METHOD AND SYSTEM FOR LICENSING BY LOCATION

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ABSTRACT

An agricultural input supplier can provide seed products by tying the compensation received for the seed products to an evaluation of the land base on which the seed products are to be planted and/or the performance of the seed products on the land base. The evaluation of the land base may be based on environmental classification and/or genotype-by-environment data. In addition to tying the compensation to the land quality and the seed performance, this approach to providing seed allows for recommendations to be made to the producer regarding which seed products should be used on the land base. The performance of the seed product on the land base may also be verified.

Recommended GxE Paradigm

- Product Lifecycle Decisions
- Characterization of Products
- Demand Planning
- Inventory Management
- Resource Efficiency
- Risk Management (internal and external)
- Product Positioning
- Product Selection

Collect Environmental & Physiological Landmark Data

Use GxE analysis tools, Period-of-years database

Measure Performance Results

Grow Products

Planning, Positioning

Classify Environments

Crop Modeling

GxE Knowledge

Analysis

14 16

12 18

22 24

26 28
Environment-standardized GGE biplot of grain yield of 18 maize hybrids (H1-H18) grown in 266 environments over three years, stratified by state.
Environment-standardized GGE biplot of grain yield of 18 maize hybrids (H1–H18) grown in 266 environments over three years, stratified by environment class.

FIG. 4
FIG. 10

Product Selection

144

146
Define Environmental Profile

148
Define Producer Profile

150
View Recommendations

FIG. 10
<table>
<thead>
<tr>
<th>Product</th>
<th>Acres</th>
<th>Risk Assessment</th>
<th>Crop Revenue Assurance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybrid1</td>
<td>Acres1</td>
<td>X prob</td>
<td>$1</td>
</tr>
<tr>
<td>Hybrid2</td>
<td>Acres2</td>
<td>Y prob</td>
<td>$2</td>
</tr>
<tr>
<td>Hybrid3</td>
<td>Acres3</td>
<td>Z prob</td>
<td>$3</td>
</tr>
</tbody>
</table>
Site Specific Information

Location

Environment and Production Information

Maturity Days
Input Traits
Output Traits
Seed Treatment
No Till
Planting Population
Nitrogen Utilization
Drought Frequency

Select Hybrid

<table>
<thead>
<tr>
<th>Hybrid Name</th>
<th>Hybrid Rank</th>
<th>Risk Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybrid1</td>
<td>99%</td>
<td>0.075 prob</td>
</tr>
<tr>
<td>Hybrid2</td>
<td>89%</td>
<td>0.15 prob</td>
</tr>
</tbody>
</table>

FIG. 12
### Site Specific Information

- **Location**
- **Soil Type**
- **Acres**

### Set Environmental Assumptions

- **Import Environment Frequency Data**
- **Set Production Practices**
- **Set Risk Levels**

### Max Number of Hybrids:

### Portfolio Results

<table>
<thead>
<tr>
<th>Product</th>
<th>Acres</th>
<th>Hybrid Rank</th>
<th>Risk Assessment</th>
<th>Revenue Assurance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybrid1</td>
<td>Acres1</td>
<td>1 (97%)</td>
<td>.15 prob</td>
<td>$</td>
</tr>
<tr>
<td>Hybrid2</td>
<td>Acres2</td>
<td>3 (87%)</td>
<td>.20 prob</td>
<td>$</td>
</tr>
<tr>
<td>Hybrid3</td>
<td>Acres3</td>
<td>2 (92%)</td>
<td>.03 prob</td>
<td>$</td>
</tr>
</tbody>
</table>

### FIG. 13
Data Collection (Site Specific)

Environmental Classification

Previous Year's Hybrid Selection and Performance

Predict Previous Year Results

Compare Predicted Results with Actual Results

FIG. 15
FIG. 18

- Harvest:
  - Auditing - Review GPS Data
  - Auditing - Weigh Tickets
  - Auditing - Yield Monitoring Data

- Growing:
  - Auditing - Remote Sensing

- Planting:
  - Auditing - Review GPS Data

- License Formation:
  - Determine Location of Land
  - Classify Land Base
  - Recommend Seed Products for Use on Land Base
METHOD AND SYSTEM FOR LICENSING BY LOCATION

CROSS-REFERENCE TO RELATED APPLICATIONS


BACKGROUND OF THE INVENTION

[0002] The present invention provides for computer-implemented methods and related methods which apply a performance-based pricing model to the selling of seed products

[0003] The productivity of ground can vary significantly, from fertile ground with a desirable actual production history (APH) to lower quality ground with a poor performance history. Producers planting on less productive ground have a greater need to keep the cost of agricultural inputs, such as seed, as low as possible. Thus, a producer may be weary of genetically superior seed products which, even though would increase performance over alternatives, have an associated premium price. Where a producer is using less productive ground they simply may not be able to justify the premium price.

[0004] What is needed therefore is a method for licensing and/or selling seed to the producer where the price of the seed is based at least in part on the location and quality of the land on which the seed is to be planted. Further needed is a method of auditing the performance of the seed product on the land base during and after planting of the seed product.

SUMMARY OF THE INVENTION

[0005] Therefore it is a primary object, feature, or advantage of the present invention to improve over the state of the art.

[0006] Another object, feature or advantage of the present invention is to provide a method to license and/or sell seed to producers where the price of the seed is based at least in part on the quality of the land on which the seed is to be planted.

[0007] Yet another object, feature or advantage of the present invention is to provide a method to license and/or sell seed to producers where the price of the seed is based at least in part on the expected performance of the seed product.

[0008] A further objective, feature, or advantage of the present invention is to assist producers in selecting the best seed product for a particular location.

[0009] A still further objective, feature, or advantage of the present invention is to verify that seed is used in the location where it is reported to be used.

[0010] Another objective, feature, or advantage of the present invention is to audit the performance of the seed product during and after the seed product has been planted on the land base.

[0011] Yet another object, feature, or advantage of the present invention is to provide additional incentives to producers for selecting seed products for a particular location with a greater likelihood of performance.

[0012] One or more of these and/or other objects, features, or advantages of the present invention will become apparent from the specification and claims that follow.

[0013] According to one aspect of the present invention a method for selling seed products for planting by a crop producer is provided. The method includes characterizing the land base where the seed will be planted, determining the type of seed to be planted, and pricing the seed product. The seed product is priced based at least in part on performance or expected performance of the seed product within the land base. To assist in determining expected performance, the land base may be characterized using environment classification systems.

[0014] A recommendation or requirement for the type of seed used may be provided. The type of seed planted at the land base may be determined at least partially based on performance of the seed product in an environmental classification associated with the land. The seed product may be recommended at least partially based on expected genotype-by-environment interactions between the seed product and the land base.

[0015] According to another aspect of the present invention, a method of selling seed products to a producer ties compensation for the seed products to the quality of the land base of the producer. The method includes evaluating the land base of the producer to determine a quality of the land base. In addition to the quality of the land base, determining the compensation for the seed product may, without limitation, be at least partially based on the expected performance of the seed product within the land base and/or the actual performance of the seed product within the land base.

[0016] Evaluation of the land base may be performed by using an environmental classification of the land base. The environmental classification may be selected from a set of environmental classes. For example, the environmental classes can be a temperate class, a temperate dry class, a temperate humid class, a high latitude class, a subtropical class or biotic classification.

[0017] The performance of the at least one seed product within the land base may also be audited. Particularly, where pricing is based on actual performance, there is a need to audit performance to ensure that a fair price is arrived upon. The auditing may be done by several different means, including, but not limited to, auditing GPS data (including, but not limited to, GPS data associated with planting and/or harvesting seed product in the land base) associated with crop production in the land base, reviewing weigh tickets and/or yield monitoring data for crops produced from the land base, and/or remote sensing of the land base.

BRIEF DESCRIPTION OF THE FIGURES

[0018] FIG. 1 is a flow diagram illustrating one process for determining genotype-by-environment interactions and using that information in categorizing land bases into different environmental classifications.

[0019] FIG. 2A to FIG. 2C provide an example of genotype by environment interactions and cross-over interactions between two different varieties in four different environmental classes.
FIG. 3 illustrates environment-standardized GGE biplot of grain yield of 18 maize hybrids (H1-H18) grown in 266 environments over three years stratified by state.

FIG. 4 illustrates environment-standardized GGE biplot of grain yield of 18 maize hybrids (H1-H18) grown in 266 environments over three years stratified by environmental class.

FIG. 5 illustrates one possible schematic for categorizing different land bases into environmental classifications based on temperatures, solar radiation, and length of photoperiod.

FIG. 6 is a bar graph representation of the frequency of various environmental classes among target population of environments (TPEs) or multi-environment trials (METs).

FIG. 7 illustrates potential categories of environmental classes identified throughout the United States in 1988 and their locations: these include temperate, temperate dry, temperate humid, high latitude, and subtropical classes.

FIG. 8 is a flow diagram illustrating information flow from an environmental profile and a producer profile to providing recommendations to a producer according to one embodiment of the present invention.

FIG. 9 is block diagram illustrating a system for determining product recommendations according to one embodiment of the present invention.

FIG. 10 is a screen display according to one embodiment of the present invention.

FIG. 11 is a screen display showing a product portfolio according to one embodiment of the present invention.

FIG. 12 is a screen display for one embodiment of an application of the present invention.

FIG. 13 is a screen display for one embodiment of an application of the present invention.

FIG. 14 is a screen display for one embodiment of the present invention showing field-by-field product recommendations.

FIG. 15 is a flow diagram for one embodiment of a sales tool for demonstrating the value of environmental classification in describing relative performance.

FIG. 16 is a screen display illustrating one example of output from a sales tool of the present invention for demonstrating the value of environmental classification in describing relative performance.

FIG. 17 is a flow diagram showing information flow in a product selection and positioning application of the present invention.

FIG. 18 is a block diagram illustrating formation of a license for planting seed product in a particular location and auditing the planting of the seed product in the location.

FIG. 19 is a flow diagram illustrating information flow in formation of a license for planting seed product in a particular location and auditing the planting of the seed product in the location.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention provides for computer-implemented methods and related methods which tie compensation received for seed products to actual performance of the seed product within a particular field (or other land base) or to expected performance of the seed product within a particular field or other land base. The present invention may use environmental classification and/or an understanding of genotype-by-environment interactions to evaluate the land base and/or determine the compensation for the seed product. Thus, seed can be recommended to, sold to, and/or provided to a producer where the compensation for or price of the seed is determined based upon performance-expected performance or actual performance.

Where the performance is actual performance, it may be audited in order to, among other things, verify the use of the seed within the particular land base. In other words, if compensation is tied to performance of a particular field, some form of auditing is needed to verify that the seed is actually planted in the field which it was purchased for. This type of verification is desirable both when the pricing is based on actual performance and expected performance. A second level type of verification is used to verify the performance of the crop. Verifying the use of the seed within the particular land base can be performed by evaluating various data typically associated with crop planting, production and harvesting.

Where the compensation provided to an agricultural input supplier (such as a seed company) is tied to performance, the agricultural input supplier has an added incentive for the producer to be successful. One way in which the agricultural input supplier can potentially increase the likelihood of the producer being successful is by making appropriate recommendations of the agricultural inputs to be used, particularly by where the agricultural input supplier is in a better position than the producer to make such a decision. A producer will understand that the agricultural input supplier is making recommendations to increase performance and may therefore be more willing to take the recommendation. In addition, the agricultural input supplier may require the producer to take their recommendations in order to reduce the risk created for it.

One method to tie compensation received for seed products to an evaluation of the land base on which the seed products are or will be planted uses knowledge of genotype-by-environment interactions to assist a producer or other customer in selecting seed products to plant in one or more fields. A “genotype” is generally defined as a cultivar, genetically homogenous (lines, clones), a hybrid of two or more parents, or heterogeneous (open-pollinated populations). An “environment” is generally defined as a set of conditions, such as climatic conditions, soil conditions, biotic factors (such as, without limitation, pests and diseases) and/or other conditions that impact genotype productivity. “Management” as used in this context generally refers to production management decisions, such as, but not limited to crop production practices. In addition, the present invention allows for the use of environmental characterization to assist in describing genotype-by-environment interactions. It is to be understood that the term “genotype-by-environment” (GxE) is to encompass what is sometimes
known or referred to as "genotype-by-environment-by management" (GxExM) as the environment associated with a plant may include management practices which affect the environment (for example, irrigation may be considered a management practice, but use of irrigation affects the growing environment).

[0041] Following, is an exemplary description regarding the use of GxE interactions and environmental classification. Next, the determination of compensation in exchange for seed products where the compensation is at least partially based on evaluating the land is discussed. Then, the verification of the performance of the seed and other means by which risk can be minimized is discussed.

GxE and Environmental Classification

[0042] Genetic manipulation alone does not ensure that a plant will perform well in a specific environment or for that matter a wide range of environments. In other words, there is no one genotype that is likely to perform best in all environments or under all management practices. The performance or phenotype results from an interaction between the plant’s genotype and the environment and the management practices used.

[0043] It is to be understood that there are some inherent difficulties in understanding such interactions. An environment at a given location changes over the years making multi-environment trials (METs) performed in the same location limited as to inferences about future crop performance. Furthermore, inferences about a crop’s future performance in different locations depend on whether the target population of environments (TPEs) is well sampled since the environment varies between different locations in one year.

[0044] To assist in analyzing such interactions, the present invention preferably uses environmental classification techniques. The environmental classification techniques are used preferably with a large set of data to relate performance of different genotypes to different environments. Environmental classification is then used when selecting the best seed products for a particular land base. Thus, for example, a producer can use environmental classification to select the best seed products for their land base based on the expected environmental conditions. Alternatively, the producer may diversify and select a combination of seed products based on a range of expected environmental conditions to thereby manage risks associated with environmental variability. Of course, environmental classification can be used by not just producers but others having interest in agricultural production.

[0045] FIG. 1 provides an overview of one GxE paradigm where GxE knowledge 12 is used in planning and positioning 18. GxE knowledge 12 can be applied to crop modeling 14. Crop modeling 14 and GxE knowledge 12 may either alone or together be used to classify environments. The GxE knowledge 12 and classified environments may be used in facilitating the positioning and/or planning 18 strategies, such as characterization of products, resource efficiency, risk management, product positions, and product selection.

[0046] Subsequent to positioning and planning, the producer will grow the selected products 26 and measure the performance results 24. The producer may also collect environmental and physiological landmark data 28 and in conjunction with performance results 24 use it in analysis 20. Analysis of environmental and physiological landmark data 28 and performance results 24 may undergone analysis 20 using GxE analysis tools or period-of-years database 22.

Building an Environmental Classification System


[0048] The present invention provides a modern approach of product evaluation where a TPE is described. The description of a TPE includes classifying the land base into an environmental class and assessing the frequency of occurrence of the range of environments experienced at a given location. The present inventors contemplate that areas of adaption (AOA) could also be evaluated. As used herein, AOA refers to a location with the environmental conditions that would be well suited for a crop or specific genotype. Area of adaption is based on a number of factors, including, but not limited to, days to maturity, insect resistance, disease resistance, and drought resistance. Area of adaptability does not indicate that the crop will grow in every location or every growing season within the area of adaption or that it will not grow outside the area. Rather it defines a generally higher probability of success for a crop or genotype within as opposed to outside that area of adaptation.

[0049] The environmental information collected may be used to develop an environmental database for research locations. Initially, multiple environment trials are performed by planting different genotypes available from a variety of sources, e.g. germplasm, inbreds, hybrids, varieties in multiple environments. These trials aid the determination of whether the TPEs are homogenous or should be categorized into different environmental classifications. The performance data of these genotypes and environmental and/or physiological landmark data from the MET are collected and entered into a data set. For example, performance data collected for a genotype of corn may include any of the following: yield, grain moisture, stalk lodging, stand establishment, emergence, mid-silk, test weight, protein, oil, and starch. Yield refers to bushels of grain per acre. Grain
moisture refers to a moisture determination made from each plot at harvest time, using an instrument such as an electrical conductance moisture meter. Stalk lodging refers to the determination of the number of broken stalks in each plot prior to harvest. Stand establishment refers to the differences between the desired planting rate for each hybrid and the final stand. Emergence refers to an emergence count made on each plot after plant emergence where emergence percentage may be computed based on the number of plants and the number of kernels planted. The mid-silking date is the Julian day of the year in which 50% of the plants show silks at one site in a region. The test weights are typically reported as pounds per bushel on grain samples at field moisture. Protein, oil and starch are typically reported as a percent protein, oil, and starch content at a designated percent grain moisture on dried samples using standard methods, for example, a near infrared transmissance whole grain analyzer.

One skilled in the art would be familiar with performance data collected for other crops, for example, soybeans, wheat, sunflowers, canola, rice and cotton. Performance data for soybeans include, without limitation, relative maturity, plant height, lodging score, seed size, protein and oil percentage, Phytophthora resistance genes, Phytophthora partial resistance, Sclerotinia rating, and yield. Relative maturity refers to a determination that is designed to account for factors, such as soybean variety, planting date, weather, latitude and disease that affect maturity date and number of days from planting to maturity. Plant height refers to a determination of the soybean plant’s height, usually determined prior to harvest. Lodging, traditionally, the vertical orientation of the plant, i.e. the degree to which the plant is erect. The lodging of a soybean plant is traditionally rated by researchers using a scale of 1 to 9 as follows: 1.0=almost all plants erect, 3.0=either all plants leaning slightly, or a few plants down, 5.0=either all plants leaning moderately (45° angle), 25-50% down, 7.0= either all plants leaning considerably, or 50-80% down, 9.0=all plants prostrate. The seed size of a soybean plant typically refers to thousands of seeds per pound. Protein and oil percentage analysis may be determined using near infrared transmissance technology and reported at 13% moisture. Phytophthora resistance genes may be determined using a hypocotyl inoculation test with several races of Phytophthora to determine the presence or absence of a particular Rps gene in a soybean plant. Soybeans may also be evaluated for phytophthora partial resistance using a ratings system, where ratings of 3.0 to 3.9 are considered high levels of partial resistance, ratings of 4.0 to 5.9 are considered moderate, ratings over 6.0 indicate very little partial resistance or protection against Phytophthora. Soybeans may also be evaluated for partial resistance to Sclerotinia. Yield refers to bushels per acre at 13 percent moisture.

Typical performance data for wheat includes, without limitation, test weight, protein percent, seed size, percent lodging, plant height, heading date, powdery mildew, leaf blotch complex (LBC), Fusarium head scab (FHS), flour yield, and flour softness. Test weight refers to a determination of pounds/bushel using harvest grain moisture. Seed size refers to thousands of harvested seeds per pound. Percent lodging as described previously refers to a rating system used to estimate the percent of plants that are not erect or lean more than 45 degrees from vertical. Plant height refers to the distance from the soil surface to the top of the heads. Heading date refers to the average calendar day of the year on which 50 percent of the heads are completely emerged. Wheat infected with powdery mildew (PM) may be determined using a scale system where each plot is rated based on a 0 to 10 scale where: 0=0 to trace % leaf area covered; 1=leaf 4 with trace—50%; 2=leaf 3 with 5-15%; 3=leaf 3 with 5-15%; 4=leaf 3 with 15-25%; 5=leaf 2 with 1-5%; 6=leaf 2 with 5-15%; 7=leaf 2 with 15-25%; 8=leaf 1 with 1-5%; 9=leaf 1 with 5-15%; and 10=leaf 1 with 15-25% leaf area covered (leaf 1=flag leaf). This scale takes into account the percentage leaf area affected and the progress of the disease upward on the plants. Leaf blotch complex (LBC) caused by Stagonospora nodorum, Pyrenophora triticirepentis and Bipolaris sorokiniana for example may be determined when most varieties are in the soft dough growth stage and rated based on the percentage of flag leaf area covered by leaf blotches. Fusarium head scab (FHS) caused by Fusarium graminearum for example may be determined when plants are in the late milk to soft dough growth stage and each plot is rated based on a disease severity estimate as the average percentage of spikelets affected per head. Flour yield refers to the percent flour yield from milled whole grain. Flour softness refers to the percent of fine-granular milled flour. Values higher than approximately 50 indicate kernel textures that are appropriate for soft wheat. Generally, high values are more desirable for milling and baking.

Typical performance data for sunflower includes, without limitation, resistance to aphids, neck breakage, brittle snap, stalk breakage, resistance to downy mildew (Plasmopara halstedii), height of the head at harvest, seed moisture, head shape, hullability, resistance to the sunflower midge, Contarinia schulzi, percentage of oil content, seed size, yield, seedling vigor, and test weight. Resistance to aphids refers to a visual rating system indicating resistance to aphids based on a scale of 1-9 where higher scores indicate higher levels of resistance. Neck breakage refers a visual ratings system indicating the level of neck breakage, typically on a scale from 1 to 9 where the higher the score signifies that less breakage occurs. Brittle snap refers to a visual rating system indicating the amount of brittle snap (stalk breakage) that typically occurs in the early season due to high winds. The ratings system is based on a scale, usually ranging from 1-9, with a higher score denoting the occurrence of less breakage. A sunflower’s resistance to Downy Mildew (Plasmopara halstedii) may be determined using a visual ratings scaled system with 9 being the highest and 1 the lowest. A higher score indicates greater resistance. Height of the head at harvest refers to the height of the head at harvest, measured in decimeters. Seed moisture refers to a determination of seed moisture taken at harvest time, usually measured as a percentage of moisture to seed weight. Head shape of a sunflower is measured visually using a scale system where each plot is rated based on a 1 to 9 scale where: 1=closed “midge” ball; 2= trumpet; 3=clam; 4=concave; 5=cone; 6=reflex; 7=distorted; 8=convex; 9=flat. Hullability refers to the ability of a hulling machine to remove seed hulls from the kernel, typically measured on a 1-9 scale where a higher score reflects better hullability. Resistance to the sunflower midge, Contarinia schulzi, is determined based on head deformation which is rated on a 1-9 scale where: 9=no head deformation (fully resistant), 5=moderate head deformation, 1=severe head deformation (fully susceptible). The percentage of oil content from the harvested grain is measured and adjusted to a 10% moisture level. The oil content of a sunflower seed may be measured for various
components, including palmitic acid, stearic acid, oleic acid, and linoleic acid, using a gas chromatograph. Seed size refers to the percentage of grain that passes over a certain size screen, usually "size 13." Seedling vigor refers to the early growth of a seedling and is often times measured via a visual ratings system, from 1-9, with higher scores indicate more seedling vigor. Yield is measured as quintals per hectare, while test weight of seed is measured as kilograms per hectoliter.

[0053] Typical performance data for canola includes, without limitation, yield, oil content, beginning bloom date, maturity date, plant height, lodging, seed shatter, winter survival, and disease resistance. Yield refers to pounds per acre at 8.5% moisture. Oil content is a determination of the typical percentage by weight oil present in the mature whole dried seeds. Beginning bloom date refers to the date at which at least one flower is on the plant. If a flower is showing on half the plants, then canola is in 50% bloom. Maturity date refers to the number of days observed from planting to maturity, with maturity referring to 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. Plant height refers to the overall plant height at the end of flowering. The concept of measuring lodging using a scale of 1 (weak) to 9 (strong) is as previously described. Seed shatter refers to a resistance to siltage shattering at canola seed maturity and is expressed on a scale of 1 (poor) to 9 (excellent). Winter survival refers to the ability to withstand winter temperatures at a typical growing area. Winter survival is evaluated and is expressed on a scale of 0 to 5 where: 0=highly resistant, 5=highly susceptible. The Western Canadian Canola/Rapeseed Recommending Committee (WCCRRC) Blackleg classification is based on percent severity index as described as follows: 0-30%=Resistant, 30%-50%=Moderately Resistant, 50%-70%=Moderately Susceptible, 70%-90%=Susceptible, and >90%=Highly susceptible.

[0054] Typical performance data for cotton includes, without limitation, yield, turnout, micronaire, length, fiber strength of cotton and color grade. Yield is measured as pounds per acre. Turnout refers to lint and seed turnout which is calculated as the percentage of lint and seed on a weight basis as a result of ginning the sub sample from each treatment. Micronaire refers to fiber fineness and maturity and are measured using air flow instrument tests in terms of micronaire readings in accordance with established procedures. Fiber length is reported in 1/8 of an inch or decimal equivalents. Fiber strength is measured in grans per tex and represents the force in grans to break a bundle of fibers one tex unit in size. Color grade for cotton takes into consideration the color, fiber color and whiteness of cotton leaves. Color grade may be determined using a two digit scale. The two digit number is an indication of the fiber color and whiteness (i.e. 13, 51, or 84). The first digit can range from 1 to 8 representing overall color with 1 being the best color and 8 representing below grade colors. The second digit represent a fiber whiteness score. This number ranges from 1 to 5, with 1 representing good white color and 5 representing yellow stained. The second number in the overall color grade represents the leaf score and represents leaf content in the sample.

[0055] Typical performance data for rice includes, without limitation, yield, straw strength, 50% Heading, plant height, and total milling, and total milling. Yield is measured as bushels per acre at 12% moisture. Straw Strength refers to lodging resistance at maturity and is measured using a numerical rating from 1 to 9 where 1=Strong (no lodging); 2=Strongly strong (most plants lodging but no lodging); 3=Intermediate (most plants moderately lodging); 5=Weak (most plants nearly flat); and 9=Very weak (all plants flat). 50% heading refers to the number of days from emergence until 50% of the panicles are visibly emerged from the boot. Plant height is the average distance from the soil surface to the tip of erect panicle. Total milling refers to the total milled rice as a percentage of rough rice. Whole milling refers to rice grains of ¾ length or more expressed as a percentage of rough rice.

[0056] The environmental and physiological landmark data may be historical using historical meteorological information along with soils and other agronomic information or collected using National Oceanic and Atmospheric Association and/or other public or private sources of weather and soil data. Potential environmental and physiological landmark data that may be collected includes but is not limited to wind, drought, temperature, solar radiation, precipitation, soil type, soil pH, planting and harvesting dates, irrigation, tilted area, previous crop, fertilizer including nitrogen, phosphorous, and potassium levels, insecticide, herbicide, and biotic data, for example, insects and disease. The environmental and physiological landmark data may then be analyzed in light of genotype performance data to determine GxE interactions.

Models

[0057] Several models for determining GxE interactions exist. Base models group or classify the locations used to test the hybrids, include several variance components, and stratify the hybrids, for example, according to locations among station-year combinations, locations, or other chosen variances.

[0058] For example, as shown in Table 1, one base model Year Station (YS) groups the locations by year-stations where a year-station designates a unique site or location by year. Other variances include blocks within locations within year-stations, hybrids, hybrids by year-station divided by the sum of hybrids by locations within year station locations as well as a residual. The YS model is disadvantageous in that a given location’s environment will vary over time so that the GxE information gleaned from the model may not be relevant for predicting hybrids that will perform well in the same location next year.

[0059] Another model for determining GxE interactions disclosed in Table 1, groups different sites by location. Other variances for the GxE model include blocks within locations, hybrids, hybrids by locations, as well as a residual. However, the GxE model is disadvantageous in that a genotype grown in locations with differing environmental conditions may have similar performance results, complicating the analysis of the specific environmental conditions that play a role in contributing to genotype performance and reducing the certainty of predicting product performance.

[0060] Unlike the previous models mentioned, the present inventors contemplate determining GxE interactions using a
model referred to herein as Environmental Classification that groups locations by environmental classifications. Thus, variances for this model include locations within environmental classifications, blocks within locations within environmental classifications, hybrids by environmental classifications divided by hybrids by locations within environmental classifications and a residual.

<table>
<thead>
<tr>
<th>Model</th>
<th>Year-Station</th>
<th>G x E</th>
<th>Environmental Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variance for location</td>
<td>Location within year-station</td>
<td>Location within environmental classification</td>
<td></td>
</tr>
<tr>
<td>Variance for location</td>
<td>blocks within locations within year-station</td>
<td>blocks within locations within environmental classifications</td>
<td></td>
</tr>
<tr>
<td>Variance for hybrids</td>
<td>hybrids</td>
<td>hybrids</td>
<td>hybrids</td>
</tr>
<tr>
<td>Stratifications</td>
<td>hybrid by year-station/locations within locations</td>
<td>hybrid by environmental classifications</td>
<td></td>
</tr>
</tbody>
</table>

Burdon has shown that genetic correlation between GxE interactions can be estimated. (Burdon, R. D. 1977. Silvae Genet., 26: 168-175.) GxE analysis may be performed in numerous ways. GxE interactions may be analyzed qualitatively, e.g., phenotype plasticity, or quantitatively using, for example, an analysis of variance approach. (Schlichting, C. D. 1986. Annual Review of Ecology and Systematics 17: 667-693.) Statistical analysis of whether a GxE interaction is significant and whether environmental changes influence certain traits, such as yield performance, of the genotypes evaluated may be performed using any number of statistical methods including but not limited to, rank correlation, analysis of variances, and stability.

Rank Correlation

The most basic categorization of GxE interaction is to evaluate GxE interactions by performing a rank correlation according to standardized tests, for example, Spearman. The Spearman rank correlation may be performed to examine the relationships among genotypes in different environments, for example, crossover interactions that occur when two genotypes change in rank order of performance when evaluated in different environments. FIG. 2 illustrates an example of GxE interactions and cross-over interactions (COI) between two different varieties, Var A and Var B, in four different environmental classes, Env 1, Env 2, Env 3 and Env 4. FIG. 2A shows that Var A and Var B out-perform each other in different environments indicating the occurrence of both GxE and COI. FIG. 2B shows that Var A performed better than Var B in each environment, indicating GxE interactions but no COI. In contrast, FIG. 2C shows that Var A and Var B each performed consistently with respect to each other in all four environments, indicating lack of GxE interactions.

Analysis of Variance (ANOVA)


Stability

Once certain genotypes are identified that perform well in a target environment they may be analyzed to determine which hybrids are more stable in yield or other metrics using various methods. One method uses a regression of genotypic performance on an environmental index. In general, the environmental index is the deviation of the mean phenotype at environment from the overall mean phenotype of all environments. Thus, the phenotype of an individual genotype with each environment is regressed on the environmental index, as described in Bernardo R. 2002, Quantitative Traits in Plants. Stemma Press, Woodbury, Minn. to generate a slope (b-value) for each genotype/ cultivar evaluated. Other methods include the joint regression analysis method proposed by Perkins, J. M. and Jinks, J. L. 1968. Heredity, 23: 339-359, Finlay, K. W. and Wilkinson, G. N. 1963. Aust. J. Res. 14: 742-754 and Eberhart, S. A. and Russell, W. A. 1966. Crop Sci. 6:36-40 to calculate the regression coefficient (b), S.E. and variance due to deviation from regression (S2d) as a parameter of stability and adaptability. The model described by Eberhart and Russell has the following formula:

\[ P_{ij} = \mu + g_i + b_j + \delta_{ij} + e_{ij} \]

where \( P_{ij} \) is the mean phenotype of genotype or cultivar \( i \) in location \( j \), \( \mu \) is the grand mean across the whole experiment for all genotypes and locations,

\( g_i \) is the effect of genotype \( i \) across all locations

\( b_j \) is the linear regression of \( P_{ij} \) on \( \tau_j \)

\( \tau_j \) is the environmental index, that is the effect of environment \( j \) across all genotypes,

\( \delta_{ij} \) is the deviation \( P_{ij} \) from the linear regression value for a given \( \tau_j \) and

\( e_{ij} \) is the within environment error.

Categorization of Land Bases into Environmental Classes

Using the information collected for or from GxE analysis, the land bases may be categorized into environmental classifications. FIG. 5 illustrates one possible schematic for categorizing different land bases into environmental classifications. With reference to FIG. 5, one method of categorizing environmental classifications is illustrated as a
flow chart. If all maximum temperatures are greater than 28° Celsius 42, then the land base may be categorized as either Temperate Dry 54, Temperate Humid 52, Temperate 56, or Subtropical 48. If all maximum temperatures are greater to or equal to 30° Celsius and solar radiation is greater than 24 and 21 at a given crop development stage, e.g. V7-R1, R3-R6 respectively 40, then the land base is characterized as Temperate Dry 54. If the maximum temperature is not greater than or equal to 30° Celsius and solar radiation is not greater than 24 at a given crop development stage, e.g. V7-R1 and 21 for R3-R6 respectively 40, then the land base is characterized as Temperate 56. However, if the maximum temperature is less than 30° Celsius and solar radiation is greater than 24 and 21 at a given crop development stage 50, then the land base is characterized as Temperate Humid 52. If the maximum temperature is not less than 30° Celsius and solar radiation is not greater than 24 and 21 at a given crop development stage 50, then the land base is characterized as Temperate Humid 56. If all maximum temperatures 42 for the land base are less than 28° Celsius then the land base is characterized as High Latitude 44. In contrast, if all maximum temperatures 42 for the land base are not less than 28° Celsius and the land base has a photoperiod less than 13.4 hours/day 46, then the land base is Subtropical 48.

[0072] Categorizing land bases into environmental classifications has several advantages. First, environmental classifications can bring an understanding of the various environments under which crops are produced. Second, occurrence probabilities for each environmental category can be assigned to each geographic location and the frequency of the classifications determined using routine methods. FIG. 6 is a bar graph representation of the frequency of various environmental classes among TPEs or METs. The frequency for each environmental class, e.g. temperate, temperate dry, temperate humid, high latitude, and subtropical, is given as a percent of the total TPE or MET tested in given year or across years. FIG. 7 illustrates potential categories of environmental classes identified throughout the United States in 1988 and their locations; these include temperate, temperate dry, temperate humid, high latitude, and subtropical classes. It will be apparent to one skilled in the art that other environmental classifications may be added as defined or deemed relevant to GxE interactions for various crops.

[0073] Some of the environmental classification may be defined using general characteristics of climates. For example, temperate may be used to refer to regions in which the climate undergoes seasonal change in temperature and moisture; typically these regions lie between the Tropic of Capricorn and Antarctic circle in the Southern Hemisphere and the Tropic of Capricorn and the Arctic circle in the Northern Hemisphere. Temperate humid may refer to regions in which the climate undergoes seasonal change in temperature and moisture and has more humidity than a temperate environment. High latitude as an environmental class may refer to regions that have a longer photoperiod than and is typically north of a particular latitude. A subtropical class may refer to regions enjoying four distinct seasons usually with hot tropical summers and non-tropical winters with a shorter photoperiod/day length; typically these regions lie between the ranges 23.5-40° N and 23.5-40° S latitude. The environmental classes may also be defined by biotic factors, such as diseases, insects, and/or characteristic of a plant. For example, an ECB class may refer to regions having European Corn Borers (ECB) or the suspected presence of ECB as evidenced by preflowering leaf feeding, tunneling in the plant’s stalk, post flowering degree of stalk breakage and/or other evidence of feeding. The environmental class Brittle may be used to refers to regions where stalk breakage of corn occurs or is apt to occur near the time of pollination and is indicative of whether a hybrid or inbred would snap or break near the time of flowering under severe winds.

[0074] It is to be understood that the environmental classifications may be used and defined differently for different crops/genotypes and that these definitions may vary from year to year, even for the same crops or genotypes. For example, in 2000-2003, trials conducted studying GxE interactions among Comparative Relative Maturity (CRM) hybrids of CRM 103-113 in different environments identified seven different environmental classes—temperate, temperate dry, temperate humid, high latitude, subtropical, ECB, and Brittle. For the study purposes, temperate was identified/defined as having a low level of abiotic stresses, a growing season adequate for CRM 103-113, and found to be frequent in Iowa and Illinois. Temperate dry was defined as temperate with some level of water and/or temperature stress and found to be frequent in Nebraska, Kansas, and South Dakota. Temperate Humid was defined as similar to the temperate environmental class but had a complex of biotic factors, such as leaf disease, that may differentially affect product performance. Temperate humid was also characterized as having a temperature and solar radiation lower than that identified in the temperate environmental class and found to be frequent in Indiana, Ohio, and Pennsylvania. The High Latitude environmental class was found to grow corn CRM 103 and earlier (growing hybrids) and experienced colder temperatures than the Temperate environmental class but with longer day-length. This environmental class was found to be frequent in Canada, North Dakota, Minnesota, Michigan, and Wisconsin. The fifth environmental class, Subtropical, was characterized as warm and humid with a short day-length and found frequently in the Deep South of the United States. Another environmental class identified was European Corn Borers (ECB) and defined as having Bacillus thuringiensis (Bt) hybrids that outyielded base genetics by at least 10%. The last environmental class Brittle defined areas with significant brittle damage with differential effect on products.

[0075] Once areas of land are categorized as environmental classes, these areas may be used in METs. Ultimately, the observed genotype performances in METs can be related to the environmental class to the TPE. By evaluating product performance in a target environment, rather than merely performance differences in METs, genotype performance data from multiple test environments can be correlated to a target environment and used to predict product performance. This correlation between a genotype’s performance and the target environment or environmental classification will lead to more precise product placement since the genotype performance is characterized within an environmental class in which it is adapted and most likely to experience after commercialization, consequently resulting in improved and more predictable product performance. The analysis of GxE interactions facilitates the selection and adoption of genotypes that have positive interactions with its location and its prevailing environmental conditions (exploitation of areas of specific adaptation). GxE analysis also aids in the identi-
fication of genotypes with low frequency of poor yield or other performance issues in certain environments. Therefore, GxE analysis will help in understanding the type and size of GxE interactions expected in a given region. The present inventors contemplate that proper selection of hybrids for a particular land base will improve agricultural potential of certain geographic areas by maximizing the occurrence of crop performance through the use of the environmental classification. In addition, this approach allows the use of statistical and probability based analysis to quantify the risk of product success/failure according to the frequency of environment classes and the relative performance of genotypes within each environment class. This early identification and selection of hybrids would enable seed producers to start seed production and accelerate the development of hybrids in winter nurseries in warmer southern climates.

Moreover, environmental classification allows for the creation of an environmental profile for all or any part of the land base classified. Environmental classifications can be determined for each producer’s land base. Similarly, the environmental performance profile of cultivars/hybrids can be determined through field experimentation or predicted using GxE analysis. In combining environmental classification frequencies for a particular land base and product performance by environmental classification, performance measurements are given an appropriate amount of relevance or weight for the land base in question. For example, the data are weighted based on long-term frequencies to compute a prediction of hybrid performance.

Use of GxE in Producer’s Selection

According to another aspect of the present invention, a method of using information that documents the environmental profile over time of a crop producer’s land base, the environmental performance profile of crop cultivars, and the producer’s objectives to select a portfolio of cultivars that maximizes and quantifies the probability that the producer’s objectives for productivity will be met. Environmental classification can be used to assist in this process.

Environmental classification can be used to determine the primary environmental drivers of GxE interaction in crops such as corn. That is, what are the primary environmental factors that cause change in the relative performance of hybrids. With this knowledge, crop production areas can be categorized into environmental frequency classes. Within these classes, hybrids tend to perform (as measured by yield) relatively similar to another. Across these classes, the relative performance of hybrids tends to be significantly different. Using historical meteorological information along with soils, pests, and other agronomic information, the frequency of these environments can be determined. This allows the creation of an environmental profile for all or any part of the geography classified. That is, a frequency distribution of the occurrence of the key Environment Classes. This can be done for each crop producer’s land base.

Similarly, the environmental performance profile of crop cultivars can be determined through field experimentation. That is, a description of relative performance of cultivars can be determined in each of the key environment classes. In combining Environment class frequencies for a particular land area and product performance by Environment Class, performance measurements are given an appropriate amount of relevance or weight for the land area in question.

Thus, this aspect of the invention involves combining of this information at the producer’s level to optimize crop productivity in such a way that it maximizes the probability of the producer’s business operation reaching its productivity goals. The present invention contemplates that information can be used from any number of classification schemes to the selection of cultivars with the objective of maximizing the probability of attainment of the productivity and business goals of a crop producer’s operation.

The approach of this aspect of the present invention does so by using compiled long term geo-referenced weather, soils, and agronomic data including biotic factors for the producer’s land base to categorize the land base in terms of how frequently annual environmental variation occurs to a degree that is likely to impact relative hybrid performance. In addition, it can incorporate the producer’s business objectives including, but not limited to preparedness to take risk. The present invention is able to combine environmental variability with producer business information to create a producer profile. Product performance information stratified by the same criteria is used to define the producer’s environmental profile (for example, environmental classes) which is then integrated with the producer’s profile.

The relative hybrid performance information that is relevant to the producer’s land base is used regardless of when and where it was generated. The present inventors are first to predict future performance of genotypes and quantify probability/risk associated with that performance using data from environments that are considered to be substantially equivalent in terms of relative hybrid response. The result is a more robust and predictive data set thus allowing more informed product selection decisions that, over time will result in a higher probability of a producer operation meeting business objectives for productivity.

FIG. 8 illustrates information flow according to one embodiment of the present invention. In FIG. 8 there is an environmental profile 100. The environmental profile can be based on one or more inputs such as environment classes 102, meteorological information 104, agronomic information 106, or field experimentation 108. In FIG. 1 there is also a producer profile 110. The producer profile 110 is based on one or more inputs such as risk tolerance 112 of the producer, business goals 114 of the producer, productivity goals 116, financing 118 considerations, third party needs 119, for example a landlord, or insurance/risk management and marketing 120 considerations. The environmental profile 100 and the producer profile 110 are combined in order to produce recommendations 122. The recommendations 122 can include risk management tools, a recommended seed product, a recommended mix of seed products, production practice recommendations, such as chemical application information, or any number of other specific recommendations as may be appropriate based on the particular environmental profile 100 and producer profile 110.

FIG. 9 illustrates one embodiment of a system 124 for producing product recommendations. In FIG. 9, a processor 126 accesses information associated with a producer
profile 110, an environmental profile 100, and a genotype by environment database 132. There is an input device 128, a recommendation output 129, and a display 130 operatively connected to the processor. The present invention contemplates that the processor 126 can be associated with a computer such as handheld computer as may be convenient for a dealer or sales agent. The present invention also contemplates that the processor profile 110, environmental profile 100, and genotype by environment database 132 may be accessible over a network, including a wide-area network such as the Internet.

[0085] Using the information in the producer profile 110, environmental profile 100, and genotype-by-environment database 132, the processor applies one or more of a product selection algorithm module 134, a product comparator 136, a production practice module and a risk comparator 138, and a product portfolio module 140. These and/or other modules are collectively the recommendation logic 142. In a simple case, the product selection algorithm module 134 would take information from the environmental profile 100, such as an environmental classification (“Temperate”, for example) in addition to information from the producer profile 110, such as a producer objective (“Maximize Yield”, “Risk Minimization”, “Low Harvest Moisture” for example) and match these criteria to products in the genotype-by-environment database 132. Of course, more specific criteria could be examined as would be the case with more complex environmental profile information and more complex producer profile information.

[0086] FIG. 10 illustrates one embodiment of a screen display 144 of a software application the present invention. In FIG. 10, a user is given the choice of selecting “DEFINE ENVIRONMENTAL PROFILE”146, “DEFINE PRODUCER PROFILE”148, and “VIEW RECOMMENDATIONS”150. Of course, the present invention contemplates that software and its accompanying user interface can be implemented in any number of ways.

[0087] FIG. 11 illustrates one embodiment of a screen display 152 of a software application of the present invention. In FIG. 11, a recommendation is given which includes a plurality of products 154, an associated number of acres 156 associated with each of the products, a risk/probability assessment 157, and a recommended crop revenue assurance 158. The present invention provides for decreasing the amount of risk associated with selection of a particular seed product by instead selecting multiple products with different GxE interactions in order to reduce risk associated with environmental variations. The resulting selection, is somewhat akin to selection of stocks in a stock portfolio.

[0088] FIGS. 12 and FIG. 13 illustrate embodiments of user interfaces to use in precision farming applications. In FIG. 12, the user interface 170 includes site-specific information associated with location information 172. The present invention contemplates that other site-specific information or historical information is accessible based on the location information 172 and may be used in product selections. In addition, environment and production information is collected. Examples of such information includes maturity days 176, input traits 178, output traits 180, seed treatment 182, whether no till practices 174 are used, the planting population 184, nitrogen utilization 186, and drought impact based on environmental classification drought frequency information 187 and soil type. Based on this information and information associated with the location 172, a recommendation 188 of at least one hybrid seed product is made. Where multiple recommendations are made, the recommendations can be ranked as well as a risk assessment 189 such as shown.

[0089] FIG. 13 illustrates another embodiment of a user interface 200 that can be used in crop production applications. Site specific information is collected such as location 172, soil type 174, and number of acres 202. In addition, there is the option to import precision farming data 204 as well as import environment of frequency data 205. There are also the options to set production practices, set environmental assumptions, set risk levels, and set the maximum number of hybrids 212. Based on the inputs, a portfolio is created that includes a plurality of products 214, an associated number of acres 216 to plant for each product, a recommendation 217 of at least one hybrid seed product, a risk assessment 218, and revenue assurance 219. Where multiple recommendations are made, the recommendations can be ranked. There is also an option to generate precision farming information 220 based on this information, such as a prescription map. The present invention contemplates that the precision farming information may indicate which acres to plant with which hybrids, give specific production practice application (such as chemical application rates), or other recommendations.

[0090] FIG. 14 illustrates one example of a field-by-field analysis showing product recommendations for a land base of a producer. As shown in FIG. 14, different land areas within a producer’s land base have different hybrids associated with them. The present invention contemplates producing such a map or field-by-field recommendations where multiple products are recommended. It should further be understood that a single producer or other user may have operations in a number of geographically diverse locations, and not necessarily the nearby fields illustrated in FIG. 14.

[0091] It should also be appreciated that the use of environmental classification and GxE interactions should be effectively communicated to customers. The effectiveness of the environmental classification process is based in part on its ability to use historical data from many locations so that all available data is used. This aspect of environmental classification would seem counter-intuitive to a customer who primarily relies upon personal knowledge in the local area. The customer’s confidence in firsthand production knowledge can be used to assist in increasing confidence in environmental classification.

[0092] FIG. 15 illustrates one example of the methodology of this aspect of the invention to assist in explaining these concepts to a producer. In step 300 site-specific data collection for a land base is performed. Based on this site-specific data collection, in step 302, the land base is given an environmental classification. In addition to this information, the type of hybrid selected in the previous year and its performance is provided by the producer in step 304. In step 306, a prediction is made as to the previous year’s production based on environmental classification. In step 308, the predicted results are compared with the actual results. The present invention also contemplates not requiring performance results from the producer until after the
previous year’s results have been predicted in case the producer is not confident that an independent prediction is made.

[0093] FIG. 16 illustrates one example of a screen display showing such comparisons. In FIG. 16, performance predictions (yield) are made for a number of different hybrids for both the previous year and the current year. In addition, a risk assessment for each hybrid may also be provided. The producer can compare the prediction for the previous year with the actual performance for that year in order to understand how well the environmental classification method can predict a result. If the producer is confident in the method’s ability to correctly predict a result, the producer will be more inclined to use the prediction made for the coming year. The present invention contemplates that the same or similar information can be presented in any number of ways. It should further be understood that such a demonstration assists in illustrating the accuracy of the system in predicting relative performance differences between seed products. Due to the number of potential variables and difficulty in controlling such variable accurate prediction of absolute performance is generally not a reasonable goal. However by selecting appropriate environmental classifications, useful insight into relative performance can be provided.

Compensation and Evaluating the Land Base

[0094] The present invention recognizes that agricultural input suppliers benefit from the success which they assist crop producers in obtaining. For example, when a seed product performs exceptionally well for a producer, such a seed product may be perceived as being of higher quality than competing products in future years. When a seed product performs poorly, such as seed product may be perceived as being of a lower quality or undesirable and the producer and other producers may be disinclined to purchase the seed product in future years. It should be appreciated that these perceptions are not facts, but merely one data point. While the genotype for each of the products may be capable of producing high performers, the circumstances regarding the environment, and the resulting GxE interactions may have limited performance. Therefore, the result of the performance has very limited utility when viewed in isolation because the same or highly similar environmental conditions may not be present in the future years. The use of the environmental classification system of the present invention is advantageous as it incorporates significant data and therefore does not limit one to an isolated and restrictive view of the performance of an agricultural input.

[0095] As previously indicated, there may be some resistance to use of an environmental classification system by particular producers because it requires reliance on data that was not observed firsthand. Also, as previously indicated, there is a benefit to suppliers of agricultural inputs to have producers provide the best results. To increase the likelihood of those results the present invention, as an example, provides for tying the compensation received for the seed product to evaluating the land base on which the seed is to be planted and/or the performance of the seed product on the land base. One way of evaluating the land base is by promoting the use of environmental classification or other systems that take into account GxE interactions.

[0096] The compensation received for the seed products can be determined in a variety of different ways and can be of many different types. This can include, without limitation, pricing the seed product based on the performance of the seed product in the land base, determining the compensation received based at least partially on the quality of the land base, providing the at least one seed products in exchange for the compensation under a license agreement, and/or tying the use of the at least one seed product within the land base to a cost of use of at least one seed product.

[0097] FIG. 18 illustrates one embodiment of the present invention wherein an agricultural input supplier 500 provides a seed product 502 to a producer 504 in exchange for compensation under a license agreement 506. The license agreement 506 includes an evaluation of the land base 514 based on an environmental classification 508 of the land base 514, a determination of the location 510 of the land base 514, the seed product 502 to be used at the land base 514, and the price 512 of the seed product 502. As a means of auditing the performance of the seed product 502 at the land base 514, verification means 516 are employed. These may include remote sensing of the field, GPS data associated with crop production, weight tickets, and yield monitoring data. Note that the verification can be of various types, including verifying that the proper type and amount of seed is planted at the agreed upon location as well as verifying the performance of the seed product.

[0098] Based on several factors, including but not limited to the environmental classification and performance of the genotype of each of the at least one seed product in the environmental profile of the land base, a recommendation for a producer regarding which seed products to use in the land base can be made. The producer accepting the recommendation and making purchases based on the recommendation may be a condition of receiving the seed product in exchange for compensation which is tied to the evaluation of the land base. The recommendation may include the selection of one or more specific products, or may include a recommendation that one or more products be selected from a particular set of products. Such a methodology encourages the producer in making decisions based on GxE interactions and/or environmental classification.

[0099] By tying the compensation received for seed products based on an evaluation of the land base and/or the performance of the seed products, the agricultural input supplier is picking up some of the risk of agricultural production. Alternating their role may be expressed as participating in value creation. One way the agricultural input supplier can add to the value is by making specific recommendations of inputs or practices which will or likely will enhance the value or performance of the crop. By making good recommendations, the agricultural supplier reduces their risks.

[0100] The agricultural input supplier can further offset the additional risk by taking positions in the grain market. In one embodiment of the invention, this may include purchasing options in order to cover any potential losses as a result of tying the compensation received for the seed products to evaluating the land base and/or the performance of the seed products on the land base. In other words, the agricultural supplier risks loss of income if its customers’ crops perform poorly. When the customers’ crops perform poorly if there is poor performance generally, then there is a greater likelihood that the price of crops will rise. Thus, the input supplier can manage risks by taking appropriate market positions. The agricultural input supplier can further manage risks by tying performance to price in diverse geographical locations and over a range of agricultural inputs to further diversify.

[0101] An additional way for the agricultural input supplier to offset risk is to require the producer to make a
minimum payment for the seed. The agricultural input supplier might also require the use of risk management instruments, such as crop insurance or crop revenue insurance based on environmental classification of the land base and the recommendations and risk assessments for seed products, herbicides, insecticides, and other inputs or production practices. Of course, the present invention contemplates combining this information with other information that may be used in determining the compensation to be received in exchange for the seed products. The input supplier may require insurance, such as multi-peril or catastrophic coverage, to ensure the producer would be able to make the minimum payment for the seed. Crop revenue coverage may also be required to protect against lost revenue caused by low prices, low yields or any combination of the two.

[0102] Another type of risk confronting an input supplier is if a producer does not comply with the terms of the agreement. For example, a producer may try to buy seed for one location but plant it at another location. A producer may try to over buy seed for a location where the purchase price is less and plant some of the seed elsewhere. A producer may under-report past or actual performance. Thus, the input supplier needs to manage the risk associated with these and other scenarios.

[0103] In order to minimize this risk, the present invention provides for means for verifying the performance of the seed product in the land base. The verification may include the use of GPS data associated with planting and/or harvesting the seed products at the land base, reviewing weigh tickets and/or yield monitoring data for crops produced from the land base, and/or remote sensing of the land base. The GPS data can be used to verify that planting operations occurred at a particular location and other planting details that assist in verifying this information. Of course, in addition to or instead of analyzing this data, field service agronomists and/or crop scouts can also verify information.

[0104] FIG. 19 provides an example of auditing the performance of a seed product. In FIG. 19, a license is formed which includes a determination of the location of the land base 550, a classification of the land base 552 and a recommendation of seed products for use on the land base. The present invention provides for using environmental classification and product recommendations in determining the licensing terms and conditions. The performance of the seed product may be audited at the planting stage by reviewing GPS data associated with planting the seed product 556. At the growing stage, the seed product may be audited by use of remote sensing 558. At the harvest stage, reviewing GPS data associated with harvesting the seed products 560, reviewing weigh tickets associated with crop production 562, and/or reviewing yield monitoring data 564 may be used to audit the performance of the seed products at the land base.

[0105] The present invention contemplates numerous variations from the specific embodiments provided herein. These include variations in the environmental classifications, performance characteristics, software or hardware where used, the type of and other variations.

[0106] All publications, patents and patent applications mentioned in the specification are indicative of the level of those skilled in the art to which this invention pertains. All such publications, patents and patent applications are incorporated by reference herein for the purpose cited to the same extent as if each was specifically and individually indicated to be incorporated by reference herein.

What is claimed:
1. A method of selling seed products for planting by a crop producer comprising:
   
   characterizing a land base at which the seed will be planted;
   
   determining the seed to be planted at the land base
   
   pricing the seed product based on performance of the seed product within the land base.

2. The method of claim 1 wherein the step of characterizing the land base comprises providing an environmental classification of the land base.

3. The method of claim 1 wherein the performance is expected performance.

4. The method of claim 3 wherein the expected performance is at least partially based on characteristics of the land base.

5. The method of claim 4 wherein the characteristics of the land base are based at least partially on an environmental classification associated with the land base.

6. The method of claim 1 wherein the step of determining the seed to be planted at the land base is at least partially based on performance of the seed product associated with an environmental classification.

7. The method of claim 1 wherein the performance is actual performance.

8. The method of claim 1 further comprising recommending at least one type of seed product for use in the land base.

9. The method of claim 8 where the step of recommending at least one type of seed product for use in the land base is at least partially based on genotype-by-environment interactions between the seed product and the land base.

10. The method of claim 9 wherein the genotype-by-environment interactions are determined at least partially based on performance data associated with the seed product.

11. The method of claim 9 wherein the genotype-by-environment interactions are determined at least partially based on environmental classifications associated with performance data of the seed products.

12. The method of claim 1 further comprising auditing the performance of the at least one seed product within the land base.

13. The method of claim 1 wherein the step of pricing the seed product based on performance of the seed product within the land base is performed by a computer in operative communication with a database of performance data associated with land bases.

14. A method of selling seed products to a producer wherein compensation for the seed products is tied to the quality of the land base of the producer, the method, comprising:

   evaluating the land base of the producer to determine a quality of the land base; determining compensation for at least one seed product at least partially based on the quality of the land base; and

   providing the at least one seed products to the producer in exchange for the compensation.

15. The method of claim 14 wherein the step of evaluating the land base comprises providing an environmental classification of the land base.

16. The method of claim 15 wherein the environmental classification is selected from a set of environmental classes,
the set of environmental classes comprising a temperate class, a temperate dry class, a temperate humid class, a high latitude class, and a subtropical class.

17. The method of claim 15 wherein the environmental classification is selected from a set of environmental classes, the set of environmental classes comprising biotic classifications.

18. The method of claim 15 wherein the quality of the land base is associated with the environmental classification.

19. The method of claim 15 wherein the quality of the land base is associated with performance of the seed product associated with the environmental classification.

20. The method of claim 14 further comprising recommending at least one type of seed product for use in the land base.

21. The method of claim 20 further comprising selecting crop insurance based on the recommendation.

22. The method of claim 20 where the step of recommending at least one type of seed product for use in the land base is at least partially based on genotype-by-environment interactions between the at least one seed product and the land base.

23. The method of claim 22 wherein the genotype-by-environment interactions are determined at least partially based on performance data associated with the seed products.

24. The method of claim 23 wherein the genotype-by-environment interactions are determined by statistical methods.

25. The method of claim 22 where the genotype-by-environment interactions are determined by a qualitative method.

26. The method of claim 25 where the qualitative method is phenotype plasticity.

27. The method of claim 22 wherein the genotype-by-environment interactions are determined at least partially based on environmental classifications associated with performance data of the seed products.

28. The method of claim 27, wherein said performance data includes at least one item from the set consisting of yield, drought resistance, grain moisture, lodging, stand establishment, emergence, mid-silk, test weight, protein, oil, and starch percentage, relative maturity, plant height, seed size, disease resistance genes, heading date, resistance to insects, brittle snap, stalk breakage, resistance to fungus, seed moisture, head shape, hullability, seedling vigor, beginning bloom date, maturity date, seed shatter, winter survival, fiber strength, and color grade.

29. The method of claim 14 wherein the step of determining compensation for at least one seed product is at least partially based on both the quality of the land base and the expected performance of the at least one seed product within the land base.

30. The method of claim 14 wherein the step of determining compensation for at least one seed product is at least partially based on both the quality of the land base and the actual performance of the at least one seed product within the land base.

31. The method of claim 14 further comprising auditing the performance of the at least one seed product within the land base.

32. The method of claim 31 wherein the step of auditing includes auditing GPS data associated with crop production in the land base.

33. The method of claim 32 wherein the GPS data is associated with planting the at least one seed product in the land base.

34. The method of claim 32 wherein the GPS data is associated with harvesting the at least one seed product from the land base.

35. The method of claim 31 wherein the step of auditing includes reviewing weight tickets for crops produced from the land base.

36. The method of claim 31 wherein the step of auditing includes reviewing yield monitoring data for crops produced from the land base.

37. The method of claim 31 wherein the step of auditing comprises remote sensing of the land base.

38. The method of claim 14 wherein the step of providing the at least one seed products in exchange for the compensation further comprises providing the at least one seed products in exchange for the compensation under a license agreement.

39. The method of claim 14 wherein the at least one seed product is a plurality of seeds.

40. The method of claims 14 wherein the step of determining compensation for at least one seed product at least partially based on the quality of the land base is performed by a computer in operative communication with a database of performance data associated with land bases.

41. A method for auditing performance of at least one seed product used in a land base in a predetermined location, comprising:

- determining the location of the land base at which the at least one seed product will be used;
- tying the use of the at least one seed product within the land base to a cost of use of the at least one seed product; and
- verifying use of the at least one seed product within said land base.

42. The method of claim 41 further comprising verifying performance of the seed product within the field.

43. The method of claim 41 wherein the step of verifying includes auditing GPS data associated with crop production in the land base.

44. The method of claim 43 wherein the GPS data is associated with planting the at least one seed product in the land base.

45. The method of claim 43 wherein the GPS data is associated with harvesting the at least one seed product from the land base.

46. The method of claim 41 wherein the step of verifying includes reviewing weight tickets for crops produced from the land base.

47. The method of claim 41 wherein the step of verifying includes reviewing yield monitoring data for crops produced from the land base.

48. The method of claim 41 wherein the step of verifying comprises remote sensing of the land base.

49. The method of claim 41 further comprising providing an environmental classification of the land base.

50. The method of claim 49 wherein the cost of use of the at least one seed product is at least partially determined based on expected genotype-by-environment interactions between the environmental classification associated with the land base and the at least one seed product.
51. The method of claim 41 further comprising recommending at least one type of seed product for use in the land base.

52. The method of claim 41 further comprising providing the at least one seed product in exchange for compensation, wherein said compensation is the cost of use of the at least one seed product.

53. A method for auditing performance of at least one seed product used in land base in a predetermined location using GPS data associated with crop production in the land base, the method comprising:

- determining the location of the land base at which the at least one seed product will be planted;
- providing the at least one seed product to be used at the land base in exchange for a compensation;
- tying the use of the at least one seed product within the land base to the compensation; and
- verifying the use of the at least one seed product using GPS data associated with crop production in the land base.

54. The method of claim 53 wherein the GPS data is associated with planting the at least one seed product in the land base.

55. The method of claim 53 wherein the GPS data is associated with harvesting the at least one seed product from the land base.

56. The method of claim 53 further comprising verifying performance of the seed product within the field.

57. The method of claim 53 further comprising providing an environmental classification of the land base.

58. The method of claim 57 wherein the cost of use of the at least one seed product is at least partially determined based on expected genotype-by-environment interactions between the environmental classification associated with the land base and the at least one seed product.

59. The method of claim 53 further comprising recommending at least one type of seed product for use in the land base.

60. A method of licensing at least one seed product for planting by a crop producer associated with a land base comprising a plurality of fields, the method comprising:

- determining the at least one seed product to be planted in each of the plurality of fields of the land base;
- providing an environmental classification of each field within the land base; and
- determining a cost of the at least one seed product for each field within the land base at least partially based on the classification of each field within the land base.

61. The method of claim 60 further comprising recommending at least one type of seed product for use in each of the plurality of fields of the land base.

62. The method of claim 61 where the step of recommending at least one type of seed product for use in the land base is at least partially based on genotype-by-environment interactions between the at least one seed product and each of the plurality of fields of the land base.

63. The method of claim 62 wherein the genotype-by-environment interactions are determined at least partially based on performance data associated with the seed products.

64. The method of claim 62 wherein the genotype-by-environment interactions are determined at least partially based on environmental classifications associated with performance data of the seed products.

65. The method of claim 60 wherein the step of determining a cost of the at least one seed product is at least partially based on both the characterization of each of the plurality of fields within the land base and the expected performance of the at least one seed product within each of the plurality of fields within the land base.

66. The method of claim 60 wherein the step of determining a cost of the at least one seed product is at least partially based on both the characterization of each of the plurality of fields within the land base and the actual performance of the at least one seed product within each of the plurality of fields within the land base.

67. The method of claim 60 further comprising auditing the performance of the at least one seed product within each of the plurality of fields within the land base.

68. A method of recommending at least one seed product for planting by a crop producer associated with a land base comprising a plurality of fields, the method comprising:

- identifying the location of the land base at which the at least one seed product will be planted;
- classifying the land base to provide an environmental classification;
- determining a recommendation of the at least one seed product to be used at the land base based on the environmental classification and performance of the genotype of each of the at least one seed product in the environmental profile of the land base;
- determining compensation for the at least one seed product at least partially based on the quality of the land base; and
- providing the at least one seed products to the producer in exchange for the compensation.

69. The method of claim 68 wherein the step of determining a cost of the at least one seed product is at least partially based on both the characterization of each of the plurality of fields within the land base and the expected performance of the at least one seed product within each of the plurality of fields within the land base.

70. The method of claim 68 wherein the step of determining a cost of the at least one seed product is at least partially based on both the characterization of each of the plurality of fields within the land base and the actual performance of the at least one seed product within each of the plurality of fields within the land base.

71. The method of claim 68 further comprising auditing the performance of the at least one seed product within each of the plurality of fields within the land base.

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