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Effects of boron and plant growth regulators on bottle gourd (*Lagenaria siceraria* (Molina) Standle.)

Abdul Majid Ansari and BM Chowdhary

Abstract
An experiment was conducted in bottle gourd to study the effect of boron and three plant growth regulator (PGR) *viz.*, gibberellic acid (GA), maleic hydrazide (MH) and ethrel (E) for vegetative, physiological and fruit characters of bottle gourd. Two concentrations of each PGR (50 ppm & 100 ppm) were used for foliar spray at 2 and 4 true leaf stages along with the 12 hours seed soaking by boron (0.05%) in combination with each level of PGRs. The vegetative characters *viz.*, vine length, number of leaves, number of nodes and inter-nodal length were significantly superior by application of GA_{100} (gibberellic acid 100 ppm). Seed soaking of boron (B_1) was also found significant in increasing number of leaves and inter-nodal length on main vine. It reveals that the best treatment combination was B_1GA_{100} (boron 0.05% + gibberellic acid 100 ppm) regarding overall vegetative characters. The earliest flower initiation was observed in GA_{50} (52.47 days after sowing) and MH_{100} (maleic hydrazide 100 ppm) both, while the best combination was B_1MH_{100}. The first female flower appearance and node number of first flower (male/female) were significantly lowered by E_{100} (ethrel 100 ppm) as well as B_1 (boron 0.05% seed treatment) application and the best treatment was B_1MH_{100}. This combination also gave maximum number of female flower and lowest number of sex-ratio (M/F). Among the fruit characters *viz.*, fruit maturity, fruit length, fruit diameter, average fruit weight, yield/vine and yield/ha were found significant effect by E_{100} and B_1 and best treatment combination was B_1E_{100}. The number of fruits/vine was observed maximum in B_1GA_{100} (4.0) followed by B_1E_{100} (3.93) and yield/plant was maximum in B_1E_{100} (4.91 kg) followed by B_1GA_{100} (4.79 kg). Inter-action effect of PGR and boron was found non-significant for all the characters studied. Based on these observations, it could be suggested that the significant increase in growth, sex-expression and fruit characters would be obtained by the spraying of E_{100} at 2 and 4 true leaf stages along with the seed soaking by boron (0.05%) for 12 hours.

Keywords: bottle gourd, boron, GH, MH, ethrel, fruit characters

Introduction

Bottle gourd (*Lagenaria siceraria* (Molina) Standle.) belongs to the family Cucurbitaceae which comprises about 90 genera and 750 species (Whitaker and Davis, 1962) [31]. Among all the cucurbits bottle gourd is an important vegetable available throughout the year. It is commonly grown in various parts of the country and popularly known as lauki, ghia, kaddu, doodhi, ghai kaddu etc. Green and tender stage of fruits are used as vegetable and for preparation of some kind of sweets, rayata, pickles etc. it contains vitamin B & C and a fair source of minerals *viz*., P, Ca and Fe. It has a cooling effect and prevents constipation.

Production of bottle gourd is influenced by a number of factors *viz*., environmental, nutritional, cultural operation, use of plant growth regulators (PGR), varietal characteristics, as well as provision of staking. So far nutrition is concern micro-nutrients play also a key role besides major nutrient elements. Boron plays a significant role in the growth and development of bottle gourd, which has been observed by many scientists. Plant growth regulators *viz*., gibberellic acid (GA), maleic hydrazide (MH), ethrel (E) and chemicals (Borax) have been found effective in such case. Primary role of boron (B) appears to be considered with foliar application and seed treatment or soil application too. The main source of B is Borax (di-sodium tetra borate=$Na_2B_4O_710H_2O$). Certain PGR also very much effective in sex expression on cucurbits including bottle gourd. Growth regulator increased the size of fruits, average fruit weight, number of fruits and yield of fruit in bottle gourd, Ethrel gave the positive result with respect to fruit length and diameter (Choudhury and Babel, 1969 [8]; Singh and Choudhury, 1989 [28]; Sinha, 1993 [29] and Prasad, 1994 [21]). The beneficial effect of PGRs on fruit weight was reported by Crane and Van Overbeek (1965) [10] who suggested sole function of fertilized ovules or seeds in relation to growth of fruit is to synthesize one or more hormone which initiated and maintained a metabolic gradient along which food could be transported from other parts of the plants towards the fruits. Mc Combs (1956) [18] opined that large size of fruit was due to an increase in cell division and cell elongation as well as enhanced metabolic activity under the influence of chemical stimulates. The role of PGR in increasing the fruit set is explained in the light of the report of Gustafson (1936) [14]. Effective role of Ethrel was in yield /plant and yield/ ha were reported by Arora *et al.* (1988) [4] in sponge gourd. Arora and Pratap (1988) [3] also reported highest yield/plant (5.17 kg) with the application of ethapone 250 ppm in pumpkin. Prasad (1994) [21] found ethrel was most effective in increased yield in bottle gourd. Bhonde (1978) [7] reported that application of MH increased the endogenous level of auxins resulting in increased fruit set in cucumber. Application of boron in bottle gourd also significantly increased yield due to increased number of female flowers and fruit set as well as fruit size (Hooda *et al.*, 1981 [16]; Maurya, 1987 [17]; Singh and Choudhury, 1989 [28]; Gedam *et al.*, 1998 [12]; Alimishaal *et al*., 1984 [1] and Verma *et al.*, 1984 [30]). Therefore, keeping these things in mind this experiment has been designed to study the effect of boron and PGR on growth and development of bottle gourd and its role in the commercial yield of this vegetable crop.

Materials and methods

The field trial was conducted at vegetable section of Horticulture garden under the faculty of agriculture, BAU, Kanke, Ranchi during *spring-summer season* (1999) summer crop. This is geographically situated at an altitude of 625 meters above mean sea level and at $23^0$17' N latitude and $85^0$19' E longitudes. This falls in the sub-tropical zone and situated in the central plateau of Jharkhand. Maximum temperature was ranging from 32^0 C to 40^0 C in summer and minimum temperature ranging from 4^0 C to 9^0 C in winter. Frost free sunny winter can be expected during winter season. Soil of the field was well drained sandy-loam in nature with rich in organic matter with good fertility status. The pH of the soil was 6.4 and available boron in the soil was0.282 mg/kg. Leveled soil surface with assured irrigation facility with expected winter and summer rain during the cropping period.

The experimental material consisted of G-2 cultivar of bottle gourd, which is popular among the vegetable growers of the state. Experiment was laid out in Randomized Block Design (Factorial) with three replications. One chemical and three PGRs *viz.*, GA (gibberellic acid), MH (maleic hydrazide) and ethrel (2-chloroethyl phosphoric acid) were used for study. Seed treatment by 0.05% borax solution for 12 hours in combination with two sprays of each PGR at 2 and 4 true leaf stages with the concentration of 50 ppm and 100 ppm. Altogether 14 treatment combination was made for the field trial. Planting distance of 1.5 m x 1.0 m was maintained with pit planting of 2-3 seed sowing in each pit and maintaining of single plant per pit to get optimum plant population. Pit was dug before 15 days of planting with 30 x 30 x 30 cm^3 and applied 20 ton/ha compost, 120 kg/ha N, 60 kg/ha p and 60 kg/ha K. Recommended package of practices was followed to raise the normal crops. Data were recorded on 20 important characters related to vegetative, physiological and fruit characters during the course of investigation which were subjected to statistical analysis using suitable techniques of different characters. The technique of analysis of variance for randomized block design (factorial) was adopted following Cochran and Cox (1967) [9].

Results and discussion

The analysis of variance for various attributes revealed significant differences among the PGRs as well as seed soaking of boron, but non-significant effect of their interaction.

Vegetative characters

Length of main vine was increased significantly by PGR application (Table 1). Maximum length (274.84 cm) was observed with GA 100 ppm being significantly superior while minimum (150.84 cm) in MH 100 ppm. The application of PGR and boron both increased the number of leaves significantly, but their interaction was non-significant. GA 100 ppm gave maximum number of leaves (123.2) which was significantly superior (Table 1). Number of nodes per vine was found significantly higher (32.5) in GA 100 ppm while boron and their interaction were non-significant. Among the treatment combination number of nodes was maximum in B_0GA_{100} (32.67). Number of branches per vine was significantly increased by PGR application and ethrel 100 ppm was found most effective (9.93). PGR and boron both showed significant effects on intermodal length on main vine. The GA 100 ppm was found best (8.5 cm) in increasing intermodal length (Table 1).

The increased length of main vine, number of leaves and number of nodes by GA might be due to the mechanism of GA in the apex, protein synthesis, cell division, auxins production, cell expansion and elongation of vine of the bottle gourd. Singh and Randhawa (1969) [27] also reported more vine length by the application of GA (75 ppm) and found reduced apical growth by MH 200 ppm and 300 ppm. Mishra *et al.* (1972) [19] showed that GA was most effective in increasing the length of vine which was also supported by Arora *et al.* (1985) [5]. Ethrel reduced the growth which might be due to decrease in level of gibberellins as also reported by Rudich *et al.* (1970) [22]. Application of ethrel caused reduction of vine length and induction of dwarfism had resulted in the increased number of branches. This result was in accordance with the finding of Arora and Pratap (1989) [3] with ethrel in Pumpkin. Saimbi and Thakur (1973) [23] also observed increased number of branches with 250 ppm and 500 ppm ethrel in summer squash. Similar results also reported by Sinha (1993) [29]. Increased intermodal length with GA might be due to cell elongation, which is specific character of gibberellins. This result was in accordance with the findings of Bhattacharya and Tokumasu (1970) [6] who found that GA promoted intermodal elongation in cucumber. Minimum intermodal length with ethrel had observed by Rudich *et al.* (1970) [22] and Anon (1970) [2] which might be due to ios-dimeric increased in girth of vine.

Physiological characters

Plant growth regulators and boron both showed significant effect among different physiological characters. GA and MH both significantly reduced the days taken for flower initiation with minimum of 52.47 days after sowing (DAS) in both (GA 50 ppm & MH 100 ppm). PGR and boron both significantly reduced the number of days taken for appearance of first female flower. Ethrel 100 ppm was found the best with minimum of 68.07 DAS. Node number of first male flower was significantly reduced by PGR and boron both and the lowest was in GA 100 ppm (4.13). Ethrel 100 ppm significantly decreased the node number of first female flower. The effect of boron was also found significant for this trait. Total number of male flowers per vine was significantly reduced by ethrel and MH. The ethrel 100 ppm gave significantly lowest (19.67) numbers of male flowers/vine. Total numbers of female flowers was significantly increased by PGR as well as boron and GA 100 ppm gave maximum (7.27) number of female flowers per vine followed by ethrel 100 ppm (7.10). The ratio of male-female (sex-ratio) was significantly reduced with the application of PGR as well as boron. The maximum sex-ratio was found with ethrel 100 ppm (2.79) and the best treatment combination (B_1E1_{00}) had a sex-ratio of 2.62 (Table 1).

All PGRs application proved to be significant in reducing the days to flower initiation and appearance of first male as well as female flowers. This result was in agreement with the finding of Sidhu *et al.* (1981) [25] in squash melon. The days to appearance of first female flower were also significantly reduced by ethrel 100 ppm which might be due to the increased of starch and carbohydrate by ethrel application which resulted in earliest production of female flowers (Singh, 1982) [26]. Umber of male flower reduced and female flower increased resulting in to reduced male female (sex ratio). This result was in conformity with the findings of Singh (1982) [26] and Sinha (1993) [29] in cucumber and Prasad (1994) [21] in bottle gourd. The possible cause of lower male-female ratio might be due to transformation of staminate buds into pistillate flowers with the application of ethrel. Another possible explanation for the action of ethrel in increasing the number of female flowers might be put forward from the suggestion of Nitsch et al. (1952) [20], who opined that differentiation and initiation of ovary primordial is dependent upon the chain biochemical events and chain of biochemical events is dependent on the auxins already present. MH reduced the digestion of starch in plant tissues and ultimately starch remains for a longer period and it also reduced the transpiration as well as respiration (Griesel, 1954) [13]. It indicates that MH reduces catabolic activities going inside the plants which reduces transpiration and other activities and thereby increased the number of female flowers and reducing the number of male flowers. Hidayatullah *et al.* (2012) [15] reported that exogenous application with 30 µmol/L, GA3 maximally increased the pistillate flower production as compared to control. Gaurav et al. (2008) [11] observed that the maximum number of female flowers was recorded in 5 ppm GA and minimum in case of 200 ppm IAA. Application of boron also significantly reduced the sex ratio (M/F). This result might be due to the increased number of female flowers because boron helps in transpiration of sugar and carbohydrate, hormone movement and ultimately flower development. This result was in agreement with the findings of Verma *et al.* (1984) [30] in bitter gourd, Almishaal *et al.* (1984) [1] in *cucurbita pepo* and Maurya (1987) [17] in cucumber.

Fruit characters

With respect to fruit characters, PGR and boron both showed significant effect (Table 1). Boron significantly reduced the number of days taken to first fruit maturity of marketable stage at 81.81 DAS but PGR and their interaction was non-significant and the best effect was in B_1E_{100}. Length of fruit increased significantly with PGR as well as boron and maximum was with ethrel 100 ppm (45.03 cm) and boron gave 40.99 cm long fruits (Table 1). The maximum diameter of fruit (8.2 cm) was recorded by ethrel 100 ppm application which showed significant effect. Boron also significantly increased fruit diameter, but their interaction effect was non-significant and best treatment combination for this trait was B_1E_{100} (8.53 cm). Average weight of fruit was increased significantly by PGR as well as boron and the maximum was in case of ethrel 100 ppm (1.183 kg) and boron gave 1.085 kg per fruit. The best treatment combination was B_1E_{100} (1.243 kg/fruit) (Table 2). PGR significantly increased number of fruits per vine and GA 100 ppm gave maximum (3.90 fruit/vine). The effect of boron was also found significant and best treatment was B_1GA_{100} (4.0) (Table 2). The PGR and boron both gave higher yield than control and it was found significant. The maximum yield was recorded under ethrel 100 ppm (195.09 q/ha) followed by GA 100 ppm (192.38 q/ha). Boron application also significantly increased yield but interaction effect was non-significant. The best treatment combination was B_1E_{100} (217.15 q/ha) followed by B_1GA_{100} (214.84 q/ha) and lowest yield was obtained in case of control i.e. B_0Control (101.27 q/ha) (Table 2).

Regarding days to fruit maturity, fruit length, fruit diameter and average fruit weight, boron was found to be effective significantly in reducing the number of days to first fruit maturity. The result was in consonance with the findings of Gedam *et al.* (1998) [12] in bitter gourd. The possible cause of earliest fruit maturity of bottle gourd might be due to the role of boron in hormone movement, initiation of flower and fruiting processes, pollen germination, carbohydrate and nitrogen metabolism of specific substances, respiration, water metabolism and water relation which may hasten the fruit maturity.

Growth regulator significantly increased the size of fruits, average fruit weight, number of fruits and yield of fruit in bottle gourd, Ethrel 100 ppm gave the best result with respect to fruit length and diameter which was in accordance with the result of Choudhury and Babel (1969) [8], Singh and Choudhury (1989) [28], Sinha (1993) [29] and Prasad (1994) [21]. The increase in fruit weight with ethrel and GA might be due to attributed to the reason that the plants remained physiologically more active in building up sufficient food stock for the developing flowers and fruits. The beneficial effect of these substances on fruit weight might further be explained in the light of the report of Crane and Van Overbeek (1965) [10] who suggested sole function of fertilized ovules or seeds in relation to growth of fruit is to synthesize one or more hormone which initiated and maintained a metabolic gradient along which food could be transported from other parts of the plants towards the fruits. McCombs (1956) [18] also opined that large size of fruit was due to an increase in cell division and cell elongation as well as enhanced metabolic activity under the influence of chemical stimulates. Heavy fruits might be due to more carbohydrate accumulation due to increased photosynthesis. The role of PGR in increasing the fruit set can possibly be explained in the light of the report of Gustafson (1936) [14]. Ethrel 100 ppm was found most effective with maximum yield /plant and yield/ ha which was in accordance with the report of Arora *et al.* (1988) [4] in sponge gourd. Arora and Pratap (1988) [3] also recorded highest yield/plant (5.17 kg) with the application of ethapone 250 ppm in pumpkin. Prasad (1994) [21] found ethrel most effective in increased yield in bottle gourd. The application of GA and MH might have also increased the endogenous level of auxins resulting in increased fruit set. Bhonde (1978) [7] reported that application of MH increased the endogenous level of auxins resulting in increased fruit set in cucumber. Maximum number of male flowers was recorded in case of 20 ppm GA and minimum in case of 200 ppm IAA. Moreover, the treatment produced maximum number of fruits (22.24/plant) and fruit weight of 6.31 kg/plant (Hidayatullah *et al.*, 2012) [15]. Application of boron in bottle gourd also significantly increased yield due to increased number of female flowers and fruit set as well as fruit size. This result was in agreement with the findings of Hooda *et al.* (1981) [16], Maurya (1987) [17], Singh and Choudhury (1989) [28], Gedam *et al.* (1998) [12], Alimishaal *et al.* (1984) [1] and Verma *et al.*

(1984) [30].

Based on these findings, it is summarized that PGR and boron both played a significant role in in regulating vegetative growth, flowering, modifying sex, sex-ratio and ultimately in fruit characters and their yield. Different chemicals had manifested their effects in different ways for vegetative characters, GA and ethrel were found to be more beneficial but with respect to floral characters and yield GA, ethrel and MH as well as boron (borax) also showed promising effects. However, ethrel 100 ppm and GA 100 ppm were superior to rest of PGR levels. Boron application was also found better than control. The interaction effect of PGR and boron (PGR x B) was statistically non-significant, but the best effect was observed in the treatment combination B_1E_{100} closely followed by B_1GA_{100}. Therefore, it can be safely concluded that seed soaking in 0.5% borax (0.05% boron) solution for 12 hours and spraying of ethrel 100 ppm or GA 10 ppm of two and four true leaf stages should be done in bottle gourd cultivation to get higher yield. However, detail studies and critical assessment on these aspects would bring in light of more spectacular result in this valuable crop.

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Table 1: Effect of boron and PGRs on different characters of bottle gourd at BAU, Kanke, Ranchi

Treatment	**Main vine length (cm)**	**Number of leaves/vine**	**Number of nodes/vine**	**Number of branches/vine**	**Intermodal length on main vine (cm)**	**Number of days to 1st flower initiation**	**Number of days to 1st male flower**	**Number of days to 1st female flower**	**1st male flower Node**	**1st female flower Node**
Effect of plant growth regulators (PGR) viz., gibberellic acid (GA), maleic hydrazide (MH) and Ethrel (E)										
GA_{50}	222.67	110.33	26.90	8.63	8.19	52.47	57.73	71.13	4.50	10.00
GA_{100}	274.84	123.20	32.50	9.80	8.48	52.67	55.83	70.43	4.13	9.13
MH_{50}	167.50	84.50	22.57	8.13	7.83	52.93	55.70	74.90	5.80	10.93
MH_{100}	150.84	71.20	22.80	7.27	7.43	52.47	54.63	72.20	5.20	9.50
$Ethrel_{50}$	177.34	93.27	24.50	8.80	7.24	53.53	59.57	70.83	4.90	10.13
$Ethrel_{100}$	157.00	84.77	24.23	9.93	6.50	53.07	57.60	68.07	4.30	8.87
Control	187.67	97.80	24.90	7.23	7.53	56.43	61.30	76.50	6.80	12.40
CD (0.05)	18.50	9.104	2.66	1.08	0.54	2.44	3.37	3.40	0.68	0.82
Effect of boron										
B_0 (Control)	186.81	91.74	25.11	8.26	7.44	53.62	58.20	73.80	5.35	10.65
B_1 (0.05%)	195.43	98.36	25.87	8.83	7.76	53.11	56.76	70.22	4.83	9.63
CD (0.05)	NS	4.87	NS	NS	0.29	NS	NS	1.82	0.37	0.44

Table 1: Cont…….

Treatment	**Number of male flower/vine**	**Number of female flower/vine**	**Sex ratio (M/F)**	**Days to fruit maturity**	**Fruit length (cm)**	**Fruit Diameter (cm)**	**Average fruit weight (kg)**	**Number of fruit/vine**	**Yield/vine (kg)**	**Yield/ha (q)**
Effect of plant growth regulators (PGR) viz., gibberellic acid (GA), maleic hydrazide (MH) and Ethrel (E)										
GA_{50}	29.53	6.13	4.85	83.83	39.40	7.30	1.013	3.47	3.533	156.28
GA_{100}	31.17	7.27	4.30	82.17	42.60	7.97	1.105	3.90	4.318	192.38
MH_{50}	24.03	5.97	4.09	86.33	34.17	6.70	0.931	3.40	3.164	139.88
MH_{100}	23.67	5.67	4.26	83.83	32.47	6.30	1.059	3.30	3.503	154.85
$Ethrel_{50}$	21.13	6.60	3.22	82.67	44.87	7.83	1.110	3.57	3.968	175.43
$Ethrel_{100}$	19.67	7.10	2.79	79.67	45.03	8.20	1.183	3.70	4.413	195.09
Control	26.53	5.57	5.32	88.17	34.60	6.70	0.902	2.80	2.530	111.87
CD (0.05)	2.27	0.66	0.46	NS	4.46	0.81	0.099	0.30	0.507	22.78
Effect of boron										
B_0(Control)	26.17	6.07	4.54	85.81	37.05	7.06	1.001	3.28	3.299	145.85
B_1 (0.05%)	24.04	6.59	3.71	81.81	40.99	7.51	1.085	3.62	3.966	175.78
CD (0.05)	1.22	0.35	0.25	3.22	2.39	0.43	0.053	0.16	0.271	12.18

Table 2: Performance of bottle gourd under different treatment combination of PGR and boron (B)

Boron PGR	**Average fruit weight (kg)**			**Number of fruits/vine**			**Yield/vine (kg)**			**Yield/ha (q)**		
	B_0	B_1	**Mean**	B_0	B_1	**Mean**	B_0	B_1	**Mean**	B_0	B_1	**Mean**
GA_{50}	0.935	1.092	**1.013**	3.20	3.73	**3.47**	2.983	4.083	**3.533**	131.893	180.523	**156.280**
GA_{100}	1.012	1.197	**1.105**	3.80	4.00	**3.90**	3.843	4.792	**4.318**	169.913	214.837	**192.375**
MH_{50}	0.937	0.925	**0.931**	3.20	3.60	**3.40**	2.992	3.336	**3.164**	132.287	147.470	**139.878**
MH_{100}	1.068	1.050	**1.059**	3.20	3.40	**3.30**	3.428	3.577	**3.503**	151.567	158.123	**154.845**
$Ethrel_{50}$	1.093	1.127	**1.110**	3.33	3.80	**3.57**	3.642	4.295	**3.968**	161.000	189.867	**175.433**
$Ethrel_{100}$	1.122	1.243	**1.183**	3.47	3.93	**3.70**	3.914	4.912	**4.413**	173.023	217.147	**195.085**
Control	0.840	0.963	**0.902**	2.73	2.87	**2.80**	2.291	2.770	**2.530**	101.270	122.463	**111.867**
Mean	**1.001**	**1.085**	**1.043**	**3.28**	**3.62**	**3.45**	**3.299**	**3.966**	**3.633**	**145.850**	**175.776**	**160.813**
CV %												
Source	**SE**	**CD(0.05)**	**CD(0.01)**	**SE**	**CD(0.05)**	**CD(0.01)**	**SE**	**CD(0.05)**	**CD(0.01)**	**SE**	**CD(0.05)**	**CD(0.01)**
PGR	**0.034**	**0.099**	**0.133**	**0.013**	**0.300**	**0.405**	**0.175**	**0.507**	**0.686**	**7.841**	**22.780**	**30.811**
Boron (B)	**0.018**	**0.053**	**0.071**	**0.055**	**0.160**	**0.217**	**0.093**	**0.271**	**0.367**	**4.191**	**12.176**	**16.469**
PGR x B	**0.048**	**NS**	**-**	**0.146**	**NS**	**-**	**0.247**	**NS**	**-**	**11.089**	**NS**	**-**

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