Effect of Plant Growth Regulator on Growth, Yield, Quality and Economic of Summer Squash (*Cucurbita pepo* L. Var. Pattypan) in Mid Hills of Uttarakhand

Comment [P1]: economics

ABSTRACT

Field study on the Effect of Plant Growth Regulator on Growth and Yield of Summer Squash (*Cucurbita pepo* L. Var. Pattypan) was conducted during 2017 (summer season). Ten treatments of plant growth regulator consist of **T_1** Control; **T_2**Ethrel 150 ppm; **T_3**Ethrel 200 ppm; **T_4**Ethrel @ 250 ppm; **T_5**Gibberellic acid (GA3) @ 25 ppm; **T_6**Gibberellic acid (GA3) @ 50ppm; **T_7**Gibberellic acid (GA3) @ 75 ppm; **T_8** Naphthalene acetic acid (NAA) @ 50 ppm; **T_9**Naphthalene acetic acid (NAA) @ 100 ppm; **T_{10}** Naphthalene acetic acid (NAA) @ 150 ppm were tried in Randomized Complete Block Design having three replication. Results revealed that the maximum number of male flowers per plant (13.63) was found under T_5 that was closely followed by T_4, T_7, T_3 and the lowest number of male flowers per plant (7.06) in T_9. In contrast the maximum number of female flowers per plant (7.86) was found under T_9 while the lowest number of female flowers per plant (4.76) was found under T_7.The lowest sex ratio (1.26) was observed with T_9, while the highest sex ratio (2.43) was observed with T_6.The maximum fruit set percent (71.58) were found under T_8 that was statistically identical by T_{10} Naphthalene acetic acid 150 ppm while the minimum fruit set (49.02) were found under T_2. Different plant growth regulators showed a statistically significant variation on number of fruits per plant. The maximum (6.03) fruits per plant in number were recorded under T_9 and the minimum fruits per plant were recorded in T_2. The yield of summer squash was recorded the maximum (414.85 q) in treatment T_9 which was closely followed by $T_{4.}$ The quality parameters *i.e.*, TSS (4.66) and shelf life (114.6 days) of summer squash was determined the maximum in T_8 as compared to other treatments. The economics of using different growth regulators revealed that the cost benefit ratio was the maximum with NAA (100 ppm) followed by Ethrel250 ppm. The overall results showed that most effective treatment for increasing femaleness and yield of Summer Squash was Ethrel (250 ppm) with maximum benefit cost ratio (4.89).

Comment [P2]: regulators

Comment [P3]: to be

Keywords: Summer Squash, Growth Regulator, quality parameters, Yield, benefit cost ratio

1. INTRODUCTION

Summer Squash (*Cucurbita pepo* L.) is one of the most important vegetable crop. It belongs to the Cucurbitaceae family. It is an annual monoecious herb *i.e.* it bears male and female flowers on the same plant. Male flowers are formed first, then the female flowers. Female flowers are characterized by an undeveloped fruit at the base. The sex expression of Summer Squash is determined by genetics as well as environment factors (e.g., photoperiod, temperature etc). Because of low temperatures and short photoperiods in early spring, the Summer Squash cultivated in spring usually have more female flowers and fewer male flowers. But later in the season because of high temperatures and long photoperiods, Summer Squash usually exhibit more male flowers and fewer female flowers. This will cause decreases of its fruit yield. Many kinds of plant growth regulator have been used in modification of sex expression in cucurbits [1, 2]. Growth regulators can change the sex ratio and series if utilized at the two-or four-leaf stage, which is the ticklish stage at which the extinction or buildup of either sex is potential[3]. Employment of any one of chemicals, or manipulating temperature and/or illumination will cause a change of sex expression in Summer Squash. However, manipulating temperature and/or illumination is more difficult than applying chemicals. Although the femaleness ratio in Squash and other monoecious cucurbit crops is mainly subjected to genetic factors, their flowering habit may be greatly varied under different environmental conditions. The most environmental factor clearly affected Squash sex ratio, are high temperature, photoperiod and nitrogen availability during early growth stage in addition to application of exogenous growth regulator [4].Growth regulators are regarded as one of the most important treatments, used nowadays in agriculture, which in most cases modify the plant growth and the subsequent fruiting. Growth regulators are dignify as one of the most substantial treatments, applied nowadays in farming, which in maximum status amend the plant growth and the following fruiting. They are utilized to catalyze seed germination, vegetative growth, flowering and fruiting in several vegetable crops. Available determination confirms that best yield can be accomplished by utilizing different concentrations of growth regulators.

2. Materials and method

2.1 Materials

2.1.1 Study site characteristics

The field experiment was conducted at Vegetable Demonstration and Research Block, Department of Vegetable Science, College of Horticulture, Bharsar, VCSG Uttarakhand University of Horticulture and Forestry, Bharsar. And is located between 29^0 20'-29^0 75' N Latitude and 78^0 10'-78^0 80' E Longitude. In general, the climate of the Bharsar represents the mild summer, higher precipitation and colder or severe cold prolonged winter. The South-East monsoon commences towards the end of June while the North-East monsoon causes occasional winter showers from November to February. During winter, snowfall is common in this region. During summer months, the valley has hot climate prevailing for few hours in a day, the maximum temperature during May-June is recorded between 30°C- 35°C however, nights are cool. December and January are the coldest months; the minimum temperature reaches to 1°C to -4°C. Relative humidity is normally highest during rainy season (July - August), often recorded near to saturation point (92-97%) and it gradually decreases towards December.

2.1.2 Treatments and experimental design

The experiment consisted of 10 treatments having different concentrations of Ethrel, Gibberellic acid and Naphthalene acetic acid *viz.*, T_1 Control; T_2Ethrel 150 ppm; T_3Ethrel 200 ppm; T_4 Ethrel @ 250 ppm; T_5 Gibberellic acid (GA_3) @ 25 ppm; T_6 Gibberellic acid (GA_3) @ 50ppm; T_7 Gibberellic acid (GA_3) @ 75 ppm; T_8 Naphthalene acetic acid (NAA) @ 50 ppm; T_9 Naphthalene acetic acid (NAA) @ 100 ppm; T_{10} Naphthalene acetic acid (NAA) @ 150 ppm. The experiment was laid out in the Randomized Complete Block Design. The treatments were replicated thrice in a plot having dimensions 3m x 1.8m and a spacing of 1m between rows and 0.6 m between plants was followed. Cultivar '*Pattypan'* of Summer Squash was chosen for the present study. Observations were recorded on growth parameters at the time of harvesting.

2.1.3 Nursery raising field preparation and transplanting

To raise the seedling, polythene bags were filled with compost mixed soil before seed sowing. Sowing of seeds was done in polythene bags and two seeds were sown in each bag. Thereafter, light irrigation was done through water can. After sowing of seeds, the polythene bags were regularly irrigated till the seedlings were ready for transplanting. Hand weeding and plant protection measure were taken as and when required.

The field was ploughed thoroughly and harrowed twice. There after field was leveled properly and plots were prepared according to the layout plan. In field raised beds were prepared to raise the crop. When the seedlings attained 4 leaves and hard enough, they were transplanted in the main field.

2.1.4 Application of growth regulators

The plant growth regulators, as per the treatments, were applied as a foliar spray with the help of hand sprayer. Care was taken to avoid spraying of one solution to other treatments. While spraying, plastic sheet was held as a barrier in between two treatments. The sprayer was washed carefully with distilled water after the application of every concentration of the solution.

2.1.5 Cultural Operations

The plots were kept free from weeds by periodic hand weeding. The crop was irrigated periodically, depending upon the requirements. All the cultural practices were kept uniform among all treatments.

2.1.6 Harvesting

The fruits were harvested when they attained maturity and full growth.

2.2 METHODS

2.2.1 Yield attributes yield and quality observation

Five competitive plants were be randomly selected from each treatment and tagged for recording data on different characters. Average mean was calculated for the different characters from the five sampled plants of each for various statistical analyses. The data was collected for the following characters:

Yield attributes

Number of male flower per plant was counted from first female flower appearance. Total number of male flowers was recorded from five plants of each treatment. Number of female flower per plant was counted from first female flower appearance. Total number of female flowers was recorded from five plants of each treatment. The sex-ratio (Male: Female) was worked out on the basis of total number of male and female flowers of selected plants. Fruit set per cent was calculated from the number of fruits to the number of female flowers produced per plant as follows:

$$\text{Fruit set per cent} = \frac{\text{No. of fruits per plant}}{\text{No. of female flowers per plant}} \times 100$$

Number of fruit was counted from first harvest stage to last harvest. The total number of fruits per plant was counted and average number of fruit was recorded.

The average weight of five fruits was calculated after the picking as per the formula given below

$$\text{Average Fruit Weight (g)} = \frac{\text{Total weight of fruits (kg)}}{\text{Number of fruits}}$$

Yield

Fruit weight recorded from all pickings from each plant was pooled and fruit yield per plant was calculated. To estimate yield, all the five plants in every plot and all the fruits in every harvest were considered. Thus the average yield per plot was measured. Yield per hectare was calculated on the basis of plot yield. The one hectare area was divided by plot area and multiplied by average yield of plot and expressed in q/ha.

Quality:

The total soluble solids (TSS) content in fruits was determined by Erma Hand Refractometer (0 to 32°Brix). The refractometer was calibrated with distilled water before use and then a few drops of fruit juice were placed on the prism and the reading was recorded. A temperature correction was applied when it was above or below 20°C [5]. The results were expressed in °Brix.Shelf life of Fruit was estimated by keeping the fruit at ambient room temperature, conditions till they shrunk and become unfit for consumption.

2.2.2 Economic analysis

Cost of cultivation was calculated on the basis of prevailing local charges for different inputs like labourer, implements, seeds, fertilizers and other chemicals, used in cultivation of crops under different treatments.Benefit cost (B: C) ratio was calculated by dividing the net return by total cost of production.

2.2.3Statistical analysis

The statistical analysis was carried out for each observed character under the study using MS-Excel, OPSTATE. The mean values of data were subjected to analysis of variance and ANOVA was set as per [6] for Randomized Complete Block Design.

3. Result and discussion

3.1 Yield attributes and yield

The present study was undertaken to study the effect of plant growth regulators on yield of summer squash. It was significantly recorded plant growth regulators on number of male flowers per plant, number of female flowers per plant, sex ratio, number of fruits per plant, average fruit weight, yield per plant yield per plot and yield per hectare of summer squash as shown in table 1.Maximum numbers of male flowers per plant were found in T_7 (Gibberellic acid @ 75ppm) 13.63, while lowest number of male flowers per plant (7.06) were found in T_1(Control). It may be because GA treatments alone stimulated vegetative extension and shifted sex expression toward maleness.

Comment [P4]: Table

Table 1. Effect of plant growth regulators on growth attributes of summer squash

Treatments	Male flower (No.)	Female flower (No.)	Sex ratio	Fruit set (%)	No. of fruits	Fruit weight (Av.)	Yield ($Plant^{-1}$)

T_1	7.06	4.76	1.86	49.02	2.00	295.67	1.50
T_2	10.60	6.00	1.82	54.32	3.00	226.33	2.33
T_3	9.26	7.70	1.83	68.30	3.03	619.00	2.40
T_4	8.40	7.86	1.26	71.19	4.06	645.67	2.85
T_5	10.80	5.10	1.71	49.22	2.80	241.00	2.24
T_6	11.56	5.00	2.30	50.68	2.86	432.00	2.10
T_7	13.63	5.36	2.43	52.17	2.00	438.00	1.98
T_8	10.56	5.46	2.12	50.21	3.13	219.33	2.05
T_9	9.93	5.73	1.58	51.92	3.26	229.67	2.30
T_{10}	8.80	6.00	1.55	71.58	3.70	300.33	2.50
$LSD_{(0.05)}$	**3.10**	**1.80**	**0.62**	**16.99**	**1.22**	**233.58**	**0.12**

T_1 Control; T_2Ethrel 150 ppm; T_3Ethrel 200 ppm; T_4 Ethrel @ 250 ppm; T5 Gibberellic acid (GA_3) @ 25 ppm; T_6 Gibberellic acid (GA_3) @ 50ppm; T_7 Gibberellic acid (GA_3) @ 75 ppm; T_8 Naphthalene acetic acid (NAA) @ 50 ppm; T_9 Naphthalene acetic acid (NAA) @ 100 ppm; T_{10} Naphthalene acetic acid (NAA) @ 150 ppm

The findings are in close conformity with the findings of [7] in Cucumber. Ethrel has been reported to increase female flower production in cucurbits. In present study also, it produced significantly more number of female flowers than control. The maximum numbers of female flowers per plant were found in T_4 (Ethrel @ 250 ppm) 7.86, while the lowest number of female flowers per plant were found in T_1 (Control) 4.76. Such results have been attributed to the physiological and biochemical changes caused by ethylene released in the plant tissues by the exogenous application of [8]. Also it may be because Ethrel is known to suppress male flower production and increase that of female flowers in number of cucurbits. Similar finding were reported by [9] in Sponge gourd and [10] in Musk melon. The lowest sex ratio treatment T_4 (Ethrel @ 250 ppm) 1.26, while high sex ratio was found in treatment T4 (Gibberellic acid @ 75 ppm) 2.43. Higher levels of GA favor vegetative extension and male sex expression; however, high levels of Ethrel tend to inhibit vegetative growth and induce female sex expression thereby increase in number of female flowers and decrease in number of male flower production due to Ethrel resulted into lower sex ratio (male to female).The findings are in close conformity with the findings of [11] in oil pumpkin. Maximum fruit set (71.58) were found under T_{10} (Naphthalene acetic acid @ 100ppm), while the minimum fruit set (49.02) were found under T_1 (Control). Similar finding were reported by [12] in cucumber and Ghani *et al.* (2013) in Bitter gourd. The maximum fruits per plant (4.06) was recorded under T_4(Ethrel @ 150ppm) and the minimum fruits per plant (2.00) were recorded in T_1 (Control). Ethrel increases the number of flowers/plant and finally lead to high number of fruits and yield. The findings are in close conformity with the findings of [13] in Summer Squash. Highest yield per plant, yield per plot and yield per hectare was obtained in treatment T_4 (Ethrel @ 250ppm) 2.40kg, 25.65 kg and 403.75q, respectively and minimum yield per plant, yield per plot and yield per hectare (212.50q) was found in treatment T_1(Control)1.50kg, 13.04 kg and 212.50q, respectively. The increases in the yield may be due to increase in number of female flowers, number of fruits, average fruit weight and lower sex ratio. The findings are in close conformity with the findings of [9] in sponge gourd and [14] in pumpkin.

3.2 Quality

Plant growth regulators had non-significant influence on TSS (Figure 1) and shelf life (Figure 2) of summer squash. However, the maximum TSS and shelf life was determined in treatment T_8 (Naphthalene acetic acid 50ppm) i.e., 4.66 and 114.6 days, respectively.

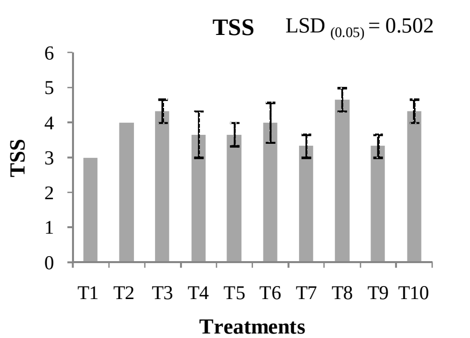

Figure 1. Effect of plant growth regulators on TSS of summer squash.Vertical bars indicate ± S.E. ofmean of the observed values.

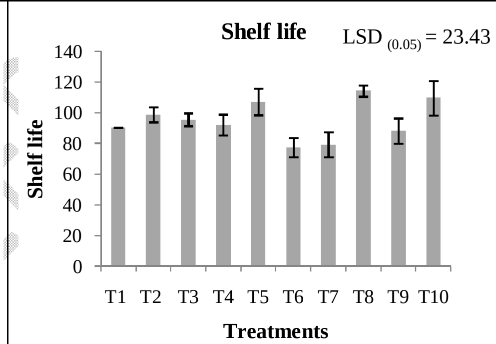

Figure 2. Effect of plant growth regulators on shelf life of summer squash. Vertical bars indicate ± S.E. ofmean of the observed values

3.3 Economic profitability

Economic profitability (Table 2) in terms of net return was obtained under treatment T_9 (Rs. 343953 ha^{-1}) which was closely followed by treatment T_4 (Rs. 301952 ha^{-1}) and the minimum net return was obtained in treatment T_1 (Rs. 108944 ha^{-1}). Whereas, high B: C ratio were obtained in treatment T_4 (Ethrel@ 250 ppm) 4.89. This was due to higher yield in the treatments Ethrel 250 ppm (T_4) resulting in higher net returns. The findings are in close conformity with the findings of [15] in Summer Squash.

Table 2. Effect of plant growth regulators on economics of summer squash

Treatments	Yield ($q\ ha^{-1}$)	Cost of production ($Rs\ ha^{-1}$)	Gross Return ($Rs.\ ha^{-1}$)	Net return ($Rs.\ ha^{-1}$)	B:C
T_1	212.50	68816	177760	108944	2.21
T_2	330.08	70402	279750	209348	3.86
T_3	340.00	70748	237760	167012	3.98
T_4	403.75	71068	373760	301952	4.89
T_5	317.33	74046	363230	289184	3.43
T_6	297.96	78675	250120	171445	2.91
T_7	280.50	83305	277000	193695	2.47
T_8	290.41	70157	289880	219723	3.29
T_9	325.83	70897	414850	343953	3.76
T_{10}	354.16	71638	287440	215802	4.12
$LSD_{(0.05)}$	**18.25**	**2540**	**32850**	**28750**	**0.64**

T_1 Control; T_2Ethrel 150 ppm; T_3Ethrel 200 ppm; T4 Ethrel @ 250 ppm; T5 Gibberellic acid (GA_3) @ 25 ppm; T6 Gibberellic acid (GA_3) @ 50ppm; T7 Gibberellic acid (GA_3) @ 75 ppm; T8 Naphthalene acetic acid (NAA) @ 50 ppm; T9 Naphthalene acetic acid (NAA) @ 100 ppm; T10 Naphthalene acetic acid (NAA) @ 150 ppm

4. Conclusion

In conclusion, plant growth regulators had the positive effect up to a certain limit on the sex modification, fruit set and yield of Summer squash.Different plant growth regulators showed a statistically significant variation on number of fruits per plant. The maximum (6.03) fruits per plant in number were recorded under T_9 and the minimum fruits per plant were recorded in T_2. The yield of summer squash was recorded the maximum (414.85 q) in treatment T_9 which was closely followed by $T_{4.}$ The quality parameters *i.e.*, TSS (4.66) and shelf life (114.6 days) of summer squash was determined the maximum in T_8 as compared to other treatments. The economics of using different growth regulators revealed that the C: B ratio was maximum with NAA (100 ppm) followed by Ethrel 250ppm.

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