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THE EFFECT OF PHOTOPERIOD AND GIBBERELLIC ACID ON STRAWBERRY *F. vesca* var. *semperflorens* (Baron Solemacher cultivar)

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Abstract: This experiment was conducted at the greenhouse facility of the Department of Applied Biology, Faculty of Agriculture, University of Helsinki, Finland, from December, 15th, 2006 till August, 20th, 2007 to determine the effects of day length, short day (SD, 8 hours) or long day (LD, 16 hours) and gibberellic acid treatments (GA_3 0, 1, 5, 25 µg/L) on the vegetative and reproductive growth of the runnerless mutant type of strawberry *F. vesca* var. *semperflorens* (Baron Solemacher, a day-neutral type). The results indicated that all plants developed longer petioles under LD conditions. Under SD conditions, a direct relationship was noted between GA_3 concentration and petiole length. Plants grown under SD conditions developed more side crowns. A direct relationship was found between the number of runners and the increasing GA_3 concentrations with the control treatment producing no runners. LD treatment increased the runner length. Increasing GA_3 concentrations increased the number of daughter plants and the length of internodes. Both SD and higher GA_3 concentrations decreased the total number of inflorescences. SD resulted in a significantly more flowers in the first inflorescence than LD, whereas plants grown under LD conditions flowered earlier. SD increased the fruit number in the first inflorescence while GA_3 decreased their number. Moreover, the SD-treated plants yielded more fruit weight in the first inflorescence than those grown under LD. In conclusion, GA_3 treatment promoted the petiole length, number and length of runners, and the length of internodes, simulating the effect of LD conditions. However, the day length treatment influenced strawberry sensitivity to GA_3 treatment.

Key words: strawberry, photoperiod, gibberellic acid.

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Introduction

Strawberry is considered one of the important crops in Egypt used for exportation, local fresh consumption and food processing. Egypt has by far the largest strawberry industry in Africa. With over 2000 small and large strawberry growers, Egypt represents the 12th country in strawberry production worldwide with a production value and level of US$ 60,090,000 and 104,000 MT, respectively (FAO, 2007).

Strawberry (Fragaria spp.) plants belong to the Rosaceae family and the cultivated strawberry, Fragaria X ananassa Duch., is octoploid (2n=56), while the most widely distributed natural species is the diploid European "Wood strawberry" *Fragaria vesca* L. with ploidy level 2n = 2x =14 (Ibrahim, 1996).

The vegetative and reproductive growth and development of strawberry are highly sensitive to several environmental factors (Braun and Kender, 1985; Battey *et al.*, 1998). Photoperiod is the primary factor controlling the transition from vegetative to reproductive growth in strawberry. Therefore, *Fragaria x ananassa* Duch. cultivars are classified as short-day (SD, Junebearing), day-neutral (DN), or long-day (LD, everbearing) with the latter not currently produced commercially (Durner *et al.*, 1984).

Several authors have studied the effects of photoperiod (Guttridge, 1985; Nicoll and Galletta, 1987; Yanagi and Oda, 1989) or exogenous GA_3 treatment (Porlingis and Boynton, 1961; Tehranifar and Battey, 1997) on the vegetative and reproductive growth of strawberry to report that GA_3 can give similar effects to those caused by LD or chilling. Moreover, GA_3 treatment may act synergistically with long photoperiods and further substitute for SD conditions or missing chilling (Tafazoli and Vince-Prue, 1978).

A key point in strawberry production is the manipulation of the plant growth and development to increase the productivity of the crops. Results of earlier studies explained how environmental (such as photoperiod and temperature) and genetic factors induce and maintain the balance between the vegetative and generative growth of strawberry (Guttridge, 1985; Braun and Kender, 1985; Durner and Poling, 1988; Larson, 1994; Battey *et al.*, 1998). In addition, plant growth regulators, including gibberellins (GA_3), have been recognized as key pieces in the control of several processes in the life cycle of strawberry plants such as controlling of growth and flowering as well as inducing earliness and out of season cropping (Guttridge and Thompson, 1959; Mudge *et al.*, 1981; Guttridge, 1985).

Despite the numerous studies conducted to investigate the effects of photoperiod and growth regulators on different strawberry cultivars, the role of GA_3 and day length on a mutant type of *F. vesca* L. is still not clarified yet. Therefore, the aims of this study were to determine the effects of photoperiod, exogenous GA_3 treatment, and their interaction on the vegetative and reproductive growth of the continuously-flowering, runnerless 'Baron Solemacher' mutant and to determine if the sensitivity to GA_3 changes in different day length treatments.

Materials and Methods

The experiment was conducted at the greenhouse facility of the Department of applied biology, Faculty of Agriculture, University of Helsinki, Finland, in the period from December, 15th, 2006 till August, 20th, 2007.

The mutant type used in this study is the Alpine *F. vesca var. semperflorens* 'Baron Solemacher' which is an octoploid, photo-insensitive, runnerless, and continuously-flowering mutant (Brown and Wareing, 1965; Ahmadi *et al.*, 1990). Seeds were sown on plates (diameter of 5 cm) filled with Sphagnum peat-sand mixture (Karkea ruukutusseos, Kekkilä Oy) on December 15th, 2006, in the University of Helsinki research greenhouse, and grown under 16 h/day (natural light + high pressure sodium 'HPS' lamps).

On January 2nd, 2007, seedlings were transferred into Plantek trays PL 64 (each tray has 64 cells, size 5x5 cm each) filled with the same substrate as earlier, one seedling per cell. In two Vefi trays, 64 seedlings were grown under LD conditions (16 hours/day), while another 64 were grown under SD conditions (8 hours/day).

Plants were illuminated with HPS lamps (Osram NAV-T 400W) providing photon flux density of 120 µmol m^{-2} s^{-1} at plant height plus natural light. In SD treatment, natural light was excluded using dark curtains from 2000 to 0800 hours. Air temperature was set to 18/15° C, and the relative humidity of the air was set to 50 % in both greenhouses. Plants were irrigated with tap water as required and fertigated with complete fertilization solution for strawberries (7-4-27 NPK) with a conductivity of 1mS cm^{-1} (Mansikan täyslannos, Kemira Oy).

On January 15th, when most of the plants had already formed two true leaves, 60 plants of each light treatment were randomly selected and further divided into 4 groups (15 plants for each group were randomly selected). Plants were labeled with color coded plastic labels identifying the light treatment (SD or LD), the plant number (from 1 to 15), and the planned

concentration of GA_3 treatment (0, 1, 5, and 25µg/L).

On January 16th, the youngest true leaf of each plant was treated with the GA_3 solution at the concentration shown on the label (0, 1, 5, or 25µg for GA0-, GA1-, GA5-, or GA25-labelled plants, respectively). GA_3 treatments were prepared using stock dilution of 25 g l^{-1} GA_3 in 100 % ethanol as basis for dilutions in 70% ethanol. Two µl of dilutions containing 0, 1, 5 or 25µg/L GA_3 were dropped with pipette (Finnpipette Digital 0.5-10 µl) on the base of the middle leaflet. The diluted solutions of (BASF Bas 125 10W) with tap water and ethanol and manually dripped at the marked leaves. Plants marked with GA0 were dripped only with 70 % ethanol. Plants were not watered on the same day of GA_3 treatment to avoid the washing effect.

On February 21st, all plants were potted into 6-cm plastic pots (Vefi Pf 308-2), filled with the same substrate, and transferred to the LD greenhouse till the end of the experiment. Every week, all plants were randomly relocated on the bench to avoid any positional effect. On April 16th, plants were transferred into 13 cm-pots containing the same substrate as above for further growth.

Measurements started on February 22nd for vegetative growth included petiole length, number of leaves, number of runners on the same dates as petiole length, length of the internodes (length > 0.5 cm), length of the runners (length > 0.5 cm), number of daughter plants, plant height (length of internodes) and number of branch crowns. The generative growth was assessed by measuring of time to flowering which is the period from the date of forcing (end of SD treatment on February, 21st) till the opening of the first flower starting from March 21st onwards, number of inflorescences, number of flowers in the first inflorescence and in the whole plant, number of ripened fruits in the first inflorescence and in the whole plant, weight of ripened fruits in the first inflorescence and in the whole plant.

Day length and GA_3 -treatment effects were subjected to two-factor analysis of variance (GLM procedure, SAS statistical software package) in randomized complete block design with 15 replications per treatment. Pairwise comparisons of the means were made with Dunken's test using significance level of 0.05 (Steel and Torrie, 1982).

Results

I: Vegetative Growth

A.Petiole length

Increasing GA_3 concentrations increased the petiole length of the treated and first leaves, but did not significantly affect the 3rd leaf. Also, LD conditions developed significantly longer petioles than SD. In addition, plants treated with higher GA_3 concentrations and LD conditions developed the longest petioles (figure 1).

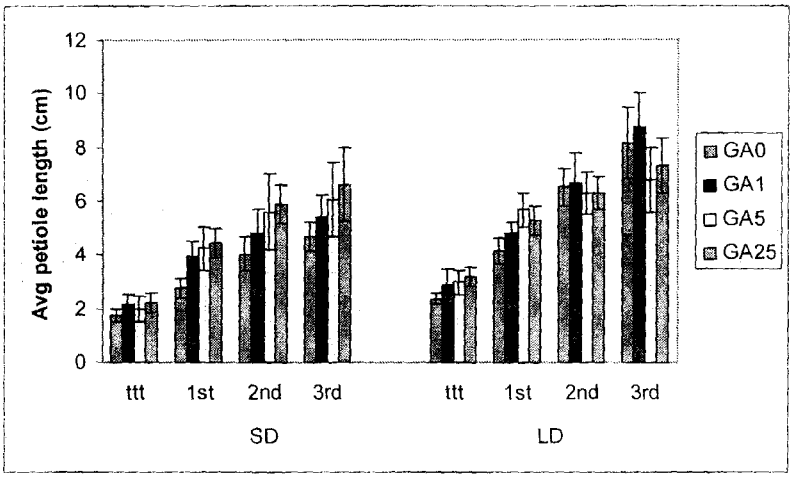


Fig.(1): Effect of different GA_3 concentrations and photoperiod on the length of petioles of GA_3 -treated leaves and first, second, and third developed leaves in plants grown in short day (SD) or long day(LD) conditions (The vertical bars represent the mean ± standard deviation).

B. Number of leaves

Although GA_3 treatment did not affect the number of leaves, it was significantly increased by SD conditions. No significant differences were recorded for the interaction of GA_3 at its different concentrations and the two photoperiods (figure 2).

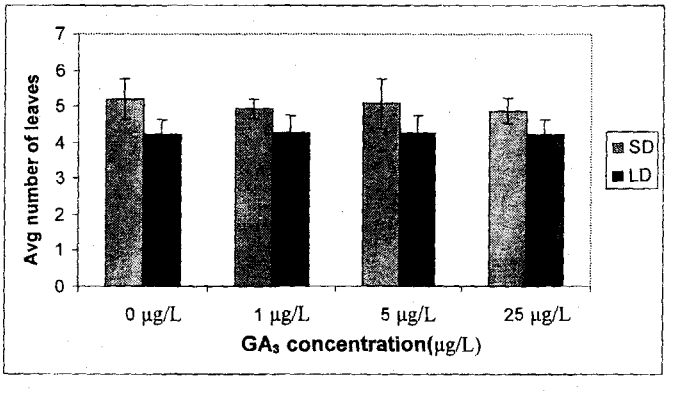


Fig.(2): Effect of GA_3 treatment on the average total number of leaves in plants grown in short day (SD) or long day (LD) conditions (5 weeks after GA_3 treatment). The vertical bars represent the mean ± standard deviation.

C.Number of runners

A direct relationship was noted between GA_3 concentrations and the total number of runners till the 11^{th} week after GA_3 treatment. This effect was approximately the same under both light conditions with the control treatment producing no runners (figures 3, 4).

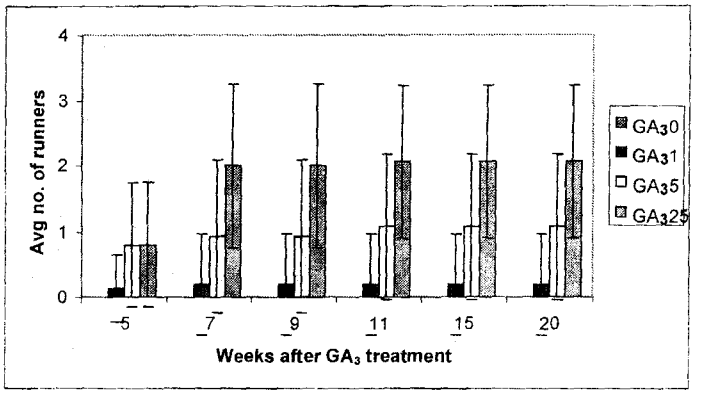
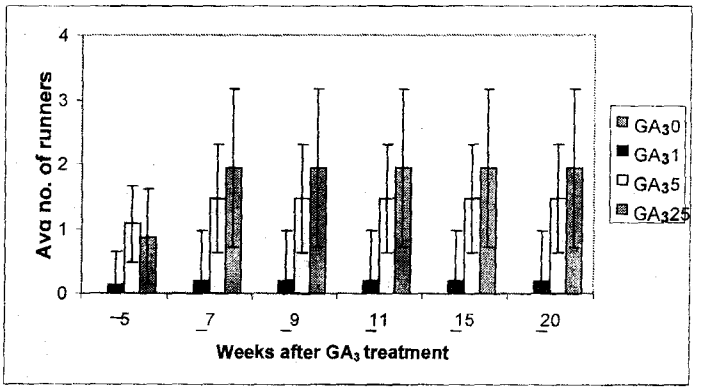


Figure (3): Effect of GA_3 treatment on the average total number of runners in mutant plants grown in short day conditions in time series (weeks after GA_3 treatment). The vertical bars represent the mean ± standard deviation.



Figure(4): Effect of GA_3 treatment on the average total number of runners in mutant plants grown in long day conditions in time series (weeks after GA_3 treatment). The vertical bars represent the mean ± standard deviation.

D. Number of daughter plants

Although the day length showed no effect on the number of daughter plants, increasing GA_3 concentrations increased its number with no significant differences for the interaction of GA_3 treatments and photoperiods (Figure 5).

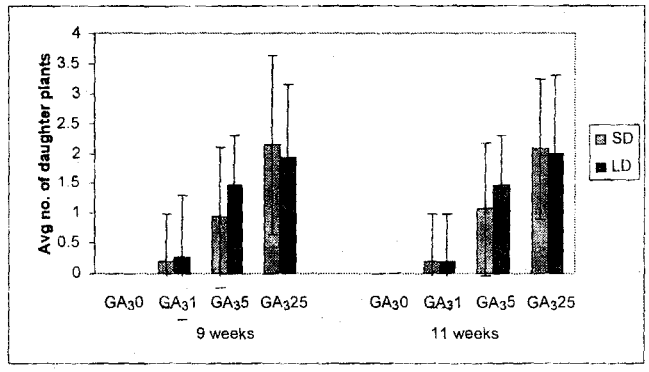


Fig.(5): Effect of GA_3 treatment on the average total number of daughter plants in plants grown in short day or long day conditions (9 and 11 weeks after GA_3 treatment). The vertical bars represent the mean ± standard deviation.

E. Number of side crowns

A reverse relationship was detected between GA_3 concentration and the total number of side crowns 9 weeks after GA_3 treatment; however, this relation was reversed after 24 weeks. The effect of GA_3 on the number of side crowns was more or less the same under both light conditions. On the other hand, SD significantly increased the number of side crowns 9 weeks after GA_3 treatment but this effect was not significant after 24 weeks (figure 6).

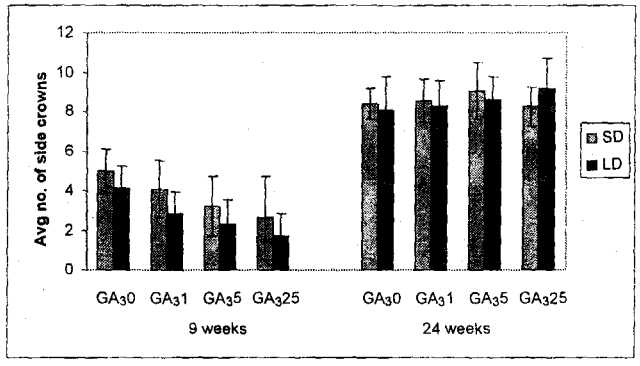
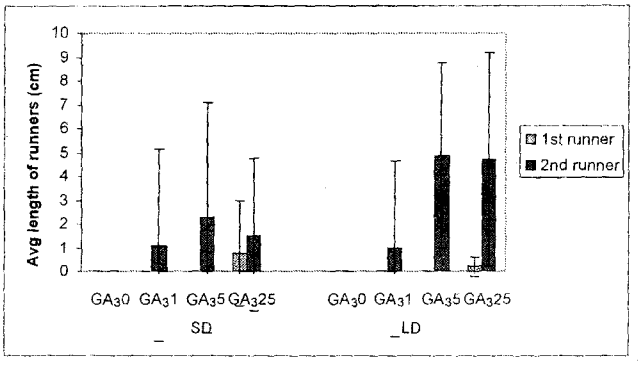


Fig.(6): Effect of GA_3 treatment on the average total number of side crowns plants grown in short day or long day conditions (9 and 24 weeks after GA_3 treatment). The vertical bars represent the mean ± standard deviation.

F. Length and source of runners

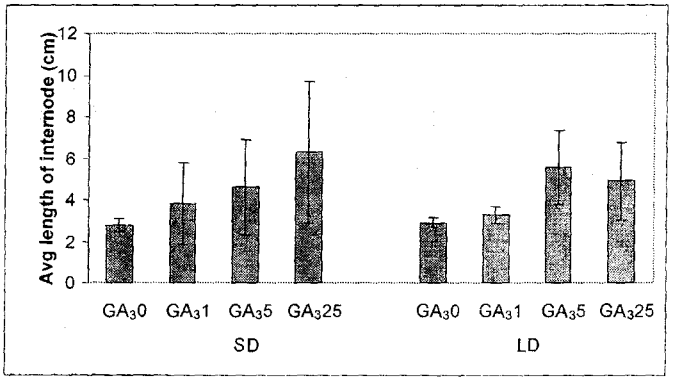
The concentration of 0µg induced no runners while 1 and 5µg developed runners in the 2nd leaf with longer runners at 5µg concentration. Moreover, treatment with 25µg concentration developed runners in the 1st and 2nd leaves. Except for the 1st runner, LD developed significantly longer runners than SD (Figures 7). The 2nd runner treated with 5 or 25µg was longer in plants grown under LD than SD conditions.



Fig(7): Effect of GA_3 treatment on the average length of runners in mutant plants grown in short day or long day conditions (The vertical bars represent the mean ± standard deviation).

G. Length of internodes

Increasing GA_3 concentrations increased the length of internodes especially in plants treated with 5 and 25µg. However, there were no significant differences between 1µg and the control treatments. The day length did not affect the length of internodes. No significant differ-ences were recorded for the interaction of GA_3 and the photoperiod (Figure 8).

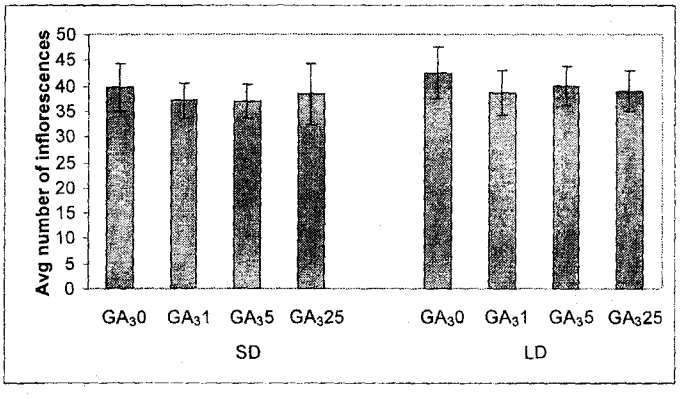


Fig(8): Effect of GA_3 treatment on the average length of internode in mutant plants grown in short day or long day conditions (The vertical bars represent the mean ± standard deviation).

II: Reproductive Growth

A. Total number of inflorescences

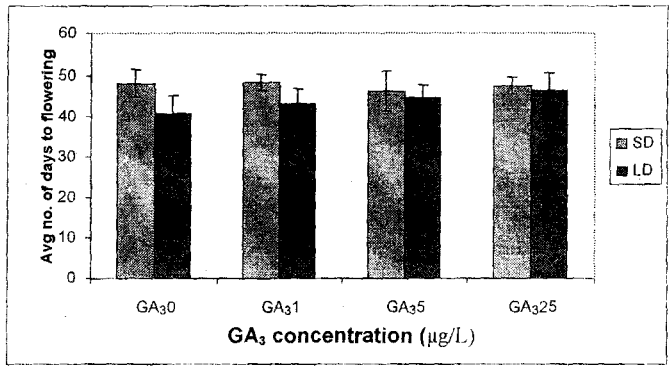
Any GA_3 treatment decreased the number of inflorescences with no clear difference among different concentrations. The lowest number of inflorescences was found when 1µg GA_3 was used and recorded a significant difference compared with the control treatment. The total number of inflorescences was significantly higher in LD than in SD conditions. No significant differences were recorded for the interaction of GA_3 and the photoperiods (Figure 9).



Fig(9): Effect of GA_3 treatment on the average total number of inflorescences in mutant plants grown in short day or long day conditions (The vertical bars represent the mean ± standard deviation).

A.Time to flowering

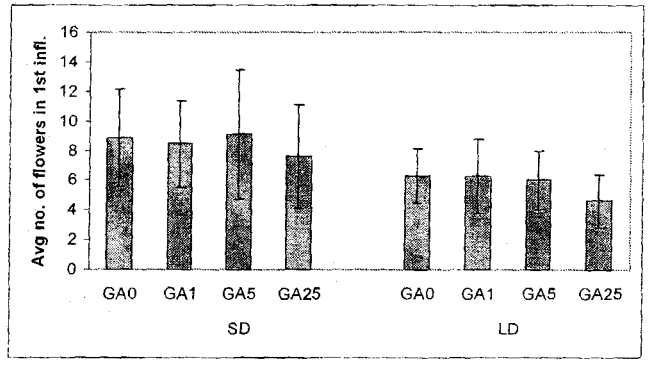
Time to flowering was almost the same in different GA_3 concentrations. Plants grown under LD conditions flowered about 4 days earlier (ranging from 1 to 8 days) than under SD conditions. GA_3 treatment delayed time to flowering under LD conditions but advanced it under SD conditions with the earliest flowers in plants treated with 5µg (Figure 10).



Fig(10): Effect of GA_3 treatment on the average number of days to flowering (from the end of the forcing date) in mutant plants grown in short day or long day conditions (The vertical bars represent the mean ± standard deviation).

B. Number of flowers in the first inflorescence

Increasing GA_3 concentrations did not affect the total number of flowers in the first inflorescence. Plants grown under SD conditions grew significantly more flowers than those grown in LD conditions. Treatment with 5µg concentration resulted in the highest number of flowers under SD conditions (Figures 11).



Fig(11): Effect of GA_3 treatment on the average total number of flowers in the first inflorescence in mutant plants grown in short day or long day conditions (The vertical bars represent the mean ± standard deviation).

D. Total number of fruits in the first inflorescence

The GA_3 treatment decreased the number of fruits in the 1st inflorescence with the least number of fruits in plants treated with 25µg. The SD conditions increased the total fruit number in the 1st inflorescence compared with LD conditions. Except for LD-grown plants treated with 1µg GA_3, the number of fruits in the 1st inflorescence decreased with increasing GA_3 treatment under both photoperiods, (Figure 12).

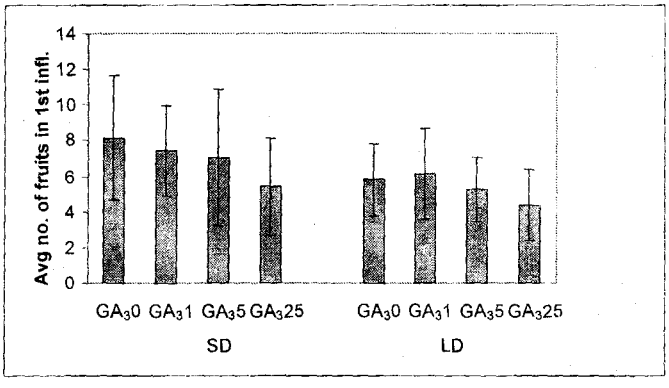


Fig.(12): Effect of GA_3 treatment on the average total number of fruits in the 1st inflorescence in mutant plants grown in short or long day conditions (The vertical bars represent the mean ± standard deviation).

E. Total weight of fruits in the first inflorescence

Plants treated with 1µg GA_3 developed the highest total fruit weight in the 1st inflorescence. On the other hand, higher GA_3 concentrations decreased the weight of such fruits. The SD-treated plants yielded more fruit weight than those grown under LD. Both the control treatment and 1µg GA_3 provided the highest weight of fruits in the 1st inflorescence when grown under SD conditions (Figure 13).

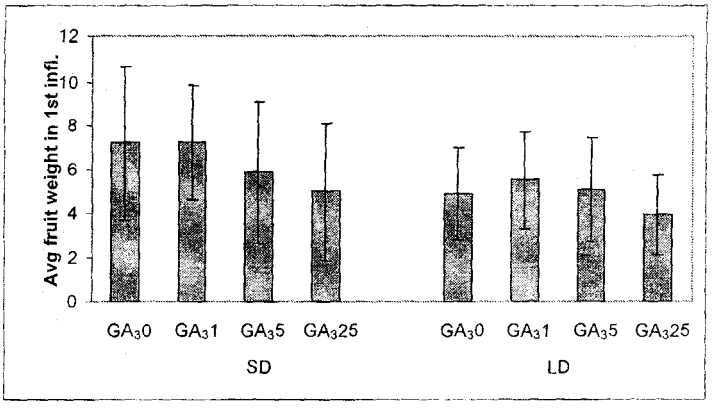


Fig.(13): Effect of GA_3 treatment on the average total fruit weight in the 1st inflorescence in mutant plants grown in short or long day conditions (The vertical bars represent the mean ± standard deviation).

Discussion

In the present study, we assessed the effect of photoperiod and increasing concentrations of GA_3 treatment on the vegetative and floral development. The measurement of the petiole length appears to be one of the best parameters to evaluate the vegetative growth (Guttridge, 1960; Jonker, 1965; Carson, 1988; Risser and Robert, 1993). The present results confirmed that petiole length was significantly increased with LD treatments. These result are in agreement with those reported by Guttridge, (1969a); Sung (1973); Wiseman and Turnbull, (1999); Manakasem and Goodwin, (2001); Sønsteby and Heide, (2006).

Similarly, increasing GA_3 concentrations increased the petiole length of the treated and the first leaves regardless the day length treatment. This result is supported by the earlier reports of Agafonov and Solovei, (1974a), Dwivedi *et al.* (1999) and Paroussi *et al.* (2002). Other authors have suggested that effect of GA_3 treatment on petiole elongation simulates that of long photoperiod or chilling (Thompson and Guttridge, 1959; Porlingis and Boynton, 1961; Guttridge and Thompson, 1964). The observation that the 3rd leaf was not evidently affected by GA_3 treatments may be explained as the direct effect of GA_3 application at the beginning of the experiment is probably lost by the time the 3rd leaf has developed.

Concerning the interaction of GA_3 and day length treatments, the results of this study showed that the effect of increasing GA_3 concentration on the petiole length was more pronounced in LD than in SD

conditions. Similarly, Paroussi *et al.*, (2002), found that petiole length was significantly increased by increasing GA_3 concentrations (0, 50, 200mg) and the combined action of GA_3-photoperiod interaction (10h and 16h). The greater response to GA_3 on plants grown under LD than under SD conditions may be explained by the regulating effect of the day length on the synthesis of a wide range of gibberellins (Taylor *et al.*, 1994) and thus affecting the kind and degree of response to GA_3 treatment.

As regard to runner formation, the present study demonstrated that GA_3 treatment of the runnerless mutant plants led to runner formation with a direct relationship between the GA_3 concentration and the number of runners. For instance, treatment with 0µg GA_3 produced no runners, while 1 and 5µg developed runners in the 2nd leaf (producing longer runners with 5µg concentration), but treatment with 25µg developed runners in the 1st and 2nd leaves. Similar results were reported on two mutants of diploid *F. vesca* which did not produce runners except after GA_3 treatment (Fadeeva and Irkaeva in 1974 and Fadeeva *et al.*, 1979). Other reports have shown that GA_3 treatment also increased runner production in poor runner producing cultivars (Caso and Radice, 1982; Turemis and Kaska, 1997). In addition, our results have demonstrated that plants developed more runners with increasing GA_3 concentrations. Similar results were reported by Verzilov and Mikhteleva, 1974a; Danek, 1984; Braun and Kender 1985; Ra-Sang *et al.* 1996; and Turemis and Kaska, 1997, Dwivedi *et al.*, 1999).

This effect of GA_3 treatment on promoting runner formation has been explained in earlier studies as GA_3 enhances the differentiation of the axillary buds to runners (Thompson and Guttridge, 1959; Guttridge and Thompson, 1964; Lee, 1971; Tafazoli and Vince-Prue, 1978; Pankov, 1992; and Paroussi et al., 2002). Other studies have illustrated that if GA_3 treatment occurs under LD conditions, more axillary buds develop into stolons than under SD conditions (Porlingis and Boynton, 1961). Therefore, higher concentrations of GA_3 are needed to accomplish a significant stimulation of stolon formation during SD conditions (Blatt and Crouse, 1970; Tafazoli and Vince-Prue, 1978). This explanation may elucidate the reason for the lower numbers of runners developed with GA_3–treated plants grown under SD than under LD conditions in the present study.

Regarding the length of runners, Soetarto (1979) and Dwivedi *et al.*, (1999) demonstrated greater runner length at higher GA_3 concentrations. However, Waithaka *et al.* (1980) reported that the length

of stolons was not consistent with increasing GA_3 concentrations.

The current study showed that SD conditions significantly increased the number of side crowns. In agreement with this result, Konsin and associates, (2001) and Sonsteby *et al.*, (2006) concluded that shorter photoperiods increased the number of branch crowns after subjecting strawberry "Korona" plants to short (12 h) photoperiods. Similarly, Kurokura *et al.*, (2005) showed that SD (10 h) conditions stimulated the formation of branch crowns than LD (13h) conditions.

As regard to the effect of GA_3 treatment on the number of branch crowns, the results of the present study showed that GA_3 treatment decreased the number of branch crowns under both photoperiods. In disagreement to this result, Singh and associates, 1960, reported that GA_3 increased the number of side branches on stolon. Another report by Elizalde and Guitman (1979) stated that GA_3 treatment of strawberries cultivar 'Rabunda' had no significant effect lateral branching.

The results of the present research demonstrated that increasing GA_3 concentrations (especially 5 and 25µg concentrations) increased the length of internodes. On the other hand, the day length had no effect on the length of internodes. In accordance to these results, earlier reports have concluded that exogenous GA_3 promotes elongation of the main axes of the plants, destroying the rosette habit whereas this response is not found in LD (Thompson and Guttridge, 1959; Porlingis and Boynton, 1961; Guttridge and Thompson, 1964; Guttridge, 1969b; Agafonov and Solovei, 1974b; Dale and associates, 1996).

The present study showed a direct relationship between GA_3 concentrations and number of daughter plants. These results are in agreement with those of other reports by Franciosi *et al.*, (1980) and Choma and Himelrick, (1984).

The results of the present work showed that GA_3 treatment decreased the total number of inflorescences; however, no clear differences were noticed among the different GA_3 concentrations. In contrast to this observation, Verzilov and Mikhteleva, (1975), reported that GA_3 treatment increased the number of inflorescences in 'Zagor'e Beauty' and 'Komsomolka' cultivars. On the other hand, Pipattanawong and associates (1996) reported that the number of inflorescences in three day-neutral strawberry cultivars (Summer Berry, Miyoshi and Enrai) was not affected by 50 ppm GA_3 treatment.

In addition, the current study has also shown that LD conditions increased the total number of inflorescences. The promoting effect of LD on inflorescences production was suggested by Nishiyama *et al.*, (2003), who

found that inflorescences ceased under SD treatments (8, 10, 12 h) in 'Summerberry' plants, while increased under LD (20 and 24 h). Similar effects of LD in Fragaria ananassa have been reported by Konsin and associates, (2001). This result has been explained in previous studies as exposure to LD after completion of floral initiation can induce earlier truss emergence than continuous exposure to SD (Moore and Hough, 1962; Sironval, 1960; Jonkers, 1965).

As shown in the present experiment, GA_3 treatment did not affect the number of flowers in the first inflorescence while decreased the total number of flowers in the whole plant. In agreement with this result, Rudolph (1987) reported that treating mother plants with GA_3 reduced the number of flowers to 12-23% of the untreated controls. Similar results have been reported in an earlier study by Tafazoli and Vince-Prue, 1978, while Kalie *et al.*, 1980 concluded that GA_3 treatment did not affect flowering.

Moreover, the present study showed that although SD conditions resulted in a significantly more flowers in the first inflorescence, LD conditions significantly increased the total number of flowers in the whole plant. In agreement to this observation, Nishiyama and associates, (1998), reported that flowering was inhibited by SD (8 h) in everbearing strawberry (Summerberry cultivar) plants, while LD (24 h) increased the number of flowers, as the production rate of axillary flowers was increased by LD. Similarly, LD significantly increased the total number of flowers in 'Korona' and 'Elsanta' plants (Sonsteby and Heide, 2006).

The results of this experiment showed that GA_3 treatment decreased the number of fruits in the 1st inflorescence and in the whole plant. Similar results have been reported by other authors (Celestre and Pierandrei, 1972; Agafonov *et al.*, 1978). However, Castro *et al.*, 1976, reported that increasing GA_3 concentrations had no effect on the number of fruits but reduced fruit weight. On the other hand, our results showed that photoperiod did not affect the total fruit number in the whole plant while SD conditions increased the fruit number in the 1st inflorescence. In a study by Sonsteby *et al.*, 2006, SD treatment (12 h) of Junebearing cultivar 'Korona' produced more fruits than control plants. Similarly, SD treatments (11 h) increased fruit numbers in cultivar Sparkle (Austin, 1991).

Thompson and Guttridge, 1960, provided the evidence to support the hypothesis that vegetative growth-promoting/flower-inhibiting substances, possibly acting in the same way as gibberellins, was produced primarily under long days (more than 15h). They found that

leaves of any age could inhibit floral initiation and that the presence of young leaves reduced the inhibitory effect of mature leaves, possibly due to the young leaves acting as sinks, thus diverting both assimilates and the inhibitor from the meristem. In this experiment, flowering may have been delayed because of a strong flower inhibition signal produced in the leaves during long day, due to a larger canopy area in the oldest plants.

As shown by the present research, treatment with 1µg GA_3 developed the highest total fruit weight in the 1st inflorescence and in the whole plant. However, higher GA_3 concentrations decreased the fruit weight in the 1st inflorescence or in the whole plant. Similar results have been reported by Tavadze and Mazanashvili (1972) and Harmail-Singh and Ranjit-Singh (1979). However, Pankov, 1992, reported that GA_3 treatment of 'Senga Sengana' and 'Yasna' cultivars had no effect on fruit yield. On the contrary, Chang and Park (1977) showed that treatment with 40 or 60 ppm GA increased fruit yields in 'Hokowase' and 'Armore' cultivars. Also, Montero *et al.* (1998) reported that treating cultivar 'Chandler' plants with GA_3 (30 or 60 µg/L) improved weight, size and color of fruits. Similarly, Sharma and Ranjit (1990) reported that treatments with GA applied at 10, 75, 100 or 150 ppm presented significantly higher yields of cultivar 'Pusa Early Dwarf' than the untreated controls. Furthermore, results of the present study have shown that although SD treatment yielded more fruit weight in the 1st inflorescence, LD condition resulted in greater total fruit weight. Similar observation was documented by Yoshida *et al.* (1991) who reported that LD (16 h) increases fruit weight of the strawberry cultivar 'Ai-berry' compared with SD conditions (8 h).

As exogenous GA_3 treatment has been shown to promote stolon formation instead of branch crowns, increase petiole length, inhibit flower initiation, and advance flowering, many authors have suggested that applications of GA_3 causes effect similar to those induced by LD in a range of growth and flowering responses (Thompson and Guttridge, 1959; Guttridge, 1969b). Therefore, it would seem that GA_3 can serve as a substitute for a growth promoting hormone produced naturally under LD conditions. However, GA_3-treated plants may present with responses not found in LD such as elongation of the main axes of the plant and so destroys the rosette habit (Guttridge and Thompson, 1964; Guttridge, 1969a). In addition, complete suppression of flower initiation and the highest level of runner production were not reached until GA_3 level caused abnormal elongation of the main stems. These facts would suggest that LD growth promoting hormone and GA_3 are not identical, although they may be closely related

(Thompson and Guttridge, 1959). Consequently, the involvement of gibberellin in the endogenous LD stimulus for vegetative growth in strawberry is not clearly established, nevertheless, it was suggested that a non-gibberellin component is involved in the plant endogenous system because exogenous GA_3 can only partly replace the LD stimulus (Guttridge, 1970). In addition, Kender *et al.*, 1971, reported that plants in a vegetative stage are more responsive to exogenous GA_3 in terms of number of runners than plants in a flowering stage. The effect of GA_3 on stolon production is cultivar related with some cultivars being less sensitive than others. This may be related to stolon formation potential.

In conclusion, GA_3 treatment led to development of runners in a runnerless mutant, in addition to its promoting effect on the petiole length, number and length of runners and the length of internodes. In contrast, it suppressed the number of side crowns and number of inflorescences. However, the number of leaves and the time to flowering did not seem to be affected by GA_3 treatment. In addition, LD conditions enhanced the length of petioles and runners, number of inflorescences, and accelerated the time to flowering, while SD increased the number of side crowns. However, the day length did not appear to affect the length of internodes or total fruit number.

Moreover, LD potentiated the effect of GA_3 treatment in a number of features including the number of side crowns, and length of runners. Likewise, SD also facilitated GA_3 action by advancing the time to flowering. In contrast, GA_3 appeared to act independent of the day length regarding the number of leaves, daughter plants, inflorescences, and flowers and the length of internodes.

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تأثير كلاً من الفترة الضوئية و حمض الجبريليك على صنف الفراولة بارون

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تم إجراء هذه التجربة في الصوب الزجاجية بمزرعة قسم الأحياء التطبيقية بكلية الزراعة ، جامعة هلسنكي، فنلندا في الفترة من١٥ ديسمبر٢٠٠٦ حتي ٢٠ اغسطس٢٠٠٧وذلك لدراسة تاثيرالفترة الضوئية (نهار قصير، ٨ ساعات و نهار طويل، ١٦ساعة) والمعاملة بالجبريلين بتركيزات (صفر ،١،٥ ، ٢٥ميكروجرام/لتر) على النموالخضرى والزهرى والثمرى في صنف الفراوله بارون المحايد بالنسبة لطول الفترة الضوئية عديم المدادات والناتج من طفرة نباتية. وقد أشارت النتائج الى زيادة طول عنق الورقة في كل النباتات تحت ظروف النهار الطويل. كما تناسبت المعاملة بالجبرلين تناسبا طرديا مع طول عنق الورقة تحت ظروف النهار القصير.كذلك زادت عدد التيجان الجانبية (الفسائل) فى النباتات النامية تحت ظروف النهار القصير. كما تناسب العدد الكلي للمدادات طرديا مع تركيز الجبرلين علما بأن التركيز صفر(معاملة الكنترول) لم يعط أي مدادات. كما أدت معاملة النهار الطويل إلى زيادة طول المدادات، كما أدت زيادة تركيز الجبرلين إلى زيادة عدد الخلفات (الناتجة من المدادات) وزيادة طول السلاميات على التاج الرئيسى. كما لوحظ أن التركيزات العالية من الجبرلين وكذلك النهار القصير أديا إلى قلة عدد النورات كما زاد العدد الكلي للازهارفى النورة الأولى فى النباتات النامية تحت ظروف النهار القصير عن تلك النامية تحت ظروف النهار الطويل مع ملاحظة ان النهار الطويل ادى لتبكير الإزهار.

أدت المعاملة بالنهار القصيرإلى زيادة العدد الكلي للثمار فى النورة الأولى بينما أدت المعاملة بالجبرلين لنقص عدد الثمار. كذلك أدت المعاملة بالنهار القصير إلى زيادة وزن الثمار فى النورة الأولى عن تلك النامية تحت ظروف النهارالطويل وتلخيص لما سبق فانه يمكن القول بأن المعاملة بالجبريلين أدت الى زيادة طول عنق الورقة و عدد و طول المدادات وطول السلاميات على التاج الرئيسى، ولكن طول النهار قد يوعثر على حساسية نبات الفراولة للمعاملة بالجبريلين.