

Artificial shortening of day length to advance the flower initiation period of Sonata

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Abstract

Within the European Goodberry framework research is executed to create new possibilities in flower induction and dormancy in soft fruit cultivations. In Belgian strawberry cultivation, a year-round production is realized with the introduction of SON-T assimilation lamps to create harvest periods in winter and early spring. The variety Sonata is preferred in early spring for its high fruit quality, high production potential and the regular fruit setting even when growth is strongly forced with heating and lighting regimes. The Junebearer Sonata is grown into a trayplant during autumn in Belgium, flower initiation and the build-up of production potential occur between half of September and half of November. Due to the high chilling requirement of the variety, trayplants cannot be planted before the December 25 and harvest cannot start before end of March. Between August 7 and September 24 Research Centre Hoogstraten covered developing Sonata trayplants in 2017 at 7.00pm until 9.00 am to artificially shorten the day length to 10 hours. Sonata could advance the start of the flower initiation phase from September 19 to August 29. The trayplants were put into cold storage on October 18, an advancement of 28 days. After 6 weeks in cold storage the trayplants were planted in a greenhouse with SON-T assimilation lamps on November 29. The first ripe fruits were harvested on February 20 2018. The artificial day shortening realized in this research a start harvest advancement of 42 days.

Keywords: day length, temperature, strawberry, Sonata, advancing, flower initiation

INTRODUCTION

Strawberry cultivation has strongly developed in North-West Europe towards a year-round production (Van Delm et al., 2016). In Belgium and the Netherlands short day cultivars like Elsanta and Sonata are planted throughout the year in different cultivation systems to cover certain periods of the year. The winter months January and February have been long without the production of berries. However with the introduction of SON-T assimilation lights in the glasshouses, production becomes possible even in these months. In early spring Sonata is preferred over Elsanta, because of the strong enforcing conditions through heating. Sonata can cope with these conditions, will set nicely shaped fruits and achieve high production rates. Elsanta will produce misshapen fruits in enforced conditions. Also for the winter cultivations Sonata is chosen as the main variety.

Growers use Sonata trayplants to plant the early cultivations. Because of the high chilling requirement, trayplants have to be in cold storage for at least 6 weeks (Lieten, 2009). Growers can put the plants in cold storage mid-November at the earliest, at that time Sonata trayplants will have realized the required high production potential through flower initiation. In Belgium the combination of day length and temperature to allow flower initiation is met half of September. The production potential is build up in the following two months (Van Delm et al., 2014). Due to this natural timing and the chilling requirement, growers cannot start planting before Christmas and the earliest production of fresh strawberries starts end of March.

To advance the season with production in January and February growers can keep trayplants in cold storage until the next autumn and plant them in October or November. In this system the plants will be put in cold storage in the first half of December and will be planted 10

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or 11 months after. Such long cold storage holds risks, due to the depletion of plant reserves during the cold storage (Lieten et al., 2008). To avoid using a year old trayplant as planting material we can advance the flower initiation period on the trayfield by artificially shortening the day length in summer (Król et al., 2012; Verheul et al., 2006; Sonsteby et al., 1998). Temperature in summer is high and day length needs to be drastically shortened to allow flower initiation, however once achieved, production potential will build up very quickly due to active growth in the mild conditions.

In 2017 Research Centre Hoogstraten tried to plant Sonata in the beginning of December with plants put in cold storage half of October. Flower initiation should start half of August and days were shortened from beginning of August to realize this goal. The trial was carried out within the H2020 project Goodberry in which several European Research programs combine their efforts to figure out the processes of flower induction and dormancy.

MATERIALS AND METHODS

On the trayfield in 2017 two objects were created. In the first object runner tips from Sonata were put into a standard peat-coir tray mixture on June 21, starting fertilizer was blended in the substrate as 5 kg/m³ Osmocote Exact Hi.End (5-6 months), 500 g/m³ Micromax and 400 g/m³ Multimix. Liquid fertilizer from a standard A- and B-bin system was sprayed between July 10 and October 13 (week 28 – week 41) to a nitrogen total of 159 kg/ha (Table 1). Between August 7 and September 24 day length was artificially shortened to 10h. On October 18 trayplants were taken from the field and put in cold storage (-2°C) until the planting date of November 29. In the second object Sonata runner tips were planted on July 11. Fertilizer was sprayed between August 7 and November 3 (week 32 – week 44) to a nitrogen total of 163 kg/ha. On November 15 trayplants were put in cold storage (-2°C) until the planting date of January 3.

Table 1 Weekly amounts of nitrogen in kg/ha applied on the trayfield Sonata in 2017 to stimulate flower induction and development. (ASD: artificial short day)

Week	ASD	Control	Week	ASD	Control
Week 25	Runner tip		Week 36	17.5	20
Week 26	0		Week 37	17.5	20
Week 27	0		Week 38	12.5	20
Week 28	5.5	Runner tip	Week 39	12.5	20
Week 29	5.5	0	Week 40	7.5	15
Week 30	7.5	0	Week 41	5.5	10
Week 31	12.5	0	Week 42	Cold storage	10
Week 32	12.5	3	Week 43		10
Week 33	17.5	5	Week 44		5
Week 34	17.5	10	Week 45		0
Week 35	17.5	15	Week 46		Cold storage

To create conditions for flower initiation half of August we artificially shortened day length to 10h in the first object. Due to the earlier planting date the trayplants already developed a sufficient vegetative crop to start with flower initiation by the beginning of August. 24h day temperature in August 2017 was varying between 16 and 20°C in Belgium and according to the relation between day length and temperature (Ito & Saito, 1962), day length shouldn't be longer than 10h to create the stimuli for flower initiation in strawberry short day cultivars (Figure 1). The plants were manually covered on a daily basis between August 7 and September 24 from 7:00pm until 9:00am. We used a black anti root foil (Agrojutex PPH 100 g/m²) to cover the

plants. To avoid contact and damage to the trayplants metal support braces were installed on the trayfield to carry the black foil. Temperature was recorded on the trayfield in open air, but not underneath the black cover.

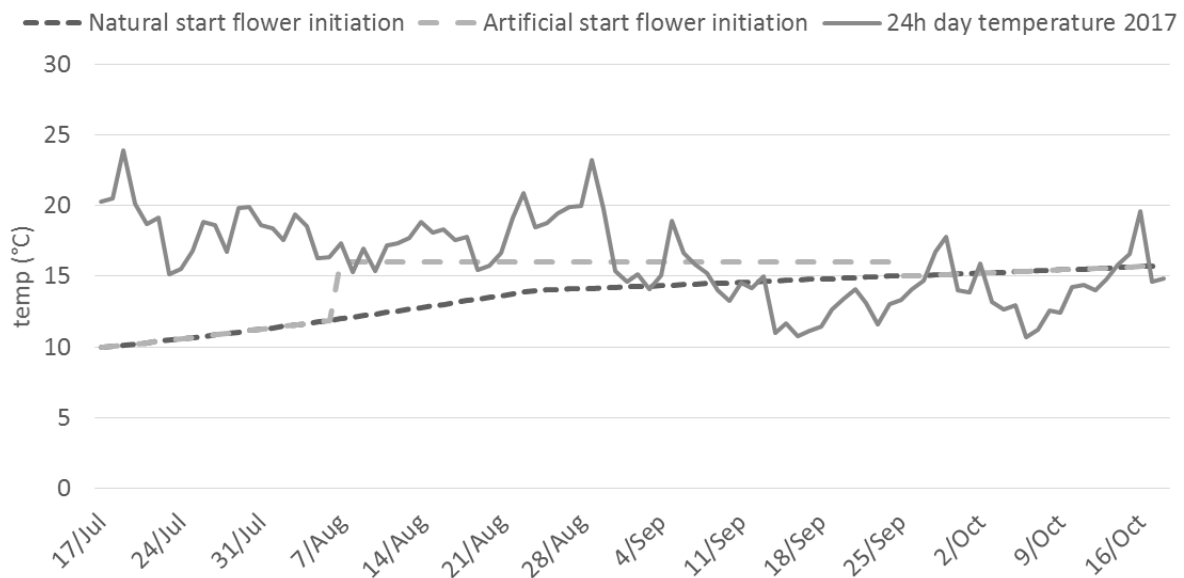


Figure 1 With artificially shortening day length down to 10h between 7/Aug and 24/Sep the first conditions for flower initiation were met close to 10 August.

Both objects of Sonata were monitored for flower initiation between the beginning of August and the end of September. Weekly, the apical meristem of three plants in each object was dissected and the development stage was scored underneath a binocular stereomicroscope (SMZ-168TL; 100x) (Taylor et al., 1997).

Sonata trayplants of object 1 were planted in 4 repeat plots in the glasshouse on November 29 2017 at a density of 10,5 pl/m². Each plot consisted out of 60 plants. Due to the early start of cold storage in October, the high chilling variety Sonata could be stored for the required 6 weeks. Trayplants of the second object were fully developed by the beginning of November. After a 7 week period in cold storage, trayplants were planted in the glasshouse on January 3 2018. The glasshouse planted on November 29 was equipped with SON-T assimilation lights (1000W/module) to generate a light intensity of 130µmol/m².s on crop level. Lights were turned on at December 5 for 7h a day and the lighting strategy was gradually increased towards 16h according to the development of the crop (Figure 2). Once the sunshine caused intensities greater than 400W on top of the glasshouse, the lights switched off, in March this regularly occurred. The glasshouse planted in January was not equipped with assimilation lights, which is a standard practice in Belgium for early glasshouse cultivations in spring. Both glasshouses were equipped with 1,7W/m² Philips GreenPower LED flowering lamps which were used on a daily basis between 6:00pm and 1:00am to stimulate crop stretching. Once the crop was stretched close to 25cm the LED lamps were switched off.

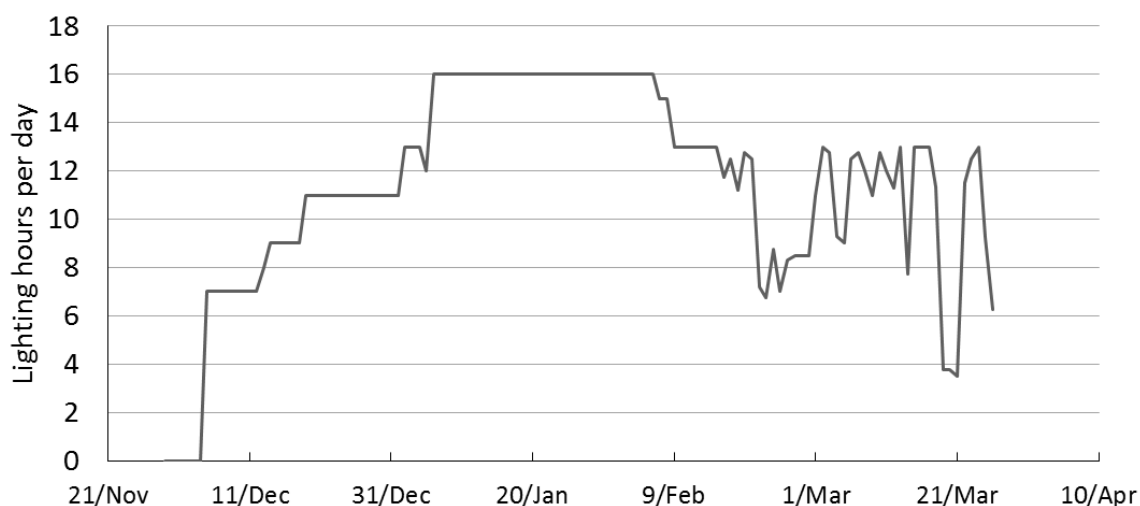


Figure 2 The lighting hours of SON-T assimilation lights gradually increased corresponding to the crop growth.

To see if the artificial shortening of day length could be considered as a success, we counted all flower trusses per plant and all flowers on each flower truss in 10 plants of each repeat shortly before the start of the harvest in the glasshouse. Depending on the plant date in the glasshouse this assessment took place on February 9 or March 21. We registered each picking of both objects in 5 different grading classes: large fruits 2A (diameter min. 35mm), large fruits A (diameter 31-35mm), small fruits (diameter <31mm), misshapen and rot fruits.

RESULTS

To realize the plant date of November 29 in the glasshouse we had to plant runner tips on the trayfield on June 20. With shortening the day length between August 7 and September 24 we tried to advance the flower initiation period of Sonata trayplants. Flower bud analysis showed that, while daily covering the plants, the first top flowers in the generative stage 2 were spotted on August 29 (Figure 3). It took Sonata up to 22 days with 10h day length to achieve generative growth. Sonata without artificial shortening of day length switched to generative growth on September 19. Covering the plants realized an advancement of 21 days in the start of flower initiation. These 21 days occur in August and September, when temperatures are high and flower initiation and development can occur swiftly to create multiple flower trusses in a short time span.

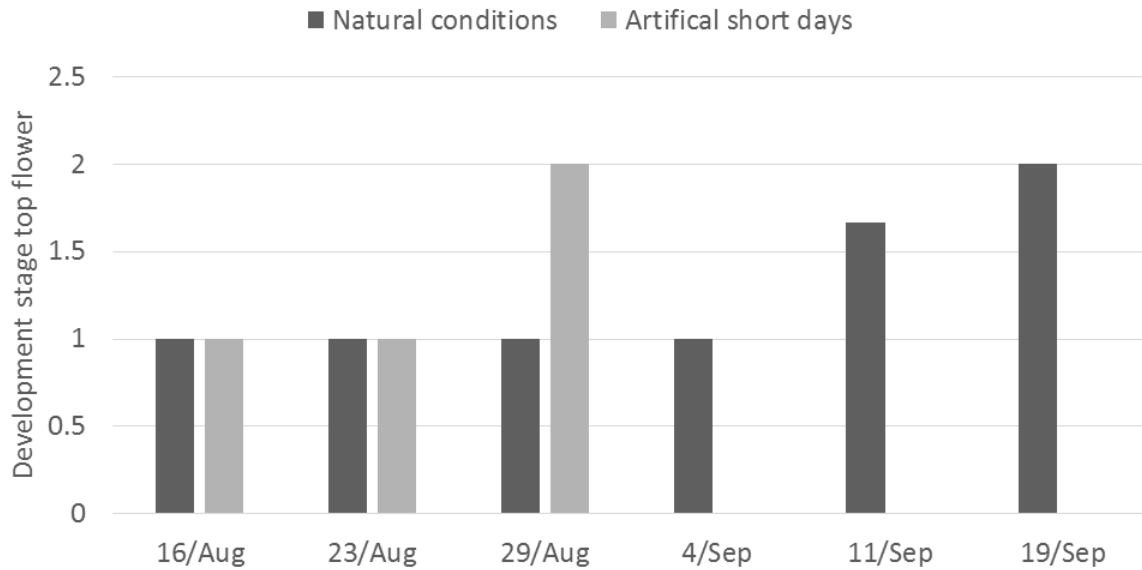


Figure 3 Through artificial shortening of day length the top flowers reached the generative stage 2 in Sonata 21 days sooner than in natural conditions.

The shortening of day length could theoretically generate a long enough period for flower initiation to create strongly developed trayplants which can be planted on November 29. On February 9 we counted 4,4 flower trusses per plant, which carried an average of 8,9 flowers per truss (Figure 4). The Sonata plants grown under natural conditions can only be planted at the end of December or in this case on January 3. To have a sufficient period of flower initiation we cannot start the period in the cold storage before half of November. On March 21 all plants were completely developed in the glasshouse and carried 5,8 trusses per plant with 7,8 flowers per truss. Both objects have realized the three trusses in the top of the plant axis and could add some extra trusses from the bottom zone of the axis (Melis et al., 2013). Possibly even side shoots were visible at the planting dates, however these were not recorded.

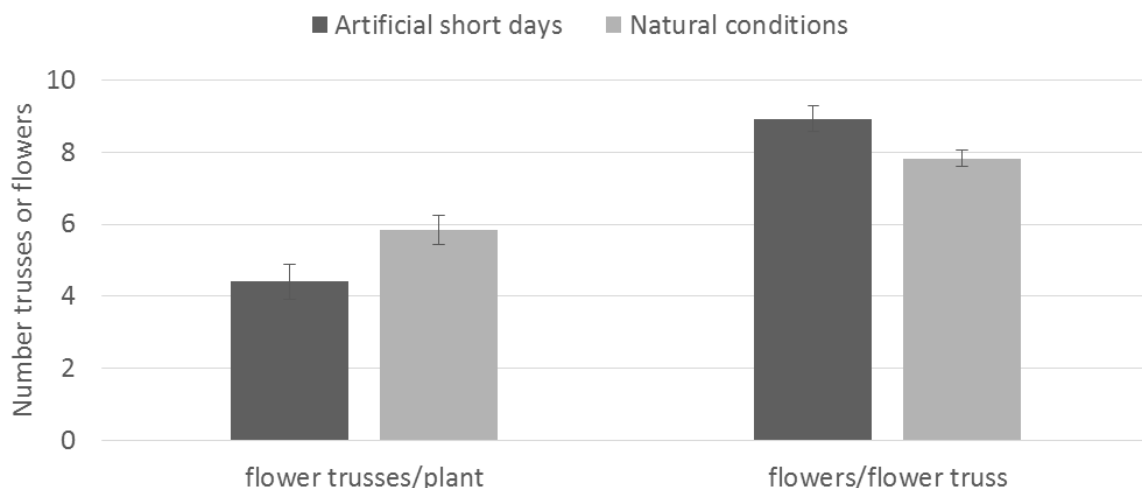


Figure 4 The Sonata trayplants were grown in different conditions on the trayfield, both objects however have realized a sufficient amount of trusses and flowers during the flower initiation period.

Trayplants receiving the artificial short days realized a production rate of 6,58 kg/m². The grading was very good with hardly any misshapen or rotten fruits, 72% of the fruits even

realized a diameter greater than 31mm. Harvest occurred between February 20 and April 19. Trayplants produced under natural conditions in autumn achieved a total production of 7,01 kg/m². The grading results are rather similar, a little more small fruits were harvested. The harvesting period ran from April 3 until May 7. The artificial shortening of the day length therefore realized an advancement of the start of the harvesting period by 42 days. In the control object, we reached 50% of the production rate on April 18, this date was advanced by 28 days, to March 21. Advancement of the flower initiation period resulted in a 28 days earlier start of the cold storage, a sooner planting date and with the help of assimilation lights the plants could exploit their full production potential in a winter cultivation.

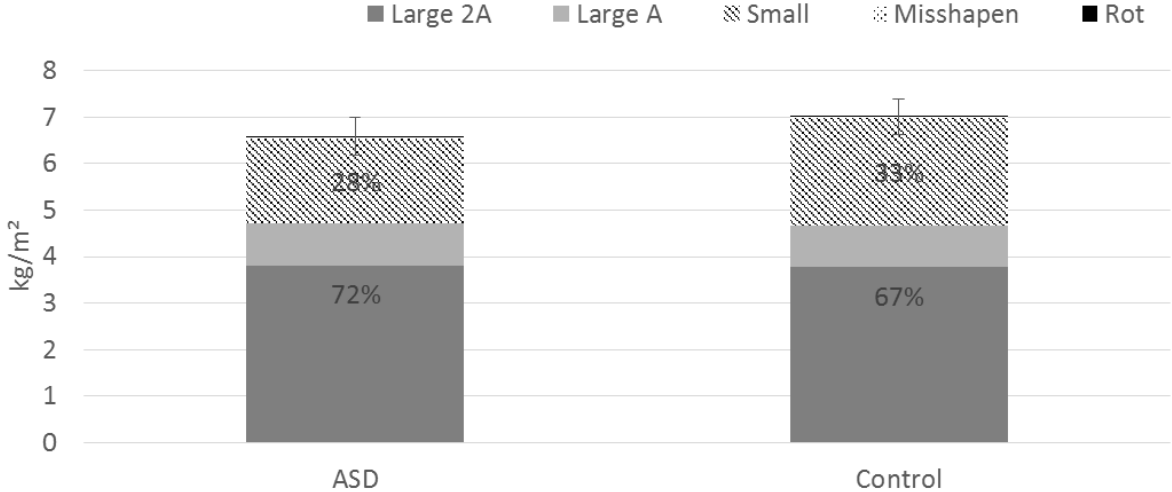


Figure 5 Production results in kg/m² (ASD: Artificial short days).

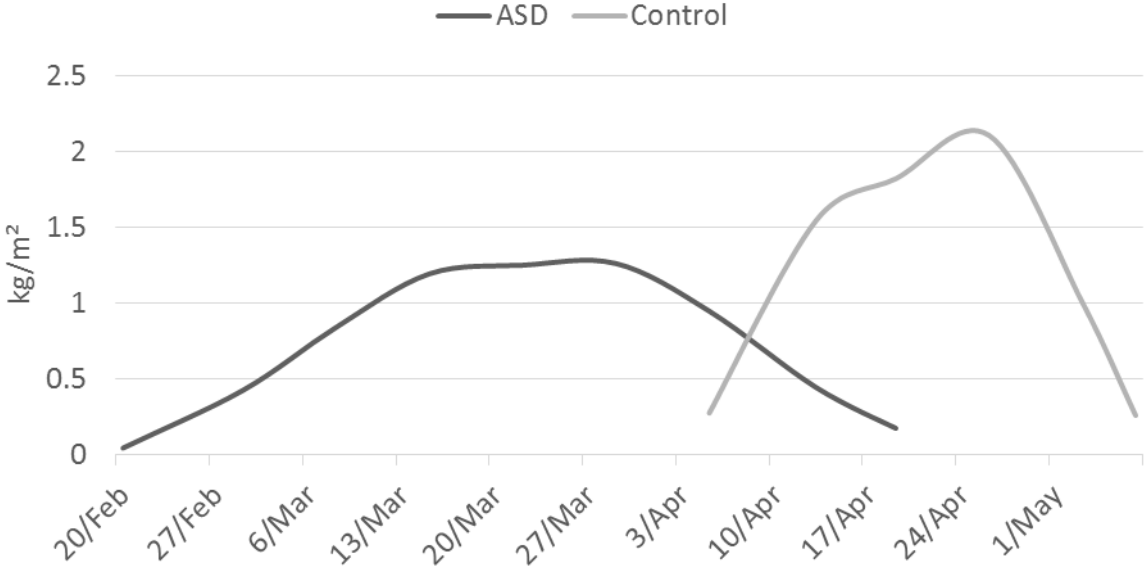


Figure 6 Harvest pattern in spring 2018 in kg/m² (ASD: Artificial short days)

DISCUSSION

Year-round strawberry production has been realized in modern strawberry cultivation in North-West Europe. The use of assimilation lights in winter has been the key factor to produce strawberries in January and February. Growers in Belgium and the Netherlands prefer

to use short-day cultivars like Sonata to grow in strongly enforced growing circumstances in glasshouses. For these cultivations growers need to plant trayplants in the glasshouse starting from half of October. However Sonata cannot build up enough production potential in autumn if cold storage is advanced. The current solution is a 10-11 month cold storage to result in one year old trayplants ready for planting at the end of the year. To avoid possible storage risks, it would be favourable to have fresh trayplants ready to plant.

The only way to get short-day cultivars grown in autumn on the trayfield ready for the following winter cultivation, is to shorten the day length artificially in summer. Sonata in Belgium normally starts with flower initiation half of September, at a day length of 13h in combination with 24h day temperatures close to 13-14°C. To get a productive trayplant ready on time to plant in the beginning of December, still respecting the cold storage of 6 weeks, the flower initiation should start half of August to have a period of 1,5-2 months for the build-up of production potential. Starting shortening the day length down to 10h in the beginning of August took 22 days before the flower initiation was visible in all plants. At a day length of 10h average temperatures up to 16°C are possible to allow for flower initiation. In this trial we measured such temperatures outside on the trayfield, but it is more than likely that the 24h day temperature underneath the black cover foil was higher. For this reason the start of flower initiation was possibly delayed for a few days or even more than a week. Once the plants had started to grow generatively, the build-up of production potential ran pretty smooth due to the mild temperatures in September. At the beginning of October the plants were fully developed and ready for the transfer to the cold storage.

Production results in the lighted glasshouse with the artificially covered trayplants were satisfying with a high rate combined with very good grading. Plant growth in winter glasshouse cultivation is easier to control, the grower controls the amount of light, the temperature,... Outside conditions are not forcing the plant to grow too fast and especially the fruit can gradually set. Starting from April and for sure May fruit ripening is enforced by warmer outside conditions, which is seen each year in the cultivations planted with Sonata at the end of December or in the beginning of January.

Research Centre Hoogstraten proved that the artificial shortening of day length is a good practice for short day cultivars to build up production potential in summer. In the future, automation should be implemented to relieve the labour intensity of the practice and to uncover the plants during the night time. Opening the cover for instance between 11:00pm and 4:00am would allow the plants to cool down which might result in a quicker start of flower initiation. An automated system could therefore realize an earlier plant production of Sonata trayplants. Sonata ready to plant half of October can produce fresh strawberries in January and February without depending on long-term cold storage.

ACKNOWLEDGMENT

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Literature Cited

Ito, H., Saito, T. (1962). Studies on the flower formation in the strawberry plant. I. Effects of temperature and photoperiod on the flower formation. *Tohoku Journal of Agricultural Research*, 13, 191-203.

Król, K. and Lech, W. (2012). Effect of shortening daylength on flower bud differentiation and crown development in 'Elsanta' strawberry. *Acta Hort.* 926, 307-313.

Lieten, P., Evenhuis, A., Baruzzi, G. (2008). Cold storage of strawberry plants. *Int. Journal of fruit science* 5:1, 75-820.

Lieten, P. 2009. Chilling requirement of strawberry cv. 'Sonata' and 'Figaro'. *Acta Hort.* 842:749–752.

Melis P., Van Delm T., Stoffels K., Baets W. 2013. Predicting potential flower trusses and their spread through flower bud analysis of strawberry plants. 2nd International Strawberry Congress, Antwerp Belgium.

Sonsteby, A., Ness, A. (1998). Short days and temperature effects on growth and flowering in strawberry (*Fragaria × ananassa* Duch.). *J. Hortic. Sci. Biotechnol.* 73, 730–736.

Van Delm, T., Melis, P., Stoffels, K., Van De Vyver, F. and Baets, W. (2014). Strawberry plant architecture and flower induction in plant production and strawberry cultivation. *Acta Hort.* 1049, 489-494.

Van Delm, T., Melis, P., Stoffels, K., Vanderbruggen, R. and Baets, W. (2016). Advancing the strawberry season in Belgian glasshouses with supplemental assimilation lighting. *Acta Hort.* 1134, 147-154.

Verheul, M., Sonsteby, A., Grimstad, S. (2006). Interactions of photoperiod, temperature, duration of short-day treatment and plant age on flowering of *Fragaria × ananassa* Duch. cv. Korona. *Sci. Hortic.* 107, 164–170.

Taylor, D.R., Atkey, P.T., Wickenden, M.F., Crisp, C.M. (1997). A morphological study of flower initiation and development in strawberry (*Fragaria × ananassa*) using cryo-scanning electron microscopy. *Annual Applied Biology*, 130, 141-152.