What yield pattern are you aiming for?

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SCAN ME

This article provides a summary of the information presented by strawberry expert Klaas Plas at the Fruit Growers Tasmania & Berries Australia webinar for strawberry growers and propagators held on 28 February 2024.

You can access a recording of the webinar at bit.ly/BA-Klaas-Plas or scan this QR code.

Thank you to Fruit Growers Tasmania for hosting and sharing this Webinar recording

Strawberry expert Klaas Plas explains the basics of strawberry tray plant production and techniques that can be used to achieve different target yields and harvest timings.

Before you decide what type of planting material you need, you must first determine what fruit production window you are aiming for. Do you want long, stable production? Or do you want a high yield in a short window? Or do you want a big first flush followed by a gap then a second flush?

There is a direct relationship between the diameter of the crown and the number of flower trusses on a strawberry plant. Plants with more developed flower trusses will yield earlier after planting but will have a shorter production period. Plants with less developed crowns will yield later but will keep fruiting for a longer period. Fruiting patterns can also be manipulated in the nursery with temperature treatments (such as cold treatment/Frigo) and in the field with alterations to growing conditions.

The different yielding patterns produced by the different plant types can be used to smooth out the fluctuations in harvest volumes. They can also be used to produce big volumes in short target windows.

Classes of strawberry planting material

In Europe, there are three main classes of bare-rooted plants and three classes of tray plants. Each class varies in crown diameter and expected yielding pattern.

Bare-rooted plants

These are traditionally grown in the soil and are sold with bare roots. The process of harvesting strawberry runners from the soil strips the tiny hairs from their roots, so the plants must put energy into regrowing their root system before they can produce leaves and then quality flowers and fruit. This makes them later fruiting than plug and tray plants with similar-sized crowns.

There are three main classes of bare-root plants:

B: 10-14mm crown diameter, little crown development, no flower trusses, later longer production period expected. These plants need to develop leaf trusses and then later flower trusses in the field. Flower induction must happen in the field.

A: 14-16mm crown diameter, with one or two flower trusses.

A+: >16mm crown diameter, flower trusses present, strong early production expected. These plants can be cold stored (Frigo), so they are available to the grower when needed.

Figure 1. A class (14-16mm crown diameter, with one or two flower trusses). Photo credit: Klaas Plas

Plug plants (~80 cm^3)

Plugs are the smallest category of tray plants and are normally 2.5 to 3.5 weeks old when they are supplied to a strawberry grower.

Plugs do not have flower trusses so flower induction must happen in the field.

Plug plants do not have an early first flush, but produce fruit for a longer period than more advanced planting materials.

Nursery tip: In the nursery, trays of plug plants can be placed side by side to maximise space efficiency without causing problems with shading (overshadowing from adjacent plants).

Plug plant (80cm^3). Photo credit: Klaas Plas

Mini tray plants (~135cm^3)

Mini tray plants are normally between 5 weeks and 5 months old when they are supplied to a strawberry grower. These plants can be cold stored (Frigo), so they are available to the grower when needed.

Mini tray plants should have at least **two crowns** and **three to five flower trusses** (in the case of 5-month-old plants).

With a larger crown and developed trusses, earlier fruiting, and higher early yields can be expected from these plants.

Nursery tip: In the nursery, Mini tray plants need to be laid out so there is one tray space between each tray to minimise overshadowing (10% shading in the nursery = 10% first flush loss, 20% shading = 20% first flush loss). Flowers that develop in the nursery must be removed so that energy is conserved and used to build the crown.

Tray plants (~135cm^3). Photo credit: Klaas Plas

Tray plants (~250cm^3)

Tray plants are the largest category of plant grown by European propagators and are normally up to 5 months old when they are supplied to a strawberry grower. Tray plants are also used in Canada where they are supplied to the strawberry grower at about 2 months old as a 'fresh' plant.

These plants can be cold stored (Frigo), so they are available to the grower when needed.

These plants should have at least **three crowns** and **four to seven flower trusses.**

With an even larger crown and more developed trusses, early fruiting and higher early yields can be expected from these plants. Strong fruiting is also expected after the first flush with already well-developed crowns and leaves.

Nursery tip: In the nursery, tray plants need to be laid out so there is one tray space between each tray to minimise overshadowing. Some nurseries make the spaces smaller (50-75% of the tray width) depending on economics and considering the yield penalty of shading.

Tray plants (~250cm^3). Photo credit: Klaas Plas

Yield patterns for different plant types

Figure 2 shows how each type of nursery plant is expected to yield after planting.

The largest size category of plant (Tray plants) is represented by the **blue line.** These plants produce a large first flush followed by a big dip in production. They then have a smaller second flush before they run out of energy and stop producing.

The second largest size category of plant (Mini tray) is represented by **the green line**. They have a smaller first flush and a smaller gap between the first and second flush. These plants will produce for a longer period than the larger tray plants.

Plug plants and Class A runners are represented by **the red line**. These plants do not have a first flush as flower induction must happen in the field. In the case of Class A runners, the first flower trusses need to be removed to get a well-balanced plant. These plants slowly build up their fruit production and will continue to produce fruit for a much longer period.

Tray plants = More trusses, big first flush, big gap after first flush, slightly shorter production period
Mini tray plants = Less trusses, smaller first flush, smaller gap after first flush, longer production period
Plug plants and Class A runners = No trusses, no first flush, longer production period

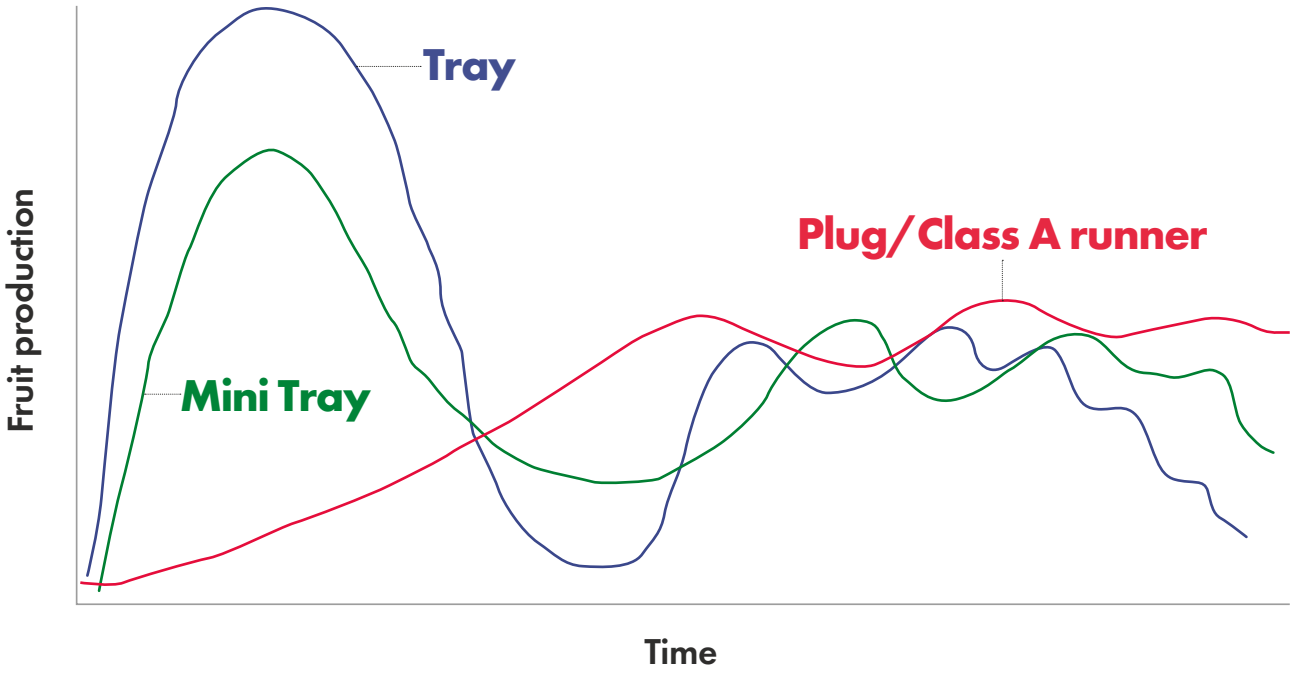

Figure 2. Expected fruit-yielding patterns of the different nursery plants

Pre-planting temperature treatments

Frigo/frozen

Frigo is the most well-known pre-planting temperature treatment. It involves storing plants (mainly A+ runners, mini tray, and tray plants) at -1.7°C and almost 100% humidity for up to 11 months.

Frigo is often used on larger plants to achieve large volumes of fruit in a short production window. These plants produce more runners and have big peaks and troughs in production.

Nursery tip: Growing media must be kept moist (but not saturated), and temperatures must stay above -1.7 °C to avoid frost damage.

Ambient

These are summer-producing plants that are propagated in autumn and overwintered in a greenhouse for planting in spring. Storing plants at ambient temperatures (10–12°C with some natural chill), as opposed to cold storage, results in more stable and longer production.

Yield patterns for different pre-plant treatments

Figure 3 shows the results of trials conducted by Flevo Berry, a breeder in the Netherlands, on the '*Favori*' strawberry cultivar. Three different pre-planting treatments were tested:

1. 'Fresh' Mini tray plants, propagated in winter and planted two and a half months later in spring;
2. 'Frigo' Tray plants, planted in winter, two months earlier than the 'Fresh' plants.
3. 'Ambient' Tray plants, planted in winter, two months earlier than the 'Fresh' plants.

These trials have been repeated over several seasons and show that:

- Ambient plants produce the most stable production
- Frigo plants produce big fluctuations in production
- Fresh plants produce a big first flush of fruit, but may have a low leaf area index (not enough leaves to support the fruit (too generative)) so the fruit can be smaller and not as tasty. To remedy this, growers need to prune flower trusses to restore the balance of leaves and flowers in the plant

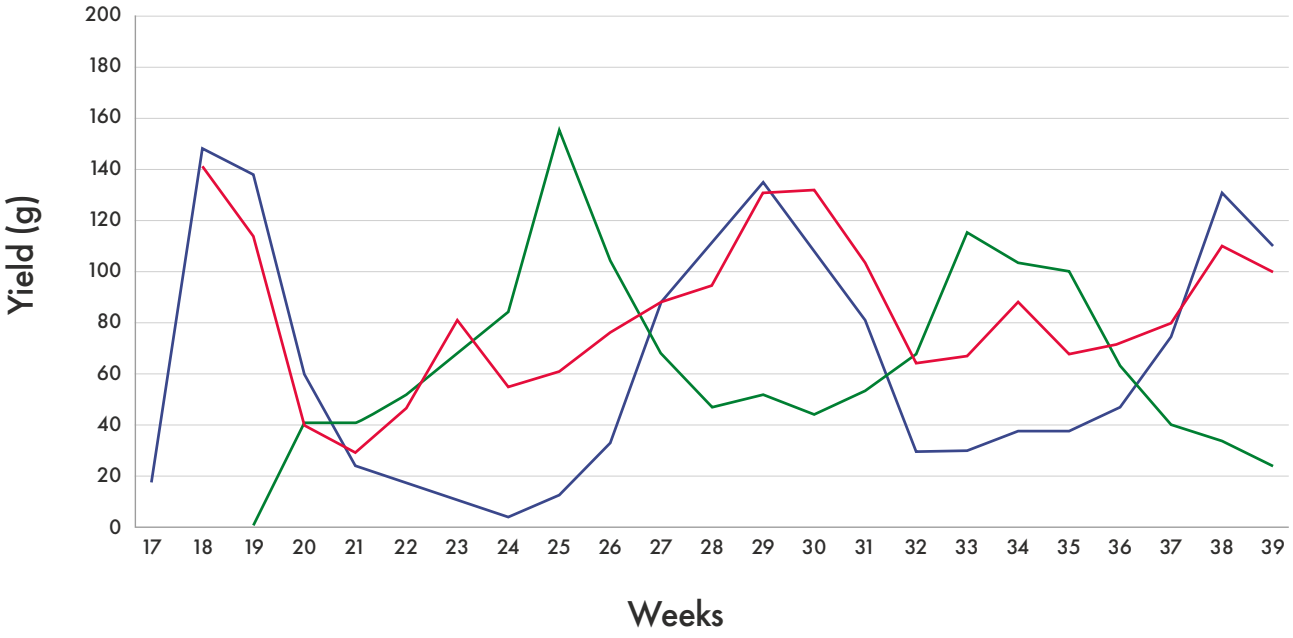

Figure 3. Comparison of yield patterns for Fresh (GREEN), Frigo (BLUE), and Ambient (RED) treatments in trials on cultivar '*Favori*' conducted by Flevo Berry in the Netherlands.

Balancing vegetative and generative growth

Vegetative

Vegetative plants have a high leaf area index and few flowers. The first flush of fruit off a young vegetative strawberry plant will be less than that of a generative plant. This is countered by a second flush that comes soon after the first flush and produces large, tasty berries.

Generative

Generative plants have few leaves and a lot of flowers. The first flush of fruit off these plants is larger but fruit are generally smaller and unpleasant tasting. These plants also take longer to recover from the first flush, so the second flush of fruit is delayed.

Photo credit: Klaas Plas

Balance is key! Leaves provide energy to the strawberry plant so that it can produce fruit. A balance between vegetative and generative growth is needed to achieve good yields of large flavoursome berries.

If you have a plant that is too generative, your aim will be to encourage more vegetative growth. If your plant has become too vegetative your aim will be to move it towards more generative growth. You can do this by changing the plants growing conditions (Table 1).

Note: if a plant becomes too vegetative it is quite difficult to shift it back to a generative state. Also, there is quite a bit of variation between varieties; there are generative varieties, vegetative varieties, and varieties that are somewhere in between.

The quickest and easiest way to move plants between vegetative and generative growth is to change the nitrogen applications. Applying more ammonium (NH_4) will encourage vegetative growth. If there is too much vegetative growth, removing ammonium from the fertiliser program will make the plant more generative. Irrigation practices can also be used to change the growth phase but can be a little riskier. Other climatic factors that influence the growth phase, such as the difference between day/night temperatures, are more difficult to manipulate.

Table 1. How to move plants between vegetative and generative growth phases

	Encouraging vegetative growth	Encouraging generative growth
Climate		
Day/Night temperature difference	Small	Big
Winter heating (greenhouse) Daily start time	Earlier	Later
Evening temperature decline	Slower	Faster
Afternoon temperature rise	Low	High
Average temperature	Low	High
Relative Humidity (RH%)	Higher	Lower
Screening (shading the crop)	More	Less
Irrigation & fertiliser		
Drip pH	4.8 to 5.3	5.3 to 5.7
EC substrate	Lower	Higher
Drip EC	Lower	Higher
Substrate moisture	Wetter	Dryer
Irrigation pulses	Shorter	Longer
Drip frequency	More frequent	Less frequent
Nitrogen	High	Low
NH_4	High	Low – none
Mechanical work		
Removing flower trusses	With caution*	No
Removing leaves	Seldom	Often
Removing runners	Often	Seldom

Ease of applying the change: Easy to change | Can change | Difficult to change

* If a plant has too many flower trusses and the prevailing climatic conditions are generative (e.g. high temperature and radiation levels in summer), some flower trusses can be removed to get the plant back into balance and promote larger, better-tasting fruit. This technique should be used with caution at other times of the year.

Tips for nursery growers

Klaas provided some specific information on how to produce plug and tray plants and examples of production techniques used throughout Europe.

Propagation = vegetative growing

In propagation, the aim is to get runners and tips, rather than flowers and fruit, so the plants need to be maintained in the vegetative growth state. Big strong leaves with a high leaf index and few flowers are what's needed. In the vegetative growth phase, you don't need to remove as many flower trusses and instead of flower trusses, your plants produce runners.

In practice, the easiest way to maintain a vegetative plant is with high nitrogen applications (27-32mg/L NH_4 and 682-806mg/L NO_3) and high substrate moisture content – relatively wet substrate but not waterlogged. If there are high levels of radiation, shading will also help.

Mother plants also need to have enough cold hours to develop runners. Cold hours are measured as the number of hours below 7°C. The number of cold hours needed depends on the variety and is generally in the range of 1000-1500 hours. Tissue culture plants don't require cold hours as the hormones that stimulate runner production are already stimulated by the tissue culture process – they are already vegetative and will produce runners without cold hours.

Tip: When planting mother plants into the coir slab, base the spacing on the number of crowns per lineal metre, not the number of plants per lineal metre. More crowns = more potential runners. Aim for 15-20 crowns per lineal metre. Remove any flower trusses on the mother plants and maintain a vegetative growing environment.

Table 2. Fertiliser recipe recommended for maintaining growth in mother plants

Nutrient	Millimoles	Milligrams per litre (mg/L)
Ammonium (NH_4)	1.5 – 1.75	27-32
Nitrate (NO_3)	11 – 13	682-806
Potassium (K)	4.25	166
Calcium (Ca)	4.25	170
Magnesium (Mg)	1.5	36.5
Phosphate (PO_4)	1	95
Sulphate (SO_4)	1.5	144
Micromoles		
Iron (Fe)	35	1.95
Manganese (Mn)	40	2.2
Zinc (Zn)	12.5	0.82
Boron (B)	15	0.16
Copper (Cu)	0.75	0.048
Molybdenum (Mo)	1	0.096

Coir the substrate of choice

Coir is the substrate Klaas recommended for plug and tray production because of its stability and structure which provides a good balance and distribution of air, water, and nutrients around the roots. Other products frequently contain a fine/dust fraction that washes down the profile with frequent irrigations. This creates a layer that blocks drainage and causes waterlogging in the cells.

Tip: Frequent irrigations are essential as moisture levels in the trays must be maintained at all times - plants must not dry out at any stage.

Healthy root growth in coir substrate. Photo credit: Klaas Plas

Heat treatment

This is a relatively new technique that is being used by growers in Hungary. They propagate (stick) plants into their coir cells and place them in a closed tunnel where the humidity is maintained at 100% for the first week using misting sprinklers that turn on and off throughout the day.

During this time, temperatures in the tunnels are allowed to reach a maximum of 50°C for an hour or so each day (temperatures above 50°C will result in damage). This high temperature-100% humidity environment has been found to kill off pests, diseases, and viruses.

This concept is like the aerated steam technique reported in the article 'The use of heat in horticulture for pest and disease control' published in the Summer 2023 Edition of the Australian Berry Journal (PAGE 99-101) available at the Website Resource Library

Under good circumstances, tray plants produce one leaf per week, so the plants are mown to keep them low. Mowing can only be used on pest and disease-free plants
Photo credit: Klaas Plas

More Resources

Klaas is very generous with the information he shares in his presentations and on his website. Links to these are provided below.

The more we learn about strawberry physiology, the more questions we have, so with this in mind we plan to have more sessions with Klaas in the future. If you haven't already, please let your local IDO know what topics interest you the most.

Follow the links below or search "Klaas Plas" on the Website Resource Library at https://berries.net.au/resource-library

- Webinar with Klaas Plas: Strawberry nursery tray plug plant quality, 28 February 2024 https://vimeo.com/917783235/7b43d082f7
- 2022 Webinar with Klaas Plas: Flower Mapping https://vimeo.com/751521288
- 2020 Webinar with Klaas Plas: Strawberries in Balance & Integrated Pest Management https://youtu.be/KhxHOXjsIps
- 2024 document: Irrigation strategies for vegetative/generative growth https://berrykonsult.com/wp-content/uploads/2024/03/Irrigation-Strawberry.pdf
- Klaas Plas Berry Konsult website: https://berrykonsult.com/en/author/klaasplas
- Beekenkamp Packaging website (to see the plastic trays referred to in this article) bit.ly/Beekenkamp

About Klaas Plas

Klaas Plas is a strawberry expert from the Netherlands with over 30 years' experience in all aspects of strawberry production. Through his company Berry Konsult, he works with growers across Europe, Canada, and Australia. He specialises in current and future integrated pest management practices in strawberries and has extensive experience in strawberry nursery plant quality.

Find out more at berrykonsult.com