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Original article – Thematic Issue

Strawberry everbearer excels in hoistable gutter system

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Summary

Hoistable gutter systems allow narrow gutter distances in strawberry greenhouses, while there still is enough room to pick, handle or treat the crop after hoisting the gutters. Increasing plant density may have an effect on plant performance and fruit quality. In 2019, a hoistable gutter system was therefore installed at Research Centre Hoogstraten. Two gutter distances of 0.96 m and 0.80 m were compared to a standard gutter distance of 1.20 m on different everbearing cultivars. Gutters are hoisted when crop treatments are necessary. This creates shading on the lower gutters, what reduces the yield per plant when the gutter distance decreased. Due to the higher plant density, the production per m² increased with narrow gutter distances. After decreasing the gutter distance to 0.96 m the production increased between 7% and 18%, depending on the variety. With a gutter distance of 0.80 m, the production increased between 21% and 38%, depending on the variety. Despite higher overall costs, a profitability study shows that in 2021 the return for the variety 'Murano' increased with 11% for a gutter distance of 0.80 m. For a gutter distance of 0.96 m we saw a decrease in return with 8%.

Keywords
everbearer, hoistable gutter system, plant density, profitability, strawberry, variety

Significance of this study

What is already known on this subject?

- Modern strawberry cultivation in Belgium is a combination of various cultivation systems using both junebearers and everbearers. Typical cultivation in soil is combined with substrate cultivation. Optimal use of space and increase in production per m² is one of the biggest concerns of growers. To do this, growers have different possibilities like working with different cultivars, plant densities, fertilization, cultivation techniques, heating.

What are the new findings?

- We focus on working with everbearer cultivars at different plant densities in a hoistable gutter system. The effect of working with different plant densities is based on basic principles on light penetration and light usage of the plant.

What is the expected impact on horticulture?

- The results of the trial will help modern strawberry growers to produce more efficient.

Introduction

Strawberries (*Fragaria* × *ananassa*) are an important horticultural product in the region of Hoogstraten and are considered a standard in quality and price setting across Europe. In 2021 Belgium has a total production of strawberries of 50,590 ton, which is 2,87% of the total production in Europe (FAOSTAT, 2023). The switch from outdoor cultivation to modern greenhouses for intense and year-round production has been going on for a while (Neri et al., 2012; Lieten, 2013; Van Delm et al., 2016). Last year there is raising interest for the use of everbearers instead of junebearers. This has multiple reasons. With everbearers it is possible to harvest fruits over a longer period. In this way the growers increase the chance of picking fruits during a period with good prices and so spread risks. Two plantings of junebearers (typically plant density of 10 plants m^{-2}) can be replaced by one planting of everbearers (typically plant density of 5 plants m^{-2}). Replacing junebearers by everbearers in this system makes that growers need four times less plants during propagation stage and also four times less tipping ground. In this way growers also need two times less substrate during the production phase. In consequence growers are able to flatten their traditional labour peak in summer for crop maintenance during propagation and planting for production. But we have to keep in mind the labour needed for crop maintenance of the everbearer plants. Attention has to be paid to the growth of the flower trusses and after every harvest peak runner tips, old flower trusses and old leaves have to be removed.

However, the land is becoming scarce, expensive and high costs are associated with these high-tech greenhouses. It is therefore important to use space as efficiently as possible. In strawberry substrate cultivation space is lost because of the picking paths between the gutters. This space is necessary to pick and maintain the crop, but also to allow light to reach the developing strawberries underneath the canopy. Everbearers are planted in a single row (5 plants m^{-2}), which makes the canopy for a large part of the cultivation smaller compared to two rows of junebearers (10 plants m^{-2}). Therefore the gutters can easily be brought closer together without the trusses and leaves tangling. Research Centre Hoogstraten is investigating the possibility of growing everbearers with a minimal gutter distance. To bring the gutters closer together, a hoistable gutter system was installed in a plastic greenhouse compartment. In this way we increase plant density and aim to increase the production per m².

Materials and methods

Set up

In a plastic greenhouse at Research Centre Hoogstraten (51°27'13''N, 4°47'39''E) two sections were equipped with a hoistable gutter system (Metazet-Formflex). Each section is

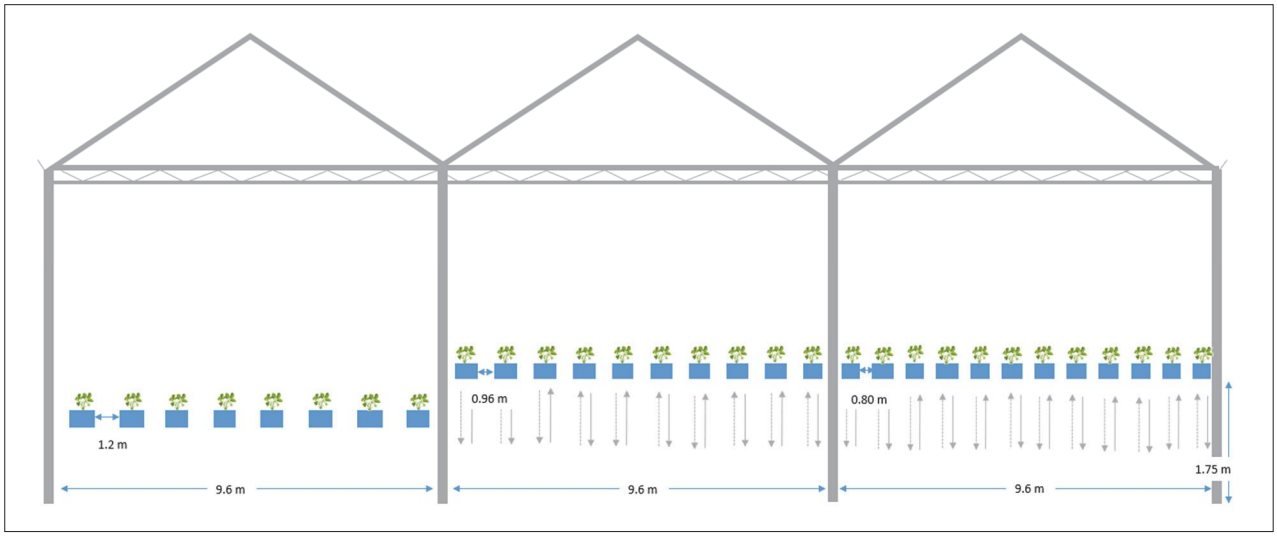


Figure 1. Sketch of greenhouse compartment with hoistable gutter system.

9.6 m wide, 29.5 m deep, and has a leg height of 6 m. The first section contains twelve gutters and the second contains ten gutters resulting in a gutter distance of 0.80 m and 0.96 m, respectively. In rest the gutters hang at a height of 1.75 m in this system. When we need to handle the crop, the gutters can be lowered with the other gutters as a counterweight. This means that when the even numbered gutters are lowered, the uneven numbered gutters rise. This way electricity use is limited and the extra investment can be kept relatively low. Both sections were compared with a normal section without hoistable gutters, containing eight gutters and a gutter distance of 1.2 m. Figure 1 shows a sketch of the greenhouse compartment. This system is tailor-made for Research Centre Hoogstraten.

Five everbearing varieties named 'Murano' (CIV, Italy), 'Favori' (Flevo Berry, The Netherlands), 'Malling™ Champion' (NIAB-EMR, United Kingdom), 'Cantus' (CIV, Italy) and 'Bravura' (Flevo Berry, The Netherlands) are tested on the different gutter distances. Plant material differs per variety and was obtained from different propagators. The plants experienced during propagation differences in fertilization, cold storage, crop maintenance, and outdoor weather conditions. Research Centre Hoogstraten worked with 'Murano' and 'Cantus' A+ plants (rhizome diameter of more than 16 mm) and 'Favori', 'Malling™ Champion' and 'Bravura' mini trayplants (runner tips planted in a cup of 135 cc).

On 31th of March 2021, all plants are planted in peat-coir-perlite growing bags (BVB Substrates) on a single row, so six plants per running meter. In this way three plant densities were created in the greenhouse compartment (7.5, 6.3 and 5 plants m^{-2} for the gutter distances 0.80 m, 0.96 m and 1.20 m, respectively). Combination of five varieties and three gutter distances creates fifteen objects. Each object consist of four repetitions of 30 plants, spread out in each section of the greenhouse. After planting, all everbearing varieties are managed in the same way.

Yield and grading

Between 21 May and 22 September 2021 the harvest of the trial occurred. From each plot of 30 plants, all strawberries were collected and graded in five classes on each picking date. Eventually each class of each plot was weighted separately. The first class 'Large 2A' contained nicely set fruit with a minimal diameter of 35 mm. The class 'Large A' had fruits with a diameter between 27 and 35 mm. The class 'Small' contained the nicely set fruit with a diameter below 27 mm. Misshapen fruit was sorted in the class 'Misshapen' and fruits infected with fruit rot or dried out fruits were sorted as 'Waste'.

Profitability study

All fruits in the trial were brought to the Belgian auction nearby Research Centre Hoogstraten (Cooperation Hoogstraten), where they were sold by variety, size and quality. Here, all fruits of a variety with the same size and quality of that day were sold at the same price. If the amount of fruits of a variety is too low they are sold together with other minor varieties as "strawberry". The price of each day was recorded and enables to calculate a turnover per m^2. A cost per m^2 was calculated including plant costs (0,35 € plant^{-1}), labour (0,80 € kg^{-1}), substrate (44 € m^{-3}) and biological control organisms. The biological control organisms used, their main target pests, the dose used and the price per m^2 are listed in Table 1. These costs were deducted from the turnover in each greenhouse section. In this profitability study, the extra costs associated with the installation of a hoistable gutter system and extra gutters have not been taken into account. These costs are company-specific.

Table 1. Biological control organisms, price and dose used during trial period.

Name biological control organism	Main target pest	Dose	Price (€ m^{-2})
Neoseiulus cucumeris (sachets)	*Frankliniella occidentalis*	0.5 sachet per running m	0.065
Neoseiulus californicus (sachets)	*Tetranychus urticae*	0.5 sachet per running m	0.15
Orius leavigatus	*Frankliniella occidentalis*	1 m^{-2}	0.26
Amblydromalus limonicus	*Frankliniella occidentalis* and *Trialeurodes vaporariorum*	40 m^{-2}	0.35
Phytoseiulus persimilis	*Tetranychus urticae*	10 m^{-2}	0.16

Statistical analysis

All results were statistically confirmed by the statistical software R (v. 4.0.0, 24/04/2020) (R Core Team, 2019), with RStudio (RStudio Team, 2016) as an integrated development environment (IDE). In order to analyse the results following packages were used: tidyverse (Wickham, 2017), multcomp (Hothorn et al., 2008,) lsmeans (Lenth, 2016), rcompanion (Mangiafico, 2020) and car (Fox and Weisberg, 2019). The statistical tests have the goal to evaluate the difference between the different objects. When the data and residues were normally distributed, an analysis of variance (ANOVA) was used. In the case both assumptions were not fulfilled a Kruskall-Wallis test was used as a non-parametric test. With each result it is clearly mentioned which test is used for the analysis. When a significant difference occurred a Tukey post-hoc test between the different objects was performed. A significant result is shown by the use of different letters. In this trial the statistical relevance between the gutter distances was calculated for each variety separately.

Results

Yield and grading

Yield and grading are the most important parameters in this trial. For each variety there is a negative effect on the yield per plant by bringing the gutters closer together. Comparing the three gutter distances, the effect is the biggest between gutter distance 0.96 m and 1.20 m. On average, yield decreased by 11.4% between 1.20 m and 0.96 m, between 0.96 m and 0.8 m there was an average reduction of 2.4%. The effect was the biggest on the variety 'Malling™ Champion' with a yield reduction of 20% between the biggest and the smallest gutter distance. With a decrease of 8% between the biggest and the smallest planting distance, the effect on yield per plant was the lowest for the variety 'Favori'. The production per plant for the variety 'Murano' dropped by 16%.

In kilograms per m², the lowest gutter distance of 0.80 m gave the highest yield. Comparing the three gutter distances, the difference in production between 0.80 m and 0.96 m is the biggest. On average, production increased by 16% between 0.96 m and 0.8 m; between 1.20 m and 0.96 m we saw an increase of 12% in production. For the variety 'Favori' the yield improved by 38% per m². For the variety 'Malling™ Champion' the differences were the smallest, the yield increased by 21%. The yield for the variety 'Murano' increased by 26% (Figure 2).

No significant differences are observed in grading of the fruits between the gutter distances per variety. Differences in grading between varieties are observed but these differences cannot be linked to the use of the hoistable gutter system and are more a variety specific characteristic. With about 60% large fruits is 'Bravura' the variety with the best grading. 'M. Champion' produces a lot of small fruits. Only 40% of the fruits are graded as large.

Profitability study

In 2021 only the variety 'Murano' had a constant supply of fruits at Cooperation Hoogstraten with its own price setting. So it was only possible to make a profitability study for 'Murano'. A return of 12.41 € m^{-2}, 10.29 € m^{-2} and 11.21 € m^{-2} was obtained for gutter distances 0.80 m, 0.96 m and 1.20 m, respectively. Striking is the lower profit that is obtained with a gutter distance of 0.96 m. The limited extra yield and higher input cause the profit to decrease. In 2021, a gutter distance of 0.80 m was the most cost-effective and 0.96 m the least cost-effective choice.

Research Centre Hoogstraten is already working for three consecutive years on this hoistable gutter system (2019, 2020 and 2021). The data obtained in this period can be used to see trends in profitability over the years. These data is a good tool for growers to take decisions about investing in these sort of systems. The calculation of the profit for

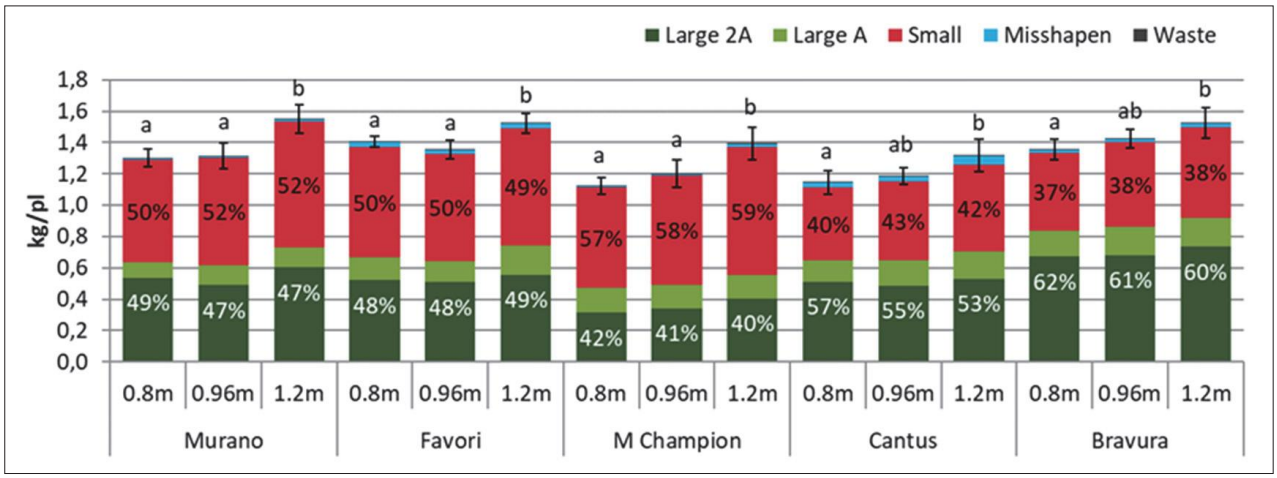


Figure 2. Yield and grading for the different varieties and gutter distances in kg plant^{-1}.

Table 2. Profit calculation for the variety 'Murano' (2021).

Parameter	0.80 m	0.96 m	1.20 m
Turnover	26.15 € m^{-2}	21.90 € m^{-2}	21.44 € m^{-2}
Plant cost	2.63 € m^{-2}	2.21 € m^{-2}	1.75 € m^{-2}
Labour	7.82 € m^{-2}	6.63 € m^{-2}	6.21 € m^{-2}
Substrate	0.88 € m^{-2}	0.73 € m^{-2}	0.59 € m^{-2}
Biological control organisms	2.42 € m^{-2}	2.05 € m^{-2}	1.68 € m^{-2}
Return	12.41 € m^{-2}	10.29 € m^{-2}	11.21 € m^{-2}

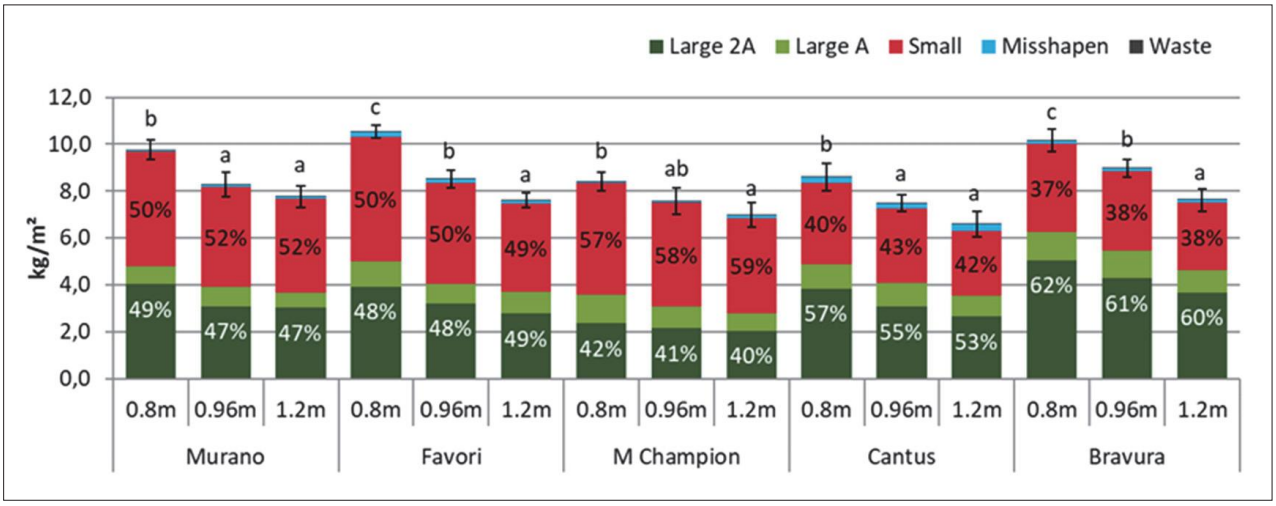


FIGURE 3. Production and grading for the different varieties and gutter distances in kg m^{-2}.

TABLE 3. Profitability (€ m^{-2}) per gutter distance and per trial period for 'Murano'.

Trial period	0.80 m	0.96 m	1.20 m
2019	12.30	10.86	9.52
2020	18.58	16.83	14.62
2021	12.41	10.29	11.21

the different years is done in the same way as in 2021. Data is only shown for the variety 'Murano' (Figure 3; Table 2).

Table 3 shows a big variability in profitability over the years. Profitability for the three gutter distances is a lot higher in 2020 in comparison with 2019 and 2021. In 2019 and 2020 both gutter distances on the hoistable gutter system succeed to increase profitability in comparison with the standard gutter distance of 1.20 m. In 2019 working on a hoistable gutter system with gutter distance of 0.80 m or 0.96 m increases profitability with 29% and 14%, respectively. In 2020 the system increases profitability for gutter distance 0.80 m and 0.96 m with 27% and 15%, respectively. In 2021 only gutter distance 0.80 m succeeds to increase profitability with 11%. Working with a gutter distance of 0.96 m in 2021 leads to a decrease in profitability of 8%. Summarizing the results for the three consecutive years the hoistable gutter system with a gutter distance of 0.80 m or 0.96 m increases the profitability with 22% or 7%, respectively.

Discussion and conclusion

Using a hoistable gutter system to increase plant density by reducing the gutter distance has a negative effect on the yield per plant. The difference is biggest between a standard system with a gutter distance of 1.2 m and a system with hoistable gutters with a gutter distance of 0.96 m. The lowering and hoisting of the gutters to make crop treatments and picking possible creates extra shading that results in a decrease in production per plant. Depending on the variety, a drop in production of between 8 and 20% per plant was obtained. This shading has a much greater effect on yield loss than the possible light loss that is caused by narrowing the gutter distance. Also the reduced light penetration between the rows and possible reflection on the soil plastic will cause plants to receive less light individually (Baets et al., 2019; Shiukhy et al., 2015). But due to the higher plant density on the hoistable gutter system, these losses were compensated and the production per m^2 increased by 21 to 38% depending on the variety.

When installing a hoistable gutter system, economically it is interesting to install the gutters as close as possible. Make sure that inflorescences and leaves do not get entangled. In our case a gutter distance of 0.80 m was for none of the varieties a problem. Growers can also choose for an intermediate solution called a swing system (Metazet-Formflex). In this system the gutters are not hoisted up and down but are swung to left and right. In this system less yield loss due to shading on the plants by hoisting one half of the gutters is observed. But the increase in plant density in a swing system is more limited in comparison with a hoistable gutter system (Janse, 2016).

The strawberry market is known as a very volatile market. Big price fluctuations per month are common (Van Rijswick, 2019). The price setting of the fruits is a complex combination of supply and demand influenced by weather conditions, economic situation consumers, etc. Growers try to cope with these price fluctuations by maximizing the period of fruit harvest on their company. Differentiation in cultivation systems is key for modern strawberry growers. Working with everbearers, which have a long harvesting period in comparison with junebearers, on a hoistable gutter system could be an extra option for strawberry growers. These price fluctuations also lead to a situation in which the profitability of using a hoistable gutter system strongly varies per year. Decisions on investment in such sort of system always have to be taken based on data of multiple years.

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