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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
14 March 2024 (14.03.2024)

WIPO | PCT

(10) International Publication Number
WO 2024/052902 A1

(51) International Patent Classification:
A01G 9/12 (2006.01) *A01G 17/06* (2006.01)
A01G 9/02 (2018.01)

(21) International Application Number:
PCT/IL2023/050951

(22) International Filing Date:
05 September 2023 (05.09.2023)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
296216 05 September 2022 (05.09.2022) IL

(71) Applicant: **R.P. GROW-TEC INNOVATIONS LTD.** [IL/IL]; 1934000 Gazit (IL).

(72) Inventors: **RAZIEL, Shlomy**; 1934000 Kibbutz Gazit (IL). **MINES, Ori**; 1934000 Kibbutz Gazit (IL). **GALANT, Nir**; 1934000 Kibbutz Gazit (IL). **PINCHUK, Omer**; Hisin 20, 6428422 Tel-Aviv (IL). **AMAR, Ron**; Argaman 21, Shimshit 1790600 (IL). **HACOHEN, Ilan**; 1232500 Kibbutz Gadot (IL). **FRADKIN, Yuval**; 1232500 Kibbutz Gadot (IL). **BAR-SADE, Raz**; 1232500 Kibbutz Gadot (IL).

(74) Agent: **BRESSLER, Eyal** et al.; DR. EYAL BRESSLER LTD., Yitzchak Rabin St. 1, Global Towers A, 18th floor, 4925110 Petach Tikva (IL).

(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, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, 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, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, 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, ME, 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).

(54) Title: MULTI-STORY HORIZONTAL TRELLISING AGROTECHNIQUES

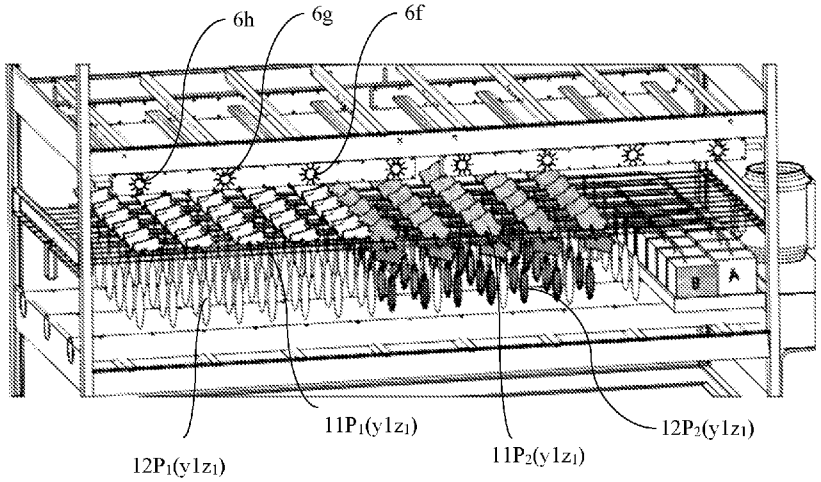


Fig. 5b

(57) Abstract: Vertical trellising agriculture is used in indoor and outdoor applications. Drawbacks of vertical trellising are known in the art, and usually concerns aspects related difficulties in compactization of the modules and cascading the production, especially in indoor controlled environments, where typical yields are up to about 350 Kg/m^2 floor. The present invention discloses multi-story horizontal trellising agro-techniques thereof; and provides a. modular vertically stackable trellising methods with greater yields per square meter floor.

WO 2024/052902 A1

[Continued on next page]

Published:
— *with international search report (Art. 21(3))*

MULTI-STORY HORIZONTAL TRELLISING AGROTECHNIQUES

FILED OF THE INVENTION

[1] The present invention pertains to multi-story horizontal trellising agro-techniques. The invention also relates to methods for three-dimensions horizontal-trellising agrotechnology.

BACKGROUND OF THE INVENTION

[2] Vertical trellising agriculture utilizes for both indoor and outdoor applications. Drawbacks of vertical trellising are known in the art, and usually concerns aspects related difficulties in compactization of the modules and cascading the production, especially in indoor controlled environments, where typical yields are up to about 350 Kg/m^2 floor. It hence a long felt need to disclose modular vertically stackable trellising system provided by greater yields per square meter floor.

SUMMARY OF THE INVENTION

[3] It is hence one object of the invention to disclose a method for continuously yielding of plants' products. The method, *inter alia*, comprises steps of providing a multi-story horizontal trellising system, characterized by one or more vertically erected stories. Each story comprises an array of growing boxes located at a first end of an array of horizontal trellising wires. The trellising wires are having a first end, located adjacent to the array of growing boxes, and an opposite end, located far from the growing boxes. Along the trellising wires there are provided two or more sections, a first section begun at the first end of the trellising wire; and a last section, terminated at the opposite end of the trellising wire. For each of the stories, placing roots of leading plants $\mathbf{P1(y_{1...n}z_{1...n})}$ within the array of growing boxes $\mathbf{1P1(y_{1...n}z_{1...n})}$), and supporting its leaves by the trellising wires; cultivating the leading $\mathbf{P1(y_{1...n}z_{1...n})}$ plants for a period of time, along the first section of the trellising wires. After a period of time, and for each of the stories, advancing leaves of the leading plants $\mathbf{P1(y_{1...n}z_{1...n})}$ from the first section to the second section; trimming and pruning canopy of the leading plants $\mathbf{P1(y_{1...n}z_{1...n})}$ along the first section; placing roots of first chasing plants $\mathbf{P2(y_{1...n}z_{1...n})}$ within a second array of growing boxes $\mathbf{1P2(y_{1...n}z_{1...n})}$, located behind the first array of growing boxes $\mathbf{1P1(y_{1...n}z_{1...n})}$; supporting leaves of the first chasing plants $\mathbf{P2(y_{1...n}z_{1...n})}$ at the beginning of the first section,

now free of canopy of the leading plants **P1($y_{1...n}z_{1...n}$)**; and allowing the first chasing plants **P2($y_{1...n}z_{1...n}$)** to yield for a given time in the first section; and after the period of time, removing both leaves of the leading plants **P1($y_{1...n}z_{1...n}$)** and their growing boxes **1P1($y_{1...n}z_{1...n}$)**; advancing the growing boxes of the first chasing plants forwards, as growing boxes of leading plants are now removed; placing roots of second chasing plants **P3($y_{1...n}z_{1...n}$)** within a second array of growing boxes **1P2($y_{1...n}z_{1...n}$)**, located behind the first array of growing boxes, now accommodating the first chasing plants **P2($y_{1...n}z_{1...n}$)**; allowing the first chasing plants **P2($y_{1...n}z_{1...n}$)** to advance along the trellis wires, and to yield at the second section; and trellising canopy of the second chasing plants **P3($y_{1...n}z_{1...n}$)** on the trellising wires at the beginning of the first section, now free of canopy and fruits of the first chasing plants **P2($y_{1...n}z_{1...n}$)**.

[4] It is another object of the invention to disclose the method as defined above, wherein it further comprises step(s) of providing the MSHTS with a member of a group consisting of light emitter, light detector, light-activation processor, CO_2 detector, growing gutter, blower, air conditioning, ventilating duct, NTP decontaminating system, water irrigator, trellising wires tensioning mechanism, stem/leaves tensioning mechanism, additives applicator, and any combination thereof.

[5] It is another object of the invention to disclose the method as defined above, wherein it further comprises step(s) of providing the growing box comprises a member of a group consisting of rockwool/substrate cube; a plastic cover; apertures; L-shaped supporting member backing the about 90ℓ-bend in stem.

[6] It is another object of the invention to disclose the method as defined above, wherein it further comprising step(s) of emitting light along the trellising wires in a rate of leaves advancing.

[7] It is another object of the invention to disclose the method as defined above, wherein the method further comprises step(s) of vibrating the trellising wire, hence improving plant's pollination, technology applied for e.g., tomatoes and peppers.

BRIEF DESCRIPTION OF THE FIGURES

[8] The present invention will become more fully understood from the detailed description and the accompanying drawings, wherein

[9] **figures 1a-c**, each of which is illustrating in a non-limiting and an out-of-scale manners a set of schemes of a portion of an MSHTS, according to an embodiment of the invention;

[10] **figures 2a** and **2b**, each of which is schematically illustrating a growing box **20** according to an embodiment of the invention;

[11] **figures 3-6**, schematically visualizing various steps in a method for continuously yielding plants' products according to an embodiment of the invention; and

[12] **figures 7a-c**, illustrating in a non-limiting manner a set of schemes of the "*Leaders & Chasers*" method, according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[13] The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which a preferred embodiment of the invention is shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, this embodiment is provided so that this disclosure will be thorough and complete and will fully convey the scope of the invention to those skilled in the art.

[14] The phrase "**controlled temperature environment**" as used herein refers to an environment created by enclosure in which a desired temperature is maintained by any method known in the art.

[15] The term "**crop**" (also denoted as "**plant**") generally refers herein to any plant grown to be harvested, post-harvested or used for any economic purpose, including agriculture crops, aquaculture crops, horticulture crops, floriculture crops, and industrial crops. Crops currently use or usable with trellising agrotechnology are an example. Non-limiting examples of crops include crops intended for human or animal consumption (e.g., human food and livestock fodder), for use as clothing (e.g., fiber crops), for use as biofuel (e.g., energy crops, algae fuel), for use in medicine, and for use as decorative, ornamental, or recreational plants. Non-limiting examples of crops intended for human or animal consumption include stem plans, some are referred in a non-limiting manner in the table below, legumes (e.g., beans, peas, lentils, soybeans), forage crops, fruits and vegetables, tree nuts, and oil, fat and wax crops (e.g., oilseed crops such as canola, sunflower, coconut, palm, rapeseed, peanuts), herbs and medicinal plants such as vanilla pods, lavender, *Cannabaceae* plants, including cannabis plants and hop plants.

[16] **Table 1** Examples of some stem vegetables and plants' product thereof

CROP NAME	***SCIENTIFIC NAME***	**FAMILY**	**COLLECTIVE NAME FOR MEMBERS OF THE FAMILY, OTHER INFO**
Examples of stem vegetables with edible aboveground stems:			
Asparagus	*Asparagus officinalis*	Asparagaceae	Asparagus family, but formerly under Liliaceae (Merrill 1912); the edible part is the young shoot commonly called "spear," best consumed when the tip is still tightly closed.
Bamboos	various species	Poaceae/Gramineae	Grass family; the edible part is the young, newly emerged shoot.
Cucumber	various species	Cucurbitaceae, also called cucurbits or the gourd family	Cucurbita – squash, pumpkin, zucchini, some gourds; Lagenaria – calabash, and others that are inedible; Citrullus – watermelon (C. lanatus, C. colocynthis) and others Cucumis – cucumber (C. sativus), various melons and vines; Momordica – bitter melon; Luffa
Kohlrabi	*Brassica oleracea var. gongylodes*	Brassicaceae/Cruciferae	Mustard family, also called Cole Crops and Crucifers; the main consumable plant part is the basal stem which forms a spherical structure.
Potato vine, kangkong	*Ipomoea aquatica*	Convolvulaceae	Morning Glory/Bindweed family; both stems and leaves are eaten cooked or blanched.
Tomato and others	*Solanum lycopersicum*	Solanaceae	Solanaceae: eggplant (S. melongena); Capsicum: chili peppers and bell peppers; Physalis;

			tomatillo (Physalis philadelphica), Physalis peruviana (Cape gooseberry) and Physalis alkekengi (Chinese lantern); Lycium: boxthorns and the goji berry, Lycium barbarum; Nicotiana: tobacco etc.
Examples of stem vegetables with edible modified underground stem denoted herein as **bulb**:			
Chive	*Allium schoenoprasum*	Amaryllidaceae	Amaryllis family; formerly under Liliaceae (Lily family, Merrill 1912) but Simpson (2010) preferred it under Alliaceae (Onion family or alliaceous crops); Alliaceae has been placed within an expanded Amaryllidaceae by the Angiosperm Phylogeny Group III (APG III, 2009).
Garlic	*Allium sativum*	Amaryllidaceae	Amaryllis family
	Allium porrum	Amaryllidaceae	Amaryllis family
Onion	*Allium cepa*	Amaryllidaceae	Amaryllis family
Shallot	*Allium cepa*, Aggregatum group	Amaryllidaceae	Amaryllis family
Examples of stem vegetables with edible modified underground stem denoted herein as **tuber**			
Jerusalem artichoke	*Helianthus tuberosus*	Asteraceae/Compositae	Sunflower or Aster family
Potato	*Solanum tuberosum*	Solanaceae	Aka: Nightshade family
Yam, ube, Asiatic yam, tugui, apali, tam-is	*Dioscorea alata*	Dioscoreaceae	Yam family

Examples of stem vegetables with edible modified underground stem denoted herein as **corm**:			
Taro, gabi	*Colocasia esculenta*	Araceae	Arum family; some varieties are grown for their edible leaves and petioles and modified lateral stems (stolons)
Yautia, tannia, bisol, karlang, palauan	*Xanthosoma sagittifolium*	Araceae	Arum family

[17] As used herein, the term "**about**" refers to an amount that is near the stated amount by 10%, 5%, or 1%, including increments therein.

[18] It is according to an embodiment of the invention wherein the crops are grown in a multi-story horizontal trellising system (**MSHTS**) and construction thereof see **figures 1a-5b**. MSHTS is characterized by length (X axis), width (Y axis) and height (Z axis). The terms "story", "level" and "floor" are interchangeably used herein below to define sections along the Z axis of MSHTS and will be marked as integers: Z_1, Z_2,..Z_n. It is well within the scope of the invention wherein the horizontal trellising system is (at least temporarily-) having only one floor, namely a "single-story horizontal trellising system", where Z=1. It is also within the scope of the invention wherein a multistory horizontal trellising system is (at least temporarily-) is configured for growing a single plant at each floor, where Y=1. As those arrangements are privet cases of an y_nz_n MSHTS, and figures discussed below are to be interpreted accordingly.

[19] As for the nomenclature used along the figures, $P_1(y_1z_3)$ defines the first (leading-) plant, located in the first growing box at the third level (story, floor-). $10P_2(y_4z_5)$, $11P_2(y_4z_5)$ and $12P_2(y_4z_5)$ denote a stem portion, leaves and fruits of a chasing plant 2, namely the one its roots are located within growing box number 4, at the fourth story, respectively.

[20] Reference is now made to **figures 1a-c**, each of which is illustrating in a non-limiting and an out-of-scale manners a set of schemes of a portion of an MSHTS **100**, utilizable along the first stage of a "*Leaders & Chasers*" method which will be defined below, according to one embodiment of the invention. **Fig. 1a** schematically depicts length, width and height of the construction (**x, y, z**). A plurality of growing boxes (**1**) on a growing gutter (**3**) is located at the lower floor, set in parallel to the width. An array of trellising wires (**2**) is provided at the higher portion of the first floor in parallel to the long axis. Textile ducts (**4**) are located in this example at the lower portion of the first floor, positioned parallel to the long axis. Blower (**5**) is located

here adjacent to the growing boxes. A set of active light fixtures and light fixtures (**6**, **7**) located in this example in the topmost portion of the first floor. Possible dimensions are provided.

[21] In each of the growing levels, an array of essentially horizontal trellising wires (2) is provided in parallel to the main longitudinal axis X. Trellising wires tensioning mechanism and stem/leaves a tensioning mechanism are an option.

[22] In at least one story, or otherwise, in more than one story (Z_1, Z_2…Z_n), or otherwise, in each story, crops are planted either *in situ* or pre-planted in a remote location on a growing level inside either commercially available or a tailor-made pot, growing box, or a dedicated container, configured by means of size and shape to fit plant growing needs (hereinafter a "**growing box**"). Growing boxes are arranged in parallel to the width main axis Y:Y. In one set of embodiments, a number of growing boxes per story is ranging from about 2 growing boxes to about 20 stories (Y_2Z_n-$Y_{20}Z_n$), e.g., about 4 boxes to about 10 growing boxes (Y_4Z_n-$Y_{10}Z_n$), etc. It is possible that a number of growing boxes $Y_{y'}$ in one story Z_{ni} is different from the number of growing boxes $Y_{y''}$ in another story Z_{nj}, namely ($Y_{y'}Z_{ni} \neq Y_{y''}Z_{nj}$); x, y, z, n, i, and j are integers equal or greater than 1. The growing box is e.g., an enveloping continuous sheet of a material, or alternatively, at least partially non-continuous member (e.g., porosive, multilayered, spiral wounded-) material made of polymer(s), cardboard, metallic materials, glass etc. It may have a single main volume or else wise, it is a multicompartment vessel or an assemble interconnected box-like jars. The growing boxes are erected perpendicular to the (essentially horizontal-) growing direction. An example of such a growing box is a cube of rock wool, placed in a dedicated gutter-like carrier.

[23] Reference is now made to **figures 2a** and **2b**, each of which is schematically illustrating a growing box **20** according to one embodiment of the invention. It comprises a Rockwool/substrate cube **21**; a plastic cover **22**; apertures **23**,**24**, provided as, e.g., drippers inlet orifices; L-shaped supporting member **25** backing the 90-bend in stem **10**. Possible dimensions are provided.

[24] Above each growing level there's a lighting level dedicated to the growing level adjunct to it, namely provide under, above and/or within the level. A traditional top-lighting requires hence a line of light emitting sources located above the growing level.

[25] It is according to an embodiment of the invention wherein the system comprises a single (Z=1) story. It is according to an embodiment of the invention wherein in total, the structure of the racks builds of 2 to about 20 stories (Z<21), e.g., about 4 to about 10 stories (Z<11), e.g., about 6 stories (Z~6). Each story consists of growth and trellising level and above it a lighting level.

[26] It is according to an embodiment of the invention wherein at a heterogenous growing system is provided useful, namely a single MSHTS for growing more than one verity of. Hence, for example, cucumbers are grown in the first story, melons in the second story, and tomatoes in the third and fourth stories (Cucumber [$Y_{1\text{-}5}Z_1$], Melon [$Y_{1\text{-}3}Z_2$], Tomato [$Y_{1\text{-}6}Z_{3\text{-}4}$]). Additionally, or alternatively, according to another embodiment of the invention, a heterogenous growing system is provided useful. Here, in a specific story (Zi) in an MSHTS, there are growing of more than one verity. Hence, for example, pumpkins are grown in the first and second growing boxes, and watermelons are grown in the third to sixth growing boxes (Pumpkin [$Y_{1\text{-}2}$ Z_i], Watermelon [$Y_{3\text{-}6}Z_i$]). A growing facility may comprise either or both homogeneous or heterogeneous MSHTS.

[27] It is according to an embodiment of the invention wherein between the racks there are locatable service aisles.

[28] An example is an MSHTS of about 0.5 to about 10 meters long, or alternatively, 1 to about 5 meters long, or alternatively about 2.4 meters long. Width ranges from 0.3 to about 5 meters; or alternatively from 0.5 to about 2.5 or alternatively about 1 meter. Height ranges from 0.5 to about 30, or alternatively from 2 to about 12 meters, or alternatively about 5 meters.

[29] MSHTS may consist of horizontal gutters across a shelf. Each gutter contains from 2 to about 12 plants, or alternatively, about 6 plants. Each rack consists of 2 to about 12 shelves, e.g., 6 shelves one set above the other.

[30] It is according to an embodiment of the invention wherein a method of MSHTS crops growing is disclosed. Along an initial stage of the growing process, a single or a few specific varieties are sown, planted, grafted, or otherwise provided within a growing media of the growing boxes; e.g., cucumbers are sown into a dedicated soilless plug.

[31] Optionally, this first stage is performed outside a growing room. Typically, a process of nursery and young plants production includes a vegetative stage, preferably done in high-care rooms in the facility itself, in order to optimize the utilization of the growing area and to obtain a specific climate condition for each stage. Significant savings of expensive space is achieved by carrying out this vegetative stage in high-density of plants per square meter, on a dedicated racks system. In a subsequent step, provide after a predefined period of time, e.g., about a month, seedlings are planted in the afore the growing boxes.

[32] Operation-wise wise, this system provides easy access for picking and leaves trimming. From a standing point at the aisle between two racks, an operator can reach to some six rows (three from each side of the aisle) and six stories up, whereas commercially available vertical trellising allows access to two rows only.

[33] Automation-wise wise, because of the clear separation between leaves and fruits, the hereto-defined MSHTS is ideal for mechanized tasks (autonomously or semi-automatic) such as robotic picking (harvesting) and pruning of leaves during growth.

[34] Auxin is a plant hormone that promotes cell growth and plants elongation. In the elongation process, Auxin alters the plant's wall plasticity hence promotes plant to vertical grow, whilst suppressing formation of new buds, thereby provides high density clusters, and increased yields. Hence, the horizontal-trellising based technology of the present invention gap between clusters ranges from to about 12 to about 15 cm, whereas in commercially available vertical trellising, a common gap between clusters traditionally ranges from 25 to 30 cm.

[35] Profitability of traditional vertical trellis is relatively limited as plants effectively yield their fruits only in the advancing top portion and leave behind a gap of growing but not yielding stem. The hereto disclosed MSHTS uniquely utilizes optimized stems length for specific verities of plants (e.g., tomatoes and cucumbers, about 220 cm (differs between strains and crops)) while the yielding stem section ranges from approximately half of that (e.g., from about 80 to about 100 cm).

[36] In one embodiment of the invention, electromagnetic radiation is transmitted by means of one or more sources. In vertical trellising systems, light projected from the ceiling downwardly hardly reaches the lower portions of the plants. In MSHTS however, leaves at each growing portion along the horizontal stem are subject to effective illumination, which optimized radiation of non-obscured light toward the leaves.

[37] Plant varieties require specific light illumination patterns (spectrum, time-resolved intensity etc.). MSHTS's dynamic lighting mechanism comprises a sensor-based monitor adapted to light selected portions along the trellising, hence, to ensure energy savings, optimal heat production, plant growth, fruit (or other plant's product) production, maximal yielding rate and profitability. MSHTS's dynamic lighting mechanism is location-sensitive so that unnecessary lighting fixtures do not consume electricity and don't emit heat that is required to be evacuated by air conditioning system (e.g., HVAC system) for a controlled temperature environment. In some of the MSHTS, light is radiated only above the canopy. In other of the MSHTS, light is radiated above, below, or within the canopy with dedicated parameters, such as spectrum, frequency and lighting time, designed for this type of lighting.

[38] Outdoor cultivation of certain plants, tomatoes for example, flowers must be pollinated by an external source, such as bees. In an indoor environment, however, it's not possible to pollinate by such a natural means. MSHTS optimizes plants' pollination by interconnecting trellising wires with effective vibrators configured to operate in a predefined frequency, intensity, pulses

profile, amplitude and timing so that the pollens are dispersed evenly and pollinate effectively. MSHTS further optimizes the location along the trellis and the timing of pruning of plants' leaves at each segment of the trellis

[39] MSHTS provides an effective *(i)* vertical stem growth within and adjacent the growing box, and then *(ii)* horizontal stem growth along the substantially horizontal trellising wires. Stem-leading clip ensures that the kinked stem does not break. It is e.g., an arch- (elbow) like member designed so an external clip may keep the stem adjacent to the stem. In an embodiment of the invention, the stem-leading clip is an arch connected to a base that covers the surface of the substrate cube and thus prevents light from reaching the substrate, to prevent contamination, e.g., by (green-) fungi, molds, etc. Lower portion of each story may comprise a few apertures: e.g., one for the plant and two for water and fertilizers irrigation pegs.

[40] Plant requires optimal conditions of temperature and humidity, where an excess of humidity develops leaf diseases. For this purpose, and according to an embodiment of the invention, MSHTS provides an array of fabric ventilation ducts, installable near the plants to condition their proximate environment with controlled humidity and temperature.

[41] According to yet another embodiment of the invention, MSHTS comprises a controlled supply and evacuation system for additives in either or both gas phase and liquid phase. The term "**additive**" refers in a non-limiting manner in this connection to biocides and preservatives (e.g., metal salts, a quaternary amine, bromomethane, ozone), plants hormones (e.g., ethylene and derivatives thereof, 1-methylcyclopropene), plants breeding agents and genetic materials, enzymes and coenzymes, plant extracts, microorganisms such as probiotics, germination agents, fertilizes, acidulants and buffers, carbon dioxide, anti-caking agents, nitrogen gas, antifoaming agents, antioxidants, bulking agents, emulsifiers, flavor enhancers, perfuming agents, fruit and seed-coating agents, fertilizers, mineral salts, calcium carbonate containing dust, stabilizers, starches, thickeners, UV stabilizers, blockers or enhancers, vitamins and minerals and any combination, derivatives and mixtures thereof.

[42] According to yet another embodiment of the invention, MSHTS comprises a controlled CO_2 supply and evacuation system for both *(i)* maximizing plants' photosynthesis and *(ii)* protecting human safety. The controlled CO_2 supply systems may comprise an array of fabric-made ducts.

[43] According to yet another embodiment of the invention, MSHTS comprises non thermal plasma emitting (NTP) system. NTP is provided useful for electrically energizing and/or ionizing matter in a gaseous state, for decontaminating dried crops of its pathogens is hereto disclosed. NTP was found extremely effective in the decontamination of *staphylococcus aureus, pseudomonas aeruginosa, escherichia coli* and *candida albicans*, and others, such as

Aspergillus brasiliensis, Salmonella, Legionella, COVID-19, molds etc. Some relevant data is derived from currently available link: https://www.vsdental.it/uploads/attachment /attachment/433/DOSSIER_scientifico%20JONX _R.03.pdf. An NTP was found effective to kill molds in a few minutes by ionizing the air, without requiring to add any additional chemicals. It is acknowledged that the number of NTP units (or their output) is proportional to the room size. Unlike other anti-molds treatments such as UV, in which molds will only be affected if they pass in proximity to the UV bulb, the hereto presented NTP system blows ionized air into the room, creates an atmosphere that neutralizes existing molds and prevents the development of new ones. Commercially available NTP and NTP-like means, are commercially available, including, e.g., DUCT™ 70MIC4C product, by Jonix S.p.A. B Corporation (Italy) and Sterionizer™ D6 by FILT AIR Ltd (Israel).

[44] NTP decontaminated plants' pathogens such as bacteria, viruses and molds dispersed in the air and pose a great danger to the quality and quantity of crops. NTP system consists of one or more independent NTP units installed within or in connection with HVAC ducts, thus ensuring optimal distribution throughout the room. An NTP unit may comprise a high voltage transformer connected to unique patented electrodes that produce electrical energy that ionized the air. Ionized air is distributed throughout the room and destroys the cell shell of the pathogens and thus they are neutralized.

[45] An MSHTS-enabled "*chasing plant*" (also denoted as "*Leaders & Chasers*") method technique is hence utilizable to fill a non-yielding gap along the stem of a first plant (P_n) with additional yielding stem portion of a subsequently following plant ("*chasing plant*", P_{n+1}) that yields, along the horizontal trellis where the first plant no longer yields. This provides, along each trellis, a continuous yielding section comprising both P_2 and P_1 stem portions. This non-stopped continuity is enabled by timely planting chasing plant P_2: When P_1 leading plant ends its yielding period, it is removed, and replaced by yet a new chaser P_3, that now chases P_2, the first chaser, and so on and so forth.

[46] Reference is made to **figures 3-6,** schematically visualizing various steps in a method for continuously yielding plants' products. The method comprises steps as follows: providing a MSHTS with one or more vertically erected stories. Each story comprises an array of growing boxes located at a first end of an array of horizontal trellising wires (**2**). The trellising wires having a first end, located adjacent to the array of growing boxes (**1**), and an opposite end, located far from the growing boxes. Along the trellising wires, there are provided two schematical sections, a first section **73** which begins at the first end of the trellising wire, near the growing boxes. A second section **74** starts immediately after the first section ends, and

terminated at the opposite end of the trellising wire. For each of the MSHTS' stories, the required steps of (i) placing roots of leading plants **P1($y_{1...n}z_{1...n}$)** within an array of growing boxes **1P1($y_{1...n}z_{1...n}$)**; and (ii) supporting its leaves or canopy thereof by the trellising wires. Then, the leading plants (**P1($y_{1...n}z_{1...n}$)** are cultivated for a period of time, along the first section of the trellising wires **73**. Cultivation refers here to various agrotechniques, including e.g., pruning, trimming, irrigating, fertilizing, etc. After that period of time, and for each of the stories: advancing leaves (namely, plants' canopy, stem and fruits, when relevant) of leading plants **P1($y_{1...n}z_{1...n}$)** from first section **73** to second section **74**. At the same time, the canopy of leading plants **P1($y_{1...n}z_{1...n}$)** is cultivated along the first section **73**. Subsequently, and it is required to place roots of the first chasing plants **P2($y_{1...n}z_{1...n}$)** within the second array of growing boxes **1P2($y_{1...n}z_{1...n}$)**, located behind the first array of growing boxes **1P1($y_{1...n}z_{1...n}$)**. Here again, leaves (or canopy thereof) of the first chasing plants **P2($y_{1...n}z_{1...n}$)** is supported from the beginning of the first section **73**, now free of the canopy of the leading plants **P1($y_{1...n}z_{1...n}$)**. The first chasing plants (**P2($y_{1...n}z_{1...n}$)** are allowed to yield for a given period of time along the first section **73**. After another period of time, both canopies of the leading plants **P1($y_{1...n}z_{1...n}$)** and their growing boxes **1P1($y_{1...n}z_{1...n}$)** are removed. Then, growing boxes of the first chasing plants are advanced forwards, as growing boxes of leading plants are now removed. As described before, roots of second chasing plants **P3($y_{1...n}z_{1...n}$)** are now placed within a second array of growing boxes **1P2($y_{1...n}z_{1...n}$)**, located behind the first array of growing boxes, now accommodating the first chasing plants **P2($y_{1...n}z_{1...n}$)**. The first chasing plants **P2($y_{1...n}z_{1...n}$)** is allowed to advance along the trellis wires, and to yield at the second section **74**. At that time, the canopy of the second chasing plants **P3($y_{1...n}z_{1...n}$)** is being supported on the trellising wires at the beginning of the first section **73**, now free of canopy and fruits of the first chasing plants **P2($y_{1...n}z_{1...n}$)**.

[47] It is in the scope of the invention wherein an objective of the nursery stages in the method using leading and chasing plants is to grow P_2's seedlings close to the stage of P_1's ripening, namely, a time when a flower becomes a fruit. For this purpose, a novel clip is provided useful for allowing seedlings to grow horizontally to this right stage and being transferred with no harm from the nursery to the commercial growing facility.

[48] Reference is now made to **figures 7a-c**, illustrating in a non-limiting manner a set of schemes of the "*Leaders & Chasers*" method, according to one embodiment of the invention. In a 1st step, (**Fig. 7a**) leading plants are placed an array of growing boxes located (**1P1($y_{1...n}z_{1...n}$)**, *n* is any integer, equal or greater than 1) in a first section, close to the trellis wires. Now the leading plants yields for a given time (e.g., in several varieties of tomatoes, about 80 days) in

the first section **73** along the trellis wires. Dimensions are listed in figure 1a as an example. After the aforesaid period of about 80 days, 2nd step begins (**Fig. 7b**). Leading plants are advancing along the trellis wires and are yielding in second section **74**. Chasing plants (**P2($y_{1...n}z_{1...n}$)**) yields along first section **73**. In 3rd step (**Fig. 7c**), original Leading plants (**P1($y_{1...n}z_{1...n}$)**) are removed, and new chasing plants (**P3($y_{1...n}z_{1...n}$)**) are provided to yield along the first section **73**, whilst old chasing plants (**P2($y_{1...n}z_{1...n}$)**) yield on the second section **74**, and so on and so forth. This cycle continues repeatedly, so there will always be yielding plants in the two sections.

[49] According to one embodiment of the invention, light advances along the advancing of plants' canopy along the trellis. Reference is now made to **figure 3b**, showing that only first light emitter **6a-b** are used for lighting the first growing section **73**, then lights **6c-d** are used (fig. 4a), and finally, when both leading and chasing plants are both trellised in sections **73** and **74** (**Fig. 5a**), all lights (**6a-g**) are used.

[50] It is well in the scope of the invention wherein more than two generations of plants are used: namely one array of leading plants and one array of chasing plants. It is also in the scope of the invention wherein more than two sections (**73, 74**) are used. Hence, e.g., a leading array of plants may be followed by two chasing plants, in and MSHTS which comprises three sections etc.

[51] An MSHTS as defined above, namely one which comprises six levels, where 1 m^2 per one level is multiplied by six to get the total yield of a 1 m^2 of floor. This MSHTS yields with some 800 kg/m^2 floor for Cucumber's strain A; 650 kg/m^2 floor for Cucumber's strain B; and some 700 kg/m^2 floor for Tomatoes strain A.

[52] In the specification, there have been disclosed typical preferred embodiments of the disclosure and although specific terms are employed, they are used in a generic and descriptive sense only and not for purposes of limitation. Some typical embodiments of the disclosure have been described. Many more examples, modifications and variations of the disclosure are possible in light of the above teachings. For instance, although the disclosure and the claims indicate specific steps to perform the invention, the steps described are not limited to a particular sequence of performance and in some circumstances two or more of these steps could be undertaken simultaneously. It is therefore to be understood that within the scope of the appended claims the disclosure may be practiced otherwise than as specifically described, and the scope of the disclosure is set out in the claims.

CLAIMS

1. A method for continuously yielding of plants products, comprising

   a. providing a multi-story horizontal trellising system, characterized by one or more vertically erected stories; each story comprises an array of growing boxes located at the first end of an array of horizontal trellising wires; said trellising wires having a first end, located adjacent to said array of growing boxes and an opposite end, located far from said growing boxes; along said trellising wires there are provided two sections, a first section **73** begun at said first end of the said trellising wire; and a second section **74**, terminated at said opposite end of the said trellising wire;

   b. for each of said stories, placing roots of leading plants **P1($y_{1...n}z_{1...n}$)** within the said array of growing boxes **1P1($y_{1...n}z_{1...n}$)**, and supporting its leaves by said trellising wires;

   c. cultivating said leading **P1($y_{1...n}z_{1...n}$)** plants for a period of time, along said the first section of said trellising wires **73**;

   d. after said period of time, and for each of said stories,

      (i) advancing leaves of said leading plants **P1($y_{1...n}z_{1...n}$)** from said first section **73** to said second section **74**;

      (ii) trimming and pruning canopy of said leading plants **P1($y_{1...n}z_{1...n}$)** along said first section **73**;

      (iii) placing roots of first chasing plants **P2($y_{1...n}z_{1...n}$)** within a second array of growing boxes **1P2($y_{1...n}z_{1...n}$)**, located behind said first array of growing boxes **1P1($y_{1...n}z_{1...n}$)**;

      (iv) supporting leaves of said first chasing plants **P2($y_{1...n}z_{1...n}$)** at the beginning of said first section **73**, now free of canopy of said leading plants **P1($y_{1...n}z_{1...n}$)**; and

      (v) allowing said first chasing plants **P2($y_{1...n}z_{1...n}$)** to yield for a given time in said first section **73**; and

   e. after said period of time,

      (i) removing both leaves of said leading plants **P1($y_{1...n}z_{1...n}$)** and their growing boxes **1P1($y_{1...n}z_{1...n}$)**;

      (ii) advancing said growing boxes of said first chasing plants forwards, as growing boxes of leading plants are now removed;

(iii) placing roots of second chasing plants **P3($y_{1...n}z_{1...n}$)** within the second array of growing boxes **1P2($y_{1...n}z_{1...n}$)**, located behind the said first array of growing boxes, now accommodating said first chasing plants **P2($y_{1...n}z_{1...n}$)**;

(iv) allowing said first chasing plants **P2($y_{1...n}z_{1...n}$)** to advance along said trellis wires, and to yield at said second section **74**; and

(v) trellising canopy of said second chasing plants **P3($y_{1...n}z_{1...n}$)** on said trellising wires at the beginning of said first section **73**, now free of canopy and fruits of said first chasing plants **P2($y_{1...n}z_{1...n}$)**.

2. The method of claim 1, further comprising step(s) of providing said MSHTS with a member of a group consisting of light emitter, light detector, light-activation processor, CO_2 detector, growing gutter, blower, air conditioning, ventilating ducts, NTP decontaminating systems, water irrigators, trellising wires tensioning mechanism, stem/leaves tensioning mechanism, additives applicator, and any combination thereof.

3. The method of claim 1, further comprising step(s) of providing said growing box comprises a member of a group consisting of Rockwool/substrate cube **21**; a plastic cover **22**; apertures **23**,**24**; L-shaped supporting member **25** backing the 90°-bend in stem **10**.

4. The method of claim 1, further comprising step(s) of emitting light along the trellising wires in a rate of leaves advancing.

5. The method of claim 1, further comprising step(s) of vibrating the trellising wire, hence improving plant's pollination.

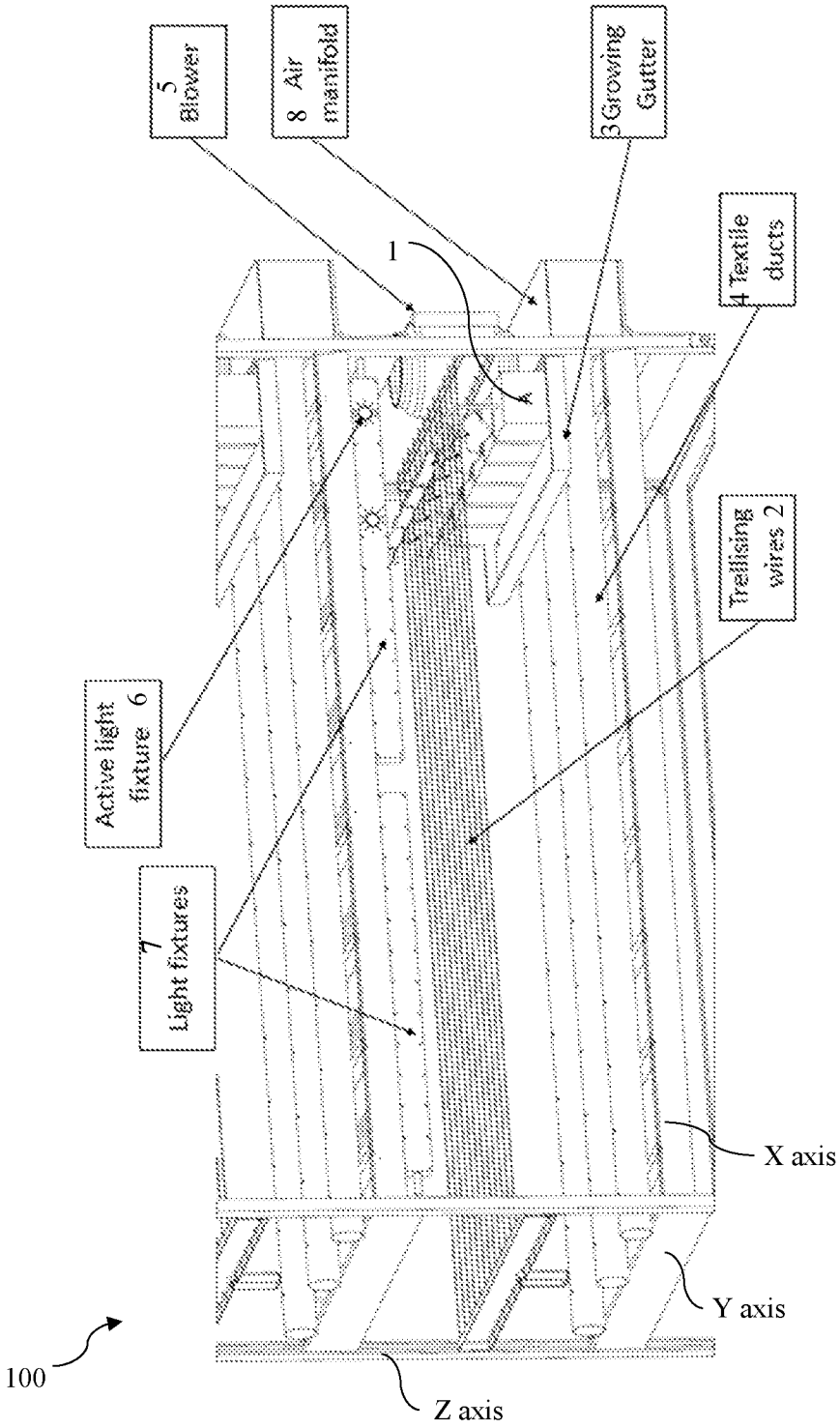

5 Blower
8 Air manifold
3 Growing Gutter
1
4 Textile ducts
Trellising wires 2
Active light fixture 6
7 Light fixtures
X axis
Y axis
Z axis
100

Fig. 1a

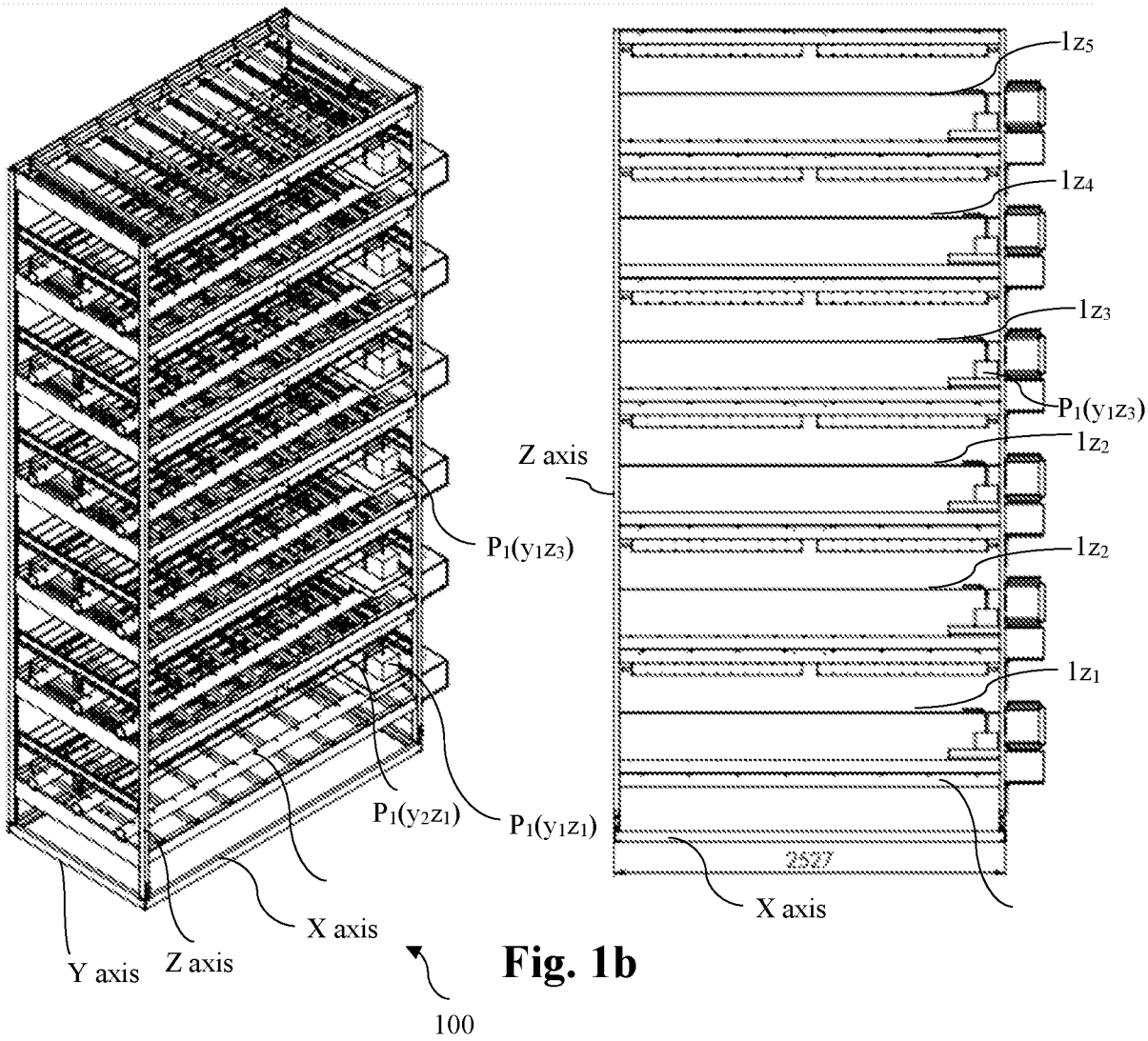

1z5
1z4
1z3
P1(y1z3)
1z2
Z axis
P1(y1z3)
1z2
1z1
P1(y2z1)
P1(y1z1)
X axis
Y axis
Z axis
X axis
100

Fig. 1b

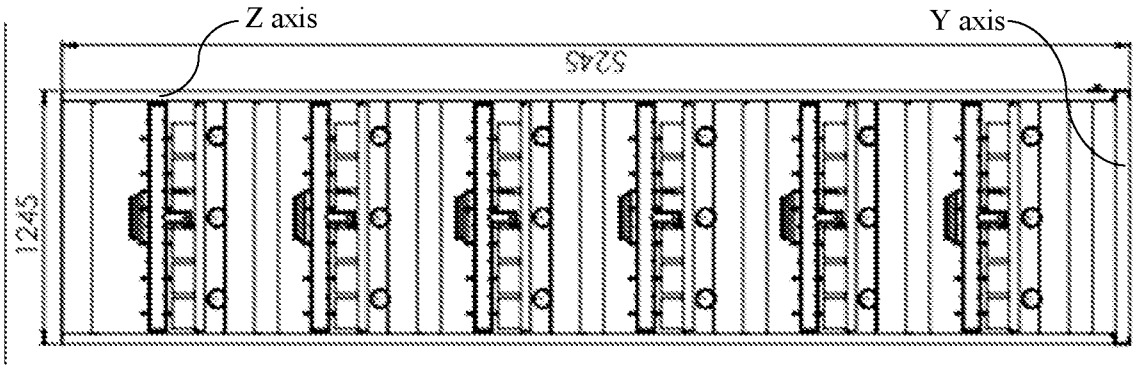

Z axis
Y axis

Fig. 1c

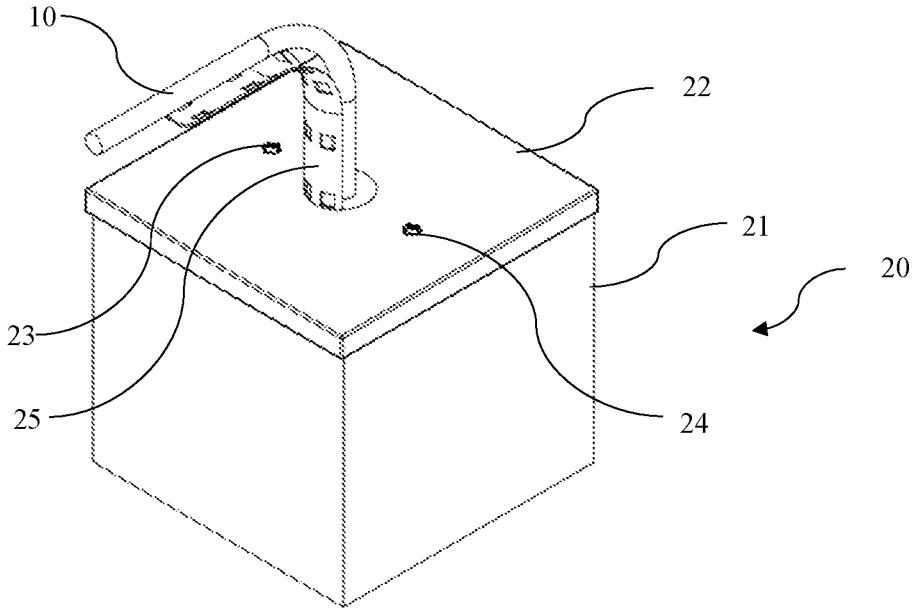


Fig. 2a

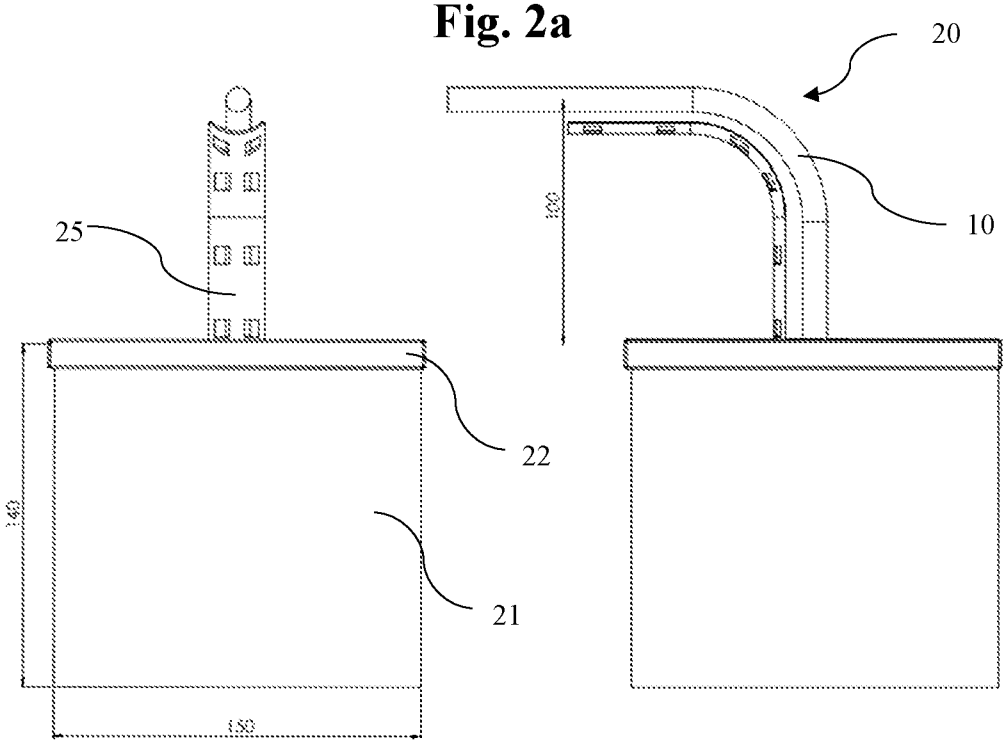


Fig. 2b

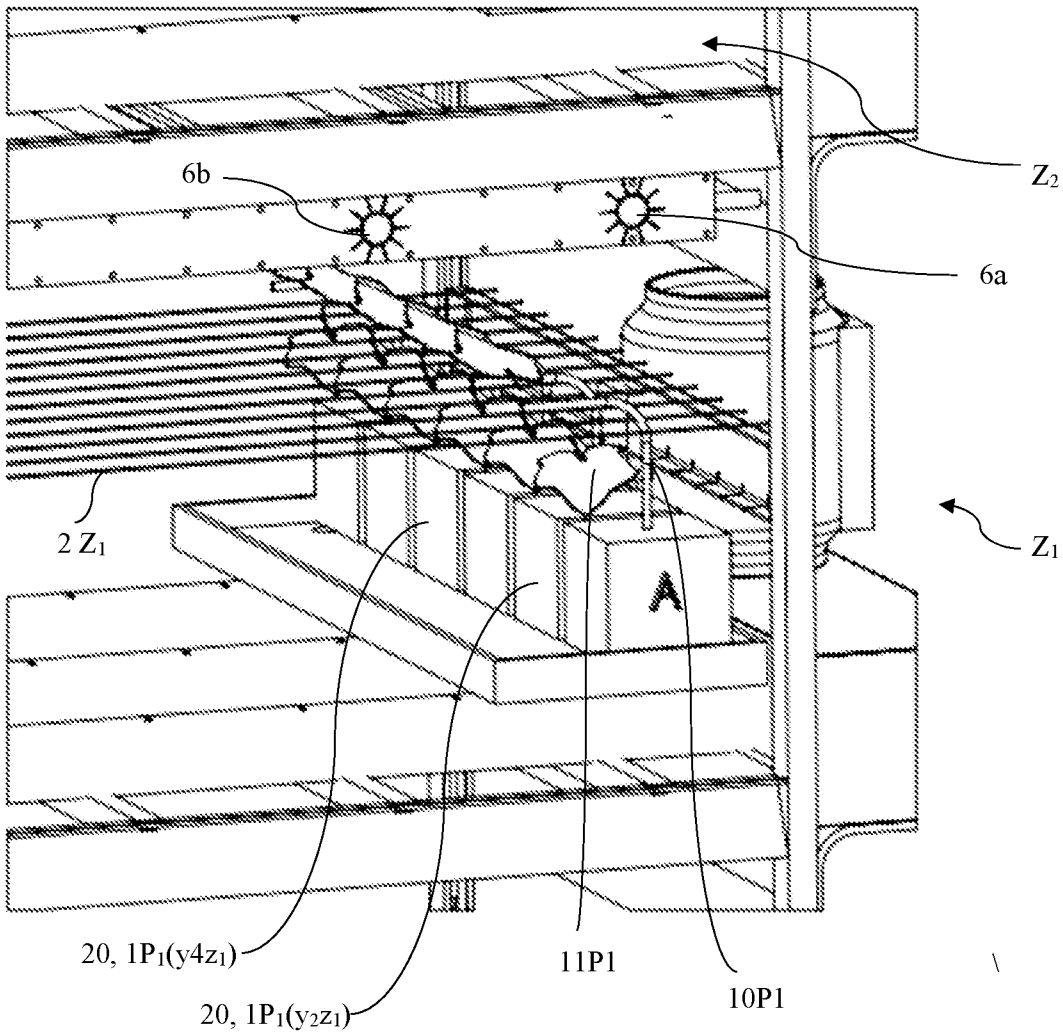


Fig. 3a

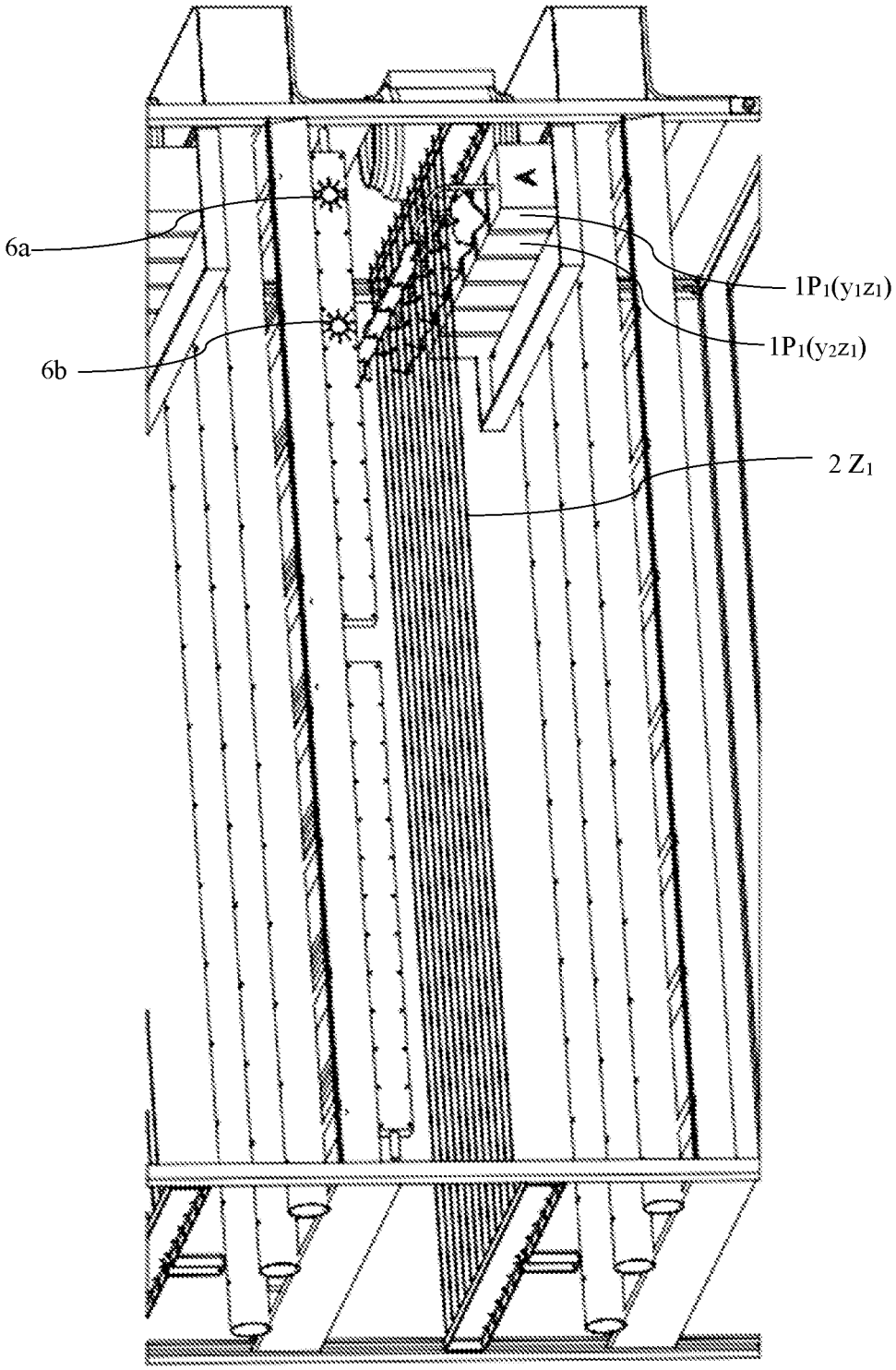


Fig. 3b

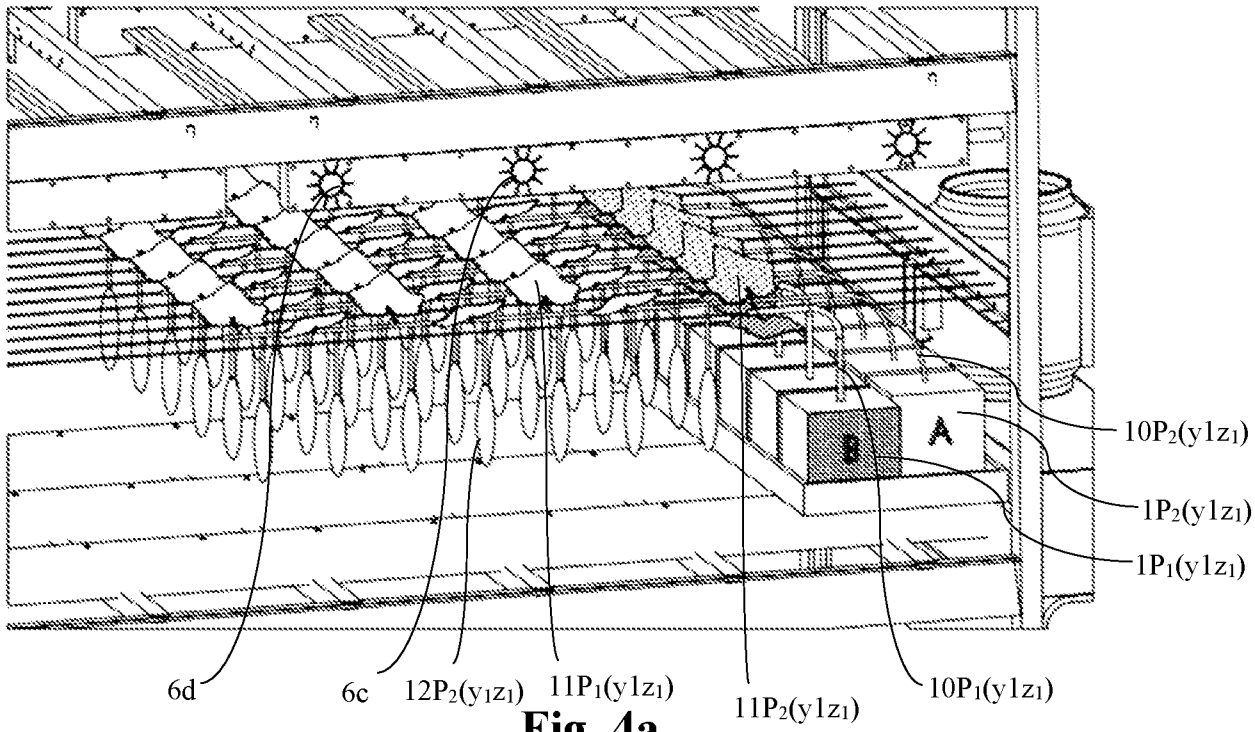

A
B
10P2(y1z1)
1P2(y1z1)
1P1(y1z1)
6d
6c
12P2(y1z1)
11P1(y1z1)
11P2(y1z1)
10P1(y1z1)

Fig. 4a

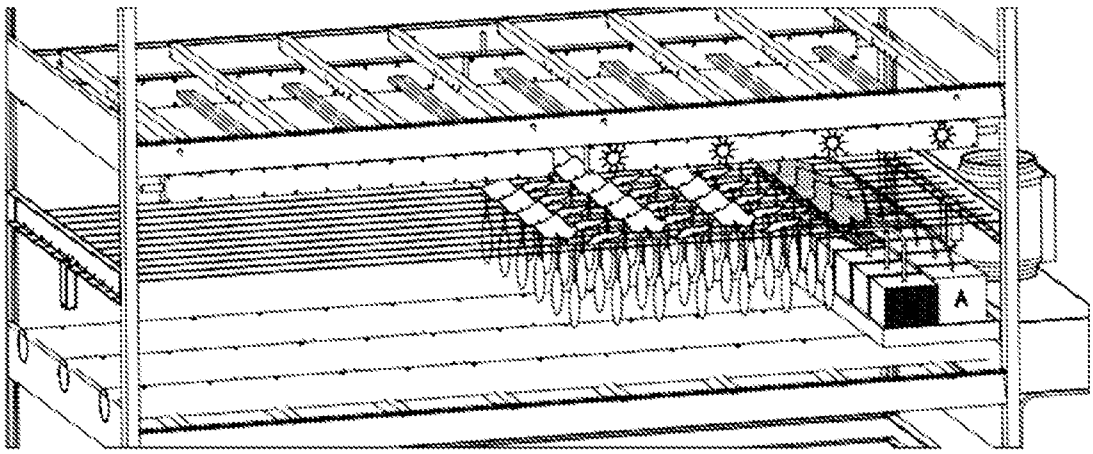

A

Fig. 4b

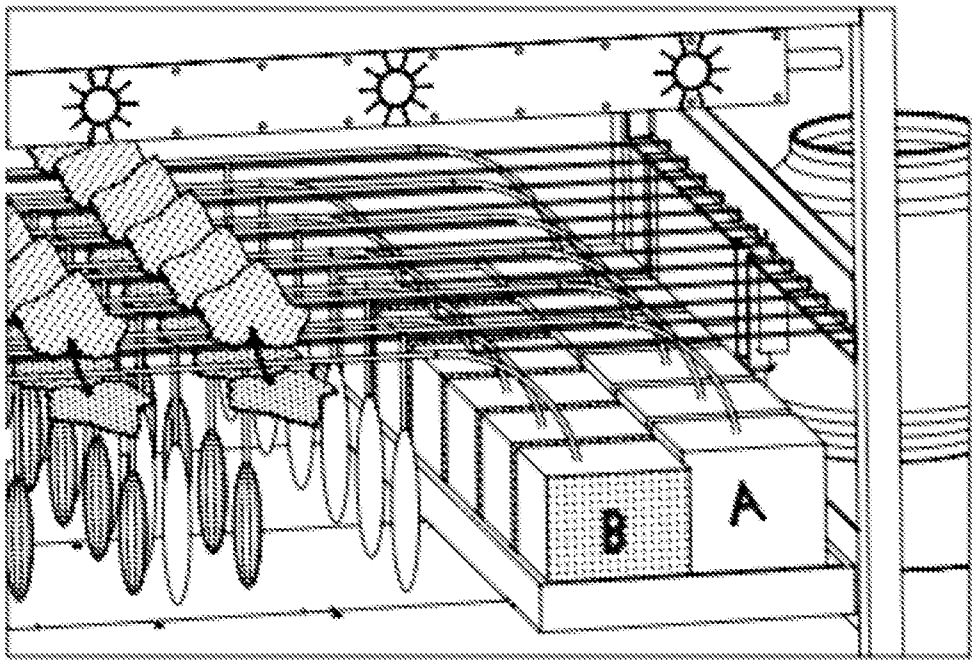


Fig. 5a

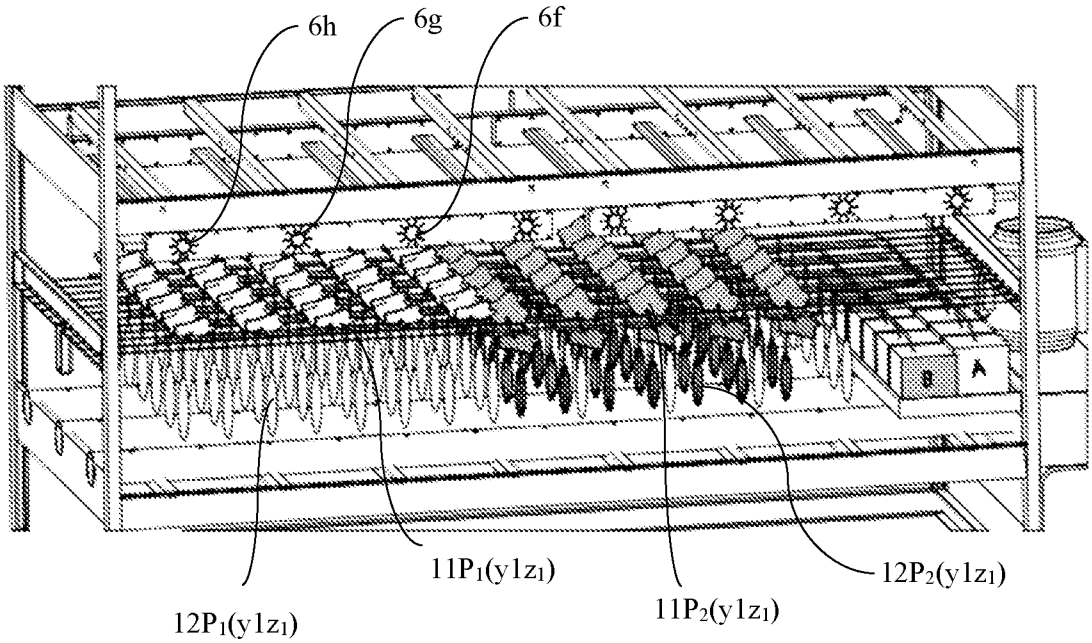


Fig. 5b

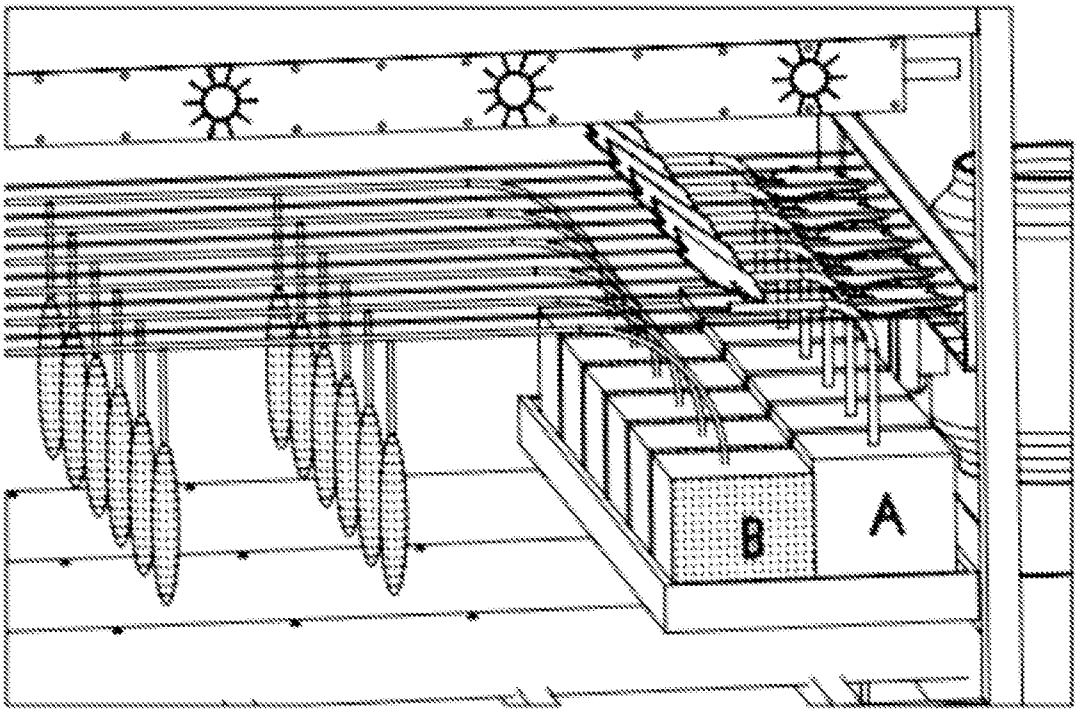
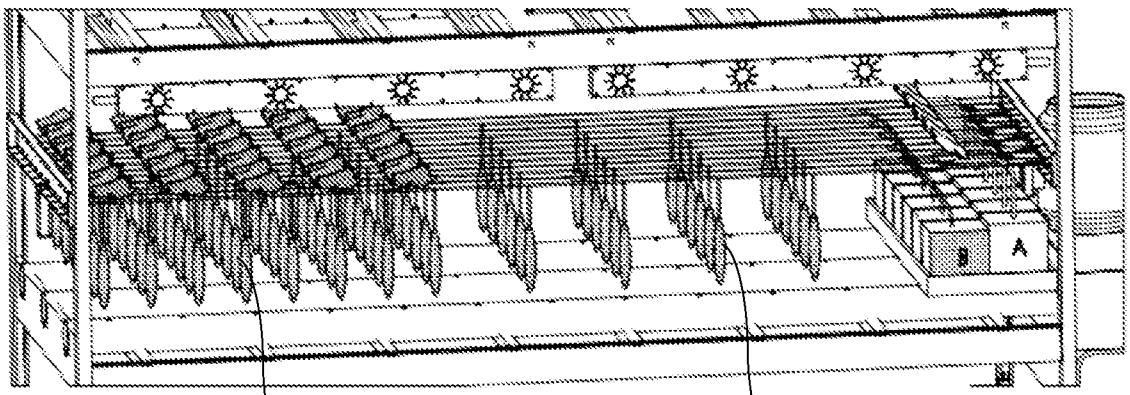


Fig.6a



$12P_2(y1z_1)$ $12P_2(y_1z_1)$

Fig. 6b

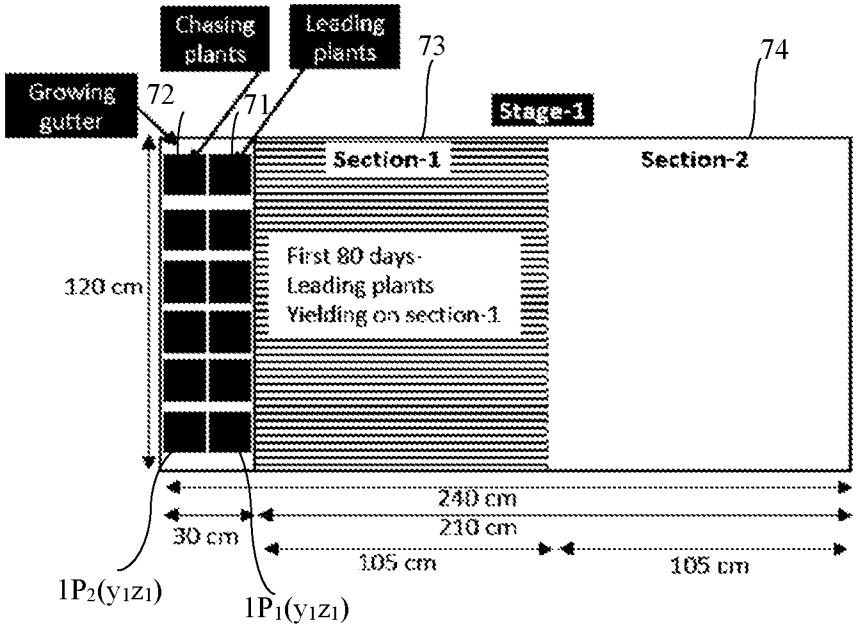

Chasing plants
Leading plants
73
74
Growing gutter
72
71
Stage-1
Section-1
Section-2
First 80 days-
Leading plants
Yielding on section-1
120 cm
240 cm
210 cm
30 cm
105 cm
105 cm
1P2(y1z1)
1P1(y1z1)

Fig. 7a

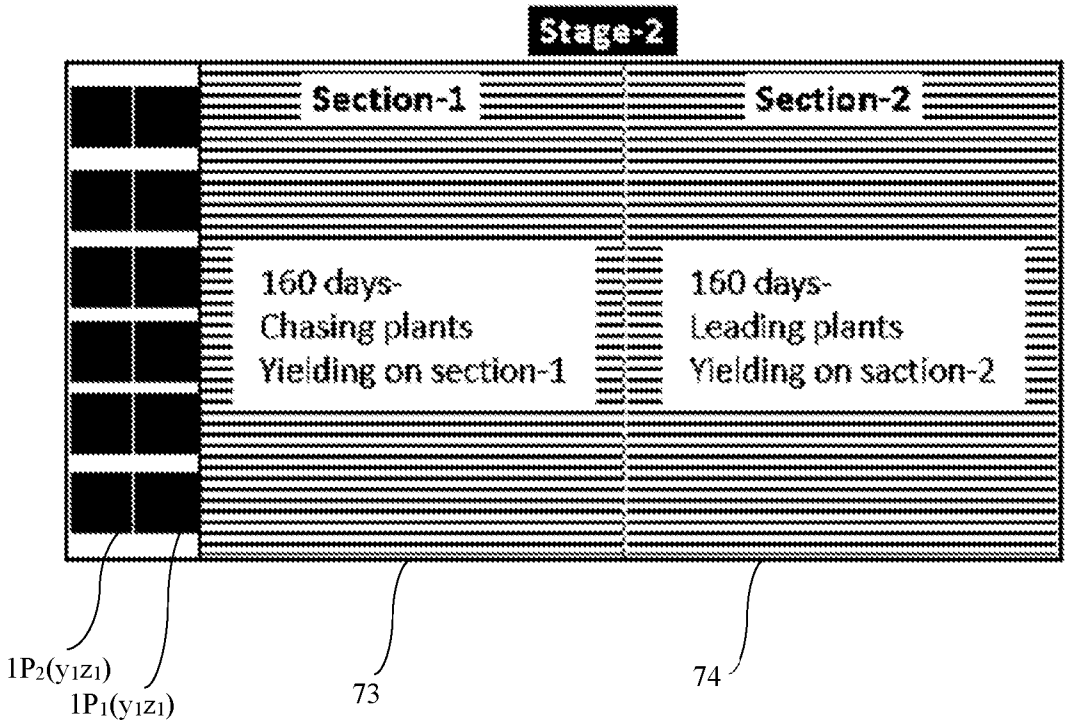

Stage-2
Section-1
Section-2
160 days-
Chasing plants
Yielding on section-1
160 days-
Leading plants
Yielding on saction-2
1P2(y1z1)
1P1(y1z1)
73
74

Fig. 7b

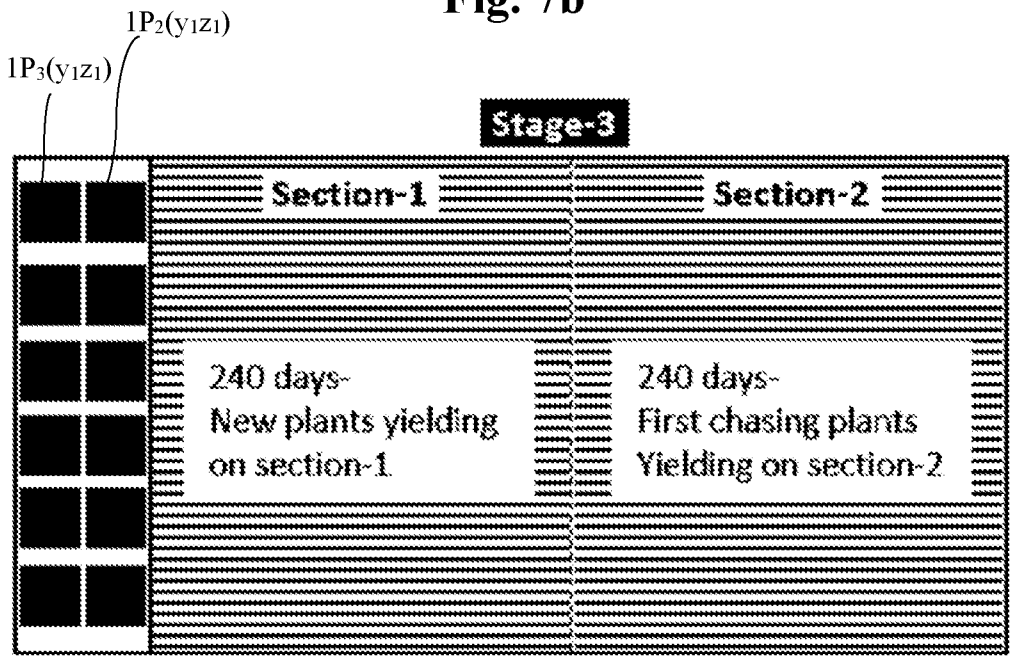

1P2(y1z1)
1P3(y1z1)
Stage-3
Section-1
Section-2
240 days-
New plants yielding
on section-1
240 days-
First chasing plants
Yielding on section-2

Fig. 7c

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL2023/050951

A. CLASSIFICATION OF SUBJECT MATTER

A01G 9/12(2023.01)i; ***A01G 9/02***(2023.01)i; ***A01G 17/06***(2023.01)i
CPC: A01G 9/12; A01G 9/023; A01G 9/027; A01G 17/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

A01G 9/12; A01G 9/02; A01G 17/06
CPC: A01G 9/12; A01G 9/023; A01G 9/027; A01G 17/06

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Databases consulted: Derwent Innovation

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2016168016 A (PANASONIC IP MAN CORP) 23 September 2016 (2016-09-23) the entire document	1-5
A	CN 105165320 A (UNIV BEIJING TECHNOLOGY) 23 December 2015 (2015-12-23) the entire document	1-5
A	CN 112385433 A (DU JINPING) 23 February 2021 (2021-02-23) the entire document	1-5
A	JP 2010068801 A (SHINRYO CORP) 02 April 2010 (2010-04-02) the entire document	1-5
A	JP 6981702 B1 (KEIHANNA KENKO YASAI KK) 17 December 2021 (2021-12-17) the entire document	1-5
A	JP 2018099038 A (MITSUBISHI CHEM CORP) 28 June 2018 (2018-06-28) the entire document	1-5

☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 December 2023	**25 December 2023**

Name and mailing address of the ISA/IL	Authorized officer
Israel Patent Office **Technology Park, Bldg.5, Malcha, Jerusalem, 9695101,** **Israel** **Israel** Telephone No. **972-73-3927212** Email: **pctoffice@justice.gov.il**	**NARGASI Ayelet** Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL2023/050951

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 11304385 B1 (BUSS JEFFREY FITZGERALD) 19 April 2022 (2022-04-19) the entire document	1-5
A	US 9357716 B1 (US AGRICULTURE) 07 June 2016 (2016-06-07) the entire document	1-5

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IL2023/050951

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
JP	2016168016	A	23 September 2016	JP	2016168016	A	23 September 2016
				JP	6458246	B2	30 January 2019
CN	105165320	A	23 December 2015	CN	105165320	A	23 December 2015
				CN	105165320	B	14 November 2017
CN	112385433	A	23 February 2021	CN	112385433	A	23 February 2021
JP	2010068801	A	02 April 2010	JP	2010068801	A	02 April 2010
				JP	5131250	B2	30 January 2013
JP	6981702	B1	17 December 2021	JP	6981702	B1	17 December 2021
				JP	2022096574	A	29 June 2022
JP	2018099038	A	28 June 2018	JP	2018099038	A	28 June 2018
				JP	6750496	B2	02 September 2020
US	11304385	B1	19 April 2022	US	11304385	B1	19 April 2022
US	9357716	B1	07 June 2016	US	9357716	B1	07 June 2016