

PLANT FACTORY PLANTING SYSTEM AND METHOD OF OPERATION

Technical field

The present invention belongs to the technical field of plant growing and specifically relates to a fruit factory planting system and method of operation.

Background technology

Plant factory planting has long attracted the attention of the research community as it can break geographical restrictions, reduce the occupation of arable land and improve labor efficiency. In recent years, domestic industry has also begun to practice it. However, most of the current plant factories are loss-making, thus severely limiting the development of this technology.

There are several reasons for the loss of plant factories: 1. high energy consumption. The energy requirements of plant factories include: light, temperature regulation, humidity regulation and carbon dioxide supplementation. According to media reports, the current electricity consumption of a kilogram of vegetables produced in a plant factory can be as high as 10 degrees, costing 20 *yuan*. 2. As a result, plant factories do not fundamentally solve the problem of the phenological period, so most of them are currently planted with plants that require only vegetative growth, such as vegetables and Chinese herbs, as well as some herbaceous flowers and a few herbaceous berries (such as strawberries); there are few successful cases for varieties with phenological period, especially woody fruit trees.

Summary of the invention

The technical problem to be solved by the present invention is to provide a plant factory planting system and a method of operation. The method can significantly reduce energy consumption, change and shorten the phenological period, and achieve annual and efficient production of perennial woody fruits.

Technical solutions adopted in the present invention are: a plant factory planting system, consisting of a plurality of independent planting units, connecting corridors and equipment. At least two of the planting units are in a group, and there is a ventilator communicating between the two planting units in the group. Day and night are exchanged between the two units in the group, and the temperature difference between day and night is realized through a heat pump unit. There are connecting corridors

between groups that are not communicated with each other. The equipment includes:
outdoor energy equipment: a photovoltaic generator set, a substation, a gas generator,
and an outdoor temperature probe and a carbon dioxide probe. Exhaust gas from the
gas generator enters each planting unit through a pipeline and a branch pipe leading to
5 each unit. The equipment installed in the connecting corridor, including an air filter at
both ends of the connecting corridor, a distribution box, a controller and a heat pump
host system inside the connecting corridor, as well as a connecting corridor temperature
probe and a connecting corridor carbon dioxide probe. The equipment installed in each
planting unit is: a lighting assembly, a temperature probe, a humidity probe, a carbon
10 dioxide probe, a light probe, an intake fan, an exhaust vent and a heat pump end system.
The main body of the planting unit is an insulated and closed structure, and a door of
the planting unit is opened at one end of the connecting corridor. There are ventilators
connected between the two planting units in the group to form air circulation. The heat
pump host system and the end system are connected through pipelines to form a heat
15 exchange system, which is switched through a valve to make the end system become a
condenser or an evaporator respectively, so as to realize the heat exchange between
different planting units.

Further, an air filter is provided at both ends of the connecting corridor, and a lift,
a stair and other equipment are provided within the connecting corridor. The invention
20 further provides a method of operating the above system, the method being specified
as follows:

1) using an artificial light source to satisfy light requirements of plants at different
physiological stages through a fully controllable light spectrum, duration and light
intensity, and to create controlled diurnal and day and night of planting cycle variations;

25 2) using an insulated and airtight building structure, the total heat within each
group is kept relatively constant by air and heat exchange, and taking away excess heat
in summer or supplementing heat in winter with a heat source or exhaust gas from a
generator through controlled exchange with the outside air;

3) the day/night interchange between two adjacent planting units is during
30 morning hours of the outside world, allowing for maximum use of valley power and
photovoltaic power on the one hand and minimal use of peak power on the other, while

at the same time all management work is done during natural daylight hours and workers do not need to work night shifts;

4) automatically switching the power supply by using the controller according to the amount of photovoltaic power generated and the time of valley power, and using
5 the grid power completely during the valley power stage, and giving priority to photovoltaic power during other periods, and using gas power generation to supplement when photovoltaic power is insufficient;

5) taking exhaust gas from the gas generator as a source of supplementary carbon dioxide, as well as a source of heat in winter;

10 6) automatically controlling the outdoor air intake by using the controller according to changes in indoor and outdoor temperature and a carbon dioxide concentration, so as to discharge excess heat in summer or supplement heat in winter, and regulate oxygen and carbon dioxide concentrations; and

7) exchanging heat by using the heat pump to create a low temperature zone, so
15 as to satisfy cooling needs of dormant plants.

The present invention further provides a specific daily cycle management method of the system, the method is described by an operation method of two adjacent planting units within a group, and the same operation method of two diurnally opposite planting units within other groups:

20 The two adjacent planting units are the planting unit one and planting unit two respectively; 0-4am of the planting unit one is in the late night period with zero light and the temperature is optimal for planting crops at night; while the corresponding time in the planting unit two is from 12-16pm, and the light is a saturation point of planting crops, and temperature is the optimum photosynthesis temperature in the daytime, and
25 is the most intense photosynthetic period; This is the time when the optimum temperature is maintained in both planting units by means of a heat pump unit. The external time for this period is between 16-20pm and the electricity consumption strategy is the transition from photovoltaic + power generation to power generation, wherein the exhaust gas from the generator supplements planting unit two with carbon
30 dioxide.

Planting unit one has an early morning period from 4-6am, when the temperature rises gradually in preparation for daytime metabolism and light remains at 0; the

corresponding planting unit two has an afternoon period from 16-18pm, when light decreases from the light saturation point to a light compensation point and to 0; as the temperature gradually decreases, photosynthesis gradually weakens; this period is characterized by a gradual equilibrium of temperature, oxygen and carbon dioxide through the exchange of air between the two planting units by means of a ventilation fan; and the outside time for this period is 20-22pm and the electricity consumption strategy is generator-based.

6-8am of the planting unit one is in the morning hours, when the light rises step by step to the light saturation point, and the temperature rises from the equilibrium point to the optimum temperature of planting crops; correspondingly, the planting unit two enters the night time from 18-20pm, when the light is zero and the temperature drops from the equilibrium point to the optimum temperature of planting crops at night; a heat pump unit transfers heat from the planting unit two to the planting unit one during this period, thus cooling the planting unit two and warming the planting unit one; the outside time for this period is 22-24pm and the electricity consumption strategy is full grid power.

8am-15pm of the planting unit one is in the morning hours, when the light at the highest light saturation point, and the temperature maintains at the optimum temperature of planting crops; correspondingly, the planting unit two enters the night time from 20pm-3am, when the light is zero and the temperature maintains at the optimum temperature of planting crops at night; the optimum temperature is maintained in both planting units by means of the heat pump unit; the outside time for this period is 0-7am when the grid is at its lowest price and the electricity consumption strategy is fully grid-based.

Planting unit one is still at its peak photosynthesis during the day at 15-16pm, which corresponds to the planting unit two at 3-4am, late at night; the outside time for this period is 7-8am, which is the parity time; the electricity consumption strategy is grid power + electricity generation, as the exhaust gas from a generator is needed to replenish the planting unit one with carbon dioxide during this period.

In the planting unit one, from 16 to 18pm, light decreases from the light saturation point to the light compensation point and to 0; as the temperature gradually decreases, photosynthesis gradually weakens; from 4 to 6am in planting unit two, the temperature

5 rises gradually in preparation for daytime metabolism and light remains at 0; this time of day is characterized by air movement through the ventilation fan, which balances temperature, oxygen and carbon dioxide in both planting units; the outside time during this period is 8-10am and the electricity consumption strategy is first generator + grid and then PV + generator as photovoltaic power generation rises.

10 At 18-20pm in the planting unit one, it is already night time, light is zero and the temperature drops gradually from the equilibrium point to the optimum temperature of planting crops at night; the corresponding planting unit two is from 6-8am, light rises step by step to the light saturation point and the temperature rises from the equilibrium point to the optimum temperature of planting crops in the daytime; the external time of this period is at 10-12am, the PV generation reaches its maximum stage and the electricity consumption strategy is PV + gas generator.

15 Planting unit one has a late night period from 20-24pm, with zero light and the temperature maintains at the optimum temperature of planting crops at night; correspondingly, the planting unit two enters the daytime, when the light is the light saturation point and the temperature maintains at the optimum temperature of planting crops in the daytime; the optimum temperature is maintained in both planting units by means of the heat pump unit; the outside time for this period is 12-16pm when the photovoltaic generation is at its maximum and the electricity consumption strategy is photovoltaic+gas generator.

20 The workers work from morning to afternoon in nature, covering the light hours of both planting units.

25 In summer, the total heat of a system increases because of the thermal conductivity of walls and the supplementary heat of the exhaust air, which can then be relied on to take away the excess heat by exchanging air with the outside world; this takes place between 2 and 5 am outside time, when the outside temperature is at its lowest and the carbon dioxide concentration is high, while at the same time the temperature in the planting unit one is at its highest.

30 In winter, the total heat of the system is reduced due to heat dissipation from walls and can be partially replenished by the exhaust gas from generator; the period for heat supplemented by the generator is mainly from 17-21pm, and the simulated time of planting unit two is from 13-17pm, and from 7-9am of external time, the simulated time

of planting unit one is from 15-17pm; if the heat supplemented by the generator does not maintain the total heat balance, the heat is supplemented by air exchange with the outside world, which is carried out for the planting unit one at 14-16pm of outside time, when the temperature is highest, the simulated time for the planting unit one is at 22-
5 24pm when the temperature is lowest; and air exchange is performed on the planting unit one.

The beneficial effects of the present invention compared to the prior art: the present invention uses a multi-layer insulated and airtight structure to minimize the impact of external environmental changes on the system, while saving land. The present
10 invention uses a combination of multiple energy sources and, by scheduling operations so that electricity from the grid is used exclusively during the valley tariff phase and the combination of photovoltaic power + gas-fired power is used in preference during other times, with the grid as a complementary electricity consumption strategy, significant savings in energy consumption can be achieved. The invention uses fans and
15 heat pumps to exchange air and transfer heat between different planting units within the same group while keeping the total heat in the system essentially stable, to achieve a temperature difference between day and night, and the temperature required for plant phenological changes, and thus for phenological regulation, while saving energy.

The present invention uses the exhaust gas from gas generators to supplement heat
20 and carbon dioxide, thus satisfying carbon dioxide requirements of the high intensity photosynthesis of plants in the case of high-density stereo planting.

Description of attached drawings

FIG. 1 shows a schematic diagram of a single-layer structure of this system: 1. planting unit one, 2. planting unit two, 3. planting unit three, 4. planting unit four, 5.
25 connecting corridor;

FIG. 2 shows a schematic diagram of the layout of the equipment in this system on a single level: 1. gas generator, 2. pipeline, 3. first unit branch pipe, 4. second unit branch pipe, 5. third unit branch pipe, 6. fourth unit branch pipe, 7. first unit intake fan, 8. second unit intake fan, 9. third unit intake fan, 10. fourth unit intake fan, 11. first unit
30 exhaust vent, 12. second unit exhaust vent, 13. third unit exhaust vent, 14. fourth unit exhaust vent, 15. first unit ventilator, 16. second unit ventilator, 17. third unit ventilator, 18. fourth unit ventilator, 19. first unit end system, 20. second unit end system, 21. third

unit end system, 22. fourth unit end system, 23. heat pump host system, 24. first air filter, 25. second air filter, 26. first lighting assembly, 27. second lighting assembly, 28. third lighting assembly, 29. fourth lighting assembly, 30. distribution box, 31. controller, 32. substation, 33. photovoltaic generator set; T1. first unit temperature probe, T2. second unit temperature probe, T3. third unit temperature probe, T4. fourth unit temperature probe; H1. first unit humidity probe, H2. second unit humidity probe, H3. third unit humidity probe, H4. fourth unit humidity probe; C1. first unit carbon dioxide probe, C2. second unit carbon dioxide probe, C3. third unit carbon dioxide probe, C4. fourth unit carbon dioxide probe, L1. first unit light probe, L2. second unit light probe, L3. third unit light probe, L4. fourth unit light probe, T5. temperature probe in the connecting corridor, C5. carbon dioxide probe in the connecting corridor, T6. outdoor temperature probe and C6. outdoor carbon dioxide probe;

FIG. 3 shows the distribution of temperature and carbon dioxide between the two adjacent planting units by air exchange without the heat pump being activated. Without the ventilator in operation, the two adjacent planting units are not communicated by air;

FIG. 4 shows a diurnal temperature difference between day and night through the heat exchange of a heat pump;

FIG. 5 shows the replenishment of carbon dioxide and heat into the planting unit via the exhaust gas from a generator;

FIG. 6 shows the exchange of air with the outside world to replenish carbon dioxide and remove excess heat. This exchange takes place outside during the hours before dawn to early morning in the summer, when the air temperature is low and the carbon dioxide concentration is high; and inside during the afternoon, when the temperature is high and the carbon dioxide concentration is low;

FIG. 7 shows that heat and oxygen are replenished through the exchange of air with the outside. This exchange takes place outside during the afternoon hours in winter and inside during the evening to early morning hours, when the outside air is warmer and the oxygen concentration is higher than inside;

FIG. 8 shows the heat exchange through the heat pump, creating a low temperature zone. The heat pump system is switched by a valve to take heat away from a zone that is in an internal simulated time of night (e.g. planting unit four in the diagram) and transfer it to another high temperature zone with an internal simulated time of day (e.g.

planting unit one in the diagram), where the temperature of planting unit four decreases and the temperature of planting unit one increases, and this excess heat is then taken away by the external air exchange;

FIG. 9 shows a schematic diagram of the building envelope, in particular the installation of photovoltaic panels on the roof and the south facade: 34. photovoltaic panels, 35. access for showering and dressing of personnel, 36. access for warehousing and product discharge, 37. access for materials entry and exit;

FIG. 10 shows correspondence between external time, planting unit one and planting unit two simulation time; based on external time, 18-22 for generation dominated, 22-6 for full grid power, 6-8 for generation + grid and 8-16 for generation + photovoltaic; and

FIG. 11 shows annual periodic variations of temperature and light in the plant factory system when growing grapes.

Specific embodiments

The technical solutions of the present invention are further explained below by means of examples, but the scope of protection of the present invention is not limited in any forms by the examples.

Example 1 Strawberry factory planting system

The strawberry factory planting system consists of a plurality of independent planting units, connecting corridors and equipment; at least two planting units are grouped together. In this example two planting units are grouped together, with ventilation fans connecting the planting units within the groups; connecting corridors are provided between the groups, but not communicated between the groups; the connecting corridors are equipped with lifts, stairs, elevators and equipment, as shown in FIG. 1. As shown in FIG. 9, the factory is a building structure with photovoltaic panels 34 installed on the south side of the building for photovoltaic power generation. On the ground floor of the building, there is an access for showering and dressing of personnel 35 on the left, an access for warehousing and product discharge 36 on the right, and an access for materials entry and exit 37 in the middle.

As shown in FIG. 2, the equipment includes: energy equipment installed outdoors: the photovoltaic generator set 33, substation 32, gas generator 1, as well as outdoor temperature probe T6 and carbon dioxide probe C6; the exhaust gas from gas generators

can enter each planting unit via the pipeline 2 and first unit branch pipe 3, second unit branch pipe 4, third unit branch pipe 5 and fourth unit branch pipe 6.

The equipment installed in the connecting corridor, including a first air filter 24 and a second air filter 25 at both ends of the connecting corridor, the distribution box 30, controller 31 and heat pump host system 23 in the connecting corridor, and the connecting corridor temperature probe T5 and connecting corridor carbon dioxide probe C5. The equipment installed in each planting unit is: a first unit lighting assembly 26, a second unit lighting assembly 27, a third unit lighting assembly 28, a fourth unit lighting assembly 29, the first unit temperature probe T1, the second unit temperature probe T2, the third unit temperature probe T3, the fourth unit temperature probe T4, the first unit humidity probe H1, the second unit humidity probe H2, the third unit humidity probe H3, the fourth unit humidity probe H4, the first unit carbon dioxide probe C1, the second unit carbon dioxide Probe C2, the third unit carbon dioxide probe C3, the fourth unit carbon dioxide probe C4, the first unit light probe L1, the second unit two light probe L2, the third unit light probe L3, the fourth unit light probe L4, the fifth unit intake fan 7, the second unit intake fan 8, the third unit intake fan 9, the fourth unit intake fan 10, the first unit exhaust vent 11, the second unit exhaust vent 12, the third unit exhaust vent 13, the fourth unit exhaust vent 14, the first unit heat pump end system 19, the second unit heat pump end system 20, the third unit heat pump end system 21, the fourth unit heat pump end system 22. The main body of the planting unit is insulated and airtight, and the door of the planting unit is opened at one end of the connecting corridor. The first unit ventilator 15, the second unit ventilator 16, the third unit ventilator 17 and the fourth unit ventilator 18 are connected between the two planting units in the group to form air circulation. The heat pump host system 23 and the first unit heat pump end system 19, the second unit heat pump end system 20, the third unit heat pump end system 21, the fourth unit heat pump end system 22 are connected by a pipeline to constitute a heat exchange system, through the valve switching, so that the first unit heat pump end system 19, the second unit heat pump end system 20, the third unit heat pump end system 21 and the fourth unit heat pump end system 22 become condensers or evaporators respectively, so as to achieve heat exchange between different planting units.

The planting unit is equipped with multiple rows of multi-layered stands to hold multiple layers of strawberries and lighting lamps above the strawberry plants.

The example assumes that a strawberry variety is accompanied by vegetative growth, flower bud differentiation, flowering and pollination, and fruit development in the fruiting period, and its temperature and light requirements are: light compensation point 10,000 lux, light saturation point 25,000 lux, the most suitable temperature at night is 8 DEG C, the photosynthetic optimal temperature during the day is 24 DEG C, and the optimal light duration is 12 hours. The present example assumes that the division of the electricity price period is: the valley electricity period is 23:00-07:00, and the peak electricity period is 8:00-11:30 (wherein 9:30-11:30 is the summer peak period), 14:00-22:00 (wherein 19:00-22:00 is the summer peak period), and other periods are the parity hours.

In this example, two adjacent planting units are used as a group to simulate the environmental changes of the day by controlling light and temperature. The time of day is therefore divided into three: the external time, the simulated time of planting unit one and the simulated time of planting unit two, with the simulated time of planting unit one and planting unit two being the opposite of day and night, and independent of the external time.

FIG. 10 shows the correspondence between the external time, the simulated time of planting unit one and planting unit two, the temperature and light variation curves of planting unit one and planting unit two, the electricity cost variation curves and the electricity consumption strategy for different time periods. The control logic for the 24-hour period is described below in the order of the simulated times for planting unit one: 0-4am of planting unit one is in the late night period with zero light and the temperature is 8 DEG C, while the corresponding time in planting unit two is from 12-16pm, with 25,000 lux of light and a temperature of 24 DEG C, which is the most intense photosynthetic period. This is the time when the optimum temperature is maintained in both planting units by means of a heat pump unit. The external time for this period is between 16-20pm and the electricity consumption strategy is photovoltaic + electricity generation, wherein the exhaust gas from the generator supplements planting unit two with carbon dioxide. Planting unit one has an early morning period from 4-6am, when the temperature rises gradually in preparation for daytime metabolism and light remains

at 0. The corresponding planting unit two has an afternoon period from 16-18pm, when light decreases from 25,000 - 20,000 - 10,000 (light compensation point) - 0. As the temperature gradually decreases, photosynthesis gradually weakens. As shown in FIG. 3, this period is characterized by a gradual equilibrium of temperature, oxygen and carbon dioxide through the exchange of air between the two planting units by means of a ventilation fan. The outside time for this period is 20-22pm and the electricity consumption strategy is generator-based, supplemented by grid power. 6-8am of the planting unit one is in the morning hours, when the light rises step by step from 0-10,000-20,000-25,000 and the temperature rises from the equilibrium point (around 16 DEG C) to the optimum temperature of 24 DEG C; correspondingly, the planting unit two enters the night time from 18-20pm, when the light is zero and the temperature drops from the equilibrium point to 8 DEG C. The heat pump unit transfers heat from planting unit two to planting unit one during this time, as shown in FIG. 4, thus cooling planting unit two and warming planting unit one. The outside time for this period is 22-24pm and the electricity consumption strategy is full grid power.

Planting unit one is at its highest light level of 25,000 lux during the daytime hours of 8am-15pm and maintains a temperature of around 24 DEG C, while planting unit two is at its light level of 0 and maintains a temperature of around 8 DEG C during the late night hours (20pm-3am). The optimum temperature is maintained in both planting units by means of a heat pump unit. The outside time for this period is 0-7am when the grid is at its lowest price and the electricity consumption strategy is fully grid-based. Planting unit one is still at its peak photosynthesis during the day at 15-16pm, which corresponds to planting unit two at 3-4am, late at night. The outside time for this period is 7-8am, which is the parity time. The electricity consumption strategy is grid power + electricity generation, as the exhaust gas from the generator is needed to replenish planting unit one with carbon dioxide during this time, as shown in FIG. 5.

In planting unit one, from 16 to 18pm, light decreases from 25,000-20,000-10,000 (light compensation point) -0. As the temperature gradually decreases, photosynthesis gradually weakens. From 4 to 6am in planting unit two, the temperature rises gradually in preparation for daytime metabolism and light remains at 0. This time of day is characterized by air movement through the ventilation fan, which balances temperature, oxygen and carbon dioxide in both planting units. The outside time during

this period is 8-10am and the electricity consumption strategy is first generator + grid and then PV + generator as the PV capacity rises. At 18-20pm in planting unit one, it is already night time, light is zero and the temperature drops gradually from the equilibrium point (around 16 DEG C) to around 8 DEG C; the corresponding planting unit two is from 6-8am, light rises step by step from 0-10,000-20,000-25,000 and the temperature rises from the equilibrium point (around 16 DEG C) to the optimum temperature of 24DEG C. At 10-12am, the PV generation reaches its maximum stage and the electricity consumption strategy is PV + gas generator. Planting unit one has a late night period from 20-24pm, with zero light and a temperature of around 8 DEG C, while planting unit two has a daytime period with 25,000 lux of light and a temperature of around 24 DEG C.

The optimum temperature is maintained by the heat pump unit controlling the two planting units. The external hours of this period are from 12-16 pm, the period of maximum photovoltaic power generation, and the electricity consumption strategy is photovoltaic + gas generator. The workers work from 7am to 4pm, covering the light hours of both planting units. In summer, the total heat of the system increases because of the thermal conductivity of the walls and the supplementary heat of the exhaust air, which can then be relied on to take away the excess heat by exchanging air with the outside world, as shown in FIG. 6. In this example, this takes place between 2 and 5 am outside time, when the outside temperature is at its lowest and the carbon dioxide concentration is high, while at the same time the temperature in planting unit one is at its highest (above 24 degrees). In winter, the total heat of the system is reduced due to heat dissipation from the walls and can be partially replenished by the exhaust gas from generator. In this example, the period for heat supplemented by the generator is mainly from 17-21pm (the simulated time of planting unit two is from 13-17pm) and from 7-9am (the simulated time of planting unit one is from 15-17pm) of external time. If the heat supplemented by the generator does not maintain the total heat balance, the heat is supplemented by air exchange with the outside world, as shown in FIG. 7, which in this example is carried out for planting unit one at 14-16pm of outside time, when the temperature is highest (simulated time for planting unit one is at 22-24pm when the temperature is lowest).

Because strawberries can fruit continuously for at least a year under the conditions described above, there is no need for dormancy and therefore no need to create a low temperature zone in this embodiment. Strawberry factory planting has only daily periodicity management, no phenological management, and after more than one year of continuous fruiting and plant ageing, the plants are directly replaced with new strawberry seedlings.

Example 2 Grapes factory planting

This example is identical to Example 1 in terms of construction and equipment, except that the grapes are grown in containers placed on the ground and supported on stands to support the vines. Grapes are woody perennials with a dormancy requirement, so that in the natural environment there is phenological changes of bud differentiation - dormancy - germination - flowering - fruiting - ripening - vegetative growth - defoliation. Each physiological stage has different requirements for temperature and light. The assumptions made in this example for a particular grape variety are as follows:

the dormant stage has a light duration of 8 hours, a temperature of 8 DEG C or less and a cooling requirement of 120 hours;

10-12 hours of light at the germination stage at 10-25 DEG C; and

the flowering stage has a light duration of 10-12 hours at 10-25 DEG C; the fruit growing stage has a light duration of 12-14 hours at 10-25 DEG C; the fruit ripening stage has a light duration of 12-14 hours at 10-25 DEG C; the vegetative growth stage has a light duration of 12-16 hours at 10-25 DEG C; the defoliation stage has a light duration of 12-10 hours at 10-25 DEG C.

The assumption of the division of the electricity price period in this example is the same as in Example 1. Although the temperature and illumination of different stages are different, the principle and management idea of the daily periodicity change of the present example is the same as Example 1. The following describes the artificial control of the environment to achieve the annual periodicity change of grapes and shorten the time. The specific implementation solution is as follows, starting from the fruit harvest, as shown in FIG. 11: after the fruit is harvested, 15 days of optimal vegetative growth time (light duration is 14 hours, temperature is minimum 10 at night and maximum 25 DEG C during the day) is given to allow the grapes to obtain sufficient nutrient accumulation; after that, the light duration is gradually shortened for 15 days, from 14

hours to 11 hours, and the temperature is as low as 10 at night and as high as 25 DEG C during the day, prompting the grapes to return nutrients to the roots and stems, enter dormant preparation, and begin to lose leaves.

5 After defoliation, reduce the light duration to 8 hours and maintain the temperature at a level below 8 DEG C at night and up to 20 DEG C during the day for 15 days to complete the cooling requirement to break dormancy; this stage requires additional cooling of the dormant planting units, as shown in FIG. 8.

10 After that, the light time is gradually extended in the following 30 days, from 8 hours to 12 hours, and the temperature is controlled at 10 DEG C at night and 25 DEG C during the day, and the grapes began to germinate and undergo vegetative growth. After that, it continued to be exposed to light for 12 hour with the temperature controlled at 10 DEG C at night and 25 DEG C during the day, and the grapes enter flowering. After that, the light time is extended until 14 hours, and the temperature is controlled at 10 DEG C at night and 25 DEG C during the day until the fruit is ripe.
15 After the fruit is harvested, it moves on to the next cycle. With this manual control method, the cycle process that originally took one year can be compressed into about 7 months, which greatly saves time and improves production efficiency.

CLAIMS

1. A plant factory planting system, wherein the system comprises a plurality of independent planting units, connecting corridors and equipment; wherein at least two planting units are grouped together and are communicated by a ventilation fan; the two units within a group are interchanged between day and night, and temperature difference between day and night is realized by means of a heat pump unit; and connecting corridors are arranged between groups that are not communicated with each other;
- the equipment comprises:
- energy equipment installed outdoors: a photovoltaic generator, a substation, a gas generator, as well as an outdoor temperature probe and a carbon dioxide probe; exhaust gas from the gas generator is piped into each planting unit through a pipeline and a branch pipe leading to each unit;
- the equipment installed in the connecting corridor comprises an air filter at both ends of the connecting corridor, a distribution box, a controller and a heat pump host system inside the connecting corridor, as well as a connecting corridor temperature probe and a connecting corridor carbon dioxide probe;
- the equipment installed in each planting unit comprises: a lighting assembly, a temperature probe, a humidity probe, the carbon dioxide probe, a light probe, an air intake fan, an exhaust vent and a heat pump end system; the main body of the planting unit is insulated and airtight, and a door to the planting unit opens at one end of the connecting corridor;
- two planting units in the group are connected by a ventilator to create air circulation; and
- the main heat pump system and the end system are connected by the pipeline to form a heat exchange system, which is switched by a valve so that the end system becomes a condenser or an evaporator respectively, thus realizing a heat exchange between different planting units.
2. The plant factory planting system according to claim 1, wherein the air filter is provided at both ends of the connecting corridor; and the connecting corridor is provided with a lift, a stair and other equipment internally.

3. The plant factory planting system according to claim 1, wherein the system is arranged in the main body of a building structure.

4. A method of operating the system by using any one of claims 1-3, wherein the method is specified as follows:

5 1) using an artificial light source to meet light requirements of plants at different physiological stages through fully controllable light spectrum, light duration and light intensity, and to create controlled diurnal and planting cycle variations;

 2) using an insulated and airtight building structure, the total heat within each group is kept relatively constant by air and heat exchange, and taking away excess heat
10 in summer or supplementing heat in winter with a heat source or exhaust gas from a generator through controlled exchange with the outside air;

 3) the day/night interchange between two adjacent planting units is during morning hours of outside world, which on the one hand allows for maximum use of valley power and photovoltaic power and minimal use of peak power, while at the
15 same time all management work is done during natural daylight hours and workers do not need to work night shifts;

 4) automatically switching the power supply by using the controller according to the amount of photovoltaic power generated and the time of valley power, and using the grid power completely during the valley power stage, and giving priority to
20 photovoltaic power during other periods, and using gas power generation to supplement when photovoltaic power is insufficient;

 5) taking exhaust gas from the gas generator as a source of supplementary carbon dioxide, as well as a source of heat in winter;

 6) automatically controlling the outdoor air intake by using the controller
25 according to changes in indoor and outdoor temperature and a carbon dioxide concentration, so as to discharge excess heat in summer or supplement heat in winter, and regulate oxygen and carbon dioxide concentrations; and

 7) exchanging heat by using the heat pump to create a low temperature zone, so as to satisfy cooling needs of dormant plants.

30 5. A specific daily cycle management method of the system according to any one of claims 1-3, wherein the method is described by an operation method of two adjacent

planting units within a group, and the operation method of two diurnally opposite planting units within other groups is the same:

the two adjacent planting units in the group are the planting unit one and planting unit two respectively; 0-4am of the planting unit one is in the late night period, the light is zero and the temperature is optimal of planting crops at night; while the corresponding time of the planting unit two is from 12-16pm, and the light is a saturation point of planting crops, and the temperature is the optimum temperature of photosynthesis of planting crops during the day, which is the most intense period of photosynthesis; this is the time when the optimum temperature is maintained in both planting units by means of a heat pump unit; the outside time of this period is 16-20pm and the electricity consumption strategy is the transition from photovoltaic + power generation to power generation, wherein the exhaust gas from the generator supplements the planting unit two with carbon dioxide;

4-6am of the planting unit one is in an early morning period, when the temperature rises gradually in preparation for daytime metabolism and light remains at 0; the corresponding planting unit two has an afternoon period from 16-18pm, when the light decreases from the light saturation point to a light compensation point to 0; as the temperature gradually decreases, photosynthesis gradually weakens; this period is characterized by a gradual equilibrium of temperature, oxygen and carbon dioxide through the exchange of air between the two planting units by means of the ventilation fan; and the outside time of this period is 20-22pm and the electricity consumption strategy is generator-based;

6-8am of the planting unit one is in the morning hours, when the light rises step by step to reach the light saturation point, and the temperature rises from the equilibrium point to the optimum temperature of planting crops during the day; correspondingly, the planting unit two enters the night time of 18-20pm, when the light is zero and the temperature drops from the equilibrium point to the optimum temperature of planting crops at night; a heat pump unit transfers heat from the planting unit two to the planting unit one during this period, thus cooling the planting unit two and warming the planting unit one; the outside time of this period is 22-24pm and the electricity consumption strategy is completely grid power;

8am-15pm of the planting unit one is in the daytime period, when the light at the highest light saturation point, and the temperature maintains at the optimum temperature of planting crops during the day; correspondingly, the planting unit two enters the night time of 20pm-3am, when the light is zero and the temperature maintains at the optimum temperature of planting crops at night; the optimum temperature is maintained in both planting units by means of the heat pump unit; the outside time of this period is 0-7am when the grid is at its lowest price and the electricity consumption strategy is completely grid-based;

planting unit one is still at its peak photosynthesis during the day at 15-16pm, and the corresponding time of the planting unit two is 3-4am, late at night; the outside time of this period is 7-8am, which is the parity time; the electricity consumption strategy is grid power + electricity generation, as the exhaust gas from the generator is needed to replenish the planting unit one with carbon dioxide during this period;

in the planting unit one, from 16 to 18pm, light decreases from the light saturation point to the light compensation point to 0; as the temperature gradually decreases, photosynthesis gradually weakens; 4-6am of the planting unit two is at the morning time, the temperature rises gradually in preparation for daytime metabolism and light remains at 0; this time is characterized by air movement through the ventilation fan, which balances temperature, oxygen and carbon dioxide in both planting units; the outside time during this period is 8-10am and the electricity consumption strategy is first generator + grid and then PV + generator as photovoltaic power generation rises;

18-20pm of the planting unit one is already in the night time, the light is zero and the temperature drops gradually from the equilibrium point to the optimum temperature of planting crops at night; the corresponding time of the planting unit two is 6-8am, the light rises step by step to the light saturation point and the temperature rises from the equilibrium point to the optimum temperature of planting crops in the daytime; the outside time of this period is at 10-12am, the PV generation reaches its maximum stage and the electricity consumption strategy is PV + gas generator;

20-24pm of the planting unit one is in a late night period, with zero light and the temperature maintains at the optimum temperature of planting crops at night; correspondingly, the planting unit two enters the daytime, when the light is the light saturation point and the temperature maintains at the optimum temperature of planting

crops in the daytime; the optimum temperature is maintained in both planting units by means of the heat pump unit; the outside time of this period is 12-16pm when the photovoltaic generation is at its maximum and the electricity consumption strategy is photovoltaic+gas generator;

- 5 workers work from morning to afternoon in nature, covering the light hours of both planting units;

in summer, the total heat of a system increases because of the thermal conductivity of walls and the supplementary heat of the exhaust air, which can then be relied on to take away the excess heat by exchanging air with the outside world; this takes place
10 between 2 and 5 am outside time, when the outside temperature is at its lowest and the carbon dioxide concentration is high, while at the same time the temperature in the planting unit one is highest; and

in winter, the total heat of the system is reduced due to heat dissipation from walls and can be partially replenished by the exhaust gas from the generator; the period for
15 heat supplemented by the generator is mainly 17-21pm, and the simulated time of the planting unit two is 13-17pm, and 7-9am of the outside time, the simulated time of the planting unit one is 15-17pm; if the heat supplemented by the generator can not maintain the total heat balance, the heat is supplemented by air exchange with the outside world; in winter, the temperature is highest at 14-16pm of the outside time, at
20 this time, the simulated time of the planting unit one is 22-24pm when the temperature is lowest, and the air exchange is performed on the planting unit one.