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Influence of plant growth regulators on growth, flowering and fruit yield of bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]

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Abstract

The present investigation was carried out with three levels each of five plant growth regulators namely, (IAA, TIBA, IBA, GA_3 and Ethrel) respectively, were sprayed at second and fourth leaves stage on bottle gourd plants to find out their response on growth, flowering and fruit yield. The study was conducted at Vegetable Research Farm, CCS, Haryana Agricultural University, Hisar during Spring-summer season of 2017-18. The results clearly indicated that application of Ethrel 200 ppm significantly increased most of the growth and fruit yield attributes over control treatment. The spraying of Ethrel 200 ppm significantly reduced the length of internodes (11.4 cm), days to appearance of first male flower and early fruit harvest (56.4; 62.7 days), number of staminate flowers per plant (102.7), sex ratio (6.0) as well as main vine length at final harvest (353.7 cm), whereas the same dose significantly increases number of primary branches /vine (16.8), numbers of pistillate flowers per plant (17.2), longer fruit length & more diameter (31.5; 7.3 cm), number of fruits per vine (7.6), average fruit weight (825.6 g) and fruit yield per plot and per hectare (27.6 kg and 349.2 q), respectively. Whereas, the spray of GA_3 60 ppm significantly reduced the number of primary branches per plant (9.9), number of pistillate flowers per plant (8.7), fruit length & diameter (22.9; 5.8 cm) number of fruit per plant (3.3) and fruit yield per plot and per hectare (18.7 kg, 238.4 q). From the study, it was concluded that bottle gourd cv.GH-22 plants when sprayed with Ethrel 200 ppm produced the maximum fruit yield (349.2q/ha).

Keywords: Bottle gourd, Growth regulators, PGR, Flowering and Fruit yield

Introduction

Bottle gourd is an important cucurbitaceous vegetable crop belongs to family Cucurbitaceae and commonly known as *ghia*, *dudhi* or *lauki* in India. It is originated from Africa and thrives best in loamy soil with a pH range of 6-7. Total area under this cucurbits vegetable crops in India during 2019-20 was 185 thousand hectare and the production was 3187 thousand metric tonnes with productivity of 16.4 t/ha (Anonymous 2019-20). This is an annual monoecious plant with trailing or climbing vine. The immature fruit is a good source of glucose and fructose. The edible fruits consist of vitamin B, ascorbic acid and minerals like potassium, calcium, phosphorus, magnesium, sodium, zinc, iron, manganese, copper and (USDA 2016). It is used to for the treatment of jaundice, diabetes, ulcer, insanity and hypertension.

Its fruits are available round the year, due to diverse agro climatic condition found in India (Thakur et al. 2013). The important stages of this crop are flowering, fruiting and yield. Due to monoceious in nature, its male and female flowers appear in different nodes and exist on the same plant (Desai et al. 2011). *Hormone* is the Greek word which derived from hormao, which means to stimulate. Currently, plant growth regulators are applied to control many physiological processes, including flowering and fruiting. Although gender expression is a mechanism of genetic control, the application of growth regulators can modify it (Ying et al. 1994). Exogenous application of growth regulators sprayed during 2-4 true leaf stage can express more female flowers by inhibiting male flowers (Hossain 2004).

Auxin, gibberellin, cytokinin, ethylene and abscisic acid are common hormones that cause female flowering in most of cucurbitaceous crop plants (Hidayatullah et al. 2012). Ethrel is a multifunctional ethylene release chemical hormone that can induce female flowers and increase fruit yield of cucurbitaceous plants. Gibberellin is

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responsible for increasing the internodes length, inducing and promoting male flowering and stimulating protein synthesis. IAA is natural occurring hormone, while IBA is artificial in nature. The main function of these hormone is for apical dominance, root induction, control fruits drops, regulation of flowering and sex determination. TIBA (2,3,5 triiodobenzoic acid) is mainly used as gametocide and mainly used for inducing male sterility and hybrid seed production in cucumber and watermelon. Growth regulators can increase fruit yield by suppressing the number of male flowers on main vine and increasing the number of female flowers on side branches (Mahida et al. 2015). In order to observe the effects of different plant growth regulators on the growth and fruit yield of bottle gourd, this research aims to find out the best plant growth regulator with its optimum dose to increase the fruit yield of bottle gourd cv. GH-22.

Materials and Methods

In the spring-summer season of 2017-18, a field trial was conducted on the Research Farm of the Department of Vegetable Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar. The soil of the experimental area has high pH, medium in organic carbon, available nitrogen and phosphorus and high in potash content. The treatment includes five levels of plant growth regulators *i.e*., IAA 50, 100 and 150 ppm, TIBA 20, 40 and 60 ppm, IBA 50, 100 and 150 ppm, GA_3 20, 40 and 60 ppm and Ethrel 100, 150 and 200 ppm were sprayed in a randomized block design (factor analysis) with three replications at 2-4 true leaves stage along with the control (water spray) treatment.

After weighing the required amounts of chemicals on the electronic balance these growth regulators were first dissolve all the PGR (except Ethrel) with a little quantity of solvent (alcohol), in one litre conical flask and then prepare their final solution according to the treatment concentration, respectively. Ethrel/Ethephon is present in liquid form, which is directly dissolved with water, while the rest of growth regulators are available in powder form. For this study fresh solutions of one litre from each of the 15 treatment combinations were prepared in separate bottle. The seed of bottle gourd cv. GH 22 were sown at a spacing of 250×60 cm in first fortnight of March month in both the year. In the last ploughing operation, the recommended farm yard manure @ 12 tons/ha was properly mixed in the soil. The recommended chemical fertilizer dosages (NPK) were applied @50:25:25 kg/ha. The full dose of phosphorus and potash fertilizer along with one third dose of nitrogenous fertilizers were applied at the time of seed sowing as basal dose, whereas the remaining two third nitrogen doses were applied at flowering and fruiting stage. When the plants reached at two true leaf stages, the first spray of the above prepared solutions were sprayed treatment wise and the same process was repeated at fourth leaves stage also.

All the recommended cultural packages of practices and plant protection measures adopted for raising a healthy crop in Haryana condition are followed to grow a successful crop. The observation were recorded in 14 quantitative characters namely *i.e*., number of branches/ vines, length of the internodes (cm), main vine length (cm), days to appearance of first female flower, number of male & female flowers/plant, sex ratio, fruit length (cm), fruit diameter (cm), days to early fruit harvesting (days), number of fruits per vine, average fruit weight (g), fruit yield per plot (kg) and fruit yield per hectare (q/ha). The experimental data recorded from various observation were analyzed in randomized block design with three replications for analysis of variance in OPSTAT (http: // 14.139.232.166 /opstat /index.asp) statistical software developed by Chaudhary Charan Singh, Haryana Agricultural University, Hisar, Haryana, India (Sheoran 2010).

Results and Discussion

Growth Parameter: The application of growth regulators had significant ($P < 0.05$) effects on all the growth, flowering and fruit yield parameters of bottle gourd crops. When the bottle gourd plants were sprayed with Ethrel 200 ppm, twicely, a significant ($P < 0.05$) increase in fruit yield (349.2 q/ha) was recorded, which was 39.3% higher than the fruit yield of control treatment. In this experiment, it was also noted that with the increase in doses of Ethrel concentration it significantly increased the number of branches per vine, number of fruits/vine and fruit yield parameters, whereas its antagonistic effect was noted on the main vine and intermodal length, fruit length & breadth, number of fruit and ultimately of fruit yield were recorded when applied in the second and fourth true leaves stages.

The maximum number of primary branches per vine (16.8) was noted when the bottle gourd plants were sprayed with Ethrel 200 ppm which was closely followed by Ethrel (150 and 100 ppm). The minimum number of primary branches per vine (9.9) and maximum main vine length (476.7 cm) and length of internodes (17 cm) were recorded when the bottle gourds plants were sprayed with GA_3 60 ppm treatment. While, the minimum vine length (353.7 cm) and shortest internodes (11.4 cm) were observed when the plant were

sprayed Ethrel 200 ppm treatment, which was found at par with results obtained from Ethrel 150 ppm for length of internodes, this might be due to the Ethrel hormone showed antagonistic effect on the main vine length and length of internodes.

The beneficial effect of Ethrel on increasing the number of branches per vine in gourd may be due to its effect on auxin, which enhances the dominance of the root tip and inhibits the germination of lateral buds. In addition to this application of Ethrel also condensed the main vine length growth, which ultimately initiated the dwarfism and resulted in the increased number of branches. The results obtained from the present study are in line with the results of previous research workers *i.e*., Hilli et al. (2010) they reported that Ethrel 500 ppm increased number of branches per plant in ridge gourd and Mahida et al. (2015) and Nagmani et al. (2015) in sponge gourd & bitter gourd and Patel et al. (2017) in bottle gourd, Similarly, Ansari and Chaudhary (2018) suggested that the significant increase in most of growth characters by seed soaking in boron (0.05%) for 12 hours followed by spraying of Ethrel100 ppm at 2 and 4 true leaf stages in bottle gourd.

Flowering parameters: In case of flowering parameters, spraying of different concentrations of growth regulators on bottle gourd plants at two to four true leaf stages will significantly affect all flowering parameters. The effect of the plant growth regulator Ethrel is observed two times beneficial, it reduces the number of days required to open the first female flower, as well as it increases the total number of female flowers per vine, while delaying the opening of male flowers in bottle gourd crop. The number of days taken to appearance of first female flower (56.4 days), number of staminate flowers per vine (102.7) and sex ratio (6.0) were recorded minimum when the bottle gourd crop plants sprayed with Ethrel 200 ppm, however, at the same time the action of same dose of Ethrel 200 ppm was recorded most effective for increasing the number of pistillate flowers per plant (17.2), which was found at par with Ethrel 150 ppm for most of flowering parameters except for number of staminate flowers per plant. The maximum number of days taken to appearance of first female flower (66.7 days), number of staminate flowers per vine (143.7) and sex ratio (16.5) were recorded when the crop plants sprayed with GA_3 60 ppm, as well as its antagonistic effect was also noticed on decreasing the number of pistillate flowers per plant (8.7) which is otherwise an important parameters for increasing the fruit yield of bottle gourd (Table 1).

Sex differentiation is controlled by the endogenous level of auxin that grows in the flowering primordium and acts as a gibberellin resistant substance during flowering. This auxin inhibits male flowers and promotes the number of female flowers (Sulochanamma 2001). This may also be due to the accumulation of high carbohydrates reserves in plants those received from various foliar applications of Ethrel, which resulted in early flowering and an increase in the number of female flowers and fruit sets. The results of present study are in close conformity with the findings of Murthi et al. (2007) they stated that spraying of MH 100 ppm followed by 150 ppm along with application of Ethrel 150 ppm are found most effective in growth and flowering traits in gherkins cv., calypso. Jadav et al.

Table 1: Influence of various plant growth regulators on growth and flowering parameters of bottle gourd

Treatments	Vine length at final harvest (cm)	Number of branches /vine	Length of Internodes (cm)	Days to appearance of first female flower	Number of pistillate flowers per plant	Number of staminate flowers per plant	Sex ratio
T_1- IAA 50 ppm	381.3	12.1	15.0	62.7	12.0	123.3	10.3
T_2- IAA 100 ppm	393.7	12.5	14.3	62.0	12.7	118.7	9.3
T_3- IAA 150 ppm	407.3	12.9	13.7	61.3	13.3	113.3	8.5
T_4- TIBA 20 ppm	371.3	11.7	14.7	63.3	11.3	119.3	10.6
T_5- TIBA 40 ppm	382.7	12.3	14.3	62.7	12.0	114.7	9.6
T_6- TIBA 60 ppm	394.0	12.6	14.0	61.7	12.7	108.0	8.5
T_7- IBA 50 ppm	361.7	11.3	14.3	62.3	11.7	121.7	10.4
T_8- IBA 100 ppm	372.3	11.6	13.7	61.7	12.7	115.3	9.1
T_9- IBA 150 ppm	383.7	11.8	13.3	61.3	13.0	107.7	8.3
T_{10}-GA_3 20 ppm	454.7	11.1	15.7	64.3	10.3	129.7	12.6
T_{11}-GA_3 40 ppm	463.0	10.6	16.3	65.7	9.3	136.3	14.7
T_{12}-GA_3 60 ppm	476.7	9.9	17.0	66.7	8.7	143.7	16.5
T_{13}-Ethrel 100 ppm	371.3	15.1	13.7	60.7	14.7	114.7	7.8
T_{14}-Ethrel 150 ppm	362.3	15.9	12.3	58.3	16.0	109.3	6.8
T_{15}-Ethrel 200 ppm	353.7	16.8	11.4	56.4	17.2	102.7	6.0
T_{16}-Control	379.7	11.6	15.0	63.3	11.3	124.3	11.0
General mean	394.3	12.5	14.5	62.4	12.4	118.4	9.5
CD at 5%	10.8	2.1	1.8	2.7	1.5	3.9	0.8

(2010) and Mehdi et al. (2012) in cucumbers and Chaursiya et al. (2015) in muskmelon reported that Ethrel 200, 300 and 150 ppm were observed most effective for increasing female flowers. Similarly, Mahida et al. (2015)) reported that Ethrel 250 ppm increased the number of female flowers, while it reduced the number of days taken to first female flowers appeared, and sex ratio in loofah. While, Ansari and Chaudhary (2018) stated that seed soaking in boron (0.05%) for 12 hours + spraying of Ethrel100 ppm significantly reduced the sex ratio in bottle gourd. Whereas, Aishwarya et al. (2019) suggested that application of Ethrel 200 ppm resulted in earliness to first pistillate flower appearance, delayed male flower appearance, highest female flowers per vine and narrow sex ratio in bitter gourd.

Fruiting parameters: The increase in Ethrel concentration significantly improved the yield and yield attributes of the bottle gourd crops, such as the number of fruits per vine, fruit length and fruit diameter (cm). The maximum fruit length & diameter (31.5; 7.3 cm) were recorded when the bottle gourd crop plants were sprayed with Ethrel 200 ppm at two to four true leaves stage, which was found at par with Ethrel 150 ppm for fruit diameter. The minimum fruit length & diameter (22.9; 5.8 cm) were recorded when the plants were sprayed with GA_3 60 ppm. Similarly the Ethrel 200 ppm was also found most effective for higher number of fruits per plant (7.6) and average fruit weight (825.6 g), however it reduces the number of days taken to first fruit harvest (62.7 days), which was closely followed by Ethrel 150 & 100 ppm for days to early fruit harvesting. The minimum number of fruits per plant (3.3) and average fruit weight (559.3 g) and maximum number of days taken to first fruit harvest (74 days) were recorded when the crop was sprayed with GA_3 60 ppm (Table 2).

The data pertaining to fruit yield per plot and per hectare revealed that application of plant growth regulator significantly increased the fruit yield per plot and per hectare, respectively. The maximum fruit yield per plot (27.6 kg) and per hectare (349.2 q) were recorded when the plants were sprayed with Ethrel 200 ppm, which was followed by Ethrel 150 and 100 ppm for per plot yield and 150 ppm alone for total fruit yield per hectare. The minimum fruit yield per plot (18.7 kg) and per hectare (238.4 q) were recorded when the plants were sprayed with GA_3 60 ppm. This might be due to the increase in the number of female flowers, number of fruits/vine, average fruit weight per vine. Which might be due to an higher rate of rate of photosynthesis activity resulted enough food accumulation, speed up transportation, and effectively use photosynthetic products to develop female flowers, fruits and increase fruit weight, which ultimately leads to higher yields. These results confirm the findings of earlier research workers Belhekar et al. (2006) and Kumar et al. (2006) stated that ethephon 250 and 300 ppm increased the average fruit length, width, fruit weight, number of fruits per plant, fruit yield and reduced the sex ratio in gourds. Murthi et al. (2007) stated that spraying of MH 100 ppm followed by 150 ppm and with Ethrel 150 ppm are found most effective in fruit yield traits in gherkins cv., calypso. Likewise, Mahala et al. (2014) and Nanaware et al. (2014) observed same effect in bottle gourd crop and Mahida et al. (2015). Ansari and Chaudhary (2018) observed a significant increase in most of the fruit yield

Table 2: Influence of various plant growth regulators on fruit yield parameters of bottle gourd

Treatments	Fruit length (cm)	Fruit diameter (cm)	Days to early fruit harvesting	Number of fruits per vine	Average fruit weight (g)	Fruit yield per plot (kg)	Pooled Fruit yield (q/ha)
T_1- IAA 50 ppm	24.6	6.3	71.0	5.0	639.7	21.6	262.3
T_2- IAA 100 ppm	25.7	6.5	69.7	5.7	657.3	22.2	268.5
T_3- IAA 150 ppm	26.1	6.7	68.3	6.0	689.5	23.5	276.4
T_4- TIBA 20 ppm	25.2	6.1	72.3	4.7	634.7	21.1	259.7
T_5- TIBA 40 ppm	25.9	6.3	71.0	5.0	657.3	22.0	263.9
T_6- TIBA 60 ppm	26.5	6.4	70.3	5.3	679.7	22.9	270.6
T_7- IBA 50 ppm	23.9	5.9	71.7	5.0	630.3	23.2	271.7
T_8- IBA 100 ppm	24.7	6.1	70.3	5.3	639.7	20.6	256.8
T_9- IBA 150 ppm	25.3	6.3	69.7	5.7	647.3	21.7	266.7
T_{10}-GA_3 20 ppm	25.1	6.4	72.3	4.3	625.3	20.2	251.3
T_{11}-GA_3 40 ppm	24.2	6.1	73.7	3.7	584.7	19.3	245.5
T_{12}-GA_3 60 ppm	22.9	5.8	74.0	3.3	559.3	18.7	238.4
T_{13}-Ethrel 100 ppm	27.8	6.9	67.0	6.0	743.7	25.4	309.3
T_{14}-Ethrel 150 ppm	29.7	7.1	64.7	6.7	783.3	26.7	331.2
T_{15}-Ethrel 200 ppm	31.5	7.3	62.7	7.6	825.6	27.6	349.2
T_{16}-Control	23.7	5.9	69.3	5.3	615.3	21.4	250.6
General mean	25.8	6.4	69.9	4.7	662.9	22.4	265.2
CD at 5%	1.3	0.4	4.5	0.7	33.6	2.8	34.3

related traits characters by seed soaking in boron (0.05%) for 12 hours + spraying of Ethrel100 ppm in bottle gourd. Kumari et al., (2019) reported that Ethrel 200 ppm could effectively increase the number of fruits per vine, fruit yield per vine and early fruit yield per hectare in bottle gourd. From the present study, it can be concluded that bottle gourd variety GH-22 produced the maximum number of fruits per vine, number of branches per vine and fruit yield when the crop was sprayed with Ethrel 200 ppm at second and fourth leaves stage.

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वर्तमान प्रयोग में पाँच पादप वृद्धि नियामकों (इण्डोल एसिटिक 50, 100 पी.पी.एम, ट्रॉयडोबेंजोइक एसिड 20, 40 व 60 पी.पी.एम इण्डोल व्यूटारिक एसिड 50, 100 व 150 पी.पी.एम जिब्रेलिक एसिड 20, 40 व 60 पी.पी.एम एवं इथ्रेल 100, 150 व 200 पी.पी.एम एवं नियंत्रक उपचार) के स्तरों को क्रमशः दूसरे और चौथे पत्तियों की अवस्था में लौकी की किस्म जी.एच,–22 के वानस्पतिक वृद्धि और फल उपज पर इन पादप वृद्धि नियामकों का प्रभाव देखने के लिए छिड़काव किया गया। लौकी के पौधों पर यह अध्ययन सब्जी शोध प्रक्षेत्र पर वर्ष 2017 व वर्ष 2018 (गर्मियों के मौसम) के दौरान किया गया। अध्ययन के परिणामों से स्पष्ट हुआ कि जब इथ्रेल 200 पी. पी.एम पादप वृद्धि रसायन का छिड़काव लौकी के पौधों में दूसरे और चौथे सत्य पत्तियों की अवस्था में किया गया, तब पौधे की वानस्पतिक वृद्धि, फलों की पैदावार और इससे संबंधित गुणों में अधिक वृद्धि हुयी। प्रयोग से तने के प्रत्येक गांठों के बीच की लम्बाई (11.4 सेमी.) प्रति लता नर पुष्प लगने और फल पकने की अवस्था (56.4 व 62.7 दिन), प्रति लता नर पुष्प लगने की संख्या (102.7), नर एवं मादा पुष्पों की संख्या के अनुपात (6:1) पाया गया तथा लता की लम्बाई (353.7 सेमी.) में कमी पायी गयी। इसके अलावा प्रयोग से प्राथमिक शाखाओं की संख्या (16.8), फल की लंबाई और व्यास (31.5 व 7.3 सेमी.) प्रति पौध मादा पुष्पों की संख्या (16.8), प्रति पौध फलों की संख्या (7.6) औसत फल का वजन (825.6 ग्राम) और फल का उपज प्रति प्रखण्ड 27.6 किग्रा. और प्रति हेक्टेयर (349.2 कुन्तल) प्राप्त की गयी जबकि जिब्रेलिक एसिड के 60 पी.पी.एम छिड़काव ने प्राथमिक शाखाओं की संख्या (9.9), प्रति पौध मादा पुष्पों की संख्या (8.7), फल की लंबाई और व्यास में (22.9 व 5.8 सेमी.) प्रति प्रखण्ड और प्रति हेक्टेयर फल का उपज (18.7 किग्रा. व 238.4 कुन्तल) न्यूनतम पायी गयी। अध्ययन से यह निष्कर्ष निकाला गया है कि लौकी की किस्म जी.एच.–22 में जब इथ्रेल 200 पी.पी.एम के साथ छिड़काव किया गया तो लौकी के फलों की अधिकतम उपज (349.2 कुन्तल प्रति हेक्टेयर) प्राप्त हुयी।

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