Journal of Berry Research 4 (2014) 217–224
DOI:10.3233/JBR-140083
IOS Press

Effect of rooting time, pot size and fertigation technique on strawberry plant architecture

Francesca Massetani[a], Gianluca Savini[b] and Davide Neri[a,*]
[a]*Department of Agricultural, Food and Environmental Sciences, Marche Polytechnic University, Ancona, Italy*
[b]*Sant'Orsola company, Pergine Valsugana, Italy*

Submitted 24 July 2014; accepted 22 September 2014

Abstract.
BACKGROUND: Flower induction and the reproductive and vegetative behavior of strawberry plants depend on several agronomic and nutritional factors.
OBJECTIVE: During propagation in the nursery, several fertigation techniques (nutrient amount and timing), rooting times and pot sizes were used to modify plant architecture.
METHODS: Different levels of nutrient applications were tested by setting the fertigation composition at 700 or 1000 μScm^{-1} electrical conductivity. Fertigation was continuous, delayed or temporary during the summer growth of Elsanta and Capri runner plants, for tray and mini-tray plant production. Early and late rooting dates were also compared.
RESULTS: The experiments showed the effects of the container type (tray and mini-tray) and the nutritional level on the plant architecture and reproductive behavior, with a major control of plant growth. Rooting time and fertigation timing also had some effects on plant architecture.
CONCLUSIONS: Propagation and fertigation techniques can become effective strategies for manipulating the architecture and the reproductive behavior of the plant. However, the interaction between many growing factors and plant growth may reduce the predictability of the effects.

Keywords: *Fragaria x ananassa Duch.*, plant propagation, flower induction, flower bud development, fertilization

1. Introduction

The strawberry plant architecture shows a determined growth pattern, with a terminal inflorescence in the crown [1], and a high variability that is related to the distribution and position of the vegetative and reproductive shoots along the crown (rosette plant). Vegetative growth and flower induction (reproductive behavior) of short-day strawberry plants are sensitive to environmental [2–4] and growing factors. In fact, flower induction is sensitive to thermo-photoperiod, which varies depending on the geographic location and season and can be modulated by changing the nursery site (altitude and latitude) and the rooting time. As for the growing factors, mineral nutrition [5–8], shading [9], leaf removal [10], water stress [11], transplanting and pot size [12] have been reported to be effective —and can be modulated— to manipulate flower induction, thanks to the high plasticity of the species. They can be applied as controlled abiotic stress to enhance the reproductive behavior of the plants [13, 14], acting on the growth rate. As a consequence, plant architecture and quality can be strongly influenced [15], especially in nursery cultivation. The nutrient level in particular has been reported to influence the growth and architecture of the plant. Nitrogen abundance can stimulate both stolon and shoot formation, and if supplied early, before short-day floral induction,

*Corresponding author: Davide Neri, Department of Agricultural, Food and Environmental Sciences, Marche Polytechnic University. Via Brecce Bianche, 60131 Ancona, Italy. Tel.: +39 0712204431; Fax: +39 0712204856; E-mail: d.neri@univpm.it.

it affects flower initiation [16–19], determining a delay or prevention of flower formation [19], in relation to the distributed amounts. On the one hand, at the beginning of inductive thermo-photoperiod conditions, nitrogen supply may stimulate flowering [7, 20]. On the other hand, low nitrogen availability may enhance the stimulating effect of inductive conditions [5–7], probably increasing plant sensitivity, but it may reduce flower production when it occurs later, during flower differentiation [21, 22], because floral organ formation requires more nitrogen [19]. Therefore, supply time plays an important role, also in the plant growth rate [23, 24].

Furthermore, the early growth of strawberry roots in small pots may increase plant sensitivity to inducing conditions [12], thus anticipating flower induction, but the subsequent growth of the root needs higher substrate volumes to avoid stress problems. The transplanting technique could therefore be evaluated to take advantage of the different pot sizes.

The effect of different fertigation techniques (application of reduced or delayed supply) applied while the plants are in the nursery and of propagation techniques (rooting time and pot size) were evaluated to modify the architecture of strawberry plants in pot.

2. Materials and methods

2.1. Plant materials

The study was conducted from mid-July to the end of October 2012 under a plastic tunnel in Pergine Valsugana (TN) in northern Italy (elev. 490 m a.s.l.; 46°04′0′′N 11°14′0′′E, 15 hours day-length in July, 14 hours in August). Runner tips from certified mother plants grown in the Po Valley were rooted in pots filled with peat mix. The most commonly grown cultivars in Italian northern regions were used for the remontant (Capri) and the non-remontant types (Elsanta). Different pot sizes were used to produce tray (250 cm^3) and mini-tray (150 cm^3) plants, respectively. Nutrition, weed and disease control were managed according to the Sant'Orsola company practice. Standard drip fertigation was provided at 1000 μS/cm electrical conductivity (EC). The nutrients were supplied at the following conventional concentrations: 5 mmol/l of NO_3, 1.8 mmol/l of H_2PO_4, 1.5 mmol/l of SO_4, 0.6 mmol/l of NH_4, 3 mmol/l of K, 4 mmol/l of Ca, 2.35 mmol/l of Mg, 20 μmol/l of Fe, 20 μmol/l of Mn, 8 μmol/l of Zn, 12 μmol/l of B, 1.75 μmol/l of Cu and 0.75 μmol/l of Mo. A lower fertigation level was arranged at 700 μS/cm electrical conductivity, reducing by 30% the nutrient content.

2.2. Treatments

Levels of nutrient applications were tested by modifying the fertigation composition and timing during the summer. The treatments described below were applied to 3 replications consisting of 225 plants each for tray plants and of 216 for mini-tray plants.

2.2.1. Cultivar Elsanta

Experiment 1: Runner tips were rooted directly in mid-July (early rooting: 18 July) and 3 weeks later (late rooting: 5 August) to produce tray plants and in mid-July (early rooting: 18 July) and 1 week later (late rooting: 30 July) to produce mini-tray plants. Part of the late rooted runners (5 August) were first grown in small pots (100 cm^3) and after 3 weeks transplanted into tray pots (transplanting). Standard fertigation (EC 1000 μS/cm) was provided to all the plants continuously from planting (continuous fertigation). Plants were sampled and dissected 7 weeks after the first planting date (week 35 of the year).

Experiment 2: Runner tips were rooted on 30 July in tray pots and 1 week later (5 August) in mini-tray pots. Standard fertigation (EC 1000 μS/cm) was provided to tray plants continuously after planting (continuous fertigation) or starting 3 weeks later (delayed fertigation). Delayed fertigation was also provided to both tray and mini-tray plants at low EC level (700 μS/cm). Plants were sampled and dissected 7 weeks after the first planting date (week 36).

Experiment 3: Runner tips were rooted on 18 July in tray pots or 2 weeks later (5 August) in mini-tray pots. Fertigation at EC 1000 μS/cm was provided to all the plants starting 3 weeks after planting (delayed fertigation). Some of the tray plants were supplied continuously and some of them over 3 weeks followed by water irrigation only for 3 weeks and then by fertigation at 1000 μS/cm (suspended fertigation). Tray plants under delayed fertigation

were debladed 6 weeks after planting. Plants were sampled and dissected 11 weeks after the first planting date (week 40).

Experiment 4: Runner tips were rooted in mid-July (early rooting: 15 July) or 2 weeks later (29 July) in tray pots or 4 weeks after early rooting (8 August) in mini-tray pots. Fertigation was provided to both tray and mini-tray plants starting 3 weeks after planting (delayed fertigation) applying different amounts of nutrients (EC 1000 and 700 μS/cm, respectively). Plants were sampled and dissected 14 weeks after the first planting date (week 44).

2.2.2. Cultivar Capri

Experiment 5: Runner tips were rooted on 5 August in tray pots. Standard fertigation (EC 1000 μS/cm) was provided continuously from planting (continuous fertigation) or starting 3 weeks later (delayed fertigation). Plants were sampled and dissected 9 weeks after the first planting date (week 40).

Experiment 6: Runner tips were rooted on 27 July in tray pots and later (8 August) in mini-tray pots. Standard fertigation (EC 1000 μS/cm) was provided to the plants continuously from planting (continuous fertigation). Plants were sampled and dissected 12 weeks after the first planting date (week 44).

2.3. Plant analysis

For each treatment, 4 to 7 plants were randomly sampled at each collecting date. The plant diameter was measured at the base of the crown. Then the plants were dissected to evaluate flower differentiation and plant architecture: bud, stolon and shoot position along the crown was recorded; all the buds were excised and dissected and their apices were exposed and examined under stereomicroscope (model SZ4045 Olympus Inc., Center Valley, PA, USA) at 40× magnification. The developmental stage of the floral buds was evaluated according to a numerical 1 to 8 scale [23, 25]. Leaves were classified as dead, expanded or unexpanded according to the vitality and the folding state of the blade. Crown fresh and dry weight (after 48 hours at 75°C) was registered.

2.4. Statistical analysis

The experimental data were subject to analysis of variance (ANOVA); differences were compared using mean separation by the Tukey-Kramer HSD test ($p \leq 0.05$). Statistical analysis was conducted using JMP Software (Release 8; SAS Institute Inc., Cary, NC, USA, 2009).

3. Results

3.1. Propagation technique

Elsanta plants produced in tray pots showed more vegetative growth, with the formation of a higher number of runners per plant, compared to mini-tray plants when supplied with delayed 1000 μS/cm EC fertigation. This effect was not always detected under delayed 700 μS/cm EC fertigation (Table 1). Mini-tray plants showed the tendency to produce shorter crowns (composed of less nodes) or similar to the tray plants. Flower differentiation of the terminal apex took place earlier in the tray plants, as detected during week 36. The plant type-EC level interaction effect on plant diameter, fresh weight, dry weight and on the amount of differentiated inflorescences was significant. Tray plants grown with delayed 700 μS/cm EC fertigation differentiated more inflorescences (Fig. 1) than mini-tray plants and compared to plants grown with 1000 μS/cm EC fertigation. They also reached a larger size of crown and a higher weight. Also in cultivar Capri, tray plants resulted larger and bigger, and produced a higher amount of runners and lateral shoots compared to mini-tray plants. They also produced more inflorescences (Table 4).

Tray plants from early rooted runner tips formed more nodes per plant and reached a higher weight under continuous fertigation and a higher number of runners under delayed fertigation, compared to late rooting (Table 2). The time of tip rooting did not significantly affect the crown size and the earliness of flower differentiation in both tray and

Table 1
Description of plants of cultivar Elsanta of different types supplied with delayed fertigation at different EC levels

Treatment	Fresh weight (g)	Dry weight (g)	Plant diameter (mm)	Nodes/plant (No.)	Runners/plant (No.)	Inflorescences/ plant (No.)	Differentiation phase of terminal apex
Plant type 700 µS/cm (sampling week 36)							
Tray	10.78[a]	2.47[a]	9.9[a]	10.5[a]	2.3[a]	1.2[a]	6
Mini-tray	9.84[a]	2.32[a]	9.4[a]	11.2[a]	2.6[a]	0[b]	–
Plant type 1000 µS/cm (sampling week 40)							
Tray	20.58[a]	3.57[a]	14.6[a]	13.0[a]	3.2[a]	1.8[a]	4.4[a]
Mini-tray	16.77[a]	2.86[a]	12.6[a]	13.6[a]	1.6[b]	1.0[a]	4.5[a]
Plant type and nutrient level (sampling week 44)							
Tray							
1000 µS/cm	40.17[ab]	9.38[ab]	13.9[ab]	16.2[a]	2.0[a]	3.8[b]	6.1[a]
700 µS/cm	54.40[a]	13.13[a]	16.6[a]	17.5[a]	1.8[a]	7.3[a]	6.1[a]
Mini-tray							
1000 µS/cm	26.70[bc]	6.58[bc]	12.8[b]	14.2[ab]	0.3[b]	3.5[b]	6.1[a]
700 µS/cm	19.51[c]	4.30[c]	10.8[b]	12.3[b]	0[b]	2.7[b]	6.7[a]

Means within a column for each sampling date followed by different letters (a–b) are significantly different according to the Tukey-Kramer HSD test at $P < 0.05$ level.

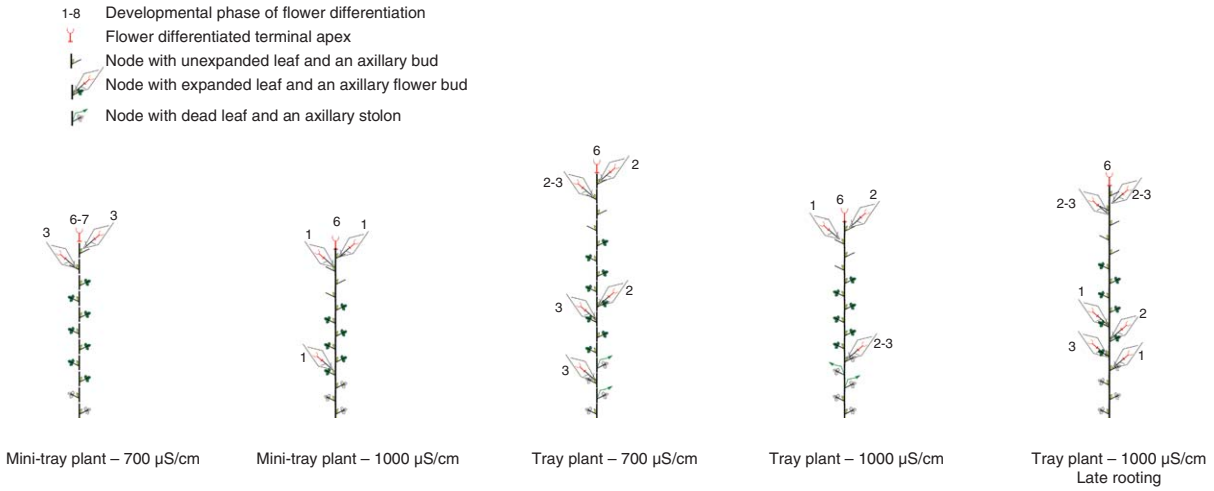

Fig. 1. Plant architecture of the mini-tray and tray plants of cultivar Elsanta produced with 700 µS/cm and 1000 µS/cm water supply, at the end of October (week 44).

mini-tray plants, even if the first appearance of flower differentiated apex was detected among the late rooted mini-tray plants during week 35.

Late rooting in mini-tray plants induced the differentiation of a higher number of inflorescences per plant. The transplanting technique did not show significant effects on plant architecture at an early stage of the plant cycle compared to direct rooting of the tips collected and planted at the same time (Table 2).

Table 2
Description of plants of cultivar Elsanta rooted at different dates and supplied with 1000 μS/cm EC water

Treatment	Fresh weight (g)	Dry weight (g)	Plant diameter (mm)	Nodes/plant (No.)	Runners/plant (No.)	Inflorescences/ plant (No.)	Differentiation phase of terminal apex
Plant type and rooting time Continuous fertigation (sampling week 35)							
Tray							
Early rooting	16.40[a]	2.97[a]	9.7[a]	13.5[a]	3.2[a]	0	–
Late rooting	5.96[c]	1.25[b]	7.7[a]	9.7[b]	2.0[ab]	0	–
Transplanting	11.41[b]	2.27[ab]	8.5[a]	10.5[b]	1.7[ab]	0	–
Mini-tray							
Early rooting	8.46[bc]	1.90[ab]	8.5[a]	10.7[b]	0.5[b]	0	–
Late rooting	7.86[bc]	1.65[b]	9.6[a]	11.5[b]	2.2[ab]	0.2	1
Rooting time Tray plant delayed fertigation (sampling week 44)							
Early rooting	40.17[a]	9.38[a]	13.9[a]	16.2[a]	2.0[a]	3.8[b]	6.1[a]
Late rooting	40.40[a]	10.86[a]	14.4[a]	16.8[a]	0.2[b]	7.2[a]	6.3[a]

Means within a column for each sampling date followed by different letters (a–c) are significantly different according to the Tukey-Kramer HSD test at $P < 0.05$ level.

Table 3
Description of tray plants of cultivar Elsanta under different types of fertigation management

Treatment	Fresh weight (g)	Dry weight (g)	Plant diameter (mm)	Nodes/plant (No.)	Runners/plant (No.)	Inflorescences/ plant (No.)	Differentiation phase of terminal apex
Nutrient level Delayed fertigation (sampling week 36)							
1000 μS/cm	13.46[a]	2.89[a]	10.7[a]	14.0[a]	0.8[b]	0.0[b]	–
700 μS/cm	10.78[a]	2.47[a]	9.9[a]	10.5[b]	2.3[a]	1.2[a]	6
Fertigation timing 1000 μS/cm (sampling week 36)							
Continuous	21.40[a]	3.86[a]	10.2[a]	13.0[b]	2.7[a]	0.0[a]	–
Delayed	20.17[a]	4.04[a]	10.6[a]	14.0[a]	1.8[a]	0.0[a]	–
Fertigation timing 1000 μS/cm (sampling week 40)							
Suspended	29.34[a]	5.24[a]	13.8[a]	15.5[a]	1.0[b]	2.3[a]	3.1[b]
Delayed	22.05[b]	3.70[b]	13.9[a]	13.3[b]	2.7[a]	1.6[a]	4.7[a]

Means within a column for each group of treatments followed by different letters (a–b) are significantly different according to the Tukey-Kramer HSD test at $P < 0.05$ level.

3.2. Fertigation technique

Application of low EC (700 μS/cm) delayed fertigation induced the growth of shorter plants compared to a higher EC level (Table 3). It was only in these plants that flower differentiation had already taken place 7 weeks after planting, and the terminal inflorescence showed high developmental flower stage. During week 36, no flower differentiation was detected in plants supplied with high EC fertigation. At the end of October (week 44), the plants supplied with low EC water showed more developed flower buds in the upper part of the crown, at the 2 positions closest to the terminal

Table 4
Description of plants of cultivar Capri of different types and of tray plants under different types of fertigation management

Treatment	Fresh weight (g)	Dry weight (g)	Plant diameter (mm)	Nodes/plant (No.)	Runners/plant (No.)	Lateral shoots (No.)	Inflorescences/ plant (No.)	Differentiation phase of terminal apex
Plant type								
Tray plant	63.97[a]	14.6[a]	15.10[a]	8.3[a]	4.3[a]	5.3[a]	14.8[a]	10.5[a]
Mini-tray plant	16.94[b]	3.68[b]	8.70[b]	10.4[a]	0.4[b]	0.8[b]	4.1[b]	9.5[a]
Fertigation timing								
Continuous	11.10[a]	23.90[a]	3.08[a]	15.00[a]	2.6[a]	0.4[a]	1.4[a]	3[a]
Delayed	11.60[a]	15.14[b]	2.16[b]	12.18[a]	2.0[a]	0.18[a]	1.5[a]	4.25[a]

Means within a column for each group of treatments followed by different letters (a–b) are significantly different according to the Tukey-Kramer HSD test at $P < 0.05$ level.

apex (Fig. 1). The delayed application of fertilizers did not show significant effects on Elsanta plant architecture at an early stage of the plant cycle compared to continuous fertigation, with the exception of a higher number of nodes.

Tray plants with the application of high EC delayed fertigation and deblading were shorter, lighter and produced more stolons than the tray plants under suspended fertigation. They also showed a more developed flower differentiation phase of the terminal apex with no differences in the number of flower differentiated buds.

The fresh and dry weight of Capri tray plants was higher under continuous fertigation than delayed fertigation, but the plants did not show significant differences in other biometric parameters or in the plant architecture.

4. Discussion and conclusions

Runner tips rooted earlier in bigger pots than mini-tray pots. In some experiments, the Elsanta tray plants showed higher vigor, detectable as larger plants (bigger crown diameter, higher weight and a higher number of nodes) and higher amounts of runners. The high vigor of the tray plants was even more remarkable for Capri plants in comparison with mini-tray plants. The tendency towards higher vegetative growth was increased in Elsanta by advancing the rooting time for the tray plants. The reproductive behavior followed a non-uniform pattern as the higher amount of differentiated inflorescences was detected in the tray plants, but the number decreased by advancing the rooting date. Nevertheless, some of these inflorescences were displaced along the median or basal portion of the crown, under the last expanded leaf, as shown through the plant architecture schemes. Buds in that position have been reported to have no direct correlation with the effective crop production because they are damaged or die during cold storage [26].

Unlike previous studies, the transplanting experiment did not confirm that the pot size affects plant sensitivity to the inducing factors [12], because moving the plant from very small pots to the tray ones seemed to have no effect on the reproductive behavior of the plant. However, based on the results, it can be argued that the different behavior detected between tray and mini-tray plants may be attributed to the pot size and not only to the different rooting time.

Different nutrient treatments were applied by manipulating the fertilizer amount and comparing delayed application of nutrient input to continuous and to suspended nutrient supply. The application of low EC level fertigation induced weaker vegetative growth of the plants in some of the experiments, forming shorter crowns. These plants formed a higher amount of flower differentiated buds and reached a more developed phase of the terminal inflorescence. This behavior is consistent with the early arrest of growth and with the hypothesis that reproductive induction takes place when the growth rate of the apex slows down [15].

Fertigation with higher EC did not increase runner formation, probably because the supply starting was delayed. Unlike continuous application, delayed application of high EC did not affect the growth or inflorescence production of the plants. The subsequent suspension of the delayed fertigation induced the growth of longer plants with delayed flower differentiation, and did not induce the expected anticipation of the terminal flower differentiation [23, 27] compared with the unsuspended supply, maybe because the plants in this last treatment were debladed and this kind of stress may reduce growth along the main axis. As a comprehensive consideration, the amount and timing of nutrient supply modified the strawberry plant architecture during growth in the nursery, especially modulating the number

of nodes and stolons along the main crown. It can be argued that the vigor of the plant can strongly affect the apical dominance of the growing shoot as it was found in other strawberry varieties and other techniques [28, 29].

The results confirmed that several agronomic and nutritional factors [30] interact with the strawberry plant behavior, but they may also interact with each other reducing the predictability of the effects without further investigations. Anyway, the observed effect of rooting time, pot size and nutritional level seems to confirm the major role that controlling plant growth has on the reproductive behavior and the possibility to manipulate it by modulating the growing conditions.

Finally, results suggest that the nutritional supply of the plants should be carefully modified in relation to plant vigor and type in order to optimize plant propagation and to better plan strawberry production. Reducing the amount of nutrients, supplying 700 μS/cm fertigation, or operating the late rooting technique are effective strategies for manipulating the reproductive behavior of the plant in the nursery in order to induce early growth arrest, enhancing flower bud differentiation and finally modifying the plant quality and architecture.

Acknowledgments

The research work was carried out thanks to the EU FP7 EUBerry project, Grant Agreement No. 265942.

References

[1] Guttridge CG. Observations on the shoot growth of the cultivated strawberry plant. J Hortic Sci. 1955;30:1-11.

[2] Serçe S, Hancock JF. The temperature and photoperiod regulation of flowering and runnering in the strawberries Fragaria chiloensis, F. virginiana, and F.×ananassa. Sci Hortic. 2005;103:167-77.

[3] Verheul MJ, Sønsteby A, Grimstad SO. Interactions of photoperiod, temperature, duration of short-day treatment and plant age on flowering of Fragaria x ananassa Duch. cv. Korona. Sci Hortic. 2006;107:164-70. doi:10.1016/j.scienta.2005.07.004

[4] Sønsteby A, Heide OM. Dormancy relations and flowering of the strawberry cultivars Korona and Elsanta as influenced by photoperiod and temperature. Sci Hortic 2006;110:57-67. doi:10.1016/j.scienta.2006.06.012

[5] Strik BC. Flower bud initiation in strawberry cultivars. Fruit Var J. 1985;39:5-9.

[6] Battey NH, Le Mièrep, Tehranifar A, Cekic C, Taylor S, Shrives KJ, et al. Genetic and environmental control of flowering in strawberry. In: Cockshull KE, Gray DJ, Seymour GB, Thomas B, editors. Genet Environ Manip Hortic Crops, Wallingford: CAB International; 1998, pp. 111-31.

[7] Lieten P. The effect of nutrition prior to and during flower differentiation on phyllody and plant performance of short day strawberry elsanta. Acta Hortic. 2002;567:345-8.

[8] Bigey J. Chilling requirements and compensation for the lack of chilling in strawberry. Acta Hortic. 2002;567:269-72.

[9] Kumakura H, Shishido Y. Effect of temperature and light condition on flower initiation and fruit development in strawberry. Jpn Agric Res Q. 1995;29:241-50.

[10] Thompson PA, Guttridge CG. The role of leaves as inhibitors of flower induction in strawberry: With one figure in the text. Ann Bot. 1960;24:482-90.

[11] Naumann WD. Die Wirkung zeitlich begrenzter Wassergaben auf Wuchs- und Ertragsleistung von Erdbeeren - (The effect of temporary watering on growth and yield performance in strawberry). Gartenbauwissenschaf. 1961;26:441-58.

[12] Fujishige N. Strawberry. In: Konishi K, Iwahori S, Kitagawa H, Yakuwa T, editors. Hortic Jpn, Tokyo: Asakura Publishing Co. Ltd; 1994, pp. 78-81.

[13] Massetani F, Gangatharan R, Neri D. Plant architecture of strawberry in relation to abiotic stress, nutrient application and type of propagation system. Genes Genomes Genomics. 2011;5:12-23.

[14] Neri D, Baruzzi G, Massetani F, Faedi W. Strawberry production in forced and protected culture in Europe as a response to climate change. Can J Plant Sci. 2012;92:1021-36. doi:10.4141/cjps2011-276

[15] Savini G, Neri D, Zucconi F, Sugiyama N. Strawberry growth and flowering. An architectural model. Int J Fruit Sci. 2005;5:29-50.

[16] Fujimoto K. Studies on physiological and ecological characteristics of strawberry "Hoko-wase" and development of new cropping type. Spec Bull Nara Agric Exp Stn. 1972;1:1-151.

[17] Furuya S, Yamashita M, Yamasaki A. Effects of nitrogen content on the flower bud initiation induced by chilling under dark condition in strawberries. Bull Veg Ornam Crops Res Stn Ser D. 1988;1:51-7.

[18] Matsumoto O. Studies on the control of flower initiation and dormancy in the cultivation of strawberry, Fragaria×ananassa Duch. Spec Bull Yamaguchi Agric Exp Stn. 1991;31:1-102.

[19] Yamasaki A, Yoneyama T, Tanaka F, Tanaka K, Nakashima N. Tracer studies on the allocation of carbon and nitrogen during flower induction of strawberry plants as affected by the nitrogen level. Acta Hortic. 2002;567:349-52.

[20] Sønsteby A, Opstad N, Myrheim U, Heide OM. Interaction of short day and timing of nitrogen fertilization on growth and flowering of "Korona" strawberry (Fragaria×ananassa Duch.). Sci Hortic. 2009;123:204-9. doi:10.1016/j.scienta.2009.08.009

[21] Van den Muijzenberg EWB. De invloed van licht en temperatuur op de periodieke ontwikkeling van de aardbei en de beteekenis daarvan voor de teelt - (The influence of light and temperature on the periodic development of the strawberry and its significance in cultivation). Meded Lab Voor Tuinbouwplantent Wagening. 1942;37:1-160.

[22] Anderson HM, Guttridge CG. Strawberry truss morphology and the fate of high-order flower buds. Crop Res. 1982;22:105-22.

[23] Savini G. Schema architetturale e fattori implicati nella differenziazione a fiore della fragola (Fragaria X ananassa Duch.) - (Architectural model and factors implicated in the flower differentiation of strawberry plant). Doctoral dissertation. Università Politecnica delle Marche, 2003.

[24] Savini G, Neri D. Strawberry architectural model. Acta Hortic. 2004;649:169-76.

[25] Jahn OL, Dana MN. Crown and inflorescence development in the strawberry, fragaria ananassa. Am J Bot. 1970;57:605-12.

[26] Bosc J-P, Neri D, Massetani F, Bardet A. Relationship between plant architecture and fruit production of the short-day strawberry cultivar Gariguette. J Berry Res. 2012;2:105-11. doi:10.3233/JBR-2012-031

[27] Desmet EM, Verbraeken LV, Baets W. Optimisation of nitrogen fertilisation prior to and during flowering process on performance of short day strawberry "Elsanta." Acta Hortic. 2009;842:675-8.

[28] Sugiyama N, Iwama T, Inaba Y, Kurokura T, Neri D. Varietal differences in the formation of branch crowns in strawberry [Fragaria ananassa] plants. J Jpn Soc Hortic Sci. 2004;73:216-20.

[29] Kurokura T, Inaba Y, Neri D, Sugiyama N. A morphological study of the development of the second inflorescences in strawberry (Fragaria×ananassa Duch.). Ann Appl Biol. 2005;146:511-5. doi:10.1111/j.1744-7348.2005.040087.x

[30] Guttridge CG. Fragaria×ananassa. In: Halevy AH, editor. Handb. Flower., vol. III, Boca Raton: CRC Press, 1985, pp. 16–33.