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Impact of benzyladenine and gibberellic acid on quality and economics of runner production in Chandler strawberry (*Fragaria* × *ananassa*) under subtropical climate

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ABSTRACT

An experiment was conducted to study the impact of plant bioregulators on quality and economics of runner production in Chandler strawberry (*Fragaria* × *ananassa* Duch.) cultivar under subtropical climatic conditions. The experiment was carried out in a randomized block design with 16 treatments and each treatment replicated thrice. The results revealed that the application of plant growth regulators enhanced the runner production in strawberry. Among all the treatments, the treatment GA_3 100 ppm recorded maximum plant height per runner (10.88 cm), petiole length (10.70 cm) and root length (5.90 cm). The treatment of GA_3 at 300 ppm + BA at 150 ppm was found superior than other treatments for producing maximum runners/mother plant (13.53), number of train/mother plant (4.10), number of runner/train (3.30), plant spread/runner (10.83cm), and number of leaves/runner plants (7.29). This treatment also gave highest cost benefit ratio (1:2.85) as compared to other treatments. However, control plants recorded maximum crown diameter (6.92 mm), crown weight (0.66 g) and leaf area (16.57).

Key words: Daughter plant, Plant growth regulators, Regeneration, Strawberry

Strawberry (*Fragaria* × *ananassa* Duch.) is an herbaceous perennial plant having compressed, shortened stem and produces runners. The fruit is an achene attached to a juicy, enlarged receptacle. The cultivated strawberry is a hybrid plant crossed between two species, *Fragaria chiloensis* and *Fragaria virginiana*. Strawberry is propagated commercially mostly by runners. Although runner formation is cultivar related, vegetative characteristics, such as leaf number, crown weight, crown diameter, leaf area, number of runner and number of plantlets (daughter plants) is affected be growth regulators.

Gibberellin sprayed on leaves can be absorbed by plants and transferred to auxillary buds. This transfer is more prominent in long photoperiods than short days. Some cultivars are more sensitive to the application of GA than others. Gibberellic acid (GA_3) is a growth regulator which stimulate the effect of long day lengths in short day plants by improving vegetative development and increasing runner production. Gibberellic acid progressively increased the plant height, canopy spread, leaf area, number of leaves, petiole length and induces stem elongation when applied exogenously to strawberry plants (Kasim *et al.* 2007, Paroussi *et al.* 2002, Sharma and Singh 2009). Application of cytokinin increased runner formation when it was used in long days and moderate temperatures between 15°C at night and 30°C in day. Cytokinin have found to increase runner formation when it was used in long days and moderate temperatures between 15°C at night and 30°C in day (Sharma 2002). Application of GA, BA and their combination increases plantlet production. Application of GA, BA and a combination of them decreased crown diameter and weight. This decrease was more pronounced as the concentration of hormones increased. A study on the effect of GA and BA on runner formation in Duch cultivar showed that spraying hormones produced highest number of runners (Dale *et al*. 1996). It also enhanced the number of runners in all strawberry varieties by specifically stimulating the stolon forming systems during long days. It is also responsible for increasing the number of runners per crown at higher rates of application (Hytonen *et al.* 2009). Runner formation increased linearly with increasing BA concentration up to 1800 ppm and is effective in increasing plantlet production than GA, however, application of GA, BA and their combination decreases crown diameter and weight. This decrease was more pronounced as the concentration of hormones increases (Dale *et al*. 1996). The strawberry growers of the warmer plains are entirely dependent on hilly areas for their planting material requirements, which make its cultivation in plains less remunerative. The runners, which are received from hilly areas have very limited growth due to short growing season as compared to plains and thus give

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ultimate weak runners with poor yield. Keeping in view the above mentioned problems the present experiment was carried out to ascertain the treatment, which can increase its runner production and provide opportunity to the farming community to grow it commercially.

MATERIALS AND METHODS

The present investigation was carried out at the Research Farm, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Udheywalla, Jammu during the year 2012-2013. Udheywalla is situated in the sub-tropical zone at 32.73° N and longitude of 74.87° E at an elevation of 327 m from the mean sea level with annual precipitation of about 1200 mm (About 70 percent rains are received during July to October). The mean annual maximum and minimum temperature are 29.60°C and 16.70°C, respectively. Summer months are hot with temperature and humidity ranging from 23.50°C to 35.50°C and 53.0 per cent to 73.50 per cent, respectively. The experiment was laid out in Randomized Block Design and were replicated thrice with 16 treatments such as: T_1 (GA_3 100 ppm), T_2 (GA_3 200 ppm), T_3 (GA_3 300 ppm), T_4 (BA 50 ppm), T_5 (BA 100 ppm), T_6 (BA 150 ppm), T_7 (GA_3 100 ppm + 50 ppm), T_8 (GA_3 100 ppm + BA 100 ppm), T_9(GA_3 100 ppm + BA 150 ppm), T_{10} (GA_3 200 ppm + BA 50 ppm), T_{11} (GA_3 200 ppm + BA 100 ppm), T_{12} (GA_3 200 ppm + BA 150 ppm), T_{13} (GA_3 300 ppm + BA 50 ppm), T_{14} (GA_3 300 ppm + BA 100 ppm), T_{15} (GA_3 300 ppm + BA 150 ppm) and T_{16} (No. application of PGRs). The runners of almost equal size and vigour were transplanted during evening hours at a spacing of 45cm × 30cm and size of plots is 1.2 × 1.4 m. The irrigation was done for seven continuous days with watering cane and gap filling was continued for one week after transplanting of runners. The treatments were given 150 days after transplanting. The stock solution of gibberellic acid, benzyl adenine and their combination was prepared by dissolving the weighed quantity of these chemicals in weak alcohol. Subsequently, the stock solutions of these chemicals are diluted with distilled water to prepare the required concentration and volume. The aqueous solutions were sprayed on the plants till the solution began to run off. To avoid mixing of these chemicals, spraying was performed carefully by covering the adjacent beds with polythene sheets. The height of three representative plants was recorded with a scale from vertical distance to the highest point of the tallest leaf to the ground level without stretching out and average was calculated. The total number of leaves of three randomly selected plants were counted and divided by the number of plants and average was calculated. The petiole length of five leaves selected at random from each of the marked plants was measured from the base of the conjunction of the lamina. The spread of three randomly selected plants were measured from north to south and east to west and expressed as a mean of the two measurements. Leaf area of five leaves of three randomly selected plants was recorded at the end of growing season and the mean was worked out. The root length of three randomly selected runner plants were measured with the help of scale and the mean was worked out. The data on number of runners/ mother plant and number of trains/mother plant were recorded by counting the total number of runners per train and number of trains per mother plant of three randomly selected mother plants and divided by number total number of selected mother plants. Total number of runners of three randomly selected mother plants were counted and divided by the total number of train at the end of growing season and the mean was worked out. The crown diameter of three randomly selected runner plants were measured with digital vernier caliper and the mean was calculated. All the observations were subjected to statistical analysis. The entire data generated from the present investigation were analyzed statistically as per the method suggested by Panse and Sukhatme (1984). Economics of different treatment combinations was calculated as per the existing market prices, the input and output cost were computed treatment wise and different economic parameters, viz net profit cost ratio were calculated. The cost of cultivation for each treatment was calculated separately taking into consideration all the cultural practices followed in the cultivation. The gross return from each treatment was calculated after deducting the crop loss at 10 %. The net profit from each treatment was calculated separately by subtracting cost of cultivation from gross return. The benefit cost ratio for each treatment was calculated by dividing the gross return with cost of cultivation.

RESULTS AND DISCUSSION

There were significant differences among the treatments of gibberellic acid, benzyladenine and their combination on vegetative growth, fruit quality and economics of runner production in Chandler strawberry grown under subtropical climate. The Table 1 revealed that the application of gibberellins and benzyladenine significantly influenced the plant height, plant spread, number of leaves, petiole length, root length, crown diameter, crown weight, number of runners, number of trains number of runner and number of runners per train. Maximum plant height (11.88 cm) and root length (6.90 cm) were obtained with the application of GA_3 100 ppm as compared to other treatments. This increase in plant height and root length of strawberry might be due to fact that gibberellins regulate the growth of strawberry plants by causing cell elongation in plant system. These results are in conformity with Qureshi *et al.* (2013). These results were also in close agreement with Paroussi *et al*. (2002), Asrey *et al*. (2003), and Kumar *et al*. (2012) who reported stimulation of plant growth in strawberry with gibberellic acid application. Gibberellic acid application to one year old plants promotes vegetative growth due to inhibition of flowering and corresponding increase in epidermal and parenchymatous cell length. Maximum number of leaf per runner plant (7.29) were obtained in plants treated with GA_3 (300 ppm) and (BA 150 ppm). The treated plants had less leaf area than the control. The maximum leaf area/runner

Table 1 Impact of benzyladenine, gibberellic acid and their combinations on vegetative growth of strawberry runner under subtropical climate

Treatment	Plant height (cm)	No. of leaves	Petiole length (cm)	Plant spread (cm)	Root length (cm)	Leaf area (cm^2)	No. of runner/ mother plant	No. of train/ mother plant	No. of runner/ train	Crown diameter (mm)
T_1	11.88	5.23	11.20	8.13	6.90	12.10	9.08	3.11	2.92	5.49
T_2	10.71	4.55	10.46	7.19	5.87	11.97	8.60	3.15	2.73	5.31
T_3	10.55	4.20	10.17	7.19	5.34	11.69	8.07	3.11	2.60	5.15
T_4	8.88	4.97	7.07	7.49	4.55	13.00	4.28	2.11	2.03	5.69
T_5	9.73	5.07	7.32	7.51	4.82	13.53	4.76	2.30	2.07	5.67
T_6	9.38	5.26	7.49	7.63	4.62	13.56	4.89	2.33	2.10	5.64
T_7	8.83	5.41	8.41	7.70	4.09	13.68	9.95	3.20	3.11	5.9
T_8	10.44	5.48	8.28	7.96	5.28	14.05	10.21	3.22	3.17	5.97
T_9	9.66	5.59	8.57	8.74	4.65	14.43	10.49	3.28	3.20	6.04
T_{10}	9.95	5.84	9.16	7.95	5.00	13.81	10.26	3.36	3.15	6.25
T_{11}	9.41	6.14	9.54	7.96	4.64	14.32	10.72	3.33	3.22	6.23
T_{12}	9.20	5.94	7.45	8.96	5.07	15.05	10.85	3.36	3.23	6.15
T_{13}	9.90	6.09	9.99	8.14	4.83	13.92	11.01	3.38	3.26	6.38
T_{14}	10.00	6.22	7.43	9.38	5.17	15.30	11.15	3.40	3.28	6.31
T_{15}	10.20	7.29	7.24	10.83	5.27	15.34	13.53	4.10	3.30	6.30
T_{16}	8.24	3.28	7.01	6.96	4.05	16.57	3.29	1.96	1.67	6.92
CD (0.05)	1.21	1.17	2.40	1.50	0.91	1.52	1.35	0.57	0.12	0.36

plant (16.57 cm^2) was recorded under control (T_{16}). In this study higher concentration of GA and BA increased the leaf number but decreased leaf area, therefore hormone treated plants had smaller leaves and these treatments decreased vegetative growth in favour of runner production. Taghavi *et al*. (2011) and Braun and Kender (1985) reported that exogenous cytokinins promoted branch crown formation in some strawberry cultivars. The later effect suggests that the cytokinin treatment may increase the number of leaves/plant. Maximum plant spread/runner plant (10.83 cm) was obtained with the application of GA_3 300 ppm + BA 150 ppm. The maximum increase in plant spread of strawberry cv. Chandler in these treatments might be due to fact that gibberellins regulate the growth of strawberry plants by causing cell elongation in plant system. Petiole length/runner plant (11.20 cm) was found highest with the application of GA_3 (100 ppm). This could be due to the fact that gibberellins increased cell division, cell elongation and a corresponding increase in epidermal and parenchyma's cell length. These findings are in conformity with those of Lolaei *et al.* (2013) and Kumar *et al*. (2012).

Data in Table 1 also depicts that maximum number of runner/mother plant (13.53), number of train/mother plant (4.10) and number of runners/train (3.10) were obtained with the application of GA_3 300 ppm + BA 150 ppm respectively, as compared to other treatments. The maximum increase in number of runners/mother plant, number of train/mother plant and number of runners/train of strawberry might be due to the synergistic combination of GA_3 and BA consistently enhanced the runner production in day neutral strawberries. Growth regulators can induce runners to form either by stimulating dormant buds to grow or by preventing flower bud initiation. GA_3 has been reported to promote runner production and inhibit flower formation in strawberry plants. These results are in accordance with the results of Eshghi *et al.* (2012) and Taghavi *et al.* (2011). The maximum crown diameter (6.92) and crown weight (0.66 g) per runner plant were observed under treatment T_{16} (Control), i.e. distilled water spray. The maximum increase in crown diameter and crown weight of strawberry cv. Chandler might be due to fact that the nutrients that are produced in vegetative growth are stored in crown. Its diameter has influential effect on yield, so the larger the diameter the stronger and more fruitful the plant. Since hormonal treatments increased number of plantlets, they had less crown diameter and crown weight than control plants. Average crown diameter and crown weight were decreased significantly by hormonal treatments. This has been reported by Dale *et al*. (1996).

The data presented in Table 2 showed that there was significant difference between the treatments of gibberellic acid and benzyladenine on cost-benefit ratio for runner production in strawberry cv. Chandler. The maximum net returns and cost-benefit ratio (1:2.85) were obtained with GA_3 300 ppm + BA 150 ppm, i.e. in treatment T_{15}, followed by treatment T_1 GA_3 100 ppm (1:2.76), however, the treatment T_{16} (control) showed least cost-benefit ratio (1:1.11). These differences might be due to the difference in their yield levels and cost of production. These findings are in conformity with Kumar *et al*. (2012), who reported

Table 2 Economics of different treatments of benzyladenine, gibberellic acid and their combinations on runner production/ha in strawberry

Treatment	Common expenditure	Treatment cost (₹)	Total input cost	Runners/ha	Average sale rate (₹/runner)	Gross income (₹)	Net return	Cost benefit ratio
T_1	360910.00	39782.50	400692.50	553880.00	2.0	1107760.00	707067.5	1:2.76
T_2	360910.00	78365.00	439275.00	524600.00	2.0	1049200.00	609925.00	1:2.38
T_3	360910.00	116947.00	507857.00	492270.00	2.0	984540.00	476683.00	1:1.93
T_4	360910.00	24685.00	415595.00	261080.00	2.0	522160.00	106565.00	1:1.25
T_5	360910.00	48170.00	439080.00	290360.00	2.0	580720.00	141640.00	1:1.32
T_6	360910.00	71655.00	462565.00	298290.00	2.0	596580.00	134015.00	1:1.28
T_7	360910.00	63267.50	454177.00	606950.00	2.0	1213900.00	759723.00	1:2.67
T_8	360910.00	86752.50	477662.50	622810.00	2.0	1245620.00	767957.50	1:2.60
T_9	360910.00	110237.50	501147.00	639890.00	2.0	1279780.00	778633.00	1:2.55
T_{10}	360910.00	101850.00	492760.00	625860.00	2.0	1251720.00	758960.00	1:2.54
T_{11}	360910.00	125335.00	516245.00	653920.00	2.0	1307840.00	791595.00	1:2.53
T_{12}	360910.00	148820.00	539730.00	661850.00	2.0	1323700.00	783970.00	1:2.45
T_{13}	360910.00	140432.50	531342.50	671610.00	2.0	1343220.00	811877.00	1:2.52
T_{14}	360910.00	163917.50	554827.50	680150.00	2.0	1360300.00	805472.50	1:2.45
T_{15}	360910.00	187402.50	578312.50	825330.00	2.0	1650660.00	1072347.50	1:2.85
T_{16}	No PGRs		360910.00	200690.00	2.0	401380.00	40470.00	1:1.11

that plant growth regulators treatments in strawberry plants gave maximum cost-benefit ratio as compared to control. In conclusion,, the present study showed that under subtropical climate the treatment GA3 300 ppm + BA 150 ppm) was found superior in runner production and this treatment gave highest cost benefit ratio (1:2:85) as compared to other treatments.

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