Environment and Ecology 40 (4C) : 2642—2649, October—December 2022
ISSN 0970-0420

Response of Bottle Gourd (*Lagenaria siceraria* (Mol.) Standl to Bioregulators and Pinching on Morpho-Phenological and Yield Attributing Traits

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Received 19 August 2022, Accepted 23 September 2022, Published on 25 November 2022

ABSTRACT

The present investigation was carried out during the summer season of 2021 and 2022 at Vegetable Research Centers, Department of Horticulture, JNKVV (MP) to ascertain the effect of bioregulators and pinching on bottle gourd var Pusa Naveen. The experiment was arranged over 21 treatment combinations comprising of three levels of pinching and seven levels of plant growth regulators laid out in a Factorial Randomized Block Design with three replicates. Maximum vine length (4.29 m) and more number of secondary branches (4.49) were obtained when pinching on bottle gourd was done at 6th node (P3). Pinching on 3rd node produced more number of female flowers (13.10), higher sex ratio (7.84), maximum number of fruits per plant (4.5), higher fruit set % (33.37%) and highest yield (215.17q/ha). Foliar application of NAA 200 gave better results for number of female flowers (14.72), narrow sex ratio (5.22), number of secondary branch (4.33), number of fruits per plant (4.91) and higher yield (224.02 q/ha). However, treatment combination with pinching operation done at 3rd node with exogenous application of NAA @200 ppm gave higher fruit yield 253 q/ha, fruit set (38.98%), number of fruits per plant (5.18), narrow sex ratio (6.67) whereas pinching at 3rd node along with NAA@100 ppm gave better morphological growth. Thus, it can be concluded that pinching at 3rd node with foliar application of NAA 200 ppm gave better morphological growth and yielded better.

Keywords Bottle gourd, Pinching, Bioregulators, NAA, Pusa Naveen.

INTRODUCTION

Bottle gourd is known as *Lagenaria siceraria* (Mol.) Standl and is a monoecious annual trailing vine exhibiting a fascinating range of floral morphology. Bottle gourd is a popularly grown cucurbitaceous crop mostly grown throughout the tropics and subtropics of the world. It displays a considerable variation in vegetative structure (Tiwari and Ram 2006). This *Lagenaria* species is a white colored flowered gourd which is originated in India and very well adapted in

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semi-arid conditions. It is highly cross pollinated crop with enormous amount of variation for many economic traits. The fruits of bottle gourd shows immense variation in shape and size ranging from flattened and discoidal form, long club shaped and can be conical, round or club shape (Tiwari and Ram 2009). Bottle gourd is highly nutritious as is a gift by nature to humans since it possess all major and micronutrients responsible for maintaining good health. In 100 g of fruit may contain protein (0.2 g), carbohydrate (2.5 g) and traces of minerals like calcium (20 mg), iron (0.7mg) and phosphorus (10 mg) (Naafe *et al*. 2022). Pinching is a form of pruning that encourages secondary and tertiary sprouts on plants thereby enhancing the secondary branch number. It produces more female flowers during spring-summer, under high temperature and long days. Pinching assists in maintaining a suitable balance between vegetative and reproductive growth of bottle gourd to maximize production. Pinching facilitates better vine spreading under open field condition by increasing the number of side shoots and boosts productivity. The sex expression of Calabash gourd is determined by environmental factors such as photoperiod and temperature and also influenced by plant growth regulators (PGR). Sex expression and sex ratio in cucurbits are important factors for governing the yield. All the cultivars of cucurbits differ in production of pistillate flowers. It is a tendency of all the cucurbits to produce more number of male flowers and less number of pistillate and hermaphrodite flowers (Anand *et al*. 2014).

Bioregulators alters the sex ratio, expression and the sequence when exogenously applied at a critical stage at which the separation of either sex is promoted during two to four leaf stage (Hossain *et al*. 2006). In varied cucurbitaceous crops, plant growth regulators tremendously influence the sex expression and floral primordia leading to either separation of male flowers or quantify the number of female flowers without imposing deleterious impact on environment. Early nodes bear staminate flowers which are larger in number whereas hermaphrodites and pistillate flowers are borne of later nodes. Delayed appearance of the flowers on the nodes leads to reduced yield. The exogenous application of the bioregulators such as Naphthalein Acetic Acid (NAA), salicylic acid and biofertisol aids in resolving this problem and increase female flowers, fruit set and bottle gourd yield (Kumai *et al*. 2019). Naphthalene acetic acid (NAA) is beneficial for induction of female flowers and reduction of male flowers in summer bottle gourd and sex expression can also be controlled by using different growth regulators (Kooner *et al*. 2000, Hidayatullah *et al*. 2012, Gaurav *et al*. 2008 and Kumar *et al*. 2000).

MATERIALS AND METHODS

A present field trial was undertaken during the summer season of 2021 and 2022 at Vegetable Research Centers, Department of Horticulture, JNKVV (MP) to ascertain the effect of bioregulators and pinching on bottle gourd var Pusa Naveen. The experiment was arranged over 21 treatment combinations comprising of three levels of pinching (P_0: No pinching, P_1: Pinching at 3rd node and P_2: Pinching at 6th node) and seven levels of plant growth regulators (G_0: water spray, G_1: NAA (100 ppm), G_2: NAA (200 ppm), G_3: Salicylic acid (0.5mM), G_4: Salicylic acid (0.7Mm), G_5: Biofertisol (5ml) and G_6: Biofertisol (7.5ml)) laid out in a Randomized Block Design (Factorial) with three replicates. The climate of the experimental field is humid subtropical climate with maximum temperature of 48°C and minimum 21°C whereas in winters he temperature goes down to 8°C in agro-climatic zone of Kaymore plateau and Satpura hills. Seeds of Bottle Gourd variety Pusa Naveen were procured from Indian Agriculture Research Institute, New Delhi. The nursery was raised in polybag under the net house condition and single seeds were sown in polybags were filled with media prepared using vermicompost and soil in the ratio of 1:1. Two sprays of PGR's were given as per the treatment dose. Foliar application of NAA, SA and bioregulators was done at 2 true leaf (fully expanded) and at 4 true leaf (fully expanded) stage of seedling with the help of a hand sprayer during evening hours. Seedlings were uprooted from the polybags and transplanted in the plots at a spacing of 2.0 m row to row and 1.0 m plant to plant having 10 plants per plot. Recommended package and practice was carried out during the course of investigation. Pinching operation was done at the third and sixth node with the help of secateurs. Five plants were tagged from each plot for recording the observations of the morphological, phenological and yield parameters namely vine length, number of

primary and secondary branches, number of male and female flowers, sex ratio, fruit set %, number of fruits per plant and fruit yield in q/ha which were subjected to statistical analysis using OP STAT software.

Analysis of variance and mean tables were calculated to interpret the results with respect to all studied characters. The pooled data of two years (2021 and 2022) has been presented herein. Earlier pinching has proved to be effective in encouraging more secondary branches, female primordia and better yield. Also, delayed appearance of female flowers on nodes can be overcome by exogenous application of bioregulators, thus, this research was designed to determine the response of the interactive effect of pinching with varied concentrations of bioregulators on morphological growth, phenophases and yield attributes of bottle gourd.

RESULTS AND DISCUSSION

Morphological and phenological parameters

The data pertaining to the morphological parameters as affected by pinching on different nodes along with the spray of bioregulators such as NAA, Salicylic acid and Biofertisol have been embodied in Table 1(a) and depicted graphically in Fig. 1 showed a significant effect. Among factor A, ie., Pinching (Table 1a), maximum vine length of 4.29 m and more number of secondary branches (4.49) were obtained when pinching on bottle gourd was done at 6th node (P_3) as per the pooled data. Minimum number of 3.87 secondary branch and 4.04 m vine length was noted under no pinching (P_0). Maximum number of 6.97 primary branches and more number of 103.19 male flowers were obtained under no pinching operation. With the removal of apical bud, cytokinin stimulated to promote more number of primary and secondary branches thus favouring production of female flowers in the basal nodes (Anand *et al*. 2014). Decrease in the production of male flower in bottle gourd may be related to higher C:N ratio due to pinching practice and release of hormones. These results are similar to the findings of Higashide *et al*. (2012) in cucumber, Lakshmi *et al*. (2014) in fenugreek and Eve *et al*. (2016) in Butternuts who documented less number of male flowers due to pinching practice in different vegetables. Eve *et al*. (2016) had concluded that pinching in bottle-gourd become physiologically active, thus the concentration of photosynthates deviate to lower plant parts that suppresses the development of the main stem and encouraged the production of branches. The arrest in apical dominance might have

Table 1 (a). Morpho-phenological parameters as influenced by combined application of different bioregulators and pinching operations on bottle gourd crop (Pooled data).

Treatments	Morpho-phenological parameters						Yield parameters		
	Vine Length (m)	Number of primary branches	Number of secondary branches	Number of male flowers	Number of female flowers	Sex ratio	Fruit set %	Number of fruits plant^{-1}	Fruit yield (Q/ha)
				Factor A (Pinching operation)					
No Pinching	4.04	6.97	3.87	103.19	11.57	8.25	31.66	4.17	195.71
Pinching at 3rd node	4.24	3.04	4.22	101.06	13.10	7.84	33.37	4.54	215.17
Pinching at 6th node	4.29	4.38	4.49	102.30	12.76	8.00	33.15	4.36	201.81
SEm±	0.042	0.067	0.064	0.728	0.128	0.099	0.248	0.048	0.603
CD (at 5%)	0.12	0.19	0.18	2.08	0.36	0.28	0.71	0.14	1.72
				Factor B (Bioregulators)					
Water spray (G0)	3.78	5.08	4.06	102.16	11.78	9.09	30.52	4.21	187.56
NAA 100 ppm (G1)	4.52	4.75	4.11	100.64	14.28	7.40	35.28	4.66	213.62
NAA 200 ppm (G2)	4.40	4.60	4.33	104.03	14.72	7.32	34.49	4.91	224.02
Salicylic Acid 0.5(G3)	4.30	4.95	4.27	103.31	12.56	7.89	32.35	4.46	200.89
Salicylic Acid 0.7 (G4)	4.06	4.70	4.23	104.77	11.39	5.52	33.00	4.47	199.22
Biofertisol 5 ml (G5)	4.11	4.78	4.07	102.12	12.72	8.26	32.13	4.30	202.52
Biofertisol 7.5 ml (G6)	4.14	4.72	4.29	100.56	12.22	8.00	31.11	4.41	201.80
SEm±	0.065	0.103	0.098	1.113	0.195	0.151	0.378	0.073	0.920
CD (at 5%)	0.18	0.29	0.28	3.18	0.56	0.43	1.08	0.21	2.63

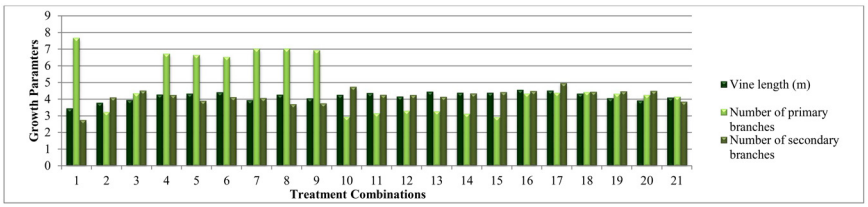

Fig. 1. Interaction effect of pinching operation and bioregulators on growth parameters of bottle gourd (Pooled values).

check and this will in turn reduce the auxin and there is an increase of florigen or cytokinin like compounds in the vine (Ciba *et al*. 2017). It is evident from the data presented in Table 1(a) that pinching on 3rd node produced more number of female flowers (13.10) and higher sex ratio (7.84). Translocation of stored towards the lateral branches lead to an increase in metabolic activity of bottle gourd plant due to pinching thus producing more carbohydrates which leads to more number of female flowers (Naafe *et al*. 2022). Higher rate of photosynthesis and accumulation of the photosynthates due to more number of leaf, leaf area and efficiencies lead to an increase in the number of female flowers production. This is in conformity with the results reported by Singh and Mangal (1982) in muskmelon, where they noted that training and pinching improves the exposure of leaves to sun light which results in an increased trapping of the solar energy for production of carbohydrate content in shoots. Increase in carbohydrate content narrows the C:

N ratio and higher metabolic activity which leads to switching from vegetative to reproductive buds (Fieller and Leschke 1970) in cucumber.

As evident from the ANOVA Table 1(b) that plant growth regulators and the interaction between plant growth regulators and pinching significantly influenced the length of vines in Bottle gourd, while their pinching was found non-significant. Effect of foliar spray of plant growth regulators with its different levels of concentration was found significant for number of secondary branches (Table 1 a). Vine length was maximum (4.52 m) under the foliar application of NAA (100 ppm) (G_1). Water spray (G_0) gave better primary branches (5.08) which exhibited significant more over the rest. The data showed that maximum number of secondary branches (4.33), more number of female flowers (14.72) and a narrow sex ratio (5.52) was found under the exogenous application of NAA 200 ppm (G_2) and were significantly superior over the other treatments. Minimum vine length and number of secondary branches were noted under water spray (G_0). The increased number of branches has enhanced the number of female flowers per vine (Patel *et al*. 2017). This might be due to the reason that the sexual differentiation is controlled by endogenous levels of auxins (NAA at 2 to 4 leaf stage) which suppressed staminate flowers and promotes more number of pistillate flowers, and thus registers lower sex ratio (Jiterwal *et al*. 2010 and Patel *et al*. 2017).

Table 1 (b). Analysis of variance of the effect of pinching operation and bioregulators on morpho-phenological parameters of bottle gourd.

Source of variance	Degree of freedom	Mean sum of square								
		Vine length (m)	Number of primary branches	Number of secondary branches	Number of male flowers	Number of female flowers	Sex Ratio	Fruit set %	Number of fruits per plant	Fruit yield (Q/ha)
Replication	2	0.056	0.798	0.220	15.374	0.317	0.315	1.650	0.111	11.938
Factor A	2	0.060	3.262**	1.670**	93.528*	3.000**	3.524**	57.970**	0.197*	4461.65**
Factor B	6	0.110*	1.769**	0.463**	16.239	10.184**	4.417**	15.449**	0.182**	1351.10**
Factor A X B	12	0.137**	1.173**	0.510**	28.954	4.093**	0.912**	27.242**	0.277**	2116.68**
Error	40	0.04	0.30	0.09	19.55	0.41	0.21	1.29	0.05	132.93
CV		4.62	6.43	7.02	4.38	4.53	5.66	3.47	4.87	2.71

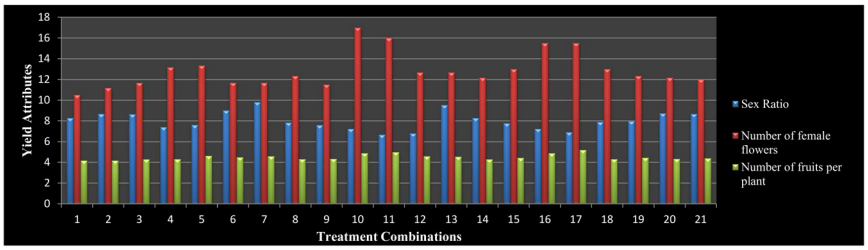

Fig. 2. Interaction effect of pinching operation and bioregulators on yield attributing traits of bottle gourd (Pooled values).

The experimental results revealed that more number of 104.77 male flowers were noted under the foliar application of salicylic acid (0.7mM). The exogenous application of the bioregulators showed a persuasive effect and enhanced the number of branches per vine, number of pistillate flowers, number of fruits per vine and produced higher fruit yield (Chovatia *et al*. 2010). Results were in conformity with the findings of Kumari *et al*. (2019), Moniruzzaman *et al*. (2020) and Wamiq *et al*. (2020) in bottlegourd and Chovatia *et al*. (2010) and Ghani *et al*. (2013) in bitter gourd. The perusal of data revealed that there was significant difference among that the treatments combinations depicting the interaction of pinching operation and bioregulators on vine length, number of primary and secondary branches per vine, number of male and female flowers and sex ratio (male:female). The data has been graphically presented in Figs. 1 and 2. It was found that maximum vine length of 4.56 m and higher number of 4.96 secondary branches were observed in treatment combination comprising of pinching at 3rd node along with foliar application of NAA @ 100 ppm (P_2G_5). The treatment combination of no pinching with water spray (P_0G_0) gave the lowest values for vine length (3.44 m) and secondary branches (2.75). Maximum number of 7.67 primary branches were obtained under the interaction comprising of no pinching with water spray (P_0G_0). Higher number of 112.00 male flowers per plant were obtained under treatment combination with no pinching and application of SA (0.7mM) (P_0G_4) whereas P_2G_2 produced the lowest number of 91.17 staminate flowers. Pistillate flowers gave a higher value (16.00) under the interaction effect of pinching at 3rd node with application of NAA @ 100 ppm (P_1G_1) though P_0G_0 produced the lowest. A narrow sex ratio of 6.67 was obtained during the interaction of pinching operation done at 3rd node with exogenous application of NAA @200 ppm (P_1G_2) whereas no pinching along with spray of SA (0.7mM) (P_0G_4) gave a wider sex ratio of 9.80 as depicted in Fig. 2. The present findings concur with the results of Patel *et al*. (2017) and Wamiq *et al*. (2020).

Yield parameters

Data regarding the effect of pinching on yield attributing traits are given in Table 1 (a) and (b) and was depicted graphically in Figs. 2 and 3. As evident from the ANOVA table that pinching practice and PGR's significantly influenced yield and its components in Bottle gourd. The analysis of variance for various attributes revealed significant differences among the pinching operations. Highest number of fruits per plant (4.54), fruit set percentage (33.37%) and maximum yield (215.17q/ha) was noted in pinching at 3rd node (P_1) which was significantly superior. The lowest values were noted under no pinching. Pimpini and Gianquinto (1992) stated that pinching is effective for better source-sink relationship which produced more number of female flowers and fruits set, thus increasing the number of fruits due to the diversion of photo assimilates towards the primary branches. Patel *et al*. (2017) concluded that pinching practice produces more number of female flowers and hence enhances the fruit yield of bottle gourd. These results are in close proximity with the results obtained by Krishanveni *et al*. (2014) in fenugreek, Tswanya and Olaniyi (2016) in tomato and Patel *et al*. (2018) in cucumber who recorded more yield per ha through pinching practices.

A close review of the pooled data revealed that the plant growth regulators had a significant influence on the yield parameters. NAA showed superiority

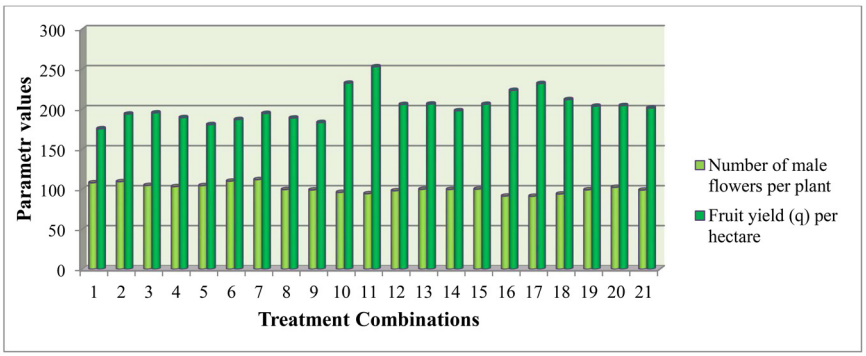

Fig. 3. Interaction effect of pinching operation and bioregulators on fruit yield and number of male flowers of bottle gourd (Pooled values).

over the other bioregulators such as salicylic acid and biofertisols. The data showed that foliar application of NAA 200 ppm (G_2) enhanced the yield of bottle gourd as it produced more number of 4.91 fruits per plant thus proving the highest fruit yield of 224.02 q/ha. However, least number of 4.21 fruits per plant were produced under control (G_0) thus providing the lowest yield of 187.56 q/ha. A higher fruit set percentage of 35.28 % was recorded under the spray of NAA 100 ppm (G_1) whereas water spray gave the lowest fruit set percentage (30.52%). NAA is used in chemical thinning and prevention of fruit drop or induction of flowering, increase fruit setting, size and thus increasing yield. The results are in close conformity with those cited by Kumari *et al*. (2019), Moniruzzaman *et al*. (2020) and Wamiq *et al*. (2020) in bottle gourd, Chovatia *et al*. (2010) and Ghani *et al*. (2013) in bitter gourd and Parmar *et al*. (2003) in sponge gourd.

Analysis of total fruit yield per plant data for the interaction effect of pinching and bioregulators showed significant results (Figs. 2- 4). The data presented in Fig. 2 showed that higher number of 5.18 fruits per plant were obtained during the interaction of pinching operation done at 3rd node with exogenous application of NAA @ 200 ppm (P_1G_2) whereas P_0G_0 and P_1G_0 gave lowest number. Fig. 4 depicts that lowest fruit set percentage (28.04%) was noted for combination with no pinching along with application of biofertisol 7.5 ml (P_0G_6) whereas pinching on 3rd node with foliar application of NAA 200 ppm (P_1G_2) gave a higher percent (38.98%). The maximum total fruit yield of 253 q/ha was recorded in pinching operation done at 3rd node with exogenous application of NAA @200 ppm (P_1G_2) whereas P_0G_0 yielded the lowest (175.62q/ha). (Fig. 3) The increase in number of fruits vine^{-1} in pinched plants along with the exogenous application of NAA is due to the activation of endogenous hormones, which accelerates the growth phases and balance the carbon nitrogen ratio that

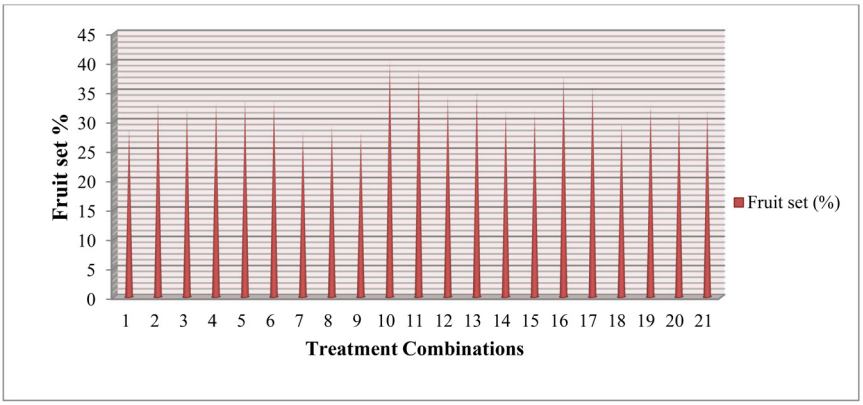

Fig. 4. Interaction effect of pinching operation and bioregulators on fruit set percentage of bottle gourd (Pooled values).

enhances female flowers production (Higashide *et al*. 2012). The present findings concur with the results of Higashide *et al*. (2012) in cucumber, Lakshmi *et al*. (2014) in fenugreek, Eve *et al*. (2016) in Butternuts, Patel *et al*. (2017) and Wamiq *et al*. (2020).

CONCLUSION

According to the result discussed, it can be concluded that pinching operation had a significant effect on the growth and yield parameters of bottle gourd. Pinching on 3rd node gave narrower sex ratio with more number of female flowers, better fruit set %, higher fruits per plant thus producing maximum yield per hectare of bottle gourd var Pusa Naveen. Exogenous application of NAA 200 ppm yielded better thus producing higher number of fruits per plant and showed better vegetative and phenological growth. Treatment combination with pinching operation done at 3rd node with exogenous application of NAA @200 ppm (P_1G_2) gave maximum fruit yield, better fruit set, higher number of fruits per plant, narrow sex ratio whereas Pinching at 6th node with the application of NAA 100 ppm gave better morphological growth. Thus, it can be concluded that pinching at 3rd node with foliar application of NAA 200 ppm gave better morphological growth and yielded better.

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