G/T	4	15035822	GT	GG	GG	GG
B4_15129592	-/+	4	15129592	-+	++	++	--
B4_15129625	T/C	4	15129625	CT	CC	CC	TT
B4_15143892	G/A	4	15143892	GG	GG	AA	GG
B4_15143933	T/G	4	15143933	TT	TT	GG	TT
B4_15144145	C/T	4	15144145	CC	CC	TT	CC

B4_15176017	G/A	4	15176017	GG	GG	AA	GG
B4_15176035	C/T	4	15176035	CC	CC	TT	CC
B4_15176043	C/T	4	15176043	CC	CC	TT	CC
B4_15213015	C/A	4	15213015	CC	CC	AA	CC
B4_15213695	C/T	4	15213695	CC	CC	TT	CC
B4_15599186	A/T	4	15599186	TT	TT	AA	TT
B4_15599198	A/G	4	15599198	GG	GG	AA	GG
B4_15599252	A/T	4	15599252	AA	AA	TT	AA
B4_15599259	C/A	4	15599259	CC	CC	AA	CC
B4_15599263	C/T	4	15599263	CC	CC	TT	CC
B4_15763700	-/+	4	15763700	--	--	++	++
B4_15763731	+/-	4	15763731	++	++	--	--
B4_15763774	A/C	4	15763774	AA	AA	CC	CC
B4_15807883	T/C	4	15807883	TT	TT	CC	CC
B4_15807901	T/C	4	15807901	TT	TT	CC	CC
B4_15807925	A/C	4	15807925	AA	AA	CC	CC
B4_15807988	T/C	4	15807988	TT	TT	CC	CC
B4_16812189	-/+	4	16812189	--	--	++	--
B4_17686905	G/C	4	17686905	GG	GG	CC	GG
B4_17686913	G/A	4	17686913	GG	GG	AA	GG
B4_17686999	C/T	4	17686999	CC	CC	TT	CC
B4_17687000	C/G	4	17687000	CC	CC	GG	CC
B4_17687009	A/G	4	17687009	AA	AA	GG	AA
B4_17687060	A/T	4	17687060	AA	AA	TT	AA
B4_18161537	A/G	4	18161537	AA	GG	AA	AA
B4_18161684	A/C	4	18161684	AA	CC	AA	AA
B4_19231744	+/-	4	19231744	--	++	++	--
B4_21663621	A/G	4	21663621	AA	GG	AA	AA
B4_26338330	C/T	4	26338330	TT	CC	CC	TT
B4_26440675	+/-	4	26440675	--	++	++	++
B4_29825295	G/T	4	29825295	TT	GG	GG	TT
B4_30910722	G/A	4	30910722	AA	GG	GG	AA
B4_30910723	G/A	4	30910723	AA	GG	GG	AA
B4_32977910	A/G	4	32977910	GG	AA	AA	GG
B4_34112222	G/A	4	34112222	AA	AA	GG	AA
B4_34194700	G/A	4	34194700	GG	GG	AA	AA
B4_34469464	G/A/T	4	34469464	AA	GG	GG	AA
B4_36869424	+/-	4	36869424	--	++	++	--
B4_40078197	G/A/T	4	40078197	GG	GG	GG	AA

Table 22: SNP and indel markers on carinata chromosome B5.

SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
B5_51211	G/A	5	51211	GG	GG	AA	GG
B5_307492	A/C	5	307492	AC	AA	AA	AA
B5_307510	+/-	5	307510	-+	++	++	++
B5_307553	C/G	5	307553	GC	CC	CC	CC
B5_307556	T/C	5	307556	CT	TT	TT	TT
B5_307559	T/C	5	307559	CT	TT	TT	TT
B5_307612	G/C	5	307612	GC	GG	GG	GG
B5_310057	C/T	5	310057	CT	CC	CC	CC
B5_310081	G/A	5	310081	AG	GG	GG	GG
B5_412702	G/A	5	412702	GG	GG	AA	AA
B5_437732	A/C	5	437732	AA	AA	CC	CC
B5_723109	A/G	5	723109	GG	GG	GG	AA
B5_723119	G/T	5	723119	TT	TT	TT	GG
B5_723134	C/A	5	723134	AA	AA	AA	CC
B5_723139	A/G	5	723139	GG	GG	GG	AA
B5_723144	+/-	5	723144	--	--	--	++
B5_723148	+/-	5	723148	--	--	--	++
B5_723149	+/-	5	723149	--	--	--	++
B5_723155	+/-	5	723155	--	--	--	++
B5_723159	T/A	5	723159	AA	AA	AA	TT
B5_723161	T/A	5	723161	AA	AA	AA	TT
B5_723853	A/G	5	723853	AG	GG	GG	AA
B5_723870	C/T	5	723870	CT	TT	TT	CC
B5_723999	T/C	5	723999	CT	CC	CC	TT
B5_724010	G/C	5	724010	GC	GG	CC	GG
B5_724017	T/G	5	724017	GT	GG	GG	TT
B5_784792	+/-	5	784792	-+	--	--	--
B5_784794	+/-	5	784794	-+	--	--	--
B5_784795	T/G	5	784795	GT	GG	GG	GG
B5_815540	A/C	5	815540	AA	AA	CC	CC
B5_855386	A/G	5	855386	AA	GG	GG	AA
B5_855457	C/T	5	855457	CC	TT	TT	CC
B5_1205637	C/T	5	1205637	CT	TT	CC	CC
B5_1205665	A/G	5	1205665	AG	GG	AA	AA
B5_1205669	C/T	5	1205669	CT	TT	CC	CC
B5_1375164	A/C	5	1375164	AC	CC	CC	AA
B5_1532375	C/G	5	1532375	CC	CC	GG	GG
B5_1532382	G/C	5	1532382	GG	GG	CC	CC

B5_1763371	C/T	5	1763371	CT	TT	CC	CC
B5_1763789	C/A	5	1763789	AC	AA	CC	CC
B5_1782666	T/C	5	1782666	CC	TT	TT	CC
B5_1782711	G/C	5	1782711	CC	GG	GG	CC
B5_1782713	G/A	5	1782713	AA	GG	GG	AA
B5_1782791	A/G	5	1782791	GG	AA	AA	GG
B5_1790874	T/G	5	1790874	TT	TT	GG	TT
B5_1790901	G/A	5	1790901	GG	GG	AA	GG
B5_1790955	A/G	5	1790955	AA	AA	GG	AA
B5_1790970	C/A	5	1790970	CC	CC	AA	CC
B5_1790991	A/G	5	1790991	AA	AA	GG	AA
B5_1790994	A/G	5	1790994	AA	AA	GG	AA
B5_1791010	G/T	5	1791010	GG	GG	TT	GG
B5_1791021	C/T	5	1791021	CC	CC	TT	CC
B5_1841778	C/A	5	1841778	AA	CC	CC	CC
B5_1841894	G/T	5	1841894	TT	GG	GG	GG
B5_1841960	A/T	5	1841960	TT	AA	AA	AA
B5_1861239	G/A	5	1861239	AG	GG	GG	GG
B5_1861284	T/A/C	5	1861284	AT	TT	TT	TT
B5_1861290	A/C	5	1861290	AC	AA	AA	AA
B5_1985401	C/T	5	1985401	CC	CC	CC	TT
B5_2048942	G/C	5	2048942	GG	GG	GG	CC
B5_2143463	C/A	5	2143463	CC	CC	CC	AA
B5_2484395	G/T	5	2484395	GG	GG	GG	TT
B5_2484401	A/T	5	2484401	AA	AA	AA	TT
B5_2484428	T/C	5	2484428	TT	TT	TT	CC
B5_2484431	C/T	5	2484431	CC	CC	CC	TT
B5_2484560	C/G	5	2484560	CC	CC	CC	GG
B5_2484562	G/A	5	2484562	GG	GG	GG	AA
B5_2484563	-/+	5	2484563	--	--	--	++
B5_2484571	A/G	5	2484571	AA	AA	AA	GG
B5_2484602	C/T	5	2484602	CC	CC	CC	TT
B5_2591800	C/A	5	2591800	AA	CC	AA	CC
B5_2683680	+/-	5	2683680	--	--	--	++
B5_2835657	T/C	5	2835657	TT	TT	TT	CC
B5_3444344	C/T	5	3444344	CC	CC	TT	CC
B5_3534020	A/T	5	3534020	AA	AA	TT	TT
B5_3534173	A/C	5	3534173	AA	AA	CC	CC
B5_3534194	G/A	5	3534194	GG	GG	AA	AA
B5_3859008	C/A	5	3859008	CC	AA	CC	CC
B5_4795509	T/C	5	4795509	TT	TT	CC	CC

B5_4795512	T/A	5	4795512	TT	TT	AA	AA
B5_4795584	A/T	5	4795584	AA	AA	TT	TT
B5_5074559	C/T	5	5074559	CC	CC	TT	TT
B5_5074601	G/A	5	5074601	GG	GG	AA	AA
B5_5538479	C/G	5	5538479	CC	CC	GG	GG
B5_5538482	G/A	5	5538482	GG	GG	AA	AA
B5_5547873	T/C	5	5547873	TT	TT	CC	CC
B5_5548068	-/+	5	5548068	--	--	++	++
B5_5576514	T/C	5	5576514	CC	CC	TT	TT
B5_6663994	+/-	5	6663994	--	++	--	++
B5_6996053	A/C	5	6996053	AA	AA	CC	AA
B5_6996090	C/T	5	6996090	CC	CC	TT	CC
B5_7026124	A/G	5	7026124	AA	AA	GG	GG
B5_7026190	G/T	5	7026190	GG	GG	TT	TT
B5_7217793	T/A	5	7217793	TT	AA	TT	AA
B5_7401822	A/G	5	7401822	GG	AA	GG	AA
B5_7401825	C/T	5	7401825	TT	CC	TT	CC
B5_7478206	A/T	5	7478206	TT	AA	TT	AA
B5_7478223	+/-	5	7478223	--	++	--	++
B5_7478238	T/C	5	7478238	CC	TT	CC	TT
B5_7478248	-/+	5	7478248	++	--	++	--
B5_7478254	C/G	5	7478254	GG	CC	GG	CC
B5_7478259	A/C	5	7478259	CC	AA	CC	AA
B5_7478264	T/A	5	7478264	AA	TT	AA	TT
B5_7661348	T/C	5	7661348	CC	TT	CC	TT
B5_7661349	G/A	5	7661349	AA	GG	AA	GG
B5_7661490	A/G	5	7661490	AA	AA	GG	AA
B5_7661517	G/T	5	7661517	GG	GG	TT	GG
B5_7765102	C/A	5	7765102	AA	CC	AA	CC
B5_7765140	C/T	5	7765140	TT	CC	TT	CC
B5_7787292	T/A	5	7787292	AA	AA	TT	TT
B5_7787293	A/G	5	7787293	AA	AA	GG	AA
B5_7787321	T/A	5	7787321	TT	TT	TT	AA
B5_8754651	G/A	5	8754651	AA	GG	GG	GG
B5_8754654	G/A	5	8754654	AA	GG	GG	GG
B5_8754804	C/G	5	8754804	GG	CC	CC	CC
B5_8754870	G/A	5	8754870	GG	GG	AA	GG
B5_8754888	A/G	5	8754888	AA	AA	GG	AA
B5_8754895	C/G	5	8754895	CC	CC	GG	CC
B5_8755098	A/T	5	8755098	TT	AA	TT	AA
B5_8755131	G/A	5	8755131	GG	GG	AA	GG

B5_10191354	G/A	5	10191354	GG	GG	AA	GG
B5_10191410	-/+	5	10191410	--	--	++	--
B5_10218994	G/A	5	10218994	GG	GG	AA	GG
B5_10260059	T/C	5	10260059	TT	TT	CC	TT
B5_10260113	T/C	5	10260113	TT	TT	CC	TT
B5_10260125	G/A	5	10260125	GG	GG	AA	GG
B5_10260131	C/G	5	10260131	CC	CC	GG	CC
B5_10260293	G/C	5	10260293	GG	GG	CC	GG
B5_10260296	T/G	5	10260296	TT	TT	GG	TT
B5_10260299	T/G	5	10260299	TT	TT	GG	TT
B5_10481826	C/G	5	10481826	CC	GG	GG	CC
B5_10481968	C/A	5	10481968	CC	AA	AA	CC
B5_10946750	A/T	5	10946750	AA	TT	AA	TT
B5_10946817	C/T	5	10946817	CC	TT	CC	TT
B5_10946847	C/T	5	10946847	CC	TT	CC	TT
B5_10951191	T/C	5	10951191	TT	CC	TT	CC
B5_10951231	T/G	5	10951231	TT	GG	TT	GG
B5_10951296	T/G	5	10951296	TT	GG	TT	GG
B5_11327481	C/T	5	11327481	TT	CC	CC	CC
B5_11327582	T/G	5	11327582	GG	TT	TT	TT
B5_11327583	C/A	5	11327583	AA	CC	CC	CC
B5_12116907	A/G	5	12116907	GG	GG	AA	GG
B5_13212345	G/A	5	13212345	GG	GG	GG	AA
B5_13212388	+/-	5	13212388	--	++	++	++
B5_13648660	C/T	5	13648660	CC	CC	TT	TT
B5_13842901	A/G	5	13842901	GG	AA	AA	AA
B5_13842927	G/A	5	13842927	AA	GG	GG	GG
B5_14836285	G/A	5	14836285	GG	AA	GG	AA
B5_14836291	G/C	5	14836291	GG	CC	GG	CC
B5_15324726	C/T/+/-	5	15324726	++	CC	CC	CC
B5_17689974	+/-	5	17689974	--	++	++	--
B5_20203884	G/T/A	5	20203884	GG	GG	TT	GG
B5_24861520	+/-	5	24861520	--	++	++	++
B5_26077557	-/A/T/+	5	26077557	AA	AA	++	AA
B5_35549427	T/G	5	35549427	TT	TT	GG	GG
B5_35760531	+/-	5	35760531	++	++	++	--
B5_35760537	+/-	5	35760537	++	++	++	--
B5_35760555	A/G	5	35760555	AA	AA	AA	GG
B5_35760566	A/G	5	35760566	AA	AA	AA	GG
B5_35760569	-/+	5	35760569	--	--	--	++
B5_35865093	A/G	5	35865093	AA	AA	AA	GG

B5_35865114	G/C	5	35865114	GG	GG	GG	CC
B5_35865155	C/T	5	35865155	CC	CC	CC	TT
B5_35963051	G/C	5	35963051	GG	GG	GG	CC
B5_35963075	C/T	5	35963075	CC	CC	CC	TT
B5_35963092	+/-	5	35963092	++	++	++	--
B5_35963096	A/+ /C/-	5	35963096	AA	++	AA	CC
B5_35963096	+/-	5	35963096	++	++	++	--
B5_36095630	A/T	5	36095630	AA	AA	AA	TT
B5_36095703	G/A	5	36095703	GG	GG	GG	AA
B5_36582190	G/A	5	36582190	GG	GG	GG	AA
B5_36582249	T/C	5	36582249	TT	TT	TT	CC
B5_36799928	G/T	5	36799928	GG	GG	GG	TT
B5_36799929	T/A	5	36799929	TT	TT	TT	AA
B5_37036213	T/G	5	37036213	TT	TT	TT	GG
B5_37036216	T/C	5	37036216	TT	TT	TT	CC
B5_37036229	C/G	5	37036229	CC	CC	CC	GG
B5_37315099	G/A	5	37315099	GG	GG	GG	AA
B5_38188415	A/G	5	38188415	GG	GG	AA	AA
B5_38188441	A/G	5	38188441	AA	AA	AA	GG
B5_39332014	G/T	5	39332014	GG	GG	GG	TT
B5_39350908	A/C	5	39350908	AA	AA	AA	CC
B5_39350919	+/-	5	39350919	++	++	++	--
B5_39350922	+ /A /G /-	5	39350922	AA	AA	++	--
B5_39350922	A/G	5	39350922	AA	AA	AA	GG
B5_39350924	A/T	5	39350924	AA	AA	AA	TT
B5_39351027	G/A	5	39351027	GG	GG	GG	AA
B5_39401319	T/A	5	39401319	TT	TT	TT	AA
B5_39401412	C/A	5	39401412	CC	CC	CC	AA
B5_39401415	A/C	5	39401415	AA	AA	AA	CC
B5_39401428	T/G	5	39401428	TT	TT	TT	GG
B5_39401465	G/A	5	39401465	GG	GG	GG	AA
B5_39402016	G/C	5	39402016	GG	GG	GG	CC
B5_39811777	A/G	5	39811777	AA	AA	AA	GG
B5_39811821	C/A	5	39811821	CC	CC	CC	AA
B5_39811870	C/A	5	39811870	CC	CC	CC	AA
B5_39847936	C/T	5	39847936	CC	CC	CC	TT
B5_39847946	C/T	5	39847946	CC	CC	CC	TT
B5_39848000	T/A	5	39848000	TT	TT	TT	AA
B5_40452889	T/A	5	40452889	TT	TT	TT	AA
B5_40452907	C/T	5	40452907	CC	CC	CC	TT
B5_40453200	C/A	5	40453200	CC	CC	CC	AA

B5_40454085	G/A	5	40454085	GG	GG	GG	AA
B5_40454118	A/T	5	40454118	AA	AA	AA	TT
B5_40533370	+/-	5	40533370	--	++	++	++
B5_40767060	+/-	5	40767060	--	++	++	++
B5_40812570	C/A	5	40812570	CC	CC	AA	CC
B5_42583833	T/C	5	42583833	CC	CC	TT	CC
B5_42583855	A/G	5	42583855	GG	GG	AA	GG
B5_42583857	C/T	5	42583857	TT	TT	CC	TT
B5_42583865	G/T	5	42583865	TT	TT	GG	TT
B5_42583893	A/T	5	42583893	TT	TT	AA	TT
B5_42583914	A/G	5	42583914	GG	GG	AA	GG
B5_42583920	C/T	5	42583920	TT	TT	CC	TT
B5_42678186	T/A	5	42678186	AA	AA	TT	AA
B5_42726375	C/T	5	42726375	TT	TT	CC	TT
B5_43181323	G/A	5	43181323	GG	GG	AA	GG
B5_43181351	G/A	5	43181351	AA	AA	GG	AA
B5_43306325	A/C	5	43306325	CC	CC	AA	CC
B5_43306340	C/A	5	43306340	AA	AA	CC	AA
B5_43306366	G/A	5	43306366	AA	AA	GG	AA
B5_43306395	T/C	5	43306395	CC	CC	TT	CC
B5_43306415	T/A	5	43306415	AA	AA	TT	AA
B5_43324578	C/A	5	43324578	AA	AA	CC	AA
B5_43324620	T/C	5	43324620	TT	TT	CC	TT
B5_43364130	C/T	5	43364130	CC	CC	TT	CC
B5_46597606	G/T	5	46597606	GG	GG	TT	TT
B5_48123651	A/G	5	48123651	AA	AA	GG	AA
B5_50249647	G/T	5	50249647	GG	GG	TT	GG
B5_50249666	T/C	5	50249666	TT	TT	CC	TT
B5_50249847	G/A	5	50249847	GG	GG	AA	GG
B5_50249855	A/G	5	50249855	AA	AA	GG	AA
B5_50508090	G/C	5	50508090	CC	CC	GG	CC
B5_50508112	C/A	5	50508112	AA	AA	CC	AA
B5_50508345	-/+	5	50508345	++	++	--	++
B5_50508397	A/C	5	50508397	CC	CC	AA	CC
B5_50659557	T/G	5	50659557	GG	GG	TT	GG
B5_50659572	T/C	5	50659572	CC	CC	TT	CC
B5_50659575	C/T	5	50659575	TT	TT	CC	TT
B5_50659713	C/G	5	50659713	GG	GG	CC	GG
B5_51028431	A/C	5	51028431	AA	CC	CC	CC

Table 23: SNP and indel markers on carinata chromosome B6.

SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
B6_1121843	A/G	6	1121843	AA	AA	AA	AA
B6_1378415	T/A	6	1378415	TT	AA	TT	TT
B6_1794485	A/G	6	1794485	GG	GG	AA	AA
B6_1794541	-/+	6	1794541	++	++	--	--
B6_2428321	A/G	6	2428321	GG	GG	AA	AA
B6_2428397	T/C	6	2428397	CC	CC	TT	TT
B6_2433394	C/T	6	2433394	TT	TT	CC	CC
B6_2457575	T/A	6	2457575	TT	TT	AA	TT
B6_2457719	G/A	6	2457719	GG	GG	AA	GG
B6_2457752	G/A	6	2457752	GG	GG	AA	GG
B6_2457753	T/A	6	2457753	TT	TT	AA	TT
B6_2457754	T/C	6	2457754	TT	TT	CC	TT
B6_2457755	A/G	6	2457755	AA	AA	GG	AA
B6_2625678	A/C	6	2625678	CC	AA	AA	AA
B6_3511110	A/C	6	3511110	CC	CC	AA	AA
B6_3527579	C/T	6	3527579	CC	CC	TT	CC
B6_3568800	T/C	6	3568800	TT	TT	TT	CC
B6_3568812	G/T	6	3568812	GG	GG	GG	TT
B6_3568815	T/G	6	3568815	TT	TT	TT	GG
B6_3570916	G/A	6	3570916	GG	GG	GG	AA
B6_3583231	T/C	6	3583231	TT	TT	CC	TT
B6_3583248	T/A	6	3583248	TT	TT	AA	TT
B6_3583276	A/G	6	3583276	AA	AA	GG	AA
B6_3583360	A/G	6	3583360	AA	AA	GG	AA
B6_3659865	C/A	6	3659865	CC	CC	AA	AA
B6_3868016	C/T	6	3868016	TT	TT	CC	CC
B6_3868025	C/T	6	3868025	TT	TT	CC	CC
B6_4063534	G/A	6	4063534	GG	GG	AA	GG
B6_4063555	A/G	6	4063555	AA	AA	GG	AA
B6_4063597	G/A	6	4063597	GG	GG	AA	GG
B6_4063598	C/T	6	4063598	CC	CC	TT	CC
B6_4063624	A/G	6	4063624	GG	GG	AA	GG
B6_4067659	T/G	6	4067659	GG	GG	TT	GG
B6_4067682	A/G	6	4067682	GG	GG	AA	GG
B6_4067692	C/T	6	4067692	TT	TT	CC	TT
B6_4067710	G/A	6	4067710	AA	AA	GG	AA
B6_4067734	G/A	6	4067734	AA	AA	GG	AA
B6_4067755	T/C	6	4067755	CC	CC	TT	CC

B6_4067767	C/T	6	4067767	TT	TT	CC	TT
B6_4067773	C/T	6	4067773	TT	TT	CC	TT
B6_4067788	G/A	6	4067788	AA	AA	GG	AA
B6_4097407	G/A	6	4097407	AA	AA	GG	AA
B6_4097455	T/C	6	4097455	CC	CC	TT	CC
B6_4751128	G/A	6	4751128	AA	AA	GG	AA
B6_4751324	G/A	6	4751324	AA	AA	GG	AA
B6_4792541	A/G	6	4792541	AA	AA	GG	AA
B6_4792583	G/A	6	4792583	GG	AA	AA	GG
B6_4809241	C/A	6	4809241	CC	CC	AA	CC
B6_4809272	A/G	6	4809272	AA	AA	GG	AA
B6_4809303	A/T	6	4809303	AA	AA	TT	AA
B6_4809318	A/G	6	4809318	AA	AA	GG	AA
B6_4809416	C/G	6	4809416	CC	CC	GG	CC
B6_4809417	A/G	6	4809417	AA	AA	GG	AA
B6_4809445	G/A	6	4809445	GG	GG	AA	GG
B6_4960047	C/T	6	4960047	CC	CC	CT	CC
B6_5085115	A/G	6	5085115	AA	AG	AA	AA
B6_5117858	G/T	6	5117858	TT	TT	GG	TT
B6_5605561	+/-	6	5605561	--	--	++	--
B6_5620862	A/G	6	5620862	AA	AA	GG	AA
B6_5620901	T/C	6	5620901	TT	TT	CC	TT
B6_5767212	A/C	6	5767212	AA	AA	CC	AA
B6_5773353	+/-	6	5773353	++	++	--	++
B6_5773373	G/C	6	5773373	GG	GG	CC	GG
B6_7156469	C/A	6	7156469	AA	AA	CC	AA
B6_7156476	G/A	6	7156476	AA	AA	GG	AA
B6_7156486	A/T	6	7156486	TT	TT	AA	TT
B6_7156487	T/A	6	7156487	AA	AA	TT	AA
B6_7156496	A/C	6	7156496	CC	CC	AA	CC
B6_7156509	G/T	6	7156509	TT	GG	GG	TT
B6_7156513	A/G	6	7156513	GG	GG	AA	GG
B6_7156657	C/T	6	7156657	TT	TT	CC	TT
B6_7318554	C/T	6	7318554	TT	TT	CC	TT
B6_7318575	G/T	6	7318575	TT	TT	GG	TT
B6_7318608	T/G	6	7318608	GG	GG	TT	GG
B6_7475254	C/A	6	7475254	CC	CC	AA	CC
B6_7482593	C/T	6	7482593	CC	CC	TT	CC
B6_7482608	T/C	6	7482608	TT	TT	CC	TT
B6_7482625	-/+	6	7482625	--	--	++	--
B6_7482630	C/A	6	7482630	CC	CC	AA	CC

B6_7482643	A/T	6	7482643	AA	AA	TT	AA
B6_7482645	+/-	6	7482645	++	++	--	++
B6_7482648	+/-	6	7482648	++	++	--	++
B6_7482691	C/G	6	7482691	CC	CC	GG	CC
B6_7482718	G/C	6	7482718	GG	GG	CC	GG
B6_7482742	C/T	6	7482742	CC	CC	TT	CC
B6_7603098	A/C	6	7603098	CC	CC	AA	CC
B6_7644233	+/-	6	7644233	--	++	++	++
B6_7899968	A/C	6	7899968	AA	AA	CC	AA
B6_7900001	+/-	6	7900001	++	++	--	++
B6_7977748	C/T	6	7977748	CC	CC	CC	TT
B6_8600850	T/C	6	8600850	TT	TT	CC	TT
B6_8600884	G/A	6	8600884	GG	GG	AA	GG
B6_8651843	G/A	6	8651843	AA	GG	GG	AA
B6_8651858	A/G	6	8651858	GG	AA	AA	GG
B6_8886941	G/A	6	8886941	GG	GG	AA	GG
B6_8886974	G/A	6	8886974	GG	GG	AA	GG
B6_8887100	C/T	6	8887100	CC	CC	TT	CC
B6_8993300	A/G	6	8993300	AA	AA	GG	AA
B6_8993339	C/T	6	8993339	CC	CC	TT	CC
B6_8993357	G/T	6	8993357	GG	GG	TT	GG
B6_8993361	A/T	6	8993361	AA	AA	TT	AA
B6_8993435	A/G	6	8993435	AA	AA	GG	AA
B6_8993450	C/T	6	8993450	CC	CC	TT	CC
B6_8994068	T/C	6	8994068	TT	TT	CC	TT
B6_8994080	G/A	6	8994080	GG	GG	AA	GG
B6_8994092	A/G	6	8994092	AA	AA	GG	AA
B6_8994205	G/A	6	8994205	GG	GG	AA	GG
B6_9166746	C/G	6	9166746	CC	GC	CC	GG
B6_9166871	G/T	6	9166871	GG	TT	GG	TT
B6_10064088	+/-	6	10064088	--	++	++	++
B6_13007972	+/-	6	13007972	--	++	++	++
B6_16264705	A/C	6	16264705	AA	AA	CC	AA
B6_16267737	A/G	6	16267737	AA	AA	GG	AG
B6_16417693	A/G	6	16417693	AA	AA	AA	GG
B6_16478090	C/A	6	16478090	CC	CC	AA	CC
B6_16714431	T/C	6	16714431	CC	TT	CC	TT
B6_16714518	A/G	6	16714518	GG	AA	GG	AA
B6_16714520	A/G	6	16714520	AA	AA	GG	AA
B6_16956791	T/A	6	16956791	AA	TT	TT	TT
B6_16997831	T/G	6	16997831	GG	TT	GG	TT

B6_16998944	A/C	6	16998944	AA	AA	CC	AA
B6_16998984	+/-	6	16998984	++	++	--	++
B6_17004465	T/A	6	17004465	TT	TT	AA	TT
B6_17004571	A/G	6	17004571	GG	AA	GG	AA
B6_17167352	C/T	6	17167352	TT	CC	CC	CC
B6_17167353	C/T	6	17167353	TT	CC	CC	CC
B6_17168449	A/C	6	17168449	CC	AA	CC	AA
B6_17168472	A/G	6	17168472	AA	AA	GG	AA
B6_17168496	G/A	6	17168496	GG	GG	AA	GG
B6_17168498	C/T	6	17168498	CC	CC	TT	CC
B6_17168573	G/T	6	17168573	GG	GG	TT	GG
B6_17184264	T/C	6	17184264	CC	TT	CC	TT
B6_17258664	C/G	6	17258664	GG	CC	GG	CC
B6_17272576	A/C	6	17272576	CC	AA	CC	AA
B6_17445757	A/G	6	17445757	GG	AA	AA	AA
B6_17445777	C/T	6	17445777	TT	CC	CC	CC
B6_17445861	C/T	6	17445861	TT	CC	CC	CC
B6_17484144	C/G	6	17484144	GG	CC	CC	CC
B6_17545623	A/C	6	17545623	CC	AA	CC	AA
B6_17617057	T/G	6	17617057	TT	TT	GG	TT
B6_17617179	C/G	6	17617179	GG	CC	CC	CC
B6_17629400	A/G	6	17629400	AA	AA	GG	AA
B6_17931814	T/C	6	17931814	CC	TT	TT	TT
B6_18195799	G/T	6	18195799	GG	GG	TT	TT
B6_18737656	T/A	6	18737656	TT	TT	AA	AA
B6_18910126	A/G	6	18910126	AA	AA	GG	GG
B6_18961665	C/A	6	18961665	CC	CC	AA	AA
B6_18961721	A/G	6	18961721	AA	AA	GG	GG
B6_18961731	G/A	6	18961731	GG	GG	AA	AA
B6_19031097	C/A	6	19031097	CC	CC	AA	AA
B6_19090688	-/+	6	19090688	--	--	++	++
B6_19107834	A/G	6	19107834	AA	AA	GG	GG
B6_19107886	G/C	6	19107886	GG	GG	CC	CC
B6_19107923	A/G	6	19107923	AA	AA	GG	GG
B6_19143187	A/C	6	19143187	AA	AA	CC	CC
B6_19387905	G/T	6	19387905	GG	GG	TT	TT
B6_19689358	A/G	6	19689358	AA	AA	GG	GG
B6_19933516	T/C	6	19933516	TT	TT	CC	CC
B6_19933631	G/A	6	19933631	GG	AG	AA	AA
B6_20015515	A/G	6	20015515	AA	AA	GG	GG
B6_20015538	G/A	6	20015538	GG	GG	AA	AA

B6_20015615	A/C	6	20015615	AA	AA	CC	CC
B6_20015622	C/T	6	20015622	CC	CC	TT	TT
B6_20015695	+/-	6	20015695	++	++	--	--
B6_20015752	C/T	6	20015752	CC	CC	TT	TT
B6_20730653	T/G	6	20730653	TT	TT	TT	GG
B6_20730671	C/A	6	20730671	CC	CC	CC	AA
B6_20730683	T/C	6	20730683	TT	TT	TT	CC
B6_20899097	C/G	6	20899097	CC	CC	GG	CC
B6_20899115	+/-	6	20899115	++	++	--	++
B6_20899140	G/T	6	20899140	GG	GG	TT	GG
B6_20899160	A/T	6	20899160	AA	AA	TT	AA
B6_20966175	G/A	6	20966175	GG	GG	AA	GG
B6_21009175	T/G	6	21009175	TT	TT	GG	TT
B6_22690043	A/T	6	22690043	TT	AA	AA	AA
B6_22690103	G/T	6	22690103	TT	GG	GG	GG
B6_22911242	+/-	6	22911242	--	--	++	++
B6_22911272	C/T	6	22911272	TT	TT	CC	CC
B6_22922426	T/A	6	22922426	AA	AA	TT	TT
B6_22922427	C/A	6	22922427	AA	AA	CC	CC
B6_25585131	C/T	6	25585131	TT	CC	CC	CC
B6_25937289	C/A	6	25937289	AA	CC	CC	CC
B6_25937312	A/G	6	25937312	GG	AA	AA	AA
B6_26036960	G/A	6	26036960	AA	GG	GG	GG
B6_26037102	G/A	6	26037102	AA	GG	GG	GG
B6_26277314	C/A	6	26277314	AA	CC	CC	CC
B6_27079710	G/C	6	27079710	CC	CC	GG	GG
B6_27079755	C/G	6	27079755	GG	CC	CC	CC
B6_27079896	T/A	6	27079896	AA	AA	TT	TT
B6_27079911	T/A	6	27079911	AA	AA	TT	TT
B6_28803769	A/G	6	28803769	GG	GG	AA	AA
B6_29127428	-/+	6	29127428	--	--	++	++
B6_29127454	C/A	6	29127454	CC	CC	AA	AA
B6_29127456	+/-	6	29127456	++	++	--	--
B6_29127552	C/T	6	29127552	CC	CC	TT	TT
B6_29127604	A/G	6	29127604	AA	AA	GG	GG
B6_29326118	T/C	6	29326118	TT	TT	CC	TT
B6_29326130	A/C	6	29326130	AA	AA	CC	AA
B6_29326193	G/A	6	29326193	GG	GG	AA	GG
B6_29417432	C/T	6	29417432	CC	CC	TT	CC
B6_29417442	C/T	6	29417442	CC	CC	TT	CC
B6_29417530	T/G	6	29417530	TT	TT	GG	TT

B6_29417542	G/C	6	29417542	GG	GG	CC	GG
B6_29417561	A/C	6	29417561	AA	AA	CC	AA
B6_29417577	A/T	6	29417577	AA	AA	TT	AA
B6_29714533	C/G	6	29714533	CC	CC	CC	GG
B6_31055897	+/-	6	31055897	++	++	++	--
B6_32132062	T/G	6	32132062	TT	TT	GG	TT
B6_32373631	C/G	6	32373631	GC	CC	CC	CC
B6_32373736	C/T	6	32373736	CC	CC	TT	TT
B6_32373770	C/T	6	32373770	CC	CC	TT	TT
B6_32373771	G/A	6	32373771	GG	GG	AA	AA
B6_32397918	A/G	6	32397918	AA	AA	AA	GG
B6_32397928	+/-	6	32397928	++	++	++	--
B6_32435494	C/T	6	32435494	CC	CC	CC	TT
B6_32435517	+/-	6	32435517	-+	++	++	--
B6_32435524	+/-	6	32435524	++	++	++	--
B6_33224416	C/T	6	33224416	CC	CC	TT	CC
B6_34318047	+/-	6	34318047	--	--	++	++
B6_34318092	C/T	6	34318092	TT	TT	CC	CC
B6_34318145	C/T	6	34318145	TT	TT	CC	CC
B6_34318200	A/G	6	34318200	GG	GG	AA	AA
B6_35373956	T/G	6	35373956	TT	TT	GG	TT
B6_35374048	C/A	6	35374048	CC	CC	AA	AA
B6_35707458	T/A	6	35707458	AA	TT	TT	TT
B6_35792938	T/A	6	35792938	AA	TT	AA	AA
B6_35792980	G/T	6	35792980	TT	GG	TT	TT
B6_35792994	T/C	6	35792994	CC	TT	CC	CC
B6_36003826	T/C	6	36003826	CC	CC	TT	TT
B6_36003893	T/G	6	36003893	GG	GG	TT	TT
B6_36003896	G/T	6	36003896	TT	TT	GG	GG
B6_36412972	A/G	6	36412972	AA	AA	GG	GG
B6_36413017	+/-	6	36413017	++	++	--	--
B6_36413018	+/-	6	36413018	++	++	--	--
B6_36413018	A/C/+/-	6	36413018	AA	AA	CC	CC
B6_36413019	+/-	6	36413019	++	++	--	--
B6_36413019	A/G/+/-	6	36413019	AA	AA	GG	GG

Table 24: SNP and indel markers on carinata chromosome B7.

SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
B7_826129	T/C	7	826129	CC	TT	TT	TT
B7_826139	A/C	7	826139	CC	AA	AA	AA
B7_826142	T/C	7	826142	CC	TT	TT	TT
B7_826191	A/C	7	826191	CC	AA	AA	AA
B7_826197	C/T	7	826197	TT	CC	CC	CC
B7_826291	C/T	7	826291	TT	CC	CC	CC
B7_963081	C/T	7	963081	CC	TT	CC	TT
B7_963108	G/A	7	963108	GG	AA	GG	AA
B7_963216	G/C	7	963216	GG	CC	GG	CC
B7_963425	G/A	7	963425	GG	AA	GG	AA
B7_963450	T/A	7	963450	TT	AA	TT	AA
B7_1084997	C/G	7	1084997	CC	GG	GG	CC
B7_1085081	+/-	7	1085081	--	++	++	--
B7_1085083	-/+C/T	7	1085083	--	CC	++	--
B7_1085083	C/T	7	1085083	TT	CC	CC	TT
B7_1085086	G/T	7	1085086	TT	GG	GG	TT
B7_1085119	C/T	7	1085119	CC	TT	TT	CC
B7_1118213	A/G	7	1118213	AA	AA	AA	GG
B7_1121830	T/C/A	7	1121830	CC	TT	CC	TT
B7_1121863	G/C	7	1121863	CC	GG	CC	GG
B7_1121866	A/G	7	1121866	GG	AA	GG	AA
B7_1121886	T/C	7	1121886	CC	TT	CC	TT
B7_1121898	A/G	7	1121898	GG	AA	GG	AA
B7_1121929	T/C	7	1121929	CC	TT	CC	TT
B7_1121935	G/A	7	1121935	AA	GG	AA	GG
B7_1121960	T/C	7	1121960	CC	TT	CC	TT
B7_1121961	T/G	7	1121961	GG	TT	GG	TT
B7_1121971	C/T	7	1121971	TT	CC	TT	CC
B7_1121991	A/C	7	1121991	CC	AA	CC	AA
B7_1122004	T/C	7	1122004	CC	TT	CC	TT
B7_1122007	A/G	7	1122007	GG	AA	GG	AA
B7_1235382	C/A	7	1235382	CC	CC	AA	AA
B7_1235401	C/G	7	1235401	CC	CC	GG	GG
B7_1235463	G/A	7	1235463	GG	GG	AA	AA
B7_1418489	T/A	7	1418489	AA	TT	AA	AA
B7_1964663	T/C	7	1964663	CC	CC	TT	TT
B7_1964681	T/C	7	1964681	TT	CC	TT	TT
B7_1964719	+/-	7	1964719	++	--	++	++

B7_2001294	G/T	7	2001294	TT	TT	GG	GG
B7_2078547	A/G	7	2078547	AA	AA	AA	GG
B7_2580651	C/T	7	2580651	TT	TT	CC	CC
B7_2585406	C/A	7	2585406	AA	AA	CC	CC
B7_2987169	T/A	7	2987169	AA	AA	TT	AA
B7_3444681	A/G	7	3444681	GG	GG	AA	AA
B7_3634860	T/A	7	3634860	AA	AA	AA	TT
B7_4080589	G/T	7	4080589	GG	GG	TT	TT
B7_4080614	-/+	7	4080614	--	--	++	++
B7_4080761	A/C	7	4080761	AA	AA	CC	CC
B7_4126649	G/A	7	4126649	GG	GG	AA	GG
B7_4126667	G/A	7	4126667	GG	GG	AA	GG
B7_4126676	G/C	7	4126676	GG	GG	CC	GG
B7_4397366	A/G	7	4397366	AA	GG	AA	AA
B7_4397429	G/T	7	4397429	GG	TT	GG	GG
B7_4397507	T/C	7	4397507	TT	CC	TT	TT
B7_4397513	T/C	7	4397513	TT	CC	TT	TT
B7_4397543	A/G	7	4397543	AA	GG	AA	AA
B7_4423294	+/-	7	4423294	--	++	++	++
B7_4489542	A/C	7	4489542	AA	AA	CC	AA
B7_4489618	T/C	7	4489618	TT	TT	CC	TT
B7_4489652	A/G	7	4489652	AA	AA	GG	AA
B7_4542554	T/G	7	4542554	TT	TT	GG	TT
B7_4542592	+/-	7	4542592	++	++	--	++
B7_4542614	A/T	7	4542614	AA	AA	TT	AA
B7_4542656	G/A	7	4542656	GG	GG	AA	GG
B7_4687430	T/A	7	4687430	AA	TT	TT	TT
B7_4715097	T/A	7	4715097	AA	AA	AA	TT
B7_4870562	G/A	7	4870562	AA	AA	GG	GG
B7_4870586	+/-	7	4870586	--	--	++	++
B7_5038523	T/C	7	5038523	TT	TT	CC	TT
B7_5098331	A/T	7	5098331	AA	AA	TT	AA
B7_5098619	T/C	7	5098619	TT	TT	CC	TT
B7_5312455	A/G	7	5312455	GG	AA	AA	AA
B7_5312514	A/G	7	5312514	GG	AA	AA	AA
B7_5359124	C/T	7	5359124	TT	CC	CC	CC
B7_5359149	A/C	7	5359149	CC	AA	AA	AA
B7_6755398	T/A	7	6755398	TT	TT	AA	TT
B7_8057983	T/G	7	8057983	TT	GT	TT	TT
B7_8078799	C/G	7	8078799	CC	CC	GG	CC
B7_8854136	T/C	7	8854136	TT	TT	CC	TT

B7_8854175	A/G	7	8854175	AA	AA	GG	AA
B7_8871859	T/A	7	8871859	TT	TT	AA	TT
B7_8871868	G/A	7	8871868	GG	GG	AA	GG
B7_8871957	A/T	7	8871957	AA	AA	TT	AA
B7_8871963	A/G	7	8871963	AA	AA	GG	AA
B7_8921956	A/C	7	8921956	AA	AC	CC	AA
B7_8921972	A/G	7	8921972	AA	AG	GG	AA
B7_8921992	G/A	7	8921992	GG	AG	AA	GG
B7_8922001	C/T	7	8922001	CC	CT	TT	CC
B7_8947531	A/G	7	8947531	AA	AA	GG	AA
B7_8947545	T/G	7	8947545	TT	TT	GG	TT
B7_8947569	G/A	7	8947569	GG	GG	AA	GG
B7_8947575	C/A	7	8947575	CC	CC	AA	CC
B7_8952042	T/C	7	8952042	TT	TT	CC	CC
B7_8952056	-/+	7	8952056	--	--	++	++
B7_8952114	T/C	7	8952114	TT	TT	CC	TT
B7_9134498	C/T	7	9134498	TT	CT	TT	CC
B7_9134524	G/T	7	9134524	GG	GT	GG	TT
B7_9134611	A/T	7	9134611	TT	AT	TT	AA
B7_9134612	G/C	7	9134612	CC	GC	CC	GG
B7_9134634	A/G	7	9134634	GG	AG	GG	AA
B7_9134635	A/C	7	9134635	AA	AC	AA	CC
B7_9134652	A/T	7	9134652	TT	AT	TT	AA
B7_9667888	T/C	7	9667888	CC	TT	TT	TT
B7_9692201	C/T	7	9692201	TT	CT	CC	CC
B7_9931734	C/T	7	9931734	CC	CC	TT	CC
B7_9931788	A/C	7	9931788	AA	CC	AA	AA
B7_9931805	G/A	7	9931805	GG	AA	AA	GG
B7_9931919	T/G	7	9931919	TT	GG	GG	TT
B7_9931935	T/A	7	9931935	TT	AA	TT	TT
B7_9931958	G/A	7	9931958	GG	AA	GG	GG
B7_9931964	T/G	7	9931964	TT	GG	TT	TT
B7_9931970	T/G	7	9931970	TT	GG	GG	TT
B7_9934701	T/G	7	9934701	TT	TT	TT	GG
B7_10617043	A/C	7	10617043	CC	AA	AA	CC
B7_10617052	T/A	7	10617052	AA	TT	TT	AA
B7_10617061	A/C	7	10617061	AA	AA	AA	CC
B7_10670400	T/G	7	10670400	GG	GG	TT	GG
B7_10803311	C/A	7	10803311	AA	AA	CC	AA
B7_10803315	A/G	7	10803315	GG	GG	AA	GG
B7_10803347	T/C	7	10803347	CC	CC	TT	CC

B7_10803365	C/T	7	10803365	TT	TT	CC	TT
B7_10868068	T/G	7	10868068	GG	GG	TT	GG
B7_10868070	T/C	7	10868070	CC	CC	TT	CC
B7_10868088	-/+	7	10868088	++	++	--	++
B7_10868106	G/A	7	10868106	AA	AA	GG	AA
B7_10868112	-/+	7	10868112	++	++	--	++
B7_10868173	A/G	7	10868173	GG	GG	AA	GG
B7_11199054	A/T	7	11199054	AA	AA	TT	AA
B7_11626291	A/G	7	11626291	AA	AA	GG	AA
B7_11626344	A/C	7	11626344	AA	AA	CC	AA
B7_13129882	T/C	7	13129882	TT	TT	TT	CC
B7_13664055	C/A	7	13664055	CC	CC	AA	AA
B7_14141321	A/G	7	14141321	AA	AA	AA	GG
B7_14141345	G/C	7	14141345	GG	GG	GG	CC
B7_14141346	T/G	7	14141346	TT	TT	TT	GG
B7_14141374	G/T	7	14141374	GG	GG	GG	TT
B7_14141452	+/-	7	14141452	++	++	++	--
B7_14141457	-/+	7	14141457	++	++	--	--
B7_14141464	G/C	7	14141464	GG	GG	GG	CC
B7_14141473	C/T	7	14141473	CC	CC	CC	TT
B7_14256144	C/G	7	14256144	CC	CC	CC	GG
B7_14480799	C/A	7	14480799	AA	CC	AA	AA
B7_14859682	A/G	7	14859682	AA	AA	GG	AA
B7_14859730	C/G	7	14859730	CC	CC	GG	CC
B7_14923947	C/G	7	14923947	CC	CC	CC	GG
B7_14923949	A/G	7	14923949	AA	AA	GG	AA
B7_14923986	A/G	7	14923986	AA	AA	GG	AA
B7_14923994	T/C	7	14923994	TT	TT	CC	TT
B7_14924002	T/C	7	14924002	TT	TT	CC	TT
B7_14924004	+/-	7	14924004	++	++	--	++
B7_14924133	T/A	7	14924133	TT	TT	AA	TT
B7_14924154	G/A	7	14924154	GG	GG	AA	GG
B7_14924164	T/C	7	14924164	TT	TT	CC	TT
B7_14924170	C/T	7	14924170	CC	CC	TT	CC
B7_14924173	T/G	7	14924173	TT	TT	GG	TT
B7_14924190	G/T	7	14924190	GG	GG	TT	GG
B7_14924203	A/C	7	14924203	AA	AA	CC	AA
B7_14952611	T/G	7	14952611	GG	GG	TT	TT
B7_14952668	A/G	7	14952668	GG	GG	AA	AA
B7_14970367	A/C	7	14970367	CC	CC	AA	AA
B7_14970397	T/C	7	14970397	CC	CC	TT	TT

B7_14970547	+/-/A/G	7	14970547	++	AA	GG	GG
B7_14970547	A/G	7	14970547	AA	AA	GG	GG
B7_15617801	+/-	7	15617801	--	++	++	++
B7_15789726	C/T	7	15789726	TT	CC	CC	CC
B7_15789729	A/G	7	15789729	GG	AA	AA	AA
B7_15789935	G/A	7	15789935	GG	GG	GG	AA
B7_15789989	C/A	7	15789989	AA	CC	CC	CC
B7_16269278	T/C	7	16269278	TT	CC	TT	CC
B7_16760982	C/A	7	16760982	CC	CC	AA	AA
B7_16761032	G/A	7	16761032	GG	GG	AA	AA
B7_16761042	+/-	7	16761042	++	++	--	--
B7_16761053	G/C	7	16761053	GG	GG	CC	CC
B7_16761169	T/G	7	16761169	TT	TT	GG	GG
B7_16761220	C/G	7	16761220	CC	CC	GG	GG
B7_16801991	T/G	7	16801991	GG	GG	TT	TT
B7_16802033	A/G	7	16802033	GG	GG	AA	AA
B7_16810563	+/-	7	16810563	--	--	++	++
B7_16810571	+/-	7	16810571	--	--	++	++
B7_17814926	T/G	7	17814926	TT	TT	TT	GG
B7_17814928	T/A	7	17814928	TT	TT	TT	AA
B7_17814937	G/C	7	17814937	GG	GG	GG	CC
B7_17814949	T/A	7	17814949	TT	TT	TT	AA
B7_17982286	A/G	7	17982286	AA	GG	GG	AA
B7_17982342	C/A	7	17982342	CC	AA	AA	CC
B7_17982382	G/A	7	17982382	GG	AA	AA	GG
B7_17982390	G/A	7	17982390	GG	AA	AA	GG
B7_18308131	A/G	7	18308131	AA	GG	GG	AA
B7_18465109	G/C	7	18465109	CC	CC	CC	GG
B7_18797232	T/A	7	18797232	TT	AT	TT	TT
B7_18797293	T/A	7	18797293	TT	AT	TT	TT
B7_19106238	C/A	7	19106238	CC	CC	AA	CC
B7_19106297	A/G	7	19106297	GG	AG	GG	GG
B7_19276190	A/C	7	19276190	CC	AC	AA	CC
B7_19506014	+/-	7	19506014	++	++	--	++
B7_19506042	G/C	7	19506042	GG	GG	CC	GG
B7_19506058	-/+	7	19506058	--	--	++	--
B7_19506073	C/T	7	19506073	CC	CC	TT	CC
B7_19518164	C/A	7	19518164	AA	AA	CC	AA
B7_19571295	A/C	7	19571295	AA	AA	CC	AA
B7_19571298	C/T	7	19571298	CC	CC	TT	CC
B7_19571436	A/G	7	19571436	AA	AA	GG	AA

B7_20056392	+/-	7	20056392	--	++	++	++
B7_21470504	C/A	7	21470504	CC	CC	AA	CC
B7_21623346	T/C	7	21623346	TT	TT	CC	TT
B7_21628835	A/C	7	21628835	AA	AA	CC	AA
B7_21687144	A/C	7	21687144	CC	CC	AA	CC
B7_23248737	G/A	7	23248737	GG	GG	AA	GG
B7_23248748	T/C	7	23248748	TT	TT	CC	TT
B7_23248764	C/G	7	23248764	CC	CC	GG	CC
B7_23248790	+/-	7	23248790	++	++	--	++
B7_23248796	G/A	7	23248796	GG	GG	AA	GG
B7_23286433	A/C	7	23286433	AA	AA	CC	AA
B7_23286467	C/G	7	23286467	CC	CC	GG	CC
B7_23286491	C/A	7	23286491	CC	CC	AA	CC
B7_23286492	A/C	7	23286492	AA	AA	CC	CC
B7_23286524	C/T	7	23286524	CC	CC	CC	TT
B7_23295627	A/C	7	23295627	AA	AA	CC	AA
B7_23295643	G/A	7	23295643	GG	GG	AA	GG
B7_23295690	A/T	7	23295690	AA	AA	TT	AA
B7_23338560	G/A	7	23338560	GG	GG	AA	GG
B7_23338582	G/C	7	23338582	GG	GG	CC	GG
B7_23338627	C/T	7	23338627	CC	CC	TT	CC
B7_23338664	A/G	7	23338664	AA	AA	GG	AA
B7_23338692	T/G	7	23338692	TT	TT	GG	TT
B7_23937818	T/C	7	23937818	TT	TT	CC	TT
B7_23937835	C/A	7	23937835	CC	CC	AA	CC
B7_23937863	G/C	7	23937863	GG	GG	CC	GG
B7_23937921	C/T	7	23937921	CC	CC	TT	CC
B7_23937928	C/T	7	23937928	CC	CC	TT	CC
B7_23937929	A/G	7	23937929	AA	AA	GG	AA
B7_23937935	C/T	7	23937935	CC	CC	TT	CC
B7_23937958	C/T	7	23937958	CC	CC	TT	CC
B7_23938008	C/T	7	23938008	CC	CC	TT	CC
B7_23938009	C/T	7	23938009	CC	CC	TT	CC
B7_23938027	G/A	7	23938027	GG	GG	AA	GG
B7_23943359	C/T	7	23943359	CC	CC	TT	CC
B7_23943384	+/-	7	23943384	++	++	--	++
B7_23943394	-/+	7	23943394	--	--	++	--
B7_23943402	T/C	7	23943402	TT	TT	CC	TT
B7_23943420	A/G	7	23943420	AA	AA	GG	AA
B7_23943829	A/C	7	23943829	AA	AA	CC	AA
B7_23943942	A/C	7	23943942	AA	AA	CC	AA

B7_23943953	G/C	7	23943953	GG	GG	CC	GG
B7_23944021	C/A	7	23944021	CC	CC	AA	CC
B7_23944026	G/A	7	23944026	GG	GG	AA	GG
B7_23944055	C/T	7	23944055	CC	CC	TT	CC
B7_23944225	G/A	7	23944225	GG	GG	AA	GG
B7_23945014	C/A	7	23945014	CC	CC	AA	CC
B7_23945040	G/T	7	23945040	GG	GG	TT	GG
B7_23945046	T/A	7	23945046	TT	TT	AA	TT
B7_23945062	A/T	7	23945062	AA	AA	TT	AA
B7_23945069	A/G	7	23945069	AA	AA	GG	AA
B7_23945078	A/G	7	23945078	AA	AA	GG	AA
B7_24752771	+/-	7	24752771	--	++	++	++
B7_25095308	C/T	7	25095308	CC	CT	CC	TT
B7_28711224	+/-	7	28711224	--	++	++	++
B7_28938294	+/-	7	28938294	--	++	--	++
B7_30061285	C/T	7	30061285	CC	CT	TT	TT
B7_30171387	A/G	7	30171387	AA	AG	GG	GG
B7_30171390	A/G	7	30171390	AA	AG	GG	GG
B7_30171528	T/C	7	30171528	TT	CC	CC	CC
B7_30299357	C/G	7	30299357	CC	GC	GG	GG
B7_30299471	T/C	7	30299471	TT	CT	CC	CC
B7_30359568	A/G	7	30359568	AA	AG	GG	GG
B7_30507519	A/G	7	30507519	AA	AA	GG	GG
B7_30507527	A/T	7	30507527	AA	AA	TT	TT
B7_30507529	T/G	7	30507529	TT	TT	GG	GG
B7_30529097	-/+	7	30529097	--	--	++	++
B7_30529101	+/-	7	30529101	++	++	--	--
B7_30529157	T/C	7	30529157	TT	TT	CC	CC
B7_30567752	G/A	7	30567752	GG	GG	AA	AA
B7_30617261	-/+	7	30617261	--	--	++	++
B7_30617446	A/T	7	30617446	AA	TT	TT	TT
B7_31453579	G/A	7	31453579	GG	GG	AA	AA
B7_32286479	G/C	7	32286479	CC	GG	GG	GG
B7_32329936	T/A	7	32329936	AA	TT	TT	TT
B7_32564354	C/T	7	32564354	TT	CC	CC	CC
B7_32564409	T/A	7	32564409	TT	AA	AA	AA
B7_32564410	+/-	7	32564410	--	++	++	++
B7_32576578	C/A	7	32576578	CC	CC	AA	AA
B7_32576691	A/G	7	32576691	AA	AA	GG	GG
B7_32959461	T/C	7	32959461	TT	CT	CC	CC
B7_32959475	C/G	7	32959475	GG	GG	CC	CC

B7_32959510	G/A	7	32959510	GG	GG	AA	AA
B7_32986198	T/G	7	32986198	GG	GT	TT	TT
B7_32986326	G/C	7	32986326	GG	GC	CC	CC
B7_33125929	T/G	7	33125929	TT	GT	GG	GG
B7_33316655	T/C	7	33316655	CC	TT	TT	TT
B7_33316728	T/C	7	33316728	TT	CT	CC	CC
B7_33316733	C/T	7	33316733	CC	CT	TT	TT
B7_33549268	+/-	7	33549268	--	-+	++	++
B7_33549355	C/A	7	33549355	CC	AC	AA	AA
B7_33606776	T/G	7	33606776	TT	GG	GG	GG
B7_35065335	C/T	7	35065335	CC	CC	TT	CC
B7_36312495	+/-	7	36312495	--	-+	--	--
B7_36677936	+/-	7	36677936	--	++	++	--
B7_36677937	G/A	7	36677937	GG	GG	GG	AA
B7_38482189	T/A	7	38482189	TT	TT	AA	TT
B7_38482206	C/T	7	38482206	CC	CC	TT	CC
B7_38482208	G/T	7	38482208	GG	GG	TT	GG
B7_38482386	G/C	7	38482386	GG	GG	CC	GG
B7_38510680	G/T	7	38510680	GG	GG	TT	GG
B7_38544790	G/A	7	38544790	GG	GG	AA	GG
B7_38608571	T/C	7	38608571	TT	TT	CC	TT
B7_39544568	T/C	7	39544568	TT	CT	CC	CC
B7_39544626	T/A	7	39544626	TT	AT	AA	AA
B7_39544697	T/C	7	39544697	TT	CT	CC	CC
B7_39544699	G/A	7	39544699	GG	AG	AA	AA
B7_39544708	T/C	7	39544708	TT	CT	CC	CC
B7_39544739	T/A	7	39544739	TT	AT	AA	AA
B7_39679990	T/C	7	39679990	TT	CT	CC	CC
B7_39680132	A/C	7	39680132	AA	AC	CC	CC
B7_39786723	T/A	7	39786723	TT	AA	AA	AA
B7_39786731	C/T	7	39786731	CC	TT	TT	TT
B7_39786732	T/C	7	39786732	TT	CC	CC	CC
B7_39833593	A/G	7	39833593	AA	AA	GG	GG
B7_39833599	G/C	7	39833599	GG	GG	CC	CC
B7_39926711	C/G	7	39926711	CC	CC	CC	GG
B7_39929055	C/T	7	39929055	CC	CC	TT	TT
B7_39971210	A/C	7	39971210	AA	AA	CC	CC
B7_39971317	T/C	7	39971317	TT	TT	CC	CC
B7_39971318	-/+	7	39971318	--	--	++	++
B7_40060721	C/A	7	40060721	CC	CC	AA	CC
B7_40074046	+/-	7	40074046	++	++	--	++

B7_40160968	A/G	7	40160968	AA	AA	GG	AA
B7_40275617	A/G	7	40275617	AA	AA	GG	AA
B7_40275618	A/C	7	40275618	AA	AA	CC	AA
B7_40275663	C/A	7	40275663	CC	CC	AA	CC
B7_40292787	G/A	7	40292787	GG	GG	AA	GG
B7_40292887	C/T	7	40292887	CC	CC	TT	CC
B7_40299802	G/T	7	40299802	GG	GG	TT	GG
B7_40299895	-/+	7	40299895	--	--	++	--
B7_40308278	G/A	7	40308278	GG	GG	AA	GG
B7_40684679	G/A	7	40684679	GG	GG	AA	GG
B7_41161522	A/T	7	41161522	AA	AA	TT	AA
B7_41161532	C/A	7	41161532	CC	CC	AA	CC
B7_41161573	A/G	7	41161573	AA	AA	GG	AA
B7_41252423	A/C	7	41252423	AA	AA	CC	AA
B7_41252425	-/+	7	41252425	--	--	++	--
B7_41270977	T/A	7	41270977	TT	TT	AA	TT
B7_41270979	G/T	7	41270979	GG	GG	TT	GG
B7_41271071	C/G	7	41271071	CC	CC	GG	CC
B7_41271086	C/T	7	41271086	CC	CT	CC	TT

Table 25: SNP and indel markers on carinata chromosome B8.

SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
B8_1090807	A/G	8	1090807	GG	AG	GG	GG
B8_1447009	G/A	8	1447009	GG	AG	GG	GG
B8_1447036	C/T	8	1447036	CC	CT	CC	CC
B8_1641528	T/G	8	1641528	TT	GT	TT	TT
B8_1743787	G/A	8	1743787	GG	AA	GG	GG
B8_1922582	C/G	8	1922582	GG	CC	CC	CC
B8_1922583	C/T	8	1922583	TT	CC	CC	CC
B8_2242534	A/G	8	2242534	GG	AA	AA	AA
B8_2242585	C/A	8	2242585	AA	CC	CC	CC
B8_2242594	T/A	8	2242594	AA	TT	TT	TT
B8_2242615	C/T	8	2242615	TT	CC	CC	CC
B8_2842440	A/G	8	2842440	GG	GG	AA	AA
B8_3054731	T/G	8	3054731	TT	TT	GG	GG
B8_3110158	+/-/G/C	8	3110158	GG	GG	++	++
B8_3138547	A/G	8	3138547	AA	AA	GG	AA
B8_3138568	-/+	8	3138568	--	--	++	--

B8_3138586	A/G	8	3138586	AA	AA	GG	AA
B8_3138589	A/G	8	3138589	AA	AA	GG	AA
B8_3138628	A/G	8	3138628	AA	AA	GG	AA
B8_3138636	C/G	8	3138636	CC	CC	GG	CC
B8_3138695	G/C	8	3138695	GG	GG	CC	GG
B8_3138696	C/T	8	3138696	CC	CC	TT	CC
B8_3186949	A/C	8	3186949	CC	CC	AA	AA
B8_3191268	G/A	8	3191268	AA	AA	GG	GG
B8_3191352	G/A	8	3191352	AA	AA	GG	GG
B8_3191405	C/T	8	3191405	TT	TT	CC	CC
B8_3370666	A/G	8	3370666	AA	AA	GG	GG
B8_4133264	G/A	8	4133264	AA	AA	GG	GG
B8_4133271	T/C	8	4133271	CC	CC	TT	TT
B8_4133289	C/G	8	4133289	GG	GG	CC	CC
B8_4133310	G/A	8	4133310	AA	AA	GG	GG
B8_4133337	A/G	8	4133337	GG	GG	AA	AA
B8_4133598	C/A	8	4133598	AA	AA	CC	CC
B8_4165900	T/A	8	4165900	AA	AA	TT	TT
B8_4595200	G/T	8	4595200	GG	TT	TT	TT
B8_4595354	G/T	8	4595354	GG	TT	TT	TT
B8_4595359	A/T	8	4595359	AA	TT	TT	TT
B8_4941194	T/A	8	4941194	AA	AA	TT	TT
B8_4948345	A/G	8	4948345	AA	AA	GG	GG
B8_4948918	A/G	8	4948918	AA	AA	GG	GG
B8_4948947	C/G	8	4948947	CC	CC	GG	GG
B8_6002014	G/A	8	6002014	GG	GG	AA	AA
B8_6002027	+/-	8	6002027	--	++	++	++
B8_6244035	T/G	8	6244035	GG	GG	TT	TT
B8_6244045	G/A	8	6244045	AA	AA	GG	GG
B8_6244225	G/A	8	6244225	AA	AA	GG	GG
B8_6244238	C/T	8	6244238	TT	TT	CC	CC
B8_6347021	T/A	8	6347021	TT	TT	AA	AA
B8_6347244	C/T	8	6347244	CC	CC	TT	TT
B8_6347257	C/G	8	6347257	CC	CC	GG	GG
B8_6347268	A/C	8	6347268	AA	AA	CC	CC
B8_6362212	T/G	8	6362212	TT	TT	GG	GG
B8_6362337	C/A	8	6362337	CC	CC	AA	AA
B8_6362359	C/T	8	6362359	CC	CC	TT	TT
B8_6417857	A/T	8	6417857	AA	AA	TT	TT
B8_6417860	+/-	8	6417860	++	++	--	--
B8_6418001	G/A	8	6418001	GG	GG	AA	AA

B8_7529862	G/A	8	7529862	GG	GG	AA	AA
B8_7529866	A/G	8	7529866	AA	AA	GG	GG
B8_7529890	A/T	8	7529890	AA	AA	TT	TT
B8_7529924	T/C	8	7529924	TT	TT	CC	TT
B8_7530033	G/A	8	7530033	GG	GG	AA	AA
B8_7530039	G/T	8	7530039	GG	GG	TT	TT
B8_7530068	C/T	8	7530068	CC	CC	TT	TT
B8_7705274	G/A	8	7705274	GG	GG	AA	AA
B8_7705306	A/G	8	7705306	AA	AA	GG	GG
B8_7705569	A/C	8	7705569	AA	AA	CC	CC
B8_7718880	G/A	8	7718880	GG	GG	AA	AA
B8_8391973	C/A	8	8391973	CC	CC	AA	AA
B8_8392009	C/T	8	8392009	CC	CC	TT	TT
B8_8392012	C/A	8	8392012	CC	CC	AA	AA
B8_8392018	G/A	8	8392018	GG	AG	AA	AA
B8_8392071	T/C	8	8392071	TT	TT	CC	CC
B8_8494304	A/G	8	8494304	AA	AA	GG	GG
B8_9935447	A/G	8	9935447	AA	AA	GG	GG
B8_9935450	T/G	8	9935450	TT	TT	GG	GG
B8_9935465	A/G	8	9935465	AA	AA	GG	GG
B8_9982889	-/+	8	9982889	--	--	++	++
B8_9982908	A/C	8	9982908	AA	AA	CC	CC
B8_10012478	A/G	8	10012478	AA	AA	GG	GG
B8_10012481	A/G	8	10012481	AA	AA	GG	GG
B8_11321729	+/-	8	11321729	--	++	++	++
B8_12164698	A/G	8	12164698	GG	GG	AA	AA
B8_12164707	T/A	8	12164707	AA	AA	TT	TT
B8_12243614	G/A	8	12243614	AA	AA	GG	GG
B8_12268285	T/G	8	12268285	GG	GG	TT	TT
B8_12268293	-/+	8	12268293	++	++	--	--
B8_12268299	A/T	8	12268299	TT	TT	AA	AA
B8_12268320	-/+	8	12268320	++	++	--	--
B8_12268406	A/C	8	12268406	CC	CC	AA	AA
B8_12268451	C/T	8	12268451	TT	TT	CC	CC
B8_12553358	C/A	8	12553358	AA	AA	CC	CC
B8_12553376	G/T	8	12553376	TT	TT	GG	GG
B8_12553381	T/A	8	12553381	AA	AA	TT	TT
B8_12577397	G/T	8	12577397	TT	TT	GG	GG
B8_12577626	C/A	8	12577626	AA	AA	CC	CC
B8_14016390	A/G	8	14016390	AA	AA	GG	GG
B8_14016489	T/C	8	14016489	TT	TT	CC	CC

B8_14017343	A/T	8	14017343	AA	AA	TT	TT
B8_14643054	A/G	8	14643054	AA	AA	GG	GG
B8_14643087	G/A	8	14643087	GG	GG	AA	AA
B8_15100151	G/T	8	15100151	GG	GG	TT	TT
B8_15560051	T/C	8	15560051	TT	TT	CC	CC
B8_15560057	C/T	8	15560057	CC	CC	TT	TT
B8_15789598	+/-	8	15789598	--	++	++	--
B8_16792895	G/A	8	16792895	AA	AA	GG	GG
B8_18048421	A/C	8	18048421	AA	AA	CC	CC
B8_18048471	C/T	8	18048471	CC	CC	TT	TT
B8_18048632	C/A	8	18048632	CC	CC	AA	AA
B8_18123926	G/T	8	18123926	GG	GG	TT	TT
B8_18313384	-/+	8	18313384	--	--	++	++
B8_18339707	C/T	8	18339707	CC	CC	TT	TT
B8_18339712	C/G	8	18339712	CC	CC	GG	GG
B8_18339748	C/T	8	18339748	CC	CC	TT	TT
B8_19149989	+/-	8	19149989	--	++	++	++
B8_22821928	+/-	8	22821928	--	++	++	++
B8_22990316	T/C	8	22990316	CC	CC	TT	CC
B8_22990325	T/A	8	22990325	AA	AA	TT	AA
B8_23239481	+/-	8	23239481	--	++	++	++
B8_23476512	G/A	8	23476512	AA	GG	GG	AA
B8_23521887	+/-	8	23521887	--	++	++	--
B8_23799163	T/A	8	23799163	AA	AA	TT	AA
B8_23799201	A/C	8	23799201	CC	CC	AA	CC
B8_23846657	G/T	8	23846657	TT	TT	GG	TT
B8_24822175	G/A	8	24822175	GG	GG	AA	AA
B8_24822309	C/T	8	24822309	CC	CC	TT	TT
B8_24894427	+/-	8	24894427	--	++	++	++
B8_28440104	T/C	8	28440104	CC	CC	TT	TT
B8_28484898	G/C	8	28484898	GG	GG	CC	CC
B8_29423999	T/G	8	29423999	TT	TT	GG	TT
B8_30988629	+/-	8	30988629	--	++	++	++
B8_32727120	G/T	8	32727120	GG	GG	TT	GG
B8_32900417	G/A	8	32900417	AA	AA	GG	GG
B8_35916210	+/-	8	35916210	--	++	++	++
B8_36057952	+/-	8	36057952	--	--	++	++
B8_39079317	G/A	8	39079317	GG	GG	GG	AA
B8_42731470	+/-	8	42731470	--	--	++	++
B8_42742470	+/-	8	42742470	--	--	++	++
B8_44851959	A/G	8	44851959	GG	GG	AA	AA

B8_44852066	A/T	8	44852066	TT	TT	AA	AA
B8_44988030	T/C	8	44988030	CC	CC	TT	TT
B8_44988044	A/G	8	44988044	GG	GG	AA	AA
B8_45665359	A/G	8	45665359	AA	AA	AA	GG
B8_45709506	C/A	8	45709506	CC	CC	AA	AA
B8_45709541	G/A	8	45709541	GG	GG	AA	AA
B8_45709739	C/T	8	45709739	CC	CC	TT	TT
B8_46319592	T/G	8	46319592	TT	TT	TT	GG
B8_46323052	+/-	8	46323052	++	++	--	++
B8_46323053	+/-	8	46323053	++	++	--	++
B8_46323054	+/-	8	46323054	++	++	--	++
B8_46323075	G/A	8	46323075	GG	GG	GG	AA
B8_46384491	T/C	8	46384491	TT	TT	CC	CC
B8_46467259	A/G	8	46467259	AA	AA	GG	GG
B8_47148213	G/T	8	47148213	GG	GG	GG	TT
B8_47148263	G/A	8	47148263	GG	GG	GG	AA
B8_47148382	C/T	8	47148382	CC	CC	TT	CC
B8_47254049	G/A	8	47254049	GG	GG	GG	AA
B8_47491185	A/G	8	47491185	AA	AA	AA	GG
B8_48103381	G/C	8	48103381	GG	GG	CC	GG
B8_48103392	A/C	8	48103392	AA	AA	CC	AA
B8_48103494	A/G	8	48103494	AA	AA	GG	AA
B8_48144356	+/-	8	48144356	++	++	--	++
B8_49616122	T/C	8	49616122	TT	TT	TT	CC
B8_49616208	C/T	8	49616208	CC	CC	CC	TT
B8_49831698	G/A	8	49831698	GG	GG	GG	AA
B8_49831746	-/+	8	49831746	--	--	--	++
B8_49831749	T/G	8	49831749	TT	TT	TT	GG
B8_49831895	C/T	8	49831895	CC	CC	CC	TT
B8_49900066	G/A	8	49900066	GG	GG	GG	AA
B8_49900202	+/-	8	49900202	++	++	++	--
B8_49900244	A/C	8	49900244	AA	AA	AA	CC
B8_49900247	A/G	8	49900247	AA	AA	AA	GG
B8_51057417	A/G	8	51057417	GG	AA	AA	AA
B8_52088117	T/C	8	52088117	CC	CC	TT	TT
B8_52088119	A/G	8	52088119	GG	GG	AA	AA
B8_52088167	G/A	8	52088167	AA	AA	GG	GG
B8_52088170	C/T	8	52088170	TT	TT	CC	CC
B8_52088326	G/T	8	52088326	TT	TT	GG	GG
B8_52727370	G/A	8	52727370	GG	GG	AA	AA
B8_52727373	G/A	8	52727373	GG	GG	AA	AA

B8_52727394	+/-	8	52727394	++	++	--	--
B8_52727398	+/-	8	52727398	++	++	--	--
B8_52727570	C/T	8	52727570	CC	CC	TT	TT
B8_52737883	G/A	8	52737883	GG	GG	AA	AA
B8_52737912	C/T	8	52737912	CC	CC	TT	TT
B8_53493020	C/G	8	53493020	GG	GG	CC	GG
B8_54089490	T/C	8	54089490	TT	TT	CC	TT
B8_54089574	G/A	8	54089574	GG	GG	AA	GG
B8_54089622	C/T	8	54089622	CC	CC	TT	CC
B8_54089625	C/T	8	54089625	CC	CC	TT	CC

Table 26: SNP and indel markers on carinata chromosome C1.

SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
C1_586106	A/T	9	586106	TT	AA	TT	AA
C1_1228180	-/+	9	1228180	--	--	--	++
C1_1242422	G/A	9	1242422	GG	GG	GG	AA
C1_1242445	C/A	9	1242445	CC	CC	CC	AA
C1_1688033	A/T	9	1688033	TT	AA	TT	TT
C1_2894373	T/A	9	2894373	AA	AA	TT	TT
C1_2894383	A/T	9	2894383	TT	TT	AA	AA
C1_3572717	T/A	9	3572717	TT	TT	TT	AA
C1_3572734	C/T	9	3572734	CC	CC	CC	TT
C1_3572737	A/G	9	3572737	AA	AA	AA	GG
C1_3572738	C/T	9	3572738	CC	CC	CC	TT
C1_3572739	A/G	9	3572739	AA	AA	AA	GG
C1_5759051	A/G	9	5759051	AA	AA	GG	AA
C1_5762693	G/A	9	5762693	GG	GG	AA	GG
C1_5762830	T/C	9	5762830	TT	TT	CC	TT
C1_5762847	T/C	9	5762847	TT	TT	CC	TT
C1_5838158	C/T	9	5838158	CC	CC	CC	TT
C1_5903286	A/G	9	5903286	AA	AA	GG	AA
C1_6033630	G/A	9	6033630	GG	GG	AA	GG
C1_6033646	A/C	9	6033646	AA	AA	CC	AA
C1_6033691	C/T	9	6033691	CC	CC	TT	CC
C1_6033737	T/G	9	6033737	TT	TT	GG	TT
C1_6054450	T/C	9	6054450	TT	TT	CC	TT
C1_7481824	+/-	9	7481824	++	++	--	++
C1_7481854	-/+	9	7481854	--	--	++	--

C1_7481868	-/+	9	7481868	--	--	++	--
C1_7973344	G/T	9	7973344	TT	TT	GG	TT
C1_7973404	G/C	9	7973404	GG	GG	CC	GG
C1_8047087	G/A	9	8047087	AA	AA	AA	AA
C1_8329614	A/G	9	8329614	AA	AA	AA	GG
C1_8995679	C/G	9	8995679	CC	CC	CC	GG
C1_8995722	G/T	9	8995722	GG	GG	GG	TT
C1_9075842	A/C	9	9075842	CC	CC	AA	AA
C1_10535408	T/C	9	10535408	TT	CC	TT	CC
C1_11205784	G/C	9	11205784	GG	CC	GG	GG
C1_11214491	-/+	9	11214491	++	++	--	--
C1_11214494	G/A	9	11214494	AA	AA	GG	GG
C1_11214602	T/G	9	11214602	TT	GG	TT	TT
C1_11238865	C/T	9	11238865	CC	TT	CC	CC
C1_11340925	C/T	9	11340925	CC	CC	CC	TT
C1_11341081	G/A	9	11341081	GG	GG	GG	AA
C1_11342007	T/C	9	11342007	TT	TT	TT	CC
C1_11342070	A/C	9	11342070	AA	AA	AA	CC
C1_11656283	G/A	9	11656283	AA	GG	AA	AA
C1_11656371	T/C	9	11656371	CC	TT	CC	CC
C1_11879045	+/-	9	11879045	--	--	++	++
C1_13213148	A/C	9	13213148	AA	CC	AA	AA
C1_13213168	-/+	9	13213168	--	++	--	--
C1_13213170	+/-	9	13213170	++	--	++	++
C1_13607542	G/C	9	13607542	GG	CC	GG	GG
C1_14274629	G/A	9	14274629	GG	AA	GG	GG
C1_14274642	T/C	9	14274642	TT	CC	TT	TT
C1_14391249	+/-	9	14391249	--	++	--	++
C1_15058347	A/G	9	15058347	AA	GG	AA	GG
C1_15091576	T/C	9	15091576	TT	CC	TT	CC
C1_15091577	T/C	9	15091577	TT	CC	TT	CC
C1_15146165	G/A	9	15146165	GG	AA	GG	AA
C1_15146199	G/A	9	15146199	GG	AA	GG	AA
C1_15146206	G/A	9	15146206	GG	AA	GG	AA
C1_15146212	A/G	9	15146212	AA	GG	AA	GG
C1_15146243	A/G	9	15146243	AA	GG	AA	GG
C1_15154306	G/A	9	15154306	GG	AA	GG	AA
C1_15198584	C/T	9	15198584	CC	TT	CC	TT
C1_15198611	T/C	9	15198611	TT	CC	TT	CC
C1_15198635	C/T	9	15198635	CC	TT	CC	TT
C1_15198646	G/A	9	15198646	GG	AA	GG	AA

C1_15753817	A/G	9	15753817	AA	GG	AA	GG
C1_15754498	A/T	9	15754498	AA	TT	AA	TT
C1_15855165	A/G	9	15855165	AA	GG	AA	AA
C1_17184379	A/G	9	17184379	GG	AA	AA	AA
C1_24823670	+/-	9	24823670	--	++	++	++
C1_25812877	T/C	9	25812877	TT	TT	TT	CC
C1_28763144	+/-	9	28763144	--	++	++	++
C1_33744223	A/G	9	33744223	AA	AA	AA	GG
C1_33744234	C/T	9	33744234	CC	CC	CC	TT
C1_33744240	C/A	9	33744240	CC	CC	CC	AA
C1_33744303	G/A	9	33744303	GG	GG	GG	AA
C1_33795936	A/C	9	33795936	AA	AA	AA	CC
C1_33796068	C/T	9	33796068	CC	CC	CC	TT
C1_35710691	G/T	9	35710691	GG	GG	GG	TT
C1_35835246	G/A	9	35835246	GG	GG	GG	AA
C1_40664205	G/A	9	40664205	GG	GG	AA	AA
C1_40941118	T/G	9	40941118	TT	TT	GG	TT
C1_40941172	T/C	9	40941172	TT	TT	CC	TT
C1_41471413	C/A	9	41471413	CC	AA	AA	AA
C1_41471437	G/C	9	41471437	GG	CC	CC	CC
C1_41648625	+/-	9	41648625	--	--	++	++
C1_42587841	T/C	9	42587841	CC	CC	TT	TT
C1_42587876	A/G	9	42587876	GG	GG	AA	AA
C1_42587881	G/C	9	42587881	CC	CC	GG	GG
C1_42587918	A/G	9	42587918	GG	GG	AA	AA
C1_42730669	A/G	9	42730669	AA	AA	AA	GG
C1_42730813	G/C	9	42730813	GG	GG	GG	CC

Table 27: SNP and indel markers on carinata chromosome C2.

SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
C2_514038	C/A	10	514038	CC	CC	CC	AA
C2_514157	T/G	10	514157	TT	TT	TT	GG
C2_1412825	A/T	10	1412825	TT	AA	TT	TT
C2_1412934	G/T	10	1412934	TT	GG	TT	TT
C2_2562301	+/-	10	2562301	--	++	++	++
C2_2669154	G/A	10	2669154	AA	GG	GG	GG
C2_2759721	A/G	10	2759721	GG	AA	GG	GG
C2_2759729	T/A	10	2759729	AA	TT	AA	AA

C2_2759828	A/G	10	2759828	GG	AA	GG	GG
C2_2759842	G/T	10	2759842	TT	GG	TT	TT
C2_2836709	T/A	10	2836709	AA	TT	TT	TT
C2_2991663	T/A	10	2991663	TT	AA	AA	AA
C2_3663311	C/T	10	3663311	CC	TT	CC	CC
C2_3670932	G/A	10	3670932	GG	AA	GG	GG
C2_4276920	G/A	10	4276920	GG	GG	AA	GG
C2_4312969	A/G	10	4312969	AA	AA	GG	AA
C2_4313001	T/A	10	4313001	TT	TT	AA	TT
C2_4904459	C/T	10	4904459	CC	TT	CC	CC
C2_4904495	G/A	10	4904495	GG	AA	GG	GG
C2_4904504	A/C	10	4904504	AA	CC	AA	AA
C2_4904610	C/T	10	4904610	CC	TT	CC	CC
C2_4904627	C/G	10	4904627	CC	GG	CC	CC
C2_5345920	T/C	10	5345920	TT	CC	TT	TT
C2_5345935	A/G	10	5345935	AA	GG	AA	AA
C2_5346054	C/T	10	5346054	CC	TT	CC	CC
C2_6992132	T/C	10	6992132	TT	CC	TT	TT
C2_7037297	G/A	10	7037297	GG	AA	GG	GG
C2_7037413	A/G	10	7037413	AA	GG	AA	AA
C2_7037447	C/G	10	7037447	CC	GG	CC	CC
C2_7037455	C/T	10	7037455	CC	TT	CC	CC
C2_7038868	A/C	10	7038868	AA	CC	AA	AA
C2_14184685	+/-	10	14184685	--	--	++	++
C2_15228924	G/T/A	10	15228924	GG	GG	TT	GG
C2_15385104	+/-	10	15385104	--	--	++	--
C2_21439079	A/G	10	21439079	GG	AA	GG	AA
C2_28463898	C/T	10	28463898	CC	CC	TT	TT
C2_29475511	C/G	10	29475511	CC	CC	CC	GG
C2_35663725	+/-	10	35663725	--	--	++	++
C2_36486176	C/T	10	36486176	CC	TT	CC	CC
C2_42185103	+/-	10	42185103	--	++	++	--
C2_45008084	-/+	10	45008084	--	--	++	++
C2_45501881	+/-	10	45501881	--	--	++	++
C2_47679077	+/-	10	47679077	--	++	++	--
C2_49092619	G/T	10	49092619	GG	GT	GG	GG
C2_49092678	T/C	10	49092678	TT	CT	TT	TT

Table 28: SNP and indel markers on carinata chromosome C3.

SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
C3_402312	A/G	11	402312	GG	GG	AA	AA
C3_403086	A/G	11	403086	GG	GG	AA	AA
C3_404181	A/T	11	404181	TT	TT	AA	AA
C3_404339	A/T	11	404339	TT	TT	AA	AA
C3_938430	C/A	11	938430	CC	CC	AA	CC
C3_938496	C/T	11	938496	CC	CC	TT	CC
C3_1850217	+/-	11	1850217	--	--	++	++
C3_1897354	A/G	11	1897354	AA	AA	AA	GG
C3_1897357	G/C	11	1897357	GG	GG	GG	CC
C3_1897360	A/C	11	1897360	AA	AA	AA	CC
C3_1908931	C/G	11	1908931	CC	CC	CC	GG
C3_3409357	C/T	11	3409357	TT	TT	CC	CC
C3_5313485	C/A	11	5313485	CC	CC	AA	AA
C3_6314829	+/-	11	6314829	--	++	++	++
C3_6598198	A/G	11	6598198	AA	AA	GG	AA
C3_6598262	G/A	11	6598262	GG	GG	AA	GG
C3_6598266	-/+	11	6598266	--	--	++	--
C3_6598271	+/-	11	6598271	++	++	--	++
C3_6598277	A/C	11	6598277	AA	AA	CC	AA
C3_6598278	C/T	11	6598278	CC	CC	TT	CC
C3_6598287	T/A	11	6598287	TT	TT	AA	TT
C3_6598295	G/A	11	6598295	GG	GG	AA	GG
C3_6598309	A/C	11	6598309	AA	AA	CC	AA
C3_6604144	T/C	11	6604144	TT	TT	CC	TT
C3_6604205	C/T	11	6604205	CC	CC	TT	CC
C3_6604298	-/+	11	6604298	--	--	++	--
C3_6677572	T/A	11	6677572	TT	TT	AA	AA
C3_6812649	G/T	11	6812649	GG	GG	GG	TT
C3_6812663	T/C	11	6812663	TT	TT	TT	CC
C3_7127918	G/A	11	7127918	GG	AA	GG	GG
C3_9013166	T/C	11	9013166	CC	TT	CC	TT
C3_9013252	T/C	11	9013252	CC	TT	CC	TT
C3_9138799	T/C	11	9138799	CC	TT	TT	TT
C3_10013183	T/C	11	10013183	CC	TT	CC	TT
C3_10037032	+/-	11	10037032	++	++	--	++
C3_10037067	A/G	11	10037067	AA	AA	GG	AA
C3_10037068	G/C	11	10037068	GG	GG	CC	GG
C3_10037076	G/A	11	10037076	GG	GG	AA	GG

C3_10037134	T/C	11	10037134	TT	TT	CC	TT
C3_10048139	C/G	11	10048139	CC	CC	GG	CC
C3_10520990	G/A	11	10520990	GG	AA	AA	GG
C3_10918852	G/T/A	11	10918852	GG	GG	TT	GG
C3_12863214	C/T	11	12863214	CC	TT	CC	CC
C3_14810500	A/T	11	14810500	TT	TT	AA	AA
C3_14810677	A/G	11	14810677	GG	GG	AA	AA
C3_15602161	C/T	11	15602161	CC	TT	TT	TT
C3_15602163	A/C	11	15602163	AA	CC	CC	CC
C3_15602216	T/C	11	15602216	TT	CC	CC	CC
C3_15930324	G/C	11	15930324	CC	GG	GG	GG
C3_15930354	+/-	11	15930354	--	++	++	++
C3_15939828	T/A	11	15939828	AA	TT	TT	TT
C3_17177929	C/A	11	17177929	AA	CC	AA	AA
C3_17178063	-/+	11	17178063	++	--	++	--
C3_17178120	G/C	11	17178120	CC	GG	CC	CC
C3_17178249	G/A	11	17178249	AA	GG	AA	GG
C3_17203544	A/G	11	17203544	GG	AA	GG	GG
C3_17216383	C/A	11	17216383	AA	CC	AA	CC
C3_17440059	C/A	11	17440059	CC	CC	AA	AA
C3_18312272	A/G	11	18312272	GG	AA	GG	GG
C3_18312296	T/A	11	18312296	AA	TT	AA	AA
C3_18312303	G/A	11	18312303	AA	GG	AA	AA
C3_18987061	+/-	11	18987061	--	++	++	++
C3_21472822	G/A	11	21472822	GG	GG	AA	AA
C3_21690969	+/-	11	21690969	--	++	++	++
C3_22569196	G/A	11	22569196	AA	GG	GG	GG
C3_22569199	G/A	11	22569199	AA	GG	GG	GG
C3_22569202	T/C	11	22569202	CC	TT	TT	TT
C3_22569226	A/G	11	22569226	GG	AA	AA	AA
C3_22569250	+/-	11	22569250	--	++	++	++
C3_23451713	A/G	11	23451713	AA	GG	AA	AA
C3_23451753	T/C	11	23451753	TT	CC	TT	TT
C3_23451962	G/T	11	23451962	GG	TT	GG	GG
C3_23452086	A/G	11	23452086	AA	GG	AA	AA
C3_24195209	C/T	11	24195209	CC	TT	TT	TT
C3_24195215	C/G	11	24195215	CC	GG	GG	GG
C3_24195238	G/A	11	24195238	GG	AA	AA	AA
C3_24195265	-/+	11	24195265	--	++	++	++
C3_24195273	+/-	11	24195273	++	--	--	--
C3_24195278	A/T	11	24195278	AA	TT	TT	TT

C3_24195282	+/-	11	24195282	++	--	--	--
C3_24195283	+/-	11	24195283	++	--	--	--
C3_24195311	-/+	11	24195311	--	++	++	++
C3_25029585	+/-	11	25029585	--	++	++	++
C3_25957548	G/A	11	25957548	GG	GG	AA	AA
C3_25957577	C/G	11	25957577	CC	CC	GG	GG
C3_25957598	A/G	11	25957598	AA	AA	GG	GG
C3_27064045	C/T	11	27064045	CC	TT	CC	CC
C3_29046232	T/G	11	29046232	TT	TT	GG	GG
C3_29046278	G/A	11	29046278	GG	GG	AA	AA
C3_29046307	G/T	11	29046307	GG	GG	TT	TT
C3_29046388	C/T	11	29046388	CC	CC	TT	TT
C3_29046395	A/C	11	29046395	AA	AA	CC	CC
C3_29754400	A/C	11	29754400	AA	AA	CC	CC
C3_29754430	C/T	11	29754430	TT	CC	CC	CC
C3_31586079	T/C	11	31586079	CC	TT	CC	CC
C3_31586707	G/T	11	31586707	TT	GG	TT	TT
C3_31631989	T/A	11	31631989	AA	TT	AA	AA
C3_31632035	A/G	11	31632035	GG	AA	GG	GG
C3_31632048	T/G	11	31632048	GG	TT	GG	GG
C3_31712163	G/T	11	31712163	TT	GG	TT	TT
C3_31713397	T/C	11	31713397	TT	CC	TT	TT
C3_31713398	T/A	11	31713398	TT	AA	TT	TT
C3_32992766	C/T	11	32992766	TT	CC	CC	CC
C3_34884215	A/C	11	34884215	CC	CC	AA	AA
C3_34907914	G/A	11	34907914	AA	AA	GG	GG
C3_34907920	A/C	11	34907920	CC	CC	AA	AA
C3_35611604	A/T	11	35611604	AA	TT	TT	TT
C3_35611645	T/C	11	35611645	TT	CC	CC	CC
C3_35611673	G/A	11	35611673	GG	AA	AA	AA
C3_36344095	C/T	11	36344095	CC	TT	CC	CC
C3_36344107	-/+	11	36344107	--	++	--	--
C3_36362939	A/G	11	36362939	AA	GG	AA	AA
C3_36375157	+/-	11	36375157	++	--	++	++
C3_36836893	C/T	11	36836893	CC	CC	TT	TT
C3_36991672	C/T	11	36991672	TT	TT	CC	CC
C3_37772500	C/G	11	37772500	CC	GG	GG	GG
C3_37772623	G/A	11	37772623	GG	AA	AA	AA
C3_42991081	+/-	11	42991081	--	++	++	--
C3_44468558	+/-	11	44468558	--	++	++	++
C3_45818710	+/-	11	45818710	--	++	++	--

C3_51753322	A/C	11	51753322	AA	AA	CC	AA
C3_51983708	C/A	11	51983708	AA	AA	CC	CC
C3_51983742	C/T	11	51983742	TT	TT	CC	CC
C3_51983757	C/T	11	51983757	TT	TT	CC	CC
C3_52950507	C/T	11	52950507	CC	TT	CC	CC
C3_52965590	T/C	11	52965590	TT	CC	TT	TT
C3_52965690	C/A	11	52965690	CC	AA	CC	CC
C3_52965696	T/G	11	52965696	TT	GG	TT	TT
C3_55767842	C/A	11	55767842	AA	CC	CC	CC
C3_56855879	G/T	11	56855879	GG	TT	GG	GG
C3_56855941	C/A	11	56855941	CC	AA	CC	CC
C3_56859509	C/T	11	56859509	CC	TT	CC	CC
C3_56859547	A/G	11	56859547	AA	GG	AA	AA
C3_56859587	A/C	11	56859587	AA	CC	AA	AA
C3_57142241	A/G	11	57142241	GG	GG	AA	AA
C3_57142510	G/T	11	57142510	TT	TT	GG	GG
C3_58071700	G/A	11	58071700	AA	AA	GG	GG
C3_58071768	A/G	11	58071768	GG	GG	AA	AA
C3_58323349	G/A	11	58323349	AA	AA	GG	GG
C3_61193980	+/-	11	61193980	--	++	++	--
C3_62100550	T/C	11	62100550	CC	TT	TT	TT
C3_62111641	C/T	11	62111641	CC	CC	TT	TT
C3_62111674	T/C	11	62111674	TT	TT	CC	CC
C3_63656665	C/A	11	63656665	CC	CC	AA	CC
C3_63656747	C/T	11	63656747	CC	CC	TT	TT
C3_64263357	A/C	11	64263357	CC	AA	AA	AA
C3_64263365	A/G	11	64263365	GG	AA	AA	AA
C3_64263380	T/A	11	64263380	AA	TT	TT	TT
C3_64471086	A/C	11	64471086	CC	AA	AA	AA

Table 29: SNP and indel markers on carinata chromosome C4.

SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
C4_316683	G/T	12	316683	TT	GG	GG	GG
C4_898830	C/G	12	898830	CC	CC	GG	GG
C4_982261	G/A	12	982261	AA	GG	GG	GG
C4_1485442	C/A	12	1485442	CC	CC	AA	AA
C4_1485472	A/C	12	1485472	AA	AA	CC	CC
C4_1763830	C/T	12	1763830	CC	TT	TT	TT

C4_1763854	T/A	12	1763854	TT	AA	AA	AA
C4_1763920	G/A	12	1763920	GG	AA	AA	AA
C4_1770658	T/C	12	1770658	TT	CT	TT	TT
C4_1841557	+/-	12	1841557	--	++	++	--
C4_2744194	T/A	12	2744194	AT	AT	AA	AA
C4_3358344	T/C	12	3358344	TT	CT	TT	TT
C4_5594359	G/A	12	5594359	GG	GG	GG	AA
C4_5867296	T/A	12	5867296	TT	AA	AA	TT
C4_5867309	G/A	12	5867309	GG	AA	AA	GG
C4_5936991	G/A	12	5936991	GG	AG	AA	GG
C4_5937000	T/C	12	5937000	TT	CT	CC	TT
C4_5937005	+/-	12	5937005	++	-+	--	++
C4_6891288	A/T	12	6891288	TT	AA	AA	AA
C4_7065484	C/A	12	7065484	CC	AA	AA	AA
C4_7065525	C/A	12	7065525	CC	AA	AA	AA
C4_7065575	A/C	12	7065575	AA	CC	CC	CC
C4_7065577	G/T	12	7065577	GG	TT	TT	TT
C4_7065591	C/A	12	7065591	CC	AA	AA	AA
C4_7313310	T/C	12	7313310	TT	CT	CC	CC
C4_9060496	G/A	12	9060496	GG	AG	GG	GG
C4_9880986	C/T	12	9880986	CC	CC	CC	TT
C4_9880995	T/A	12	9880995	TT	TT	TT	AA
C4_9881027	T/A	12	9881027	TT	TT	TT	AA
C4_10126279	G/A	12	10126279	GG	GG	GG	AA
C4_10126285	A/T	12	10126285	AA	AA	AA	TT
C4_10126326	G/A	12	10126326	GG	GG	GG	AA
C4_10152940	A/T	12	10152940	AA	AA	AA	TT
C4_10153067	T/A	12	10153067	TT	TT	TT	AA
C4_10153111	G/A	12	10153111	GG	GG	GG	AA
C4_10888972	G/A	12	10888972	GG	GG	AA	GG
C4_10995930	T/A	12	10995930	TT	TT	AA	TT
C4_16680120	-/+	12	16680120	--	--	--	++
C4_21789986	+/-	12	21789986	--	++	++	--
C4_22725587	+/-	12	22725587	--	++	++	--
C4_27450819	T/G	12	27450819	GG	TT	GG	TT
C4_32528514	G/A	12	32528514	AA	AA	AA	GG
C4_32528517	C/G	12	32528517	GG	GG	GG	CC
C4_33927249	T/G	12	33927249	TT	TT	GG	GG
C4_37868619	C/A	12	37868619	CC	CC	CC	AA
C4_37868763	G/A	12	37868763	GG	GG	GG	AA
C4_37868766	G/T	12	37868766	GG	GG	GG	TT

C4_37985818	C/T	12	37985818	CC	CC	CC	TT
C4_38052425	T/C	12	38052425	TT	TT	TT	CC
C4_38052612	G/C	12	38052612	GG	GG	GG	CC
C4_38114258	G/A	12	38114258	GG	GG	GG	AA
C4_38135264	G/A	12	38135264	GG	GG	GG	AA
C4_38135266	C/A	12	38135266	CC	CC	CC	AA
C4_38135330	A/G	12	38135330	AA	AA	AA	GG
C4_38135333	T/C	12	38135333	TT	TT	TT	CC
C4_38149116	C/T	12	38149116	CC	CC	CC	TT
C4_38149201	T/C	12	38149201	TT	TT	TT	CC
C4_38748104	C/T	12	38748104	TT	TT	TT	CC
C4_39340740	+/-	12	39340740	--	++	++	++
C4_40489982	C/T	12	40489982	CC	CC	TT	CC
C4_40700520	A/T	12	40700520	AA	AA	TT	TT
C4_40729697	C/T	12	40729697	CC	CT	CC	CC
C4_42120786	C/T	12	42120786	CC	CC	TT	TT
C4_42399184	+/-	12	42399184	--	++	++	++
C4_42476790	C/A	12	42476790	CC	CC	CC	AA
C4_44105942	C/G	12	44105942	GG	GG	CC	GG
C4_45069785	A/T	12	45069785	TT	TT	TT	AA
C4_45069866	C/G	12	45069866	GG	GG	GG	CC
C4_45547283	A/G	12	45547283	AA	AA	GG	AA
C4_45632158	C/T	12	45632158	CC	CC	TT	TT
C4_45632227	G/A	12	45632227	AA	AA	GG	GG
C4_45632323	G/C	12	45632323	GG	GG	GG	CC
C4_45632341	T/G	12	45632341	TT	TT	TT	GG
C4_45632344	C/T	12	45632344	CC	CC	CC	TT
C4_45632353	T/G	12	45632353	TT	TT	TT	GG
C4_49259378	T/G	12	49259378	TT	TT	GG	TT
C4_52861602	G/A	12	52861602	GG	GG	AA	AA
C4_53426635	C/T	12	53426635	TT	TT	CC	CC
C4_53426676	G/A	12	53426676	AA	AA	GG	GG
C4_53426689	T/C	12	53426689	CC	CC	TT	TT
C4_53426737	T/A	12	53426737	AA	AA	TT	TT
C4_53426743	A/G	12	53426743	GG	GG	AA	AA
C4_53426794	A/G	12	53426794	GG	GG	AA	AA
C4_53426812	G/A	12	53426812	AA	AA	GG	GG
C4_53426815	T/A	12	53426815	AA	AA	TT	TT

Table 30: SNP and indel markers on carinata chromosome C5.

SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
C5_1387661	C/G	13	1387661	CC	CC	GG	GG
C5_1925770	+/-	13	1925770	--	++	++	++
C5_1934828	C/T	13	1934828	TT	TT	CC	CC
C5_1934903	G/C	13	1934903	CC	CC	GG	GG
C5_1935530	A/G	13	1935530	GG	GG	AA	AA
C5_3640476	T/C	13	3640476	TT	TT	CC	CC
C5_4066621	C/T	13	4066621	TT	TT	CC	CC
C5_4066845	C/T	13	4066845	TT	TT	CC	CC
C5_4185197	+/-	13	4185197	++	++	--	++
C5_5250227	+/-	13	5250227	--	--	++	++
C5_5445243	T/C	13	5445243	CC	CC	TT	TT
C5_5445297	T/C	13	5445297	CC	CC	TT	TT
C5_5445321	T/C	13	5445321	CC	CC	TT	TT
C5_5445333	T/C	13	5445333	CC	CC	TT	TT
C5_7112785	G/A	13	7112785	GG	GG	AA	GG
C5_7165498	T/C	13	7165498	TT	TT	CC	CC
C5_8910868	+/-	13	8910868	--	++	++	--
C5_9557046	G/T	13	9557046	GG	GG	TT	GG
C5_9772976	C/T	13	9772976	CC	CC	CC	TT
C5_9773007	T/C	13	9773007	TT	TT	TT	CC
C5_10278536	T/C	13	10278536	CC	TT	TT	CC
C5_10452538	G/A	13	10452538	GG	GG	AA	AA
C5_10524532	G/A	13	10524532	AA	AA	GG	GG
C5_10524552	G/A	13	10524552	GG	GG	AA	GG
C5_12281663	G/A	13	12281663	GG	GG	GG	AA
C5_12281675	-/+	13	12281675	--	--	--	++
C5_12281691	T/C	13	12281691	TT	TT	TT	CC
C5_12281717	A/T	13	12281717	AA	AA	AA	TT
C5_12400648	C/G	13	12400648	CC	CC	GG	GG
C5_12400655	G/A	13	12400655	GG	GG	AA	AA
C5_13142196	G/A	13	13142196	GG	GG	GG	AA
C5_13236566	-/+	13	13236566	--	--	++	++
C5_14611995	G/A	13	14611995	AA	AA	GG	AA
C5_16938494	G/A	13	16938494	AA	AA	GG	GG
C5_16938510	A/G	13	16938510	GG	GG	AA	AA
C5_17169179	C/T	13	17169179	TT	TT	CC	TT
C5_17178493	A/T	13	17178493	AA	AA	TT	AA
C5_17545655	T/G	13	17545655	GG	GG	TT	GG

C5_17545689	C/T	13	17545689	TT	TT	CC	TT
C5_18337376	+/-	13	18337376	--	++	++	++
C5_25474382	G/A	13	25474382	GG	GG	AA	GG
C5_26042650	+/-	13	26042650	--	++	++	++
C5_27102262	C/T	13	27102262	CC	CC	TT	TT
C5_27782232	G/A	13	27782232	AA	GG	GG	GG
C5_27782234	+/-	13	27782234	--	++	++	++
C5_28778609	+/-	13	28778609	--	++	++	++
C5_35449882	A/T	13	35449882	AA	AA	TT	AA
C5_36675849	G/C	13	36675849	GG	GG	CC	GG
C5_36713233	T/C	13	36713233	TT	TT	CC	TT
C5_36789687	A/G	13	36789687	AA	AA	GG	AA
C5_36929185	+/-	13	36929185	--	++	++	--
C5_36970999	C/T	13	36970999	CC	CC	TT	CC
C5_37097664	T/C	13	37097664	TT	TT	CC	TT
C5_37251392	+/-	13	37251392	--	++	++	++
C5_38104699	T/G	13	38104699	GG	GG	TT	GG
C5_38104777	T/C	13	38104777	CC	CC	TT	CC
C5_38104808	T/C	13	38104808	CC	CC	TT	CC
C5_38104843	C/T	13	38104843	TT	TT	CC	TT
C5_38678731	G/A	13	38678731	AA	AA	GG	GG
C5_38678765	G/A	13	38678765	AA	AA	GG	GG
C5_38753994	C/T	13	38753994	TT	TT	CC	TT
C5_40054532	T/A	13	40054532	TT	TT	AA	TT
C5_40054533	T/C	13	40054533	TT	TT	CC	TT
C5_40054577	G/A	13	40054577	GG	GG	AA	GG
C5_40054593	G/A	13	40054593	GG	GG	AA	GG
C5_40054756	G/C	13	40054756	GG	GG	CC	GG
C5_40058118	C/G	13	40058118	CC	CC	GG	CC
C5_40058127	C/T	13	40058127	CC	CC	TT	CC
C5_40058166	A/G	13	40058166	AA	AA	GG	AA
C5_40058188	T/A	13	40058188	TT	TT	AA	TT
C5_40058191	G/A	13	40058191	GG	GG	AA	GG
C5_40058224	C/T	13	40058224	CC	CC	TT	CC
C5_40380584	A/C	13	40380584	AA	AA	CC	AA
C5_41138635	+/-	13	41138635	--	++	--	++
C5_41390375	A/T	13	41390375	AA	TT	AA	TT
C5_41518695	T/G	13	41518695	GG	TT	GG	TT
C5_42950437	A/G	13	42950437	AA	AA	GG	AA
C5_44114003	A/T	13	44114003	AA	AA	TT	AA

Table 31: SNP and indel markers on carinata chromosome C6.

SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
C6_24089	T/G	14	24089	TT	TT	GG	TT
C6_93254	C/T	14	93254	CC	CC	TT	TT
C6_202280	G/C	14	202280	CC	CC	CC	GG
C6_202295	T/A	14	202295	AA	AA	TT	TT
C6_202302	T/A	14	202302	AA	AA	AA	TT
C6_202313	G/T	14	202313	TT	TT	TT	GG
C6_255563	-/+	14	255563	++	++	--	--
C6_2568340	C/A	14	2568340	CC	CC	AA	CC
C6_4406227	C/A	14	4406227	CC	AC	CC	CC
C6_5886822	C/A	14	5886822	CC	CC	AA	CC
C6_5886834	G/T	14	5886834	GG	GG	TT	GG
C6_6353028	G/A	14	6353028	GG	GG	AA	GG
C6_6353047	G/A	14	6353047	GG	GG	AA	GG
C6_6612369	G/T	14	6612369	GG	GG	TT	GG
C6_6612445	G/T	14	6612445	GG	GG	TT	GG
C6_7679720	C/T	14	7679720	TT	TT	CC	TT
C6_7679743	A/G	14	7679743	GG	GG	AA	GG
C6_7679746	G/A	14	7679746	AA	AA	GG	AA
C6_8592083	T/C	14	8592083	TT	TT	CC	TT
C6_8944447	A/G	14	8944447	AA	GG	GG	GG
C6_9865953	G/A	14	9865953	GG	GG	AA	GG
C6_11947991	G/T/A	14	11947991	GG	GG	TT	GG
C6_12705722	G/A	14	12705722	GG	GG	AA	GG
C6_13531301	C/T	14	13531301	CC	CC	TT	CC
C6_13826462	G/T	14	13826462	GG	GG	TT	GG
C6_13826463	A/G	14	13826463	AA	AA	GG	AA
C6_13826487	A/G	14	13826487	AA	AA	GG	AA
C6_13964406	A/G	14	13964406	AA	AA	GG	AA
C6_16005270	T/C	14	16005270	CC	TT	CC	TT
C6_16005327	T/A	14	16005327	AA	TT	AA	TT
C6_16142925	+/-	14	16142925	--	++	++	++
C6_16477949	A/G	14	16477949	AA	GG	AA	GG
C6_16477968	T/C	14	16477968	TT	CC	TT	CC
C6_16478002	G/T	14	16478002	GG	TT	GG	TT
C6_16478026	A/G	14	16478026	AA	GG	AA	GG
C6_16614484	C/T	14	16614484	CC	CC	TT	CC
C6_16622533	C/T	14	16622533	CC	CC	TT	CC
C6_16848729	C/G	14	16848729	CC	GG	CC	GG

C6_16848746	C/G	14	16848746	CC	GG	CC	GG
C6_17323368	T/C	14	17323368	CC	TT	TT	TT
C6_18030349	G/T	14	18030349	GG	GG	TT	GG
C6_18151727	T/G	14	18151727	GG	TT	GG	TT
C6_18151805	G/A	14	18151805	AA	GG	AA	GG
C6_18882747	G/A	14	18882747	AA	AA	GG	AA
C6_18882816	G/T	14	18882816	TT	TT	GG	TT
C6_18882819	A/G	14	18882819	GG	GG	AA	GG
C6_19044288	C/G	14	19044288	GG	CC	CC	CC
C6_20876797	A/T	14	20876797	AA	AA	TT	AA
C6_20876961	C/T	14	20876961	CC	CC	TT	CC
C6_20971447	G/A	14	20971447	AA	GG	AA	GG
C6_20971505	C/T	14	20971505	TT	CC	TT	CC
C6_22640278	-/+	14	22640278	++	++	--	++
C6_22640280	-/+	14	22640280	++	++	--	++
C6_22640318	A/T	14	22640318	TT	TT	AA	TT
C6_22656269	-/+	14	22656269	++	--	--	--
C6_22721393	+/-	14	22721393	--	--	++	--
C6_22721425	G/T	14	22721425	TT	TT	GG	TT
C6_22866300	-/+	14	22866300	++	++	--	++
C6_22866325	C/G	14	22866325	GG	GG	CC	GG
C6_23081200	T/C	14	23081200	CC	CC	TT	CC
C6_23993706	A/G	14	23993706	GG	AA	GG	AA
C6_23993718	A/T	14	23993718	TT	AA	TT	AA
C6_24019940	T/C	14	24019940	CC	TT	CC	TT
C6_24449411	C/T	14	24449411	CC	CC	TT	CC
C6_24449418	T/C	14	24449418	TT	TT	CC	TT
C6_24449473	C/A	14	24449473	CC	CC	AA	CC
C6_24449477	C/T	14	24449477	CC	CC	TT	CC
C6_25720166	G/C	14	25720166	CC	GG	GG	GG
C6_25720171	C/T	14	25720171	TT	CC	CC	CC
C6_25720366	T/C	14	25720366	CC	TT	TT	TT
C6_26585077	C/T	14	26585077	CC	CC	TT	CC
C6_26840602	A/C	14	26840602	AA	AA	CC	AA
C6_26840631	C/G	14	26840631	CC	CC	GG	CC
C6_27006788	A/G	14	27006788	AA	AA	GG	AA
C6_27320829	C/A	14	27320829	CC	CC	AA	CC
C6_27827378	C/T	14	27827378	CC	CT	CC	CC
C6_28278252	G/A	14	28278252	AA	AA	GG	AA
C6_29254507	C/T	14	29254507	CC	CC	TT	CC
C6_29514323	T/G	14	29514323	TT	TT	GG	TT

C6_29520688	T/C	14	29520688	TT	TT	CC	TT
C6_29520718	C/T	14	29520718	CC	CC	TT	CC
C6_29532194	C/T	14	29532194	CC	CC	TT	CC
C6_29555286	A/C	14	29555286	AA	AA	CC	AA
C6_29555363	C/G	14	29555363	CC	CC	GG	CC
C6_30033684	G/A	14	30033684	AA	AA	GG	AA
C6_30033699	T/A	14	30033699	AA	AA	TT	AA
C6_30427059	A/C	14	30427059	AA	AA	CC	AA
C6_30427081	A/G	14	30427081	AA	AA	GG	AA
C6_30430778	T/G	14	30430778	TT	TT	GG	TT
C6_31139142	T/C	14	31139142	TT	TT	CC	TT
C6_31139163	G/T	14	31139163	GG	GG	TT	GG
C6_31139226	T/C	14	31139226	TT	TT	CC	TT
C6_32122093	C/G	14	32122093	GG	GG	CC	GG
C6_34943575	+/-	14	34943575	--	++	++	--
C6_36597190	T/A	14	36597190	TT	AA	TT	TT
C6_39032026	+/-	14	39032026	--	++	++	++

Table 32: SNP and indel markers on carinata chromosome C7.

SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
C7_909494	A/T	15	909494	TT	TT	AA	AA
C7_1130798	G/T	15	1130798	TT	TT	GG	GG
C7_6486311	T/C	15	6486311	TT	TT	TT	CC
C7_6624414	T/G	15	6624414	TT	TT	GG	GG
C7_10972567	+/-	15	10972567	--	++	++	++
C7_12406426	C/T	15	12406426	TT	TT	CC	TT
C7_18359899	+/-	15	18359899	--	++	++	++
C7_18935652	C/A	15	18935652	CC	CC	AA	AA
C7_20486186	A/G	15	20486186	AA	AA	GG	GG
C7_21624264	G/A	15	21624264	GG	GG	AA	AA
C7_21641823	T/C	15	21641823	TT	TT	CC	CC
C7_21714705	C/G	15	21714705	CC	CC	GG	GG
C7_21729681	T/G	15	21729681	TT	TT	GG	GG
C7_21729719	C/T	15	21729719	CC	CC	TT	TT
C7_21818649	C/T	15	21818649	CC	CC	TT	TT
C7_21957117	A/G	15	21957117	AA	AA	GG	GG
C7_22557067	T/C	15	22557067	TT	TT	CC	CC
C7_24579415	T/A	15	24579415	TT	TT	AA	AA

C7_29185256	+/-	15	29185256	--	--	++	++
C7_30487954	+/-	15	30487954	--	++	++	--
C7_33396571	T/C	15	33396571	TT	TT	CC	CC
C7_34452746	T/A	15	34452746	TT	TT	AA	AA
C7_35269822	T/A	15	35269822	TT	TT	AA	AA
C7_36185793	T/C	15	36185793	CC	CC	TT	TT
C7_37344449	+/-	15	37344449	--	++	++	--
C7_39320758	A/G	15	39320758	GG	GG	AA	AA
C7_39320815	T/C	15	39320815	CC	CC	TT	TT
C7_39797620	A/G	15	39797620	GG	AA	GG	AA
C7_40368011	G/A	15	40368011	GG	GG	AA	AA
C7_40404145	C/T	15	40404145	CC	CC	TT	TT
C7_40404156	G/T	15	40404156	GG	GG	TT	TT
C7_40435622	C/G	15	40435622	GG	GG	CC	CC
C7_40653772	C/T	15	40653772	CC	CC	TT	TT
C7_40718159	G/A	15	40718159	AA	AA	GG	GG
C7_41809998	A/G	15	41809998	GG	GG	AA	AA
C7_41810007	C/T	15	41810007	TT	TT	CC	CC
C7_41810010	C/T	15	41810010	TT	TT	CC	CC
C7_41810151	C/T	15	41810151	TT	TT	CC	CC
C7_41810157	T/A	15	41810157	AA	AA	TT	TT
C7_41810174	A/G	15	41810174	GG	GG	AA	AA
C7_41810211	T/C	15	41810211	CC	CC	TT	TT
C7_42734039	A/G	15	42734039	GG	GG	AA	GG
C7_42734095	G/A	15	42734095	AA	AA	GG	AA
C7_43196058	C/G	15	43196058	CC	CC	GG	CC
C7_43295854	+/-	15	43295854	--	--	++	++
C7_43304964	A/G	15	43304964	GG	GG	AA	AA
C7_43345503	T/G	15	43345503	GG	GG	TT	TT
C7_43352313	T/C	15	43352313	CC	CC	TT	TT
C7_43451277	+/-	15	43451277	--	++	++	++
C7_44017882	+/-	15	44017882	--	--	++	++
C7_44949816	T/A	15	44949816	TT	TT	TT	AA
C7_44949822	A/G	15	44949822	AA	AA	AA	GG
C7_44949828	A/G	15	44949828	AA	AA	AA	GG
C7_45644517	G/T	15	45644517	TT	GG	GG	GG
C7_45644539	C/T	15	45644539	TT	CC	CC	CC
C7_45644544	C/T	15	45644544	CC	CC	TT	TT
C7_45644559	C/G	15	45644559	CC	CC	GG	GG
C7_45644565	A/T	15	45644565	AA	AA	TT	TT
C7_45644567	A/C	15	45644567	AA	AA	CC	CC

C7_45644570	A/G	15	45644570	GG	AA	AA	AA
C7_45644571	A/G	15	45644571	GG	AA	AA	AA
C7_45644581	C/A	15	45644581	AA	AA	CC	CC
C7_46217833	T/C	15	46217833	TT	TT	CC	TT
C7_46217845	C/T	15	46217845	TT	CC	TT	CC

Table 33: SNP and indel markers on carinata chromosome C8.

SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
C8_8999853	G/A	16	8999853	AA	AA	GG	GG
C8_12000274	+/-	16	12000274	--	++	++	--
C8_12308303	G/T	16	12308303	TT	TT	GG	GG
C8_16945255	T/A	16	16945255	TT	TT	AA	TT
C8_19061669	T/C	16	19061669	TT	TT	TT	CC
C8_19061705	C/T	16	19061705	CC	CC	CC	TT
C8_19061720	C/T	16	19061720	CC	CC	CC	TT
C8_19061734	G/A	16	19061734	GG	GG	GG	AA
C8_19137488	A/G	16	19137488	AA	AA	AA	GG
C8_20504784	A/T	16	20504784	AA	AA	TT	AA
C8_21329699	C/T	16	21329699	CC	CC	TT	TT
C8_21329849	C/G	16	21329849	CC	CC	GG	GG
C8_21344626	G/C	16	21344626	GG	GG	CC	GG
C8_21344660	A/G	16	21344660	AA	AA	GG	AA
C8_23831734	T/C	16	23831734	TT	TT	CC	TT
C8_23831737	T/G	16	23831737	TT	TT	GG	TT
C8_25638545	+/-	16	25638545	--	++	++	++
C8_28770177	A/T	16	28770177	TT	TT	AA	TT
C8_28770286	A/G	16	28770286	GG	GG	AA	GG
C8_28770303	G/A	16	28770303	AA	AA	GG	AA
C8_29439006	T/A	16	29439006	AA	TT	TT	TT
C8_29495239	A/G	16	29495239	AA	GG	AA	AA
C8_29495251	T/A	16	29495251	TT	AA	TT	TT
C8_29495266	G/A	16	29495266	GG	AA	GG	GG
C8_29495269	T/C	16	29495269	TT	CC	TT	TT
C8_29495311	G/A	16	29495311	GG	AA	GG	GG
C8_29495314	A/G	16	29495314	AA	GG	AA	AA
C8_30065039	A/G	16	30065039	GG	GG	AA	AA
C8_32201249	G/C	16	32201249	GG	CC	GG	GG
C8_32201250	T/A	16	32201250	TT	AA	TT	TT
C8_32201254	G/A	16	32201254	GG	AA	GG	GG
C8_32201256	A/T	16	32201256	AA	TT	AA	AA

C8_32201323	G/T	16	32201323	GG	TT	GG	GG
C8_32201350	G/C	16	32201350	GG	CC	GG	GG
C8_32201353	C/T	16	32201353	CC	TT	CC	CC
C8_32201374	T/C	16	32201374	TT	CC	TT	TT
C8_32232879	T/A	16	32232879	AA	TT	TT	TT
C8_32232931	G/T	16	32232931	TT	GG	GG	GG
C8_32232937	+/-	16	32232937	--	++	++	++
C8_32232944	C/A	16	32232944	AA	CC	CC	CC
C8_32315514	T/C	16	32315514	CC	TT	TT	TT
C8_32315528	T/C	16	32315528	CC	TT	TT	TT
C8_33640895	C/T	16	33640895	CT	CC	CC	CC
C8_33640903	-/+	16	33640903	+	--	--	--
C8_33729431	T/C	16	33729431	TT	TT	CC	CT
C8_33729463	A/G	16	33729463	AA	AA	GG	GG
C8_33729494	T/C	16	33729494	TT	TT	CC	CC
C8_33729509	G/A	16	33729509	GG	GG	AA	AA
C8_33729608	T/C	16	33729608	TT	TT	CC	CC
C8_35634493	G/A	16	35634493	AG	GG	GG	GG
C8_35805925	T/A	16	35805925	TT	TT	AA	AA
C8_35805945	G/A	16	35805945	GG	GG	AA	AA
C8_35805960	G/A	16	35805960	GG	GG	AA	AA
C8_35809971	T/C	16	35809971	TT	TT	CC	CC
C8_36353741	+/-	16	36353741	--	++	++	++
C8_36354350	C/A/T	16	36354350	CC	CC	CC	AA
C8_37203182	G/A	16	37203182	GG	AG	GG	GG
C8_37698686	T/C	16	37698686	CC	TT	TT	CC
C8_37698950	-/+	16	37698950	++	--	--	++
C8_38414269	A/T	16	38414269	AA	AA	TT	TT
C8_38414317	A/G	16	38414317	AA	AA	GG	GG
C8_38414431	T/C	16	38414431	TT	TT	CC	CC
C8_38414443	C/T	16	38414443	CC	CC	TT	TT
C8_38414449	C/G	16	38414449	CC	CC	GG	GG
C8_38419315	+/-	16	38419315	++	++	--	--
C8_38440964	C/A	16	38440964	CC	CC	AA	AA
C8_38441013	A/G	16	38441013	AA	AA	GG	GG
C8_38442686	G/A	16	38442686	GG	GG	AA	AA
C8_38637684	A/G	16	38637684	GG	GG	AA	AA
C8_39593512	C/A	16	39593512	AA	AC	CC	CC
C8_41291159	G/A	16	41291159	GG	GG	AA	GG
C8_41646633	C/G	16	41646633	GG	GG	CC	GG

Table 34: SNP and indel markers on carinata chromosome C9.

SNP ID	alleles	chrom	pos	A110	A120	AGR044-312DF	AGR044-3A22A
C9_1150655	G/C	17	1150655	CC	GG	CC	CC
C9_2986721	T/A	17	2986721	AA	AT	TT	TT
C9_4464952	T/C	17	4464952	TT	TT	CC	CC
C9_4464955	C/T	17	4464955	CC	CC	TT	TT
C9_4467991	T/C	17	4467991	CC	CC	TT	TT
C9_4622488	G/A	17	4622488	GG	GG	AA	AA
C9_4622489	C/T	17	4622489	CC	CC	TT	TT
C9_4622501	A/C	17	4622501	AA	AA	CC	CC
C9_5396787	A/T	17	5396787	AA	AA	TT	TT
C9_5396807	G/A	17	5396807	GG	GG	AA	AA
C9_5396811	A/G	17	5396811	AA	AA	GG	GG
C9_5396815	T/C	17	5396815	TT	TT	CC	CC
C9_5396817	G/A	17	5396817	GG	GG	AA	AA
C9_5396821	T/C	17	5396821	TT	TT	CC	CC
C9_5396823	G/A	17	5396823	GG	GG	AA	AA
C9_5396832	G/A	17	5396832	GG	GG	AA	AA
C9_5397996	C/T	17	5397996	CC	CC	TT	CC
C9_5398029	T/A	17	5398029	TT	TT	AA	TT
C9_5398031	G/A	17	5398031	GG	GG	AA	GG
C9_5398035	T/A	17	5398035	TT	TT	AA	TT
C9_7047673	+/-	17	7047673	--	++	++	++
C9_8056244	C/T	17	8056244	TT	CC	CC	CC
C9_8573741	-/+	17	8573741	++	--	--	--
C9_8607012	+/-	17	8607012	--	++	++	++
C9_8854826	T/C	17	8854826	CC	CT	TT	TT
C9_8859063	T/C	17	8859063	CC	TT	TT	TT
C9_8859153	T/C	17	8859153	CC	TT	TT	TT
C9_8859183	+/-	17	8859183	--	++	++	++
C9_8859184	+/-	17	8859184	--	++	++	++
C9_8859191	+/-	17	8859191	--	++	++	++
C9_8859196	C/T	17	8859196	TT	CC	CC	CC
C9_8890402	C/G	17	8890402	GG	CC	CC	CC
C9_8890454	T/C	17	8890454	CC	TT	TT	TT
C9_8890455	T/G	17	8890455	GG	TT	TT	TT
C9_8890463	G/A	17	8890463	AA	GG	GG	GG
C9_8898506	A/G	17	8898506	AA	GG	AA	GG
C9_8898645	C/G	17	8898645	CC	GG	CC	GG
C9_10496364	T/C	17	10496364	TT	TT	CC	TT

C9_10496502	G/T	17	10496502	GG	GG	TT	GG
C9_17146315	G/C	17	17146315	CC	GC	CC	CC
C9_17720710	C/T	17	17720710	TT	TT	CC	CC
C9_17720729	T/G	17	17720729	GG	GG	TT	TT
C9_17720754	T/A	17	17720754	AA	AA	TT	TT
C9_17770546	G/A	17	17770546	AA	AA	GG	GG
C9_18613556	T/C	17	18613556	CC	CC	TT	TT
C9_19289756	C/A	17	19289756	AA	AA	CC	CC
C9_19289827	A/G	17	19289827	GG	GG	AA	AA
C9_19289835	A/T	17	19289835	TT	TT	AA	AA
C9_19289837	A/C	17	19289837	CC	CC	AA	AA
C9_20058811	C/T	17	20058811	TT	TT	CC	CC
C9_20058834	G/A	17	20058834	AA	AA	GG	GG
C9_20141737	T/G	17	20141737	GG	GG	TT	TT
C9_20141756	A/G	17	20141756	GG	GG	AA	AA
C9_24205200	+/-	17	24205200	--	++	++	++
C9_30221517	+/-	17	30221517	--	++	++	--
C9_31103055	+/-	17	31103055	--	++	++	--
C9_42557630	A/G	17	42557630	GG	GG	AA	AA
C9_42619426	C/A	17	42619426	AA	AA	CC	CC
C9_42863241	C/T	17	42863241	TT	TT	CC	CC
C9_42863293	C/T	17	42863293	TT	TT	CC	CC
C9_42869989	+/-	17	42869989	--	--	++	++
C9_43003823	A/G	17	43003823	GG	GG	AA	AA
C9_43105259	C/T	17	43105259	TT	TT	CC	CC
C9_43199256	G/C	17	43199256	CC	CC	GG	GG
C9_43458273	A/G	17	43458273	GG	GG	AA	AA
C9_43458352	G/T	17	43458352	GG	GG	TT	TT
C9_43808934	A/G	17	43808934	AA	AA	AA	GG
C9_43809004	G/C	17	43809004	GG	GG	GG	CC
C9_43809015	A/G	17	43809015	AA	AA	AA	GG
C9_43817827	G/T	17	43817827	GG	GG	GG	TT
C9_43817859	T/C	17	43817859	TT	TT	TT	CC
C9_43817984	T/C	17	43817984	TT	TT	TT	CC
C9_45319859	C/T	17	45319859	TT	TT	CC	CC
C9_45319868	T/C	17	45319868	CC	CC	TT	TT
C9_49816416	G/A	17	49816416	GG	GG	GG	AA
C9_49816530	G/A	17	49816530	GG	GG	GG	AA
C9_49816536	+/-	17	49816536	++	++	++	--
C9_50008950	+/-	17	50008950	++	++	--	--
C9_50424646	A/G	17	50424646	GG	AA	GG	AA

C9_50424663	-/+	17	50424663	++	--	++	--
C9_50424667	-/+	17	50424667	++	--	++	--
C9_50424745	G/A	17	50424745	AA	GG	AA	GG
C9_51300325	C/T	17	51300325	CC	CC	TT	TT
C9_51832143	T/A	17	51832143	AA	TT	AA	TT
C9_51832149	C/G	17	51832149	GG	CC	GG	CC
C9_51832179	G/T	17	51832179	TT	GG	TT	GG
C9_52000849	T/A	17	52000849	AA	TT	TT	TT
C9_52000858	-/+	17	52000858	++	--	--	--
C9_52000921	T/G	17	52000921	GG	TT	TT	TT
C9_52105915	T/C	17	52105915	CC	CC	TT	TT
C9_52252000	G/T	17	52252000	TT	GG	GG	GG
C9_54035506	C/T	17	54035506	CT	CC	CC	CC
C9_54365078	T/C	17	54365078	TT	TT	CC	TT
C9_54366668	G/C	17	54366668	GG	GG	CC	GG

[0046] In another embodiment, the invention provides a plant, or part thereof, whose genotype has greater than 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98% or 99% of the single nucleotide polymorphisms and indel markers of Tables 19 to 35 in common with AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015.

[0047] In another embodiment, the invention provides a plant, or part thereof, whose genotype has greater than 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98% or 99% of the single nucleotide polymorphisms and indel markers of Tables 19 to 35 in common with AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015, and wherein the plant part is an ovule, a leaf, pollen, a seed, an embryo a root, a root tip, a pod, a flower, a stalk, a cell, or a protoplast.

[0048] In another embodiment, the invention provides a seed whose genotype has greater than 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98% or 99% of the single nucleotide polymorphisms and indel markers of Tables 19 to 35 in common with AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015.

[0049] In another embodiment, the invention provides a cell of a plant, or part thereof, whose genotype has greater than 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98% or 99% of the single nucleotide polymorphisms and indel markers of Tables 19 to 35 in common with AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015.

[0050] In another embodiment, the invention provides a cell of a plant, or part thereof, whose genotype has greater than 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98% or 99% of the single nucleotide polymorphisms and indel markers of Tables 19 to 35 in common with AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-

123015, and wherein the plant part is an ovule, a leaf, pollen, a seed, an embryo a root, a root tip, a pod, a flower, a stalk, a cell, or a protoplast.

[0051] In another embodiment, the invention provides a cell of a seed whose genotype has greater than 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98% or 99% of the single nucleotide polymorphisms and indel markers of Tables 19 to 35 in common with AGR044-312D, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123015.

[0052] In another embodiment, the invention provides a plant, or part thereof, whose genotype has greater than 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98% or 99% of the single nucleotide polymorphisms and indel markers of Tables 19 to 35 in common with AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014.

[0053] In another embodiment, the invention provides a plant, or part thereof, whose genotype has greater than 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98% or 99% of the single nucleotide polymorphisms and indel markers of Tables 19 to 35 in common with AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, and wherein the plant part is an ovule, a leaf, pollen, a seed, an embryo a root, a root tip, a pod, a flower, a stalk, a cell, or a protoplast.

[0054] In another embodiment, the invention provides a seed whose genotype has greater than 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98% or 99% of the single nucleotide polymorphisms and indel markers of Tables 19 to 35 in common with AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014.

[0055] In another embodiment, the invention provides a cell of a plant, or part thereof, whose genotype has greater than 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98% or 99% of the single nucleotide polymorphisms and indel markers of Tables 19 to 35 in common with AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014.

[0056] In another embodiment, the invention provides a cell of a plant, or part thereof, whose genotype has greater than 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98% or 99% of the single nucleotide polymorphisms and indel markers of Tables 19 to 35 in common with AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014, and wherein the plant part is an ovule, a leaf, pollen, a seed, an embryo a root, a root tip, a pod, a flower, a stalk, a cell, or a protoplast.

[0057] In another embodiment, the invention provides a cell of a seed whose genotype has greater than 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98% or 99% of the single nucleotide polymorphisms and indel markers of Tables 19 to 35 in common with AGR044-3A22, wherein a representative sample of said seed has been deposited under ATCC Accession number PTA-123014.

6. DEPOSITS

[0058] Applicant has made a deposit of at least 2500 seeds of *Brassica carinata* Cultivar AGR044-312D with the American Type Culture Collection (ATCC), Manassas, VA 20110 USA, ATCC Deposit No. PTA-123015. The seeds deposited with the ATCC on April 12, 2016 were taken from the deposit maintained by Agrisoma Biosciences Inc. since prior to the filing data of this application. This deposit of the *Brassica carinata* Cultivar AGR044-312D will be maintained in the ATCC depository, which is a public depository, for a period of 30 years, or 5 years after the most recent request, or for the effective life of the patent, whichever is longer, and will be replaced if it becomes nonviable during that period. Additionally, Applicant has satisfied all the requirements of 37 C.F.R. §§1.801- 1.809, including providing an indication of the viability of the sample. Applicant imposes no restrictions on the availability of the deposited material from the ATCC; however, Applicant has no authority to waive any restrictions imposed by law on the transfer of biological material or its transportation in commerce. Applicant does not waive any infringement of his rights granted under this patent or under the Plant Variety Protection Act (7 USC 2321 et seq.).

[0059] Applicant has made a deposit of at least 2500 seeds of *Brassica carinata* Cultivar AGR044-3A22 with the American Type Culture Collection (ATCC), Manassas, VA 20110 USA, ATCC Deposit No. PTA-123014. The seeds deposited with the ATCC on April 12, 2016 were taken from the deposit maintained by Agrisoma Biosciences Inc. since prior to the filing data of this application. This deposit of the *Brassica carinata* Cultivar AGR044-3A22 will be maintained in the ATCC depository, which is a public depository, for a period of 30 years, or 5 years after the most recent request, or for the effective life of the patent, whichever is longer, and will be replaced if it becomes nonviable during that period. Additionally, Applicant has satisfied all the requirements of 37 C.F.R. §§1.801- 1.809, including providing an indication of the viability of the sample. Applicant imposes no restrictions on the availability of the deposited material from the ATCC; however, Applicant has no authority to waive any restrictions imposed by law on the transfer of biological material or its transportation in commerce. Applicant does not waive any infringement of his rights granted under this patent or under the Plant Variety Protection Act (7 USC 2321 et seq.).

[0060] The foregoing invention has been described in detail by way of illustration and example for purposes of exemplification. However, it will be apparent that changes and modifications such as single gene modifications and mutations, somatoclonal variants, variant individuals selected from populations of the plants of the instant cultivar, and the like, likewise are considered to be within the scope of the present invention.

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CLAIMS:

1. A seed of *Brassica carinata* cultivar designated AGR044-312D, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123015.
2. A plant of *Brassica carinata* cultivar AGR044-312D, or a part thereof, produced from the seed of claim 1.
3. A *Brassica carinata* plant, or parts thereof, having essentially all of the physiological and morphological characteristics of the plant of claim 2 when grown in the same location under the same environmental conditions.
4. A tissue culture of protoplasts or regenerable cells of the plant, or part thereof, of claim 2.
5. A method for producing *Brassica carinata* seed comprising crossing *Brassica carinata* plants and harvesting the resulting *Brassica carinata* seed, wherein at least one *Brassica carinata* plant is the plant of claim 2.
6. A method for producing a first generation (F1) hybrid *Brassica carinata* seed comprising crossing the plant of claim 2 with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid *carinata* seed, and wherein the plant of claim 2 is either a female parent or a male parent.
7. A method of producing a *Brassica carinata* variety produced from the plant of claim 2, wherein the *Brassica carinata* variety comprises a desired trait, the method comprising the steps of:
 - (e) crossing a plant of cultivar AGR044-312D with another *Brassica carinata* variety comprising the desired trait;
 - (f) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait;
 - (g) backcrossing the selected progeny plants that have the desired trait with plants of cultivar AGR044-312D to produce backcross progeny seed; and
 - (h) growing the resultant backcross progeny seed and selecting backcross progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-312D.
8. The method of claim 7, wherein steps (c) and (d) are repeated until the *Brassica carinata* variety produced from cultivar AGR044-312D has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-312D when grown in the same location under the same environmental conditions.
9. The method of claim 7 or 8, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.
10. A plant, or part thereof, or seed thereof, produced by the method of any one of claims 5-9.

11. A seed of *Brassica carinata* cultivar designated AGR044-3A22, wherein a representative sample of the seed has been deposited under ATCC Accession number PTA-123014.
12. A plant of *Brassica carinata* cultivar AGR044-3A22, or a part thereof, produced from the seed of claim 11.
13. A *Brassica carinata* plant, or parts thereof, having essentially all of the physiological and morphological characteristics of the plant of claim 12 when grown in the same location under the same environmental conditions.
14. A tissue culture of protoplasts or regenerable cells of the plant, or part thereof, of claim 12.
15. A method for producing *Brassica carinata* seed comprising crossing *Brassica carinata* plants and harvesting the resulting *Brassica carinata* seed, wherein at least one *Brassica carinata* plant is the plant of claim 12.
16. A method for producing a first generation (F1) hybrid *Brassica carinata* seed comprising crossing the plant of claim 12 with a different *Brassica carinata* plant and harvesting the resultant F1 hybrid *carinata* seed, and wherein the plant of claim 12 is either a female parent or a male parent.
17. A method of producing a *Brassica carinata* variety produced from the plant of claim 12, wherein the *Brassica carinata* variety comprises a desired trait, the method comprising the steps of:
 - (e) crossing a plant of cultivar AGR044-3A22 with another *Brassica carinata* variety comprising the desired trait;
 - (f) growing the resultant F1 hybrid seed and selecting one or more progeny plants that have the desired trait;
 - (g) backcrossing the selected progeny plants that have the desired trait with plants of cultivar AGR044-3A22 to produce backcross progeny seed; and
 - (h) growing the resultant backcross progeny seed and selecting backcross progeny plants that have the desired trait to produce the *Brassica carinata* variety produced from cultivar AGR044-3A22.
18. The method of claim 17, wherein steps (c) and (d) are repeated until the *Brassica carinata* variety produced from cultivar AGR044-3A22 has the desired trait and essentially all of the physiological and morphological characteristics of cultivar AGR044-3A22 when grown in the same location under the same environmental conditions.
19. The method of claim 17 or 18, wherein the desired trait is selected from the group consisting of male sterility, disease resistance, fungal resistance, pest resistance, herbicide tolerance, abiotic stress tolerance, and altered metabolism.
20. A plant, or part thereof, or seed thereof, produced by the method of any one of claims 15-19.

PATENT COOPERATION TREATY

PCT

DECLARATION OF NON-ESTABLISHMENT OF INTERNATIONAL SEARCH REPORT (PCT Article 17(2)(a), Rules 13^{ter}.1(c) and (d) and 39)

Applicant's or agent's file reference 83998818	IMPORTANT DECLARATION	Date of mailing (<i>day/month/year</i>) 15 June 2017 (15-06-2017)
International application No. PCT/CA2017/050474	International filing date (<i>day/month/year</i>) 18 April 2017 (18-04-2017)	(Earliest) Priority date (<i>day/month/year</i>) 22 April 2016 (22-04-2016)
International Patent Classification (IPC) or both national classification and IPC IPC: <i>A01H 5/00</i> (2006.01) , <i>A01H 1/00</i> (2006.01) , <i>A01H 1/02</i> (2006.01) , <i>A01H 5/10</i> (2006.01) ,		
Applicant AGRISOMA BIOSCIENCES INC.		

This International Searching Authority hereby declares, according to Article 17(2)(a), that **no international search report will be established** on the international application for the reasons indicated below.

1. ☒ The subject matter of the international application relates to:
 - a. ☐ scientific theories.
 - b. ☐ mathematical theories.
 - c. ☒ plant varieties.
 - d. ☐ animal varieties.
 - e. ☒ essentially biological processes for the production of plants and animals, other than microbiological processes and the products of such processes.
 - f. ☐ schemes, rules or methods of doing business.
 - g. ☐ schemes, rules or methods of performing purely mental acts.
 - h. ☐ schemes, rules or methods of playing games.
 - i. ☐ methods for treatment of the human body by surgery or therapy.
 - j. ☐ methods for treatment of the animal body by surgery or therapy.
 - k. ☐ diagnostic methods practised on the human or animal body.
 - l. ☐ mere presentations of information.
 - m. ☐ computer programs for which this International Searching Authority is not equipped to search prior art.
2. ☐ The failure of the following parts of the international application to comply with prescribed requirements prevents a meaningful search from being carried out:

☐ the description
☐ the claims
☐ the drawings
3. ☐ A meaningful search could not be carried out without the sequence listing; the applicant did not, within the prescribed time limit:

☐ furnish a sequence listing in the form of an Annex C/ST.25 text file, and such listing was not available to the International Searching Authority in a form and manner acceptable to it; or the sequence listing furnished did not comply with the standard provided for in Annex C of the Administrative Instructions.

☐ furnish a sequence listing on paper or in the form of an image file complying with the standard provided for in Annex C of the Administrative Instructions, and such listing was not available to the International Searching Authority in a form and manner acceptable to it; or the sequence listing furnished did not comply with the standard provided for in Annex C of the Administrative Instructions.

☐ pay the required late furnishing fee for the furnishing of a sequence listing in response to an invitation under Rule 13^{ter}.1(a) or (b).
4. Further comments:

Name and mailing address of the ISA/CA Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 001-819-953-2476	Authorized officer Kalie Gossen (819) 639-7809
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