Research article

RESPONSE OF CUCUMBER (*Cucumis sativus* L. CV. BHAKTAPUR LOCAL) TO THE APPLICATION OF PLANT GROWTH REGULATORS IN PLASTIC TUNNEL

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ABSTRACT

The field experiment was conducted to know the yield performance of cucumber var. Bhaktapur Local with the application of plant growth regulators (PGRs) in the farmers' field of Lamjung, Nepal during September to November, 2013. Five treatments (Four PGRs; NAA @10 ppm, GA_3 @ 50ppm, GA_3@100ppm, MH@ 60ppm and distilled water as control) were replicated six times under walk-in plastic tunnel. The experiment was laid out in randomized complete block design. The first 30 flowers of each plant were used for the observation. PGRs were sprayed in 2-4 true leaf stage of seedling, 20 days after first spray and 10 days after second spray. The research revealed that NAA @ 10 ppm had higher effect in sex expression, fruit set and yield than rest of the treatments.GA_3 @ 100 ppm had significantly higher number of male flowers and more vine growth than other treatments. Branch per plant was obtained as the highest with MH @60 ppm followed by NAA @10 ppm. The marketable fruit yield was significant with NAA @10 ppm followed by MH@ 60 ppm, GA_3 @50 ppm, GA_3 @100 ppm than control. It is concluded that thermo-sensitive variety of cucumber Bhaktapur Local can be grown with the use of plant growth regulators particularly, NAA@ 10 ppm, under walk-in plastic tunnels during the autumn-winter season in the mid hills of Nepal.The research further indicated that cucumber can be a profitable and a potential agriculture enterprise for the area.

Keywords: B:C ratio, fruit set, off-season, sex expression

INTRODUCTION

Cucumber is a cash generating crop for poor farmers residing near the markets and roads and is extensively grown in low to high hill of Nepal (Subedi et al., 1996). Spring-summer is considered as the normal season while the rest of the year (rainy to early-spring) is regarded as the off-season. Among various factors; improper sex ratio, poor fruit set, poor fruit growth and developments are the major abiotic factors that limit the off-season cucumber production.

Rademacher (2018) defined plant growth regulators (PGRs) as naturally occurring or synthetic compounds which even at low doses affect developmental or metabolic processes in higher plants Sharma et al.(2013) reported that endogenous plant growth regulators play vital physiological and biochemical process in plants.

Most cucurbits require a standard proportion of male and female flowers for better fruit set due to their monoecious nature. Mia et al. (2014) reported that exogenous application of PGRs may shift the sex expression in cucurbits toward femaleness, increasing the number of pistillate flowers, number of fruits/ plant, individual fruit weight and yield. The popular cultivar of cucumber in Nepal i.e. Bhaktapur Local is highly thermo-sensitive,which is prone with production of male flower malady. Sharma and Bhattarai (2006) also observed that the summer grown vines of Bhaktapur Local in low hills became absolutely androecious producing only male flowers. Maleness is major problem in cucumber which greatly decrease the fruit yield (Singh et al., 2015).Tantasawat et al. (2015) found that foliar application of PGRs in cucurbits has changed the physiological and developmental processes that include plant vegetative growth, sex expression, yield, and yield components. In the cucurbit production, the use of PGRs must be specific which can finally enhance the production (Kaur et al., 2018). Consumer nowadays are highly conscious about selection of food and their production or processed types (Khanal, 2020). So improvement in fruit set of Cucumber is necessary as expansion of agriculture land is difficult because of heavy population pressure on land. Cucumber growers, agriculture technicians and researcher agreed that strange sex expression lead to poor fruit set is one of the major problems causing low yield in cucumber during off-season (Subedi & Sharma, 2005).

Plant growth regulator is environmentally and toxicologically safe which help to enhance productivity and food safety of Nepalese agriculture. Plant growth regulators has quick impact on vegetative as well as yield of the crops(Kaur et al., 2018) .Exogenous application of plant growth regulators can alter the 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). Ghani et al. (2013) stated that the PGRs have great potentialities to influence plant growth morphogenesis. Sapkota et al.(2020) reported that NAA@50 ppm has better fruit yield (70.17 t/ha) than NAA @ 100 ppm (54.39 t/ha) in cuumber cultivar Malini in Chitwan condition. Dalai et al.(2015) found that number of female flower per plant in cucumber treated with GA @ 30 ppm(24.21) and NAA @ 50 ppm(25.21) was more in comparision to control(19.31). Kaur et al.(2016) reported that the application of maleic hydrazide and ethephon @ 100 ppm lead to early production and yield in cucumber.

Most research works of cucumber in Nepal is particularly concentrated on variety selection, general management and cultivation practices etc, while sex regulation is mostly neglected. The present study investigated improvements to the yield of off-season cucumber during autumn-winter season in western mid hill of Nepal.

MATERIALS AND METHODS

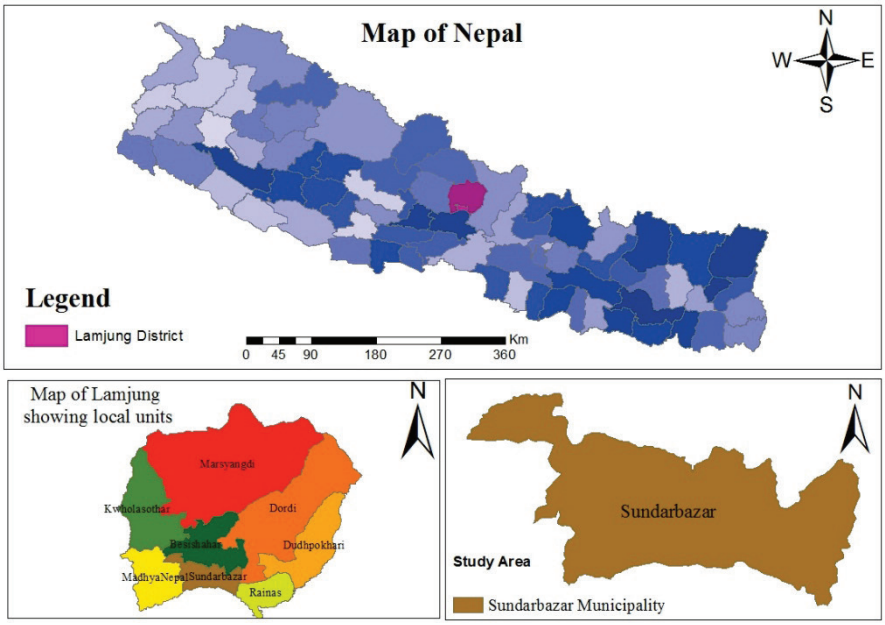

Figure 1. Map of Nepal showing the study area

The field experiment was conducted at Sundarbazar, Lamjung district of Nepal.The site lies between 28º12ˈ0ˮ North latitude and 84 º 22'0" East longitudes. The trial was done under walk-in plastic tunnel during autumn-winter period. Bhaktapur Local, a popular cross- pollinated variety of cucumber especially grown in mid-hill region was selected. The seed from Nasik Company of Chitwan was used. The experiment was laid out in factorial randomized complete block design (RCBD) consisting of five treatments (Four concentrations of PGRs- NAA 10 ppm, GA_3 50 ppm, GA_3 100 ppm and MH 60 ppm and one water spray i.e.control). All standard management practices were adopted other than treatments as in cucumber (Mollier, 2010).Well decomposed FYM @30 mt/ha was coupled with basal dose of nitrogenous, phosphoricand potassium fertilizers at the rate of 100:80:80 kg ha^{-1} in pit soil at least a day before sowing.Seeding was done directly into the centre of the pit and gap filling was done 20 days after seeding for where necessary. Multiplex® 2.5ml$liter^{-1}$ of water was sprayed twice for all treatments. Prophylactic spray of Blitox-50®@2 g $liter^{-1}$ of water was made 40 DAS to avoid fungal diseases. Heading system of staking was practiced under walk-in plastic tunnel. PGRs were prepared by employing the procedure as suggested by Shrestha et al.(1991).Required amount of analytical PGRs was weighed to prepare 500 ml stock solution having 5000

ppm strength. At first the weighed amount of PGRs was dissolved in few ml of Ethanol/acetic acid, and well mixed by using vertex magnetic stirrer. Then, the double distilled water was added to make the final volume of stock solution i.e. 500 ml. pH of each stock solution was maintained at 6.5 by adding 0.1 N NaOH or 0.1 N HCl solution where applicable. Prepared stock solution was stored in cool and dry places. The brown bottle was also covered with black polythene to avoid alteration in chemical properties of PGRs due to the presence of light. The number of plastic tunnels used in experiment was three with individual size (12m×4m) having two replication in each tunnel.

Table 1. Details of autumn-winter experiment in off-season cucumber under walk in plastic tunnel, Sundarbazar, Lamjung

Particulars	Quantity	Remarks
No of replications	6	4 plants/treatment/replication
No. of plants/tunnel	10x2=20	13.5 m length and 1 m width
Planting geometry	1.5 m x 1 m	Each plant canopy in tunnel

Working solutions of required strength were prepared from the stock solution at the time of spraying. Separate sprayer was used to each PGRs. First application of PGRs was made on 2-4 true leaf stage, 2nd application was made 20 days after the first and the 3rd application was made 10 days after the second application. Each flower stalk/stem of first thirty flower was marked with a woolen thread to ensure the fruit set and flower drop. Yield and yield attributing parameters were recorded in every three succeeding days interval from November 6 (1st harvest) to November 30, 2013 (9th harvest) . The benefit-cost ratio (B/C ratio) was calculated using the formula given by Subedi et al. (2019).

B/C ratio = Gross income / Total costs

Where, Gross income = Total cucumber production (kg) ×Price of cucumber,

Total costs = sum total of all variable costs.

Collected data were subjected to manage by using MS-Excel, and analysis of variance was done by using Genstat 15th edition software for the design employed. Duncan's Multiple Range Test (DMRT) for mean separations was done as per the reference of Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Phenological characteristics and sex expression

The period from sowing to opening of the first male flowers was earlier than that of female flowers in all the treatments (Table 1), however, the earliest flowering was recorded with GA 100ppm while the latest flowering was observed in control. It clearly showed that the hormonal application enhanced the days to flowering but it was statistically insignificant in case of number of days to male flower but significant in case of number of days to female flower. It showed that all hormonal treated cucumber plants were significantly earlier in female flower opening than control.

Table 2. Effect of Plant growth regulators on number of days taken to flowering in off-season cucumber under walk-in plastic tunnel, Sundarbazar, Lamjung

Treatments	Number of days to first	
	Male flower	Female flower
Control	45.53	49.02[a]
NAA @10 ppm	43.28	46.43[c]
GA_3 @ 50 ppm	43.38	46.18[c]
GA_3@100 ppm	42.50	47.00[c]
MH@60 ppm	43.95	48.03[b]
SEm (±)	0.29	0.27
LSD (P=0.05)	ns	0.79**
CV, %	1.63	1.38
Grand mean	43.73	47.33

Note: Treatment mean represented by DMRT do not differ significantly at 5% level of significance. NAA, Napthaleic acetic acid; GA, Gibberellic acid; MH, Malic hydrazide.

The effect of PGRs on number of days to first male flower appearance was non-significant . It may due to the fact thatthat PGRs had minimum effect on opening of male cucumber flowers. Iranbakhsh and Ebadi (2008) also recorded the appearance of more male flowers when the combination of IAA 100 ppm and GA_3 500 ppm was used for cucumber in poly house. Similarly, Mia et al. (2014) also stated similar finding that application of PGRs varied maleness and femaleness in bottle gourd. Hossain et al. (2006) also found that the application of GA_3 at different level (<70 ppm) at pre-flowering stage significantly influenced flowering behavior and fruiting characteristics in bitter gourd. Sapkota et al.(2020) reported that NAA 50 ppm had higher number of male and female flower over NAA 100 ppm in cucumber.

Table 3. Effect of Plant growth regulators on number of male and female flowers and sex ratio in first thirty flowers in off-season cucumber under walk-in plastic tunnel, Sundarbazar, Lamjung

Treatments	Male flower	Female flower	Sex ratio(M:F)
Control	21.17[b]	8.83[b]	2.61[b]
NAA@10 ppm	18.58[c]	11.42[a]	1.68[c]
GA_3 @50 ppm	19.13[c]	10.38[a]	1.87[c]
GA_3 @100 ppm	22.04[ab]	7.96[bc]	2.79[ab]
MH@60 ppm	22.83[a]	7.17[c]	3.23[a]
SEm (±)	0.43	0.36	0.13
LSD (P=0.05)	1.27**	1.10**	1.93**
CV, %	5.09	9.55	14.67
Grand mean	20.75	9.15	2.43

Note: Treatment mean represented by DMRT do not differ significantly at 5% level of significance. NAA, Napthaleic acetic acid; GA, Gibberellic acid; MH, Malic hydrazide.

PGRs treatments had significantly lowered the male to female flower ratio (Table-2). Results also revealed that NAA significantly lowered the male to female flower ratio in cucumber compared with other treatments. Among GA_3 treatments, GA_3 at 50 ppm resulted in the lowest sex ratio.

Adequate research articles are available in accordance and against related to the impact of plant growth regulators in cucurbits, however, auxins are generally recommended for femaleness and GA are recommended for maleness in cucumber. Sandra et al.(2015) reported that application of NAA 200 ppm, GA_3 50 ppm and etheral 50 ppm were important for modification of sex expressions in cucumber. Jadav et al.

(2010) conducted an experiment for the suppression of staminate flowers and promotion of pistillate flowers in cucumber using various doses of PGRs, mainly- NAA (100 and 200 ppm), GA_3 (10 and 20 ppm), ABA (10 and 20 ppm), KIN (10 and 20 ppm), and ethrel (200 and 300 ppm).

Table 4. Effect of Plant growth regulators on number of branch per plant at 55 Days after seeding (DAS) in off-season cucumber under walk-in plastic tunnel, Sundarbazar, Lamjung

Treatments	Number of branch/plant
Control	5.76
NAA @10 ppm	6.35
GA_3 @50 ppm	5.83
GA_3 @100 ppm	6.00
MH@60 ppm	6.45
SEm (±)	0.049
LSD (P=0.05)	ns
CV, %	3.64
Grand mean	6.07

The use of plant growth regulators had no significant influence on total number of branches per plant at 55 days after seeding (Table-3). Both maleic hydrazide and auxin derivative hormones were effective in reducing the height of the main stem and increasing the number of primary branches. Application of GA_3 100 ppm had beneficial result in vine length, number of leaves per plant, number of branches per plant and leaf area in cucumber (Kadi et al., 2018).

Fruit set

The variety Bhaktapur Local is a thermo-sensitive monoecious crop. Hence, the variation in temperatures and hormonal level greatly influence the expression of either male or female flowers. The proportion of male and female flower is the key determining factor for fruit set and yield.

Table 5. Effect of Plant growth regulators on total marketable yield in first thirty female flowers in off-season cucumber under walk-in plastic tunnel, Sundarbazar, Lamjung

Treatments	Marketable yield per plant(g)
Control	1181.08[b]
NAA@10 ppm	2480.58[a]
GA_3 @50 ppm	1971.05[a]
GA_3 @100 ppm	1843.17[a]
MH@60 ppm	1951.08[a]
SEm (±)	203.90
LSD (P=0.05)	601.50*
CV (%)	26.49
Grand mean	1885.39

Note: Treatment mean represented by DMRT differ at 5% level of significance. NAA, Napthaleic acetic acid; GA, Gibberellic acid; MH, Malic hydrazide

The treatments differed significantly with respect to marketable fruit yield at NAA 10 ppm having maximum values compared to other treatments (Table 4).The fruits of normal shape and more than 300 g in weight were counted as marketable yield. Large number of small fruit was left in first thirty flowers predominantly in NAA 10 ppm plant followed by MH 60 ppm that was unsuitable for marketing .

Economics of cucumber production

$GA_3$100ppm and $GA_3$50ppm applied treatment incurred the highest total cost of production (NRs.6,40,450) per hectare whereas the lowest cost of production (NRs.6,38,950) per hectare was incurred in control treatment (Table-5). The major cost contributors were labor, fertilizer, farm machinery, bamboo for staking , gibberellic acid and malic hydrazide. The difference in cost of cultivation was mainly due to cost of inputs. Although level of GA_3 increased the cost of production, the net return was obtained as the highest with NAA @ 10ppm.

Kaur et al. (2018) reported that yield in term of fruit weight per plant and total yield per hectare was higher in all treatments of MH and Ethephon than control. Combination of GA_3 20 ppm and NAA100 ppm gave maximum yield in cucumber (Dalai et al.,2015).

Table 6. B:C ratio of off season cucumber production under the influence of plant growth regulators in Sundarbazar, Lamjung

Treatments	Fruit yield (kg ha^{-1})	Price (Rs kg^{-1})	Gross income (NRs.)	Total cost (NRs.)	Net return (NRs.)	B:C ratio
Control	17180	50	859000	638950	220050	1.34
NAA@10ppm	23710	50	1185500	639220	546280	1.85
GA_3 @50ppm	18310	50	915500	640450	275050	1.42
GA_3 @100ppm	18600	50	930000	640450	289550	1.45
MH @60ppm	19180	50	959000	639370	319630	1.49

The average yield 19.4 t ha^{-1} was recorded from all plots which was higher than the national average (14.99 t ha^{-1}) as of 2012/2013 (VDD, 2013). However, it was slightly lower than the yield of commercial cucurbit cultivation (25-30 t ha^{-1}).

Weather and cucumber performance

A great variation was recorded in maximum and minimum temperatures outside and inside tunnel. Comparatively earlier flowering was observed in this experiment might be due to the higher minimum and maximum temperature than the outside environment. Timely irrigation and warm temperature inside tunnel was favourable for the growth and development of cucumber

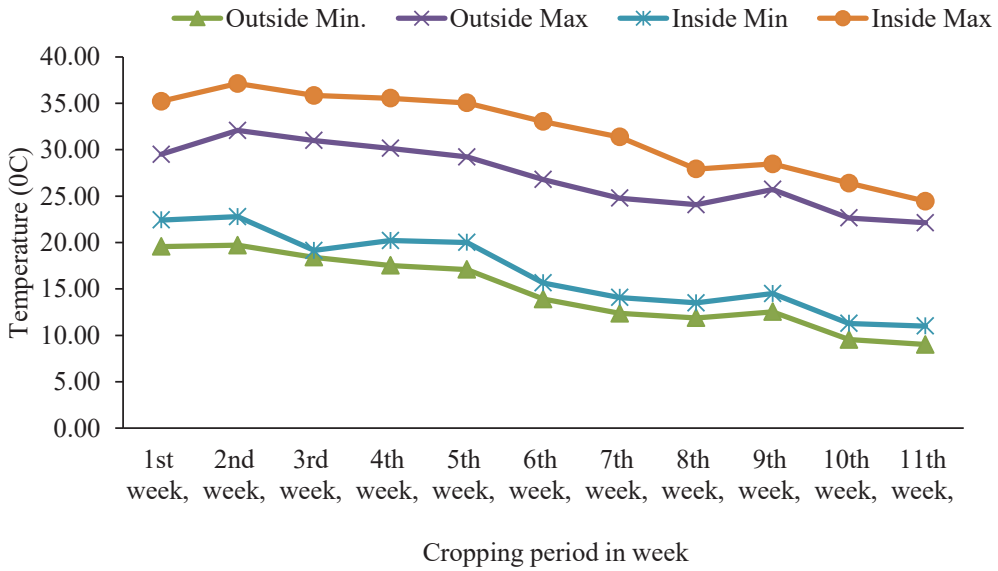

Figure 2. Temperature regime during the study period

CONCLUSION

Off-season cucumber cultivation by using the thermo sensitive cv. Bhaktapur Local is possible in mid-hills of Nepal with an average yield of 19.4 t ha^{-1} underwalk-in plastic tunnel as the temperature ranges mostly 20-30 ^{0}C with occasionally daily maximum at 35 ^{0}C. Plant growth regulators significantly influenced the male:female flower ratio and other yield attributing characteristics during autumn-winter season. Especially NAA @ 10 ppm increased female flowers, better fruit set and higher yield (23.71 t ha^{-1}). This yield was 38% higher than that of control (17.18 t ha^{-1}). PGRs helps to obtain higher yield including benefit cost ratio and the crop appears to be highly profitable and remunerative during autumn–winter season (off-season crop).

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