Research Article

EFFECT OF PLANT GROWTH REGULATORS ON FLOWERING AND FRUIT YIELD OF CUCUMBER (*Cucumis sativus* cv. Malini) IN CHITWAN, NEPAL

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ABSTRACT

An experiment was done at Rambagh, Chitwan during March to May 2018 with the objective to evaluate the effect of plant growth regulators on growth, flowering and yield of cucumber (*Cucumissativus*.) cv. Malini. The experiment consisted of nine treatments *viz.,* control (no spray), silver nitrate 250 ppm spray, ethephon 250 ppm spray, gibberellic acid (GA_3) 300 ppm spray, napthalene acetic acid (NAA) 50 ppm spray, silver nitrate 500 ppm spray, ethephon 250 ppm spray, gibberellic acid (GA_3) 500 ppm spry, and napthalene acetic acid (NAA) 100 ppm spray; each treatment was replicated thrice. Findings revealed that use of plant growth regulators significantly affected growth, flowering and fruit yield of cucumber. The highest plant height was measured for GA_3 300 ppm spray whereas lowest plant height was measured for NAA 100 ppm spray. Likewise, GA_3 300 ppm spray had produced highest number of lateral branches. On the other hand, highest number of male flower was recorded in control, but highest number of female flower was recorded for ethephon 250 ppm spray whereas it was lowest for control (14.00). The highest and lowest fruit length was recorded if GA_3 500 ppm and ethephon 250 ppm were sprayed, respectively. Likewise, the highest fruit numbers per plant was recorded in GA_3 300 ppm application whereas the control had the lowest number of fruit produced. The highest fruit yield was produced from the application of GA_3 300 ppm (109.7 t/ha) while the lowest fruit yield was recorded in control (40.53 t/ha). The B: C ratio was high in GA_3 300 ppm (4.37) application as well. These results indicate the benefit of spraying GA_3 300 ppm to have a better performance and fruit yield of cucumber compared to the other treatments with varied concentrations of NAA and GA_3.

Key words: Cucumber, Plant growth regulators, Flowering, Sex expression

INTRODUCTION

Cucumber (*Cucumissativus*L.) is one of the most important and popular vegetable crops belonging to the family Cucurbitaceae. It is extensively grown for fresh market in the world, total area under cucumber cultivation in Nepal is 8,789 ha, with the production of 129,226t of fresh cucumber and the productivity of 14.7 t/ha (MoAD, 2016).It is a warm season crop, and has little or no tolerance to frost. Growth and development of cucumber are favored by temperature above 20°C. The optimum temperature for growing is between 20°C and 30°C. Unbranched lateral tendrils developed at the leaf axils. As the lateral branches are developed, flower clusters appear at leaf axils (Ahmed et al., 2004).

Cucumber is a monoecious, the first flowers to appear near the base of a cucumber plant are male. A week after male flower initiation, the female flowers appear with the small cucumber fruit at the base (Bantoc, 1964). Cucumber exhibits a fascinating range of floral morphology, including staminate, pistillate and hermaphrodite flowers occurring in various arrangements and yielding several types of sexual expression (Thapa et al., 2011).

Sex expression in cucumber is genetically controlled, but it is subjected to modification by environmental factors and application of growth regulators. Some researchers have reported the effects of plant growth regulators on themodification of sex expression in cucumber flowers (Vadigeri et al., 2001; Rafeekher et al., 2002). There is a wide range in sex ratio of cucumber.Female and male flower ratio may vary up to 1:15 to 1:13. It can be minimized by some mechanical techniques and chemical practice. The long day and higher temperature generally promote production of male flowers in cucumber (Seshadri, 1990).

Exogenous application of plant growth regulators can alter sex ratio and sequence if applied at the two- or four-leaf stage, which is the critical stage at which the suppression or promotion of either sex is possible (Hossain et al., 2006).It was reported that exogenous application of PGRs may shift the sex expression in cucurbits towards femaleness, increasing the number of pistillate flowers, number of fruit/plant and individual fruit weight as well as yield (Mia et al., 2014).

First few flowers borne in cucumber are staminate which are not significantly important considering yield and production of cucumber (Rafeekher et al., 2002). Thus inducing early female flowers could benefit farmers with early harvest of fruit. Among the cucurbits, cucumber as being popular among the farmers for the commercial production due to its increasing demands in the market. PGRs, associated with increasing female flowers (Dhakal et al., 2019) could result in increased fruit yield(Kiełkowska & Havey, 2012).Thus farmers would be benefitted by

both early harvest and higher yield by using PGRs. Application of PGRs for inducing female flowers in cucurbits is very common abroad, but not largely practiced in Nepal. Under this context, an experiment was done to evaluate the effect of exogenous application of different PGRs to determine the changes in flowering behaviour along with sex expression, so as to improve the fruit yield of cucumber.

MATERIAL AND METHODS

The field experiment was done at Bharatpur Municipality-05, Rambagh, located about 5 km east south from the Agriculture and Forestry University, Rampur, Chitwan. The location of the research site is 27°65" N latitude and 84°38" E longitude with an elevation of 198 meter from sea level. A total area of 408 m^2, with total 27 plots, each of 4m×2.5m size, consisting 4 rows of 5 plants was allotted by maintaining 1m row to row and 0.5m plant to plant spacing. Malini variety of cucumber was used whereas 2 different concentrations of 4 plant growth regulators i.e., GA_3, $AgNo_3$, ethephon, and NAA were considered in the treatments. Thus treatments used in experiment were T_1-control, T_2- 250 ppm $AgNo_3$ spray, T_3-250 ppm ethephon spray, T_4-300 ppm GA_3spray, T_5-50 ppm NAA spray, T_6-500 ppm $AgNo_3$spray, T_7-500 ppm ethephon spray, T_8-500 ppm GA_3spray,and T_9-100 ppm NAA spray, respectively. Randomized complete block design was used with the arrangement of three replications for each treatment. Seed was sown on 11th March 2018, and pit formation was followed by transplanting on 31st March, 2019. Application of growth regulators were made in 3 instalments, i.e.,2-4 true leaf stage, 7th days after 1st spray, and 7th days after second spray, to the leaf and twigs of plant.

3-4 weeding was done whereas, staking was done with bamboo stakes, arranged in grid, at a distance 1.5m between rows, and with the length of 2.5m covering 10 vines. Irrigation was given on transplanting, during fertilizer application, and during critical period (flowering, fruiting), but during fruiting, somehow, it was met by natural rainfall. Collection of data was done by covering at morphological, floral and metrical measurements,by selecting 6 plants, excluding border plants from each plot. Data collection was done in 15 days after transplanting (DAT), 30 DAT, and 45 DAT, respectively, for various parameters i.e., plant height, number of branches per plant, number of male and female flower per plant, sex ratio, number of fruit, fruit length, diameter, fruit yield. Economic analysis was done by calculating B: C ratio. All the recorded data was arranged in MS-Excel, and were subjected to analysis of variance (ANOVA). Mean comparison was done by Duncan's Multiple Range Test, using R-STAT.

RESULTS AND DISCUSSION

Plant height (cm)

The mean plant height of cucumber at 15 DAT was statistically similar ($p>0.05$) that ranged 99 cm to 114 cm (Silver nitrate 500 ppm) (Table 1). At 30 DAT, plant height of different treatments were statistically significant ($p<0.05$) with the highest height for the treatment of GA_3 300 ppm spray, but it was statistically similar ($p>0.05$) to the treatments GA_3 500 ppm spray and NAA 50 ppm spray. Spraying of ethephon 250 ppm had produced lowest plant height at 30 DAT (Table 1).

At 45 DAT, the mean plant height of cucumber plants remained statistically different ($p<0.05$) among the treatments. The highest height was attained if plants were sprayed with GA_3 300 ppm, but it was statistically similar ($p>0.05$) to the treatments- NAA 50 ppm spray and Silver nitrate 500 ppm spray. Control, NAA 100 ppm spray, GA_3 500 ppm spray, all had similar and lowest plant height (Table 1). Hayasi et al. (2001) also reported that the treatment with GA_3 caused of stimulation of cell enlargement and thus the increment in the plant height. These findings are close corroboration of our study findings.

Table 1.Effect of plant growth regulatorson plant height (cm/plant) of cucumber cv. Malini, Chitwan, 2018

Treatments	Plant height (cm)		
	15DAT	30DAT	45DAT
Control	99.97	152.72^{bc}	197.06^{bcd}
Silver nitrate 250 ppm	106.17	153.78^{abc}	199.06^{bcd}
Silver nitrate 500 ppm	114.78	156.67^{abc}	201.67^{abc}
Ethephon 250 ppm	105.67	138.94^{d}	194.00^{bcd}
Ethephon 500 ppm	100.72	147.83^{cd}	193.44^{bcd}
GA_3 300 ppm	103.50	166.39^{a}	211.94^{a}
GA_3 500 ppm	96.05	163.72^{ab}	193.94^{bcd}
NAA 50 ppm	105.11	161.11^{ab}	205.33^{ab}
NAA 100 ppm	90.11	139.94^{d}	189.37^{d}
Sem(±)			
CV	8.53	4.52	3.43
LSD	NS	12.01	11.78
Grand mean	102.45	153.41	198.47

Note: Treatment means in columns followed by common letters are not significantly different from each other based on DMRT at 5% level of significance

Number of lateral branch per plant

Number of lateral branch per plant was not significantly influenced ($p>0.05$) at15 DAT, but it was significantly influenced at 30 and 45 DAT ($p<0.05$) (Table 2). At 30 DAT, higher number of lateral branches was recorded in GA_3 300 ppm spray, and the lowest number of lateral branches was recorded in control, but it was statistically at par ($p>0.05$) with silver nitrate 250 ppm spray. At 45 DAT, highest number of lateral branches was recorded in GA_3 300 ppm spray, and the lowest number of lateral branches was recorded in control, but it was statistically at par ($p>0.05$) with silver nitrate 250 ppm spray. Gibberellic acid is one of those growth regulators that have positive effect on plant growth through the effect on cell division and elongation (Batlang et al., 2006). Our findings match well to that of earlier studies.

Table 2.Effect of plant growth regulators on number of lateral branches per plant of cucumber cv. Malini,Chitwan, 2018

Treatments	Number of lateral branch per plant		
	15DAT	30DAT	45DAT
Control	5.06	8.57^{f}	10.63^{e}
Silver nitrate 250 ppm	5.67	8.63^{f}	11.13^{e}
Silver nitrate 500 ppm	5.39	9.60^{e}	12.03^{d}
Ethephon 250 ppm	5.44	10.67^{d}	12.43^{cd}
Ethephon 500 ppm	5.61	11.41^{bc}	12.33^{cd}
GA_3 300 ppm	6.08	12.57^{a}	15.47^{a}
GA_3 500 ppm	5.94	11.87^{b}	14.63^{b}
NAA 50 ppm	5.67	11.05^{cd}	12.73^{c}
NAA 100 ppm	5.22	11.17^{cd}	12.97^{c}
Sem(±)			
CV	16.30	2.91	3.10
LSD	NS	0.53	0.68
Grand mean	5.56	10.61	12.71

Note: Treatment means in columns followed by common letters are not significantly different from each other based on DMRT at 5% level of significance

Number of male and female flower per plant

Number of total male and female flowers per plant was significantly influenced ($p<0.05$) at different dates after transplanting (Table 3). Highest number of male flower was recorded in control, and it was statistically at par ($p>0.05$) with Silver nitrate 250 ppm spray, and NAA 50 ppm spray whereas the lowest number of male flower was recorded in NAA 100 ppm spray. Highest number of female flower was recorded in GA_3 500 ppm spray and, it was statistically at par ($p>0.05$) with GA_3 300 ppm spray, ethephon 250 ppm spray, NAA 50 ppm spray, and silver nitrate 250 ppm spray. In control, lowest number of female flower was recorded (Table 3). Maryam Golabadi et al. (2018) reported the positive effect of highest doses of $AgNO_3$ (300ppm), and 500ppm that had increased the number of male flowers, and also the number of male nodes.The lower dose of GA_3 had promoted male flowers, but higher concentration of GA_3 had antagonist effect as it induced female nodes and triggered the effect of ethylene. Farhana (2015) also reported the increased femaleness at higher dose of GA_3 in cucumber.

Grand mean of sex ratio of cucumber was statistically significant ($p<0.05$) as measured at different dates after transplanting (Table 3). Highest sex ratio was recorded in control and the lowest was recorded in GA_3 500 ppm spray, but it was statistically similar ($p>0.05$) to the treatments- ethephon 250 ppm spray, GA_3 300 ppm spay, silver nitrate 500 ppm spray, and NAA 100 ppm spray.The number of fruit per plant was recorded higher in GA_3 300 ppm spray, but was statistically at par ($p>0.05$) with GA_3 500 ppm spray, ethephon 250 ppm spray, and ethephon 500 ppm spray. The lowest number of fruit per plant was recorded in Control. Fruit setting percentage of cucumber was statistically similar ($p>0.05$) at different dates that ranged 44.48% to 60.59% (GA_3 300 ppm). Hossain (2004) conducted an experiment to study the effect of ripen-15(ethephon) which showed the positive effect on production of female flower in cucumber and bittergourd.

Table 3.Effect of plant growth regulators on total number of male and female flower and sex ratio of cucumber cv. Malini, Chitwan, 2018

Treatments	Number of male and female flowers, sex ratio, fruit per plant and fruit setting% per plant at different dates				
	TMF	TFF	Sex ratio	FPP	Fruit Setting (%)
Control	43.94^{a}	14.00^{d}	3.17^{a}	6.83^{c}	51.08
Silver nitrate 250 ppm	42.11^{ab}	19.56^{ab}	2.16^{b}	7.89^{bc}	44.48
Silver nitrate 500 ppm	37.20^{bcd}	19.56^{ab}	1.91^{bcd}	9.11^{bc}	47.25
Ethephon 250 ppm	34.67^{cd}	20.89^{a}	1.67^{cd}	10.39^{abc}	51.12
Ethephon 500 ppm	34.17^{d}	17.50^{bc}	2.03^{bc}	9.83^{abc}	59.67
GA_3 300 ppm	36.83^{cd}	22.33^{a}	1.68^{cd}	13.22^{a}	60.59
GA_3 500 ppm	33.83^{d}	22.89^{a}	1.51^{d}	10.56^{ab}	48.15
NAA 50 ppm	39.61^{abc}	20.17^{ab}	1.98^{bc}	9.50^{bc}	48.32
NAA 100 ppm	27.33^{e}	14.78^{cd}	1.96^{bcd}	7.89^{bc}	57.43
Sem (±)					
CV	7.64	9.19	11.83	19.39	24.74
LSD	4.85	3.04	0.41	3.21	NS
Grand mean	36.64	19.07	2.01	9.56	52.01

Note: Treatment means in columns followed by common letters are not significantly different from each other based on DMRT at 5% level of significance

TMF= Total male flower, TFF= Total female flower, FPP= Fruit per plant

Fruit quality

Fruit diameter was highest for NAA 100 ppm spray, GA_3 300 ppm spray and GA_3 500 ppm spray treatments, but it was statistically similar ($p>0.05$) to the rest of the treatments, except ethephon 250 ppm spray, and 500 ppm spray (Table 4).

Fruit length was measured highest for GA_3 300 ppm spray, but it was statistically at par ($p>0.05$) to the rest of the treatments. The lowest length was measured in ethephon 250 ppm spray. Gibberellic acid is one of those growth regulators that had positive effect on plant growth through the effect on cell division and elongation (Batlang et al., 2006).The reduced fruit length due to ethephon treatments are in line with the findings of Rafeekher et al. (2002), and Vadigeri et al. (2001).

Table 4.Effect of plant growth regulators on fruit quality of cucumber cv. Malini, Chitwan, 2018

Treatments	Fruit diameter (cm)	Fruit length (cm)	Max. fruit wt. (g.)	Average wt.(g)
Control	18.43^{abc}	20.00^{c}	373.33^{b}	348.78^{bc}
Silver nitrate 250 ppm	19.57^{ab}	20.27^{abc}	373.33^{b}	350.14^{bc}
Silver nitrate 500 ppm	17.83^{abc}	19.76^{bc}	350.00^{bc}	341.98^{bc}
Ethephon 250 ppm	17.60^{bc}	18.17^{c}	308.33^{d}	306.86^{d}
Ethephon 500 ppm	17.20^{c}	18.73^{c}	333.33^{cd}	320.62^{cd}
GA_3 300 ppm	19.80^{a}	22.50^{a}	430.00^{a}	403.31^{a}
GA_3 500 ppm	19.80^{a}	22.33^{ab}	440.00^{a}	406.30^{a}
NAA 50 ppm	19.00^{abc}	20.40^{abc}	341.98^{bc}	360.69^{b}
NAA 100 ppm	19.83^{a}	20.17^{bc}	386.67^{b}	344.95^{bc}
Sem(±)				
CV	5.65	5.93	5.66	5.05
LSD	1.84	2.07	36.67	30.93
Grand mean	18.79	20.25	374.63	353.74

Note: Treatment means in columns followed by common letters are not significantly different from each other based on DMRT at 5% level of significance

Fruit Yield

The fruit yield per vine and fruit yield per hectare was significantly influenced ($p<0.05$) by the use of different plant growth regulators (Table 5). Fruit yield per vine was highest for the treatment with GA_3 300 ppm spray, and was statistically different ($p<0.05$) to the rest of the treatments, except $GA_3$500 ppm spray. The treatment with $GA_3$500 ppm spray had second highest yield whereas control and the treatment with NAA 100 ppm spray had the lowest fruit yield (Table 5). Mostly, cucurbitaceous vegetables, soon after flower, anthesis fails to fertilize, combined application of GA_3 and NAA would make the female part of the flower more active and hence reduce the abortion so better fertilization would take place. These findings are in close conformity with the findings of Aisha et al. (2006). Similarly, Hossain (1974) also reported a gradual increase in the yield per plant with higher concentration of GA_3.

Table 5.Effect of plant growth regulators on fruit yield of cucumber cv. Malini, Chitwan in 2018

Treatments	Yield	
	Fruit yield per plant (Kg)	Yield (t/ha)
Control	4.27 ^{c}	40.53^{d}
Silver nitrate 250 ppm	5.45^{b}	62.91^{c}
Silver nitrate 500 ppm	5.83b	62.91c
Ethephon 250 ppm	5.53^{b}	64.46^{c}
Ethephon 500 ppm	6.13^{b}	64.04^{c}
GA_3 300 ppm	7.99^{a}	109.77^{a}
GA_3 500 ppm	7.22^{a}	88.36^{b}
NAA 50 ppm	5.92^{b}	70.17^{bc}
NAA 100 ppm	5.70^{b}	54.39^{cd}
Sem(±)		
CV	9.43	15.84
LSD	0.98	18.81
Grand mean	6.00	68.59

Note: Treatment means in columns followed by common letters are not significantly different from each other based on DMRT at 5% level of significance

Economic analysis

Economic analysis of cucumber was significantly influenced by the use of different doses of plant growth regulators. The cost of cultivation was relatively high in silver nitrate 500 ppm (351.4 per 000NRs/ha) spray treatment, and it was relatively low in the case of control (27.94 per 000NRs/ha) (Table 6).The grand mean of gross return was calculated NRs.1, 028,900/ha whereas the grand mean of net return was calculated NRs.727, 700/ha, respectively. The highest gross return was obtained from GA_3 300 ppm spray, and the lowest return was obtained from Control. The net return was found relatively high in GA_3 300 ppm spray, similarly, the lowest net return was obtained in Control (Table 6). The B: C ratio was relatively high in GA_3 300 ppm spray treatment, and it was relatively low in the case of control. Ajay et al. (2018) reported that among the various growth regulators, the Cost: Benefit ratio was 1:2.6 for GA_3 @100 ppm spray. The market cost of silver nitrate was high in comparison to other treatments so the cost of cultivation was high for this treatment.

Table 6.Effect of plant growth regulators on cost of cultivation, and B: C ratio of cucumber cv. Malini, Chitwan, 2018

Treatments	Cost of cultivation (000NRs/ha)	Gross return (000NRs/ha)	Net return (000NRs/ha)	B:C Ratio
Control	279.4	608.0^{d}	328.6^{d}	1.18
Silver nitrate 250ppm	315.4	943.7^{c}	628.3^{cd}	1.99
Silver nitrate 500ppm	351.4	940.7^{c}	589.3^{cd}	1.68
Ethephon 250 ppm	281.7	966.8^{c}	685.1^{c}	2.43
Ethephon 500 ppm	284.0	960.7^{c}	676.7^{c}	2.38
GA_3 300 ppm	306.4	1646.5^{a}	1340.1^{a}	4.37
GA_3 500 ppm	324.4	1325.3^{b}	1000.9^{b}	3.09
NAA 50 ppm	282.6	1052.5^{bc}	769.9^{bc}	2.73
NAA 100 ppm	285.7	815.8^{cd}	530.1^{cd}	1.86
Sem(±)		9.41	9.41	0.32
CV		15.8	22.4	23.0
LSD		28.21	28.20	0.96
Grand mean		1028.9	727.7	2.41

Note: Treatment means in columns followed by common letters are not significantly different from each other based on DMRT at 5% level of significance

CONCLUSION

Among the different treatments of plant growth regulators used, GA_3 300 ppm spray performed comparatively better for most of the parameters considered in this research. GA_3 300 ppm spray treatment attained highest plant height, produced highest lateral branches; produced higher fruit set percentage, total number fruit per plant as well as the total fruit yield. Likewise, application of GA_3 500 ppm spray had resulted better total female flowers, lowest sex ratio (M/F), fruit length and average fruit weight. The B: C ratio was higher for GA_3 300 ppm application treatment. Considering these all results, the findings of this study suggested that application of GA_3 300 ppm spray would be more advantageous to get higher production and profit from cucumber production.

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