academicJournals

Vol. 8(8), pp. 361-367, 25 February, 2014
DOI: 10.5897/JMPR10.032
ISSN 1996-0875

http://www.academicjournals.org/JMPR

Journal of Medicinal Plant Research

Full Length Research Paper

Altered sex expression by plant growth regulators: An overview in medicinal vegetable bitter gourd (*Momordica charantia* L.)

MA Baset Mia[1,2*], MS Islam[3] and ZH Shamsuddin[1]

[1]Department of Land Management, Faculty of Agriculture, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor DE, Malaysia.
[2]Department of Crop Botany, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur 1706, Bangladesh.
[3]Department of Agricultural Extension, Khamar Bari, Dhaka, Bangladesh.

Received 23 January, 2010; Accepted 15 July, 2010

Bitter gourd is one of the popular vegetables for its medicinal values. It is monoecious cucurbitaceous plants which have imbalance sex ratio of male-female flowers that causes lower fruit yield. Different research works on cucurbits like bitter gourd and other related crops in respect of plant growth regulators, plant nutrients, and priming practices have been conducted in different parts of the world. Literatures related to the present study have been reviewed and found that bitter gourd genotypes produced larger male-female ratio and the induction of male flower was earlier than that of female ones. Growth regulators have significant positive effect on yield and yield components. Application of gibberellic acid (GA_3) enhanced the length of main vine, but decreased the primary branches while ethylene producing chemicals Canadian Environmental Protection Act (CEPA) increased the number of primary branches per plant. Application of auxin like 1-naphthaleneacetic acid (NAA) at 50 and 100 ppm and CEPA at 150 ppm also proved to be effective in inducing earlier female flowers at lower node. Application of CEPA at 150 ppm and NAA at 50 ppm was found to be the best treatments for reducing sex ratio by increasing the female flowers by suppressing the male ones, and consequently induce higher yield.

Key words: Bitter gourd, sex ratio, medicinal plant, yields.

INTRODUCTION

Value added productivity in the agriculture sector can be further enhanced through increasing the values from existing industries by cultivating new commercial crops such as herbal products. Bitter gourd (*Momordica charantia* L.) a medicinal plant, belonging to cucurbitaceous family is one of the most popular vegetables in Bangladesh and also in other Asian countries namely China, Taiwan, Malaysia, Vietnam, Thailand, India and

*Corresponding author. E-mail: miabaset@yahoo.com.

the Philippines. It is adapted to a wide range of environments and can be grown in tropical and subtropical climates (Lim, 1998; Reyes et al., 1994). This vegetable is a different nature's bountiful gifts to mankind, which does not only have fabulous digestional properties, it is a storehouse of remedies for many common ailment. The fruits, leaves and even the roots of *M. charantia* have been used in Ayurveda for a number of diseases such as a bitter stomachic, laxative and anathematic. A compound known as 'charantin' present in the bitter gourd is used in the treatment of diabetes to lower blood sugar level (Anunciado and Masangkay, 2002). The fruit accumulates bitterness with time due to build up of three pentacyclic triterpenes momordicin, momordicinin and momordicilin, and then loses the bitterness during ripening (Begum et al., 1997; Cantwell et al*.,* 1996). The whole extract of the fruit is also advocated in diseases of spleen, liver, rheumatism and gout. The immature fruit of bitter gourd is valued for its bitter flavor, considered to bring out the flavor in other ingredients. It is usually eaten fresh (stuffed and/or sliced) but can also be pickled and has been canned in brine (Vinning, 1995).

The plant also has a rich amount of vitamin C, iron, phosphorus and carbohydrates (Behera, 2004). The small type bitter gourd, 'uchja' fruits contained relatively more protein (2.1%), lipid (1.0%), ash (1.33%) and iron (9.4 mg/100 g) than the large type fruit 'karala', as well as good levels of carbohydrate (7.2%), sugars (0.42%), phosphorous (140 mg/100 g) and ascorbic acid (74 mg/100 g), and was therefore considered to have the best nutritional value (Choudhury, 1990; Kale et al.,1991; Kore et al., 2003). So, 'uchja' is considered as a high priced vegetable throughout the year for its medicinal value and unique taste.

Bitter gourd is a monoecious plant, naturally, inducing greater number of male flowers than the female flowers. This flowering behavior is not advantageous and economical, because it results in lower fruit set and yield, which is a common problem in bitter gourd cultivation. To have the higher yield, the male and female flower ratio needed to be synchronized. Maleness and femaleness can usually be altered by environmental variables such as temperature, photoperiod and nutrition or by the application of plant growth regulators (Krishnamoorthy, 1981).

Attempts have been made to overcome the aforementioned problem, and several investigations have been done in this regard in different parts of the world. Proper and judicious use of plant growth regulators with balanced fertilizer, especially N, P, K is one of the ways to increase the crop yield of bitter gourd. Use of adequate mineral nutrients and balance supply of plants hormone within the plant may play vital role in the control of plant growth and fruit setting capability of bitter gourd. Application of indol acetic acid (IAA) increased the female flowers in cucurbit as suggested by Basu et al*.* (1994). Similarly, higher number of female flower and fruit set in bitter gourd was recorded by enhanced N application (Ali et al., 1995). On the other hand, Samdyan et al. (1994) found that application of N fertilizer in combination of growth regulators produced higher yield as compared to growth regulator alone. Melissa and Nina (2005) reported that exogenous applications of 1-naphthaleneacetic acid (NAA) and gibberellic acid (GA_3) at the 5-leaf stage in bitter gourd induced parthenocarpy. Numerous research works have been done in the use of plant hormones and mineral nutrients separately or in combination, especially in 'uchja'. Keeping these views in mind, the present review works have been initiated with the objectives to investigate the influence of plant growth regulators with mineral nutrients to synchronized male/female flowers by lowering sex ratio and thereby increase fruit setting.

DISCUSSION

Plant growth regulators on growth, sex expression and fruit yield

Exogenous application of growth regulators may shift the sex expression towards femaleness by increasing the production of female flower and suppressing that of male flower in cucurbitaceous plants. Plant growth regulators have positive effect on the production of early flowering and yield. Growth regulators can decrease male and female flower ratio and increasing the number of fruits per plant and individual fruit weight as well as increase the total yield.

The role of plant growth regulators in various physiological and biochemical processes in plant is well known from its identification. Root and flower buds initiation, development of flowers and fruits are controlled by different physiological processes. In many crops like cucurbitaceous ones, these processes can often be altered to man's benefit by proper application of plant growth regulators. The concept that plant growth and development are regulated by a substance produced in minute quantities is one organ that elicits a response in another was first suggested by Julius von Sachs, the father of plant physiology. The term plant growth regulators (PGRs) cover the broad category of organic substances (other than vitamins and nutrients) that in minute amounts, promote, inhibit, or otherwise modify physiological processes (Wareing and Phillips, 1978). The PGRs, where endogenous (phytohormones) or exogenous, elicit essentially the same plant responses. Presently, PGRs are used to control a host of physiological processes in crop production, including flowering and fruiting (fruit set and parthenocarpy), partitioning of assimilate, germination, growth suppression, and post harvest ripening (Weaver, 1975).

The principle in sex modification in cucurbits lies in altering the sequence of flowering and sex ratio. Besides the environmental factors, endogenous levels of auxins, gibberellins, ethylene and abscisic acid, at the time and the seat of ontogeny determine the sex ratio and sequence of flowering (Leopold and Kriedemann, 1975). Exogenous application of plant regulators can alter the sex ratio and sequence, if applied at 2 or 4 leaf stage, the critical stage at which the suppression or promotion of either sex is possible. Hence, modification of sex to desired direction has to be manipulated by exogenous application of plant regulators once, twice or even thrice, at different intervals (Devies, 1987).

Ravindran (1971) reported that the exogenous application of ethral (2-Chlorothyl phosphonic acid) at concentrations ranging from 200 to 600 ppm induced stunting growth, retardation and male sterility and the production of male flowers significantly reduced in bitter gourd. Similarly, in cucumber (*Cucumis sativus* L.), application of ethral up to 500 ppm (Bhandary et al., 1974) increased the female flowers. They stated that ethrel concentration up to 500 ppm delayed male flowering up to 14 days and advanced female flowering by up to 9 days, while number of male flower were also reduced and female flowers increased by the application of same treatments. Higher ethrel concentrations were detrimental, whereas sex expression of snake gourd could be altered by foliar application of ethephon (ethrel) at 250 ppm and fruit yield could also be increased (Cantliffe, 1976). Mishra et al. (1976) reported that in cucumber maximal suppression of staminate flowers was obtained by the application of 400 ppm of ethrel. In case of fruit yield and yield components like number of pistillate flowers, fruit numbers plants^{-1}, fruit size and fruit weight were increased in *Trichosanthes anguina* plants by the application of ethrel at 50 to 150 ppm. The best result was obtained with ethrel at 150 ppm (Ramaswamy et al., 1976). In *Luffa acutangula* seedlings treated with 500, 1000 or 2000 ppm of ethrel, Patnaik et al. (1974) reported that ethephon treated plants produced pistillate flowers only, but the number of fruits and total yield were inferior to those of untreated plants. Verma et al. (1980) reported that ethrel treatments (50, 100, 150 and 200 ppm) were the most effective in increasing the number of female flowers, producing the largest number of fruits and greatest fruit weight plant^{-1} in cucumber. They further reported that all the treatments reduced the number of male flowers.

Krishnamoorthy (1981) studied the effect of ethrel at 250 to 1000 ppm on growth, flowering and sex expression of *Cucurbita pepo* L. They stated that ethrel increased the number of female flowers and decreased of male flowers. Li (1983) reported that ethrel at 200 or 300 ppm could lower the site of the first female flower, promote the appearance of female flowers, increase the number of fruits and leaf area, reduce the number of male flower, fruit setting and increase yields of three cucumbers. The ethylene-releasing chemical, ethrel enhanced the development of pistillate flowers and delays development of staminate flowers of monoecious cucurbits (Sheshadri, 1986).

Sreeramulu (1987) treated the sponge gourd plants at 3-true leaf stage with ethrel solution (100 mg/L). He observed that ethrel not only increased the number of pistillate flowers, but also hastened the appearance of the first female flower. The effect of ethrel on the staminate flowers was the opposite, that is, it delayed the appearance of the first staminate flower and also decreased the total number of female flowers. The sex ratio (staminate: pistillate) is decreased from 12.1:1 to 6.8:1. Plants were sprayed with different growth regulators at the 2 and 4 true leaf stages. The total yield (2.39 kg plant^{-1}) was the highest in plants treated with ethrel (ethephon) at 100 ppm. The average control yield was 0.69 kg plant (Arora et al., 1985). Singh and Choudhury (1988) stated that ethrel at 50 and 100 ppm induced the first pistillate flowers earlier and at lower nodes in cucumber and bottle gourd, but delayed the appearance of female flowers in water melon. Karim et al. (1990) treated hybrid seedlings of cucumber with water, ethephon (250 and 350 ppm) at 1, 2, 3 and 4 leaf stage. Seedlings treated with ethephon at any stage produced more female flowers than water treated plants. The maximum increase in the number of female flowers occurred with 250 ppm ethephon applied at the 2-leaf stage.

Seed germination was not influenced by ethrel and the first female flower development was marginally earlier with ethrel treatment. Al-Masoum and Al-Masri (1999) reported that cucumber cv. Beit Alpha grown in a greenhouse in 1996 to 1997 was treated with ethephon at 250, 350 and 450 ppm at the seedling stage (2 to 4 true leaves). They obtained positive effect of ethephon on the early and total yield, late number of female flowers, number of male flowers, days to the first female flowers, number of nodes to the first female flower, number of nodes to the first male flower and plant height. Ethephon induced femaleness (pistillate flowers) on the main stem that led to greater fruit production.

Negi et al. (2003) studied the effect of ethephon and row spacing on the growth and yield of bitter gourd. Treatments comprised: two ethephon levels (0 and 250 ppm) and three row spacing (1.0, 1.25 and 1.50 m). Ethephon (250 ppm) reduced the length of main vine and number of branches and delayed the appearance of the first male and female flowers. Increasing row spacing increased the total number of female flowers per plant and appearance of the first female flower at the lower nodes. The fruit number as well as total fruit yield per plant increased with increased in spacing and decreased with ethephon application.

Choudhury and Singh (1970) reported that NAA 100 ppm, IAA 100 and 200 ppm, Maleic Hydrazide (MH) 50 and 200 ppm were equally effective in suppressing the male flowers and increasing the number of female flowers in cucumber. The effects subsequently increased the percentage of fruit set and ultimately the yield. Bisaria (1974) found that foliar spray of NAA at 100 ppm increased the number of female flower per plant and the sex ratio was reduced in cucurbits. Pandey and Singh (1976) compared the effects of seed soaking for 24 h in solutions of 2, 4- D at 1.5 ppm, MH and NAA, each at 200 pmm and GA_3 at 50 ppm and foliar spraying with 2, 4-D at 0.5 to 1.0 ppm, applied at the 2 true leaf and 4 to 5 true leaf stages. The number of pistillate flowers of *Luffa cylindrica* was increased by seed treatment with MH and NAA at 200 ppm and by spraying with NAA at 100 and 150 ppm, MH at 100 to 200 ppm and GA_3 at 10 ppm, staminate flower numbers were decreased by MH at 200 ppm, NAA at 100 ppm and GA_3 at 10 ppm. The ratio of pistillate: staminate flower numbers was increased by all treatments except 2, 4-D and GA_3 at 25 and 50 ppm. Fruit set was enhanced by all treatments except GA_3 at 50 ppm and 2, 4-D. Yields were increased by seed treatment with NAA at 200 ppm and by spraying with NAA and MH at 150 and 200 ppm, respectively.

Gopalkrishnan and Choudhury (1978) reported that in contrast with Tri-iodobenzoic acid (TIBA), GA_3 in general produced the largest number of female flowers; GA_3 at the lowest concentration of 10 ppm produced more number of female flowers in first year. In the first year MH 100 to 600 ppm as well as NAA and IAA at 50 to 150 ppm induced larger number of female flowers. TIBA from 50 to 200 ppm gave a significant increased in the number of fruits and weight of fruits of water melon.

An investigation was conducted to study the influence of various chemicals (ethrel, NAA, Clinical Care Classification (CCC), MH, para-chlorophenoxyacetic acid (PCPA), ascorbic acid and boron) on the growth, flowering and yield of bitter gourd. PCPA at 100 ppm improved plant growth significantly. The treatment of CCC at 250 and 500 ppm produced female flowers about 12 days earlier in comparison to control plant. Maximum fruit yield per plant (3123 g) was produced under CCC 250 ppm followed by ascorbic acid 25 ppm and cycocel 350 ppm (Mangal et al., 1981). Similarly, Ahmad and Gupta (1981) found that the minimum ratio of male to female flower was reached at 1000 ppm of cycocel in case of smooth gourd and at 1500 ppm in bottle gourd and snake gourd. Nodes per female flower as well as days to flower were minimum at 1000 ppm in snake gourd and 1500 ppm in smooth gourd and bottle gourd. Earliest node for first female flower was observed at 1000 ppm in smooth gourd and snake gourd but at 1500 ppm in bottle gourd.

Verma et al. (1984) found that ethrel 100 ppm delayed the appearance of first male and female flowers. Application of MH 200 ppm and boron 3 and 4 ppm produced the earliest female flowers, but at a higher node, while ethrel 100 ppm induced the first staminate and pistillate flower at the lowest nodes at 6.5 and 9.5, respectively. Boron 4 ppm also proved superior to all and MH 100 ppm did not response much. The number of fruits per plant and average weight of fresh fruit was increased significantly in both varieties.

Islam (1995) stated that application of GA_3 was effective in improving the yield components of bitter gourd when applied at low concentration of 10 ppm. The inhibitory effect of GA_3 applied at the rate of 100 ppm was observed on production of fruits with lesser number of filled seeds, dry matter of seeds, weight of 100 seeds, seed yield and percent seed vigor index. Irrespective of concentration, the application of GA_3 reduced the total number of staminate flowers. The ratio between the staminate and pistillate flowers as fruit setting was low. The number, length, diameter and weight of fruits were not influenced by GA_3 application. Wang and Zeng (1996) reported that gibberellic acid at 25 to 100 ppm increased the number of female flowers up to 80 days. Baruah and Das (1997) observed that plants sprayed with NAA at 25 ppm and MH at 50 ppm produced the best yields (5.48 and 4.86 kg $plant^{-1}$, respectively) in *Lagenaria siceraria*. Yield decreased with late sowing dates from 5.49 to 2.62 kg $plant^{-1}$. Tomar and Ramgiry (1997) conducted an experiment and found that plants treated with GA_3 showed significantly greater plant height, number of branches $plant^{-1}$, number of fruit $plant^{-1}$ yield.

Gedam et al. (1998) conducted an experiment in 1992 where bitter gourd plants were sprayed at 40, 55, 70, 80 and 100 days after sowing with GA_3 at 15, 25 and 35 ppm, NAA at 50, 100 and 150 ppm, ethephon at 50, 100, and 150 ppm, MH at 100, 200, and 300 ppm and boron at 2, 4 and 6 ppm with water (control). GA_3 at 35 ppm produced the earliest female flower and NAA at 50 ppm produced the earliest male flower. Fruit maturity was the earliest in plants treated with 50 ppm NAA or 4 ppm boron. Fruit and seed yields were also the highest in these treatments. Melissa and Nina (2005) reported that exogenous applications of NAA and GA_3 at the 5-leaf stage induced parthenocarpy. Fruit length of bitter gourd treated with NAA decreased significantly compared with that of the control. The fruit diameter increased significantly at 100 ppm NAA, possibly due to larger cell size induced by this growth substance. Treatment with GA_3 did

Table 1. Effect of different levels of plant growth regulators and NPK fertilizers on sex expression in bitter gourd.

Treatment	Days to flower		Node of first flowering		Flowers plant^{-1}		Sex ratio
	Male	Female	Male	Female	Male	Female	(M/F)
Plant growth regulators (ppm)							
Control	38	53	10.50	12.20	310	27.42	11.31
GA_3 50	35	49	9.55	11.80	383	29.42	13.02
NAA 50	37	41	8.45	7.00	250	35.14	7.48
NAA 100	36	46	10.75	8.90	285	33.43	8.11
CEPA 150	40	42	8.50	6.50	210	38.33	5.48
CEPA 300	33	43	6.25	9.70	342	31.43	10.88
LSD ($_{0.05}$)	0.95	0.75	0.35	0.85	12.45	1.65	0.55
NPK fertilizers (kg ha^{-1})							
$N_0 P_0 K_0$	45	48	15	9.50	175	24.47	7.15
$N_0 P_{45} K_{60}$	36	46	13	8.83	235	27.26	8.62
$N_{60} P_{45} K_{60}$	38	45	12	8.33	250	32.95	7.59
$N_{90} P_{45} K_{60}$	37	45	12	7.92	350	38.12	9.18
$N_{120} P_{45} K_{60}$	39	46	13	8.83	310	33.63	9.22
$N_{90} P_0 K_{60}$	38	46	14	9.17	288	28.80	10.00
$N_{90} P_{30} K_{60}$	37	45	13	8.42	345	33.69	10.24
$N_{90} P_{60} K_{60}$	35	44	14	8.58	335	34.21	9.79
$N_{90} P_{45} K_0$	37	46	13	8.83	290	33.86	8.56
$N_{90} P_{45} K_{80}$	37	45	13	8.75	350	38.28	9.14
LSD ($_{0.05}$)	1.05	1.14	1.12	1.75	15.85	1.37	0.98

not significantly increase the fruit length while its fresh weight and diameter decreased significantly at 20 ppm compared with the control.

Our results (Table 1) suggested that Canadian Environmental Protection Act (CEPA) and NAA at both concentrations induced first female flower 10 to 12 days earlier than control at lower nodes, whereas GA_3 induced male flowers earlier to all other treatments. CEPA 150 ppm and NAA 50 ppm increased the total number of female flowers by 40 and 29%, respectively. CEPA 150 ppm proved to be the best treatment for reducing the sex ratio.

Combined effect of plant growth regulators and plant mineral nutrients

Pandey and Singh (1973) found that soil application of up to 100 kg N ha^{-1} increased the number of pistillate and staminate flower and the yield where the sex ratio was not affected in bottle gourd. Application of MH approximately doubled the proportion of female flowers and also increased yield. Combined application of N and MH produced more female flowers and the greater yield. Suresh and Pappiah (1991) conducted a trial with bitter gourd where N and P_2O_5 were applied at 0, 40 and 80 and 0, 30 and 60 kg ha^{-1}, respectively and MH was sprayed at 0, 100 and 200 ppm solution. The highest yield was obtained with 80 kg N and 45 kg P_2O_5 ha^{-1} and 200 ppm MH. Samdyan et al. (1994) conducted field trials where bitter gourd plants received N fertilizer at 25, 50 or 75 kg ha^{-1}, with cycocol at 100 or 250 ppm, ethrel at 50 or 100 ppm, GA_3 at 10 or 25 ppm or MH at 25 or 50 ppm. Nitrogen at 75 kg ha^{-1} produced the thickest rind and highest fruit dry matter (DM) content, while 50 kg ha^{-1} gave the highest flesh weight and ascorbic acid and total soluble solid (TSS) contents. Among the growth regulators, MH at 50 ppm gave the thickest and heaviest rind, while cycocel at 250 ppm gave the highest DM, ascorbic acid and TSS contents and flesh thickness and weight. The combination of 75 kg N ha^{-1} + 50 ppm MH gave the thickest and heaviest rind and thickest flesh. Ghosh and Basu (1983) conducted an experiment to study the effect of plant growth regulators on sex expression in *M. charantia* L. by the application of GA_3, IAA and 3-hydroxymethyl oxindole (HMO). All plant growth regulators stimulated female flowering. Both IAA and HMO accelerated ethylene evolution in the seedlings of this plant. While a low concentration of ethrel promoted flowering. The effect was reversed with increased

Table 2. Interaction effect of different levels of NPK fertilizers and plant growth regulators on initiation of first flower (male and female) of ‘uchja’ (BG-5 genotype) grown in summer, 2007.

NPK fertilizer	*Days to first flowering													
	Control		GA-50		NAA-50		NAA-100		CEPA-150		CEPA-300		Mean	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
$N_0P_0K_0$	49	53	48	49	46	45	38	50	42	44	45	45	45	48
$N_0P_{45}K_{60}$	42	55	32	50	32	42	39	45	38	42	30	44	36	46
$N_{60}P_{45}K_{60}$	45	52	35	48	35	43	35	43	41	41	35	43	38	45
$N_{90}P_{45}K_{60}$	46	53	31	47	36	40	35	46	38	40	33	43	37	45
$N_{120}P_{45}K_{60}$	45	55	35	47	40	40	38	48	40	43	35	45	39	46
$N_{90}P_0K_{60}$	48	53	32	49	39	40	35	44	40	43	32	45	38	46
$N_{90}P_{30}K_{60}$	45	51	36	48	35	41	36	47	37	43	32	41	37	45
$N_{90}P_{60}K_{60}$	43	51	30	49	30	40	38	44	40	42	30	40	35	44
$N_{90}P_{45}K_0$	46	52	35	50	38	42	32	45	42	42	30	43	37	46
$N_{90}P_{45}K_{80}$	45	53	32	48	36	41	36.2	46	40	40	31	42	37	45
Mean	45	53	35	49	37	41	36	46	40	42	33	43	-	-
CV%		4.15		LSD(0.05): F = 4.5,				PGR = 3.25				F × PGR = 6.75		

*No. of days after sowing of seeds. F: Effect of different levels of NPK fertilizers. PGR: Effect of different plant growth regulators. F × PGR = Interaction effect of different levels of NPK fertilizers and plant growth regulators. CV: Coefficient of variance.

concentrations. Surprisingly, GA_3 was the most effective growth regulator in increasing femaleness. In untreated plants, levels of endogenous GA-like substance increased progressively up to the age of 60 days at which the ratio of male to female flowers was lower. Our research findings suggested that combined effect of mineral nutrient NPK at the rates of 90, 45 and 60 kg ha^{-1} with plant growth regulator CEPA 150 ppm was superior to all treatments for increasing the total number of female flowers (Table 1).

Conclusions

Among the many factors which determine the low yield, sex ratio and synchrony of male-female flowers and suitable genotype are more important. Days to first flower initiation, number of total female flower and sex ratio was significantly influence by different genotypes. The days to first male and female flowers varied from 39.4 to 51.17. The results indicated that the days to flowers initiation might be controlled by inherent characters of genotypes.

Application of different doses of plant growth regulators and NPK fertilizer significantly influenced the female flower induction and synchrony of male-female flowers. Application of CEPA at 150 ppm and NAA at 50 ppm produced lower sex ratio by increasing the female flowers by 40 and 28% over control (no spray). Among the plant growth regulators, CEPA is the superior of all for producing maximum number of female flowers $plant^{-1}$. On the other hand, the combined effect of treatment $N_{90}P_{45}K_{60}$ with CEPA 150 ppm was better for producing higher number of female flowers $plant^{-1}$ by enhancing the maximum branches $plant^{-1}$ (Table 2).

Conflict of Interests

The author(s) have not declared any conflict of interests.

REFERENCES

Ahmad I, Gupta PK (1981). Effect of cyocel on sex expression in three members of cucurbitaceae. Indian J. Hort. 38:100-102.

Ali N, Rehman M, Hussain SA (1995). Response of *Momordica charantia* L. (Bitter gourd) cultivars to nitrogen levels. Sarhad J. Agric. 11(5):585-589.

Al-Masoum AA, Al-Masri H (1999). Effect of ethephon on flowering and yield of monoecious cucumber. Egyptian J.Hort. 26:229-236.

Anunciado RVP, Masangkay JS (2002). Effects of bitter gourd (*Momordica charantia* L.) administration on alloxan-induced diabetic mice. Philippine-J. Vet. Med. 39(15):15-20.

Arora SK, Pandita ML, Partap PS, Sidhu AS (1985). Effect of ethephon, GA_3, MH and nitrogen on vegetative growth, flowering and fruiting of cucurbitaceous crops. J. Am. Soc. Hort. Sci. 32(5):392-395.

Baruah GKS, Das RK (1997). Effect of plant growth regulators on vegetative growth, flowering and yield of bottle gourd at different sowing dates. Ann. Agric. Res. 18(3):371-374.

Basu PS, Banerjee S, Susmita D (1994). Hormonal regulation of flowering and fruit development: effects of dikegulac on flowering, fruit setting and development of *Momordica charantia* L. and *Luffa acutangula*. Indian J. Plant Physiol. 37 (4):282-285.

Behera TK (2004). Heterosis in bittergourd. J. New Seeds 6(2/3):217-222.

Bhandary KR, Shetty KPV, Sulikeri GS (1974). Effect of ethrel (2-Chloro ethyl phosphonic acid) on the sex expression and yield of cucumber

(*Cucumis sativus* L.). Progressive Hort. 6(2/3):49-57.
Bisaria AL (1974). Sex expression and fruit development in cucumber as effect by gibberellins. Indian J. Hort. 16:233-235.
Cantliffe DJ (1976). Improved fruit set on cucumber by plant growth regulator sprays. Proceedings of the Florida State Hort. Soc. 89:94-96.
Cantwell M, Nie X, Zong RJ, Yamaguchi M (1996). Asian vegetables: Selected fruit and leafy types. Progress in new crops. Ed.: Janick, J. Arlington, VA, ASHS Press pp. 488-495.
Choudhury B (1990). Vegetables, National Book Trust, India, A-5. Green Park, New Delhi- 110016. p. 165.
Choudhury B, Singh N (1970) Chemical sex modification and its effect on fruiting of cucumber (*Cucumis sativus* L.) at three locations. Indian J. Hort. 27(3/4):180-183.
Devies PJ (1987). Plant hormones and their role in plant growth and development. Kluwer Academic Publishers, London pp. 232-239.
Gedam VM, Patil RB, Suryawanshi YB, Mate SN (1998) Effect of plant growth regulators and boron on flowering, fruiting and seed yield in bitter gourd (*Mormordica charantia* L.). Seed Res. 26(1):97-100.
Ghosh S, Basu PS (1983). Hormonal regulation of sex expression in *Momordica charantia L.* Physiol. Plant. 57(2):301.
Gopalkrishnan PK, Chowdhury B (1978). Effect of plant growth regulators sprays on modification of sex ratio, fruit set and development in watermelon (*Citrullus lanatus*). Indian J. Hort. 35:235-241.
Islam MS (1995) Seed production studies on bitter gourd (*Momordica charantia*). Seed Sci. 33:121-123.
Kale AA, Gadakh SR, Adsule RN (1991). Physico-chemical characteristics of improved varieties of bitter gourd (*Momordica charantia* L.). Maharashtra J. Hort. 5(2):56-59.
Karim AJ, Splittstoesser WE, Skirvin RM (1990). Ethephon and gibberellic acid influence sex expression of glasshouse grown cucumbers. Plant Growth Regulators Soc. Am. 18(2):67-72.
Kore VN, Dhanwate HP, Thorat ST, Mahajan TS, Patil RS, Mane AV (2003). Comparative studies on chemical composition of fruits and fruit yield of improved bitter gourd (*Momordica charantia* L.) genotypes. J. Soil Crop 13(1):91-94.
Krishnamoorthy HN (1981). Plant growth substances. Tata McGraw-Hill Publishing Company Ltd. New Delhi pp. 169-175.
Leopold AC, Kriedemann PE (1975). Plant growth and development. 2^{nd} Ed. Tata McGraw-Hill Publishing Company Ltd. New Delhi pp. 138-326.
Li G (1983). A preliminary report on the influence of ethrel on the growth and yield of cucumber. Acta Horticult. Sin. 10(2):119-124.
Lim TK (1998). Loofahs, gourds, melons and snake beans. The New Rural Industries. Ed.: K. W. Hyde. Canberra, Rural Industries Research and Development Corporation pp. 212-218.
Mangal JL, Pandita ML, Singh GR (1981). Effect of various chemicals on growth, flowering and yield of bitter gourd (*Mormordica charantia*). Indian J. Agric. Res. 15(3):185-188.
Melissa FT, Nina MC (2005) Effects of naphthaleneacetic acid (NAA) and gibberellic acid (GA_3) on fruit morphology, parthenocarpy, alkaloid and chlorophyll content in bittergourd (*Momordica charantia* L. 'Makiling'). Philippines Agric. Sci. 88:35-39.
Mishra RS, Panigrahi RK, Panda SC (1976). Chemical regulation of sex expression in relation to growth and yield in cucumber. Orissa J. Hort. 4(1/2):57-61.
Negi PK, Khurana SC, Singh VP (2003). Effect of spacing and ethephon on growth and yield of bitter gourd. Haryana J. Hort. Sci. 32(3/49):276-278.
Pandey RP, Singh K (1976). Effect of plant growth regulators on sex expression, fruit set and yield of sponge gourd (*Luffa cylindrica* Poem.). Hortic. Abstract 499(11):733.
Patnaik A, Mishra RS, Nayak GC, Maharana T (1974). Effect of cycocel and ethrel on sex expression and yield of ridge gourd. Bangladesh Hort. 2(2):19-22.
Ramaswamy NC, Govindaswamy V, Ramanujam C (1976). Effect of ethrel and planofix on flowering and yield of snake gourd (*Trichosanthes anguina* L.). Annamalai Agric. Univ. Ann. Res. 6:187-189.
Ravindran DN (1971). Effect of photopeiod and growth substances on sex expression in snake gourd (*Trichosanthes anguina* L.). South Indian Hort. 15:1-21.
Reyes MEC, Gildemacher BH, Jansen GJ (1994). *Momordica charantia* L. Plant Resources of South-East Asia: Vegetables. (Ed.: Siemonsma JS, Piluek K). Wageningen. The Netherlands Pudoc Scientific Publishers pp. 206-210.
Samdyan JS, Srivastava VK, Arora SK (1994). Use of growth regulators in relation to nitrogen for enhancing quality indices of bitter gourd (*Mormordica charantia*). Haryana Agril. Univ. J. Res. 24:102- 106.
Sheshadri VS (1986). Cucurbits. In: Vegetables Crops in India, edited by T. K Bose and M. G. Som. 1986. Naya Prokash, Calcutta, India. pp. 91-166.
Singh RK, Choudhury B (1988). Differential response of chemicals on sex modification of three genera of cucurbits. Indian J. Hort. 45(1-2):89-99.
Sreeramulu N (1987). Effect of ethrel on sex expression and endogenous auxin content in sponge gourd (*Luffa cylindrica*). Indian J. Hort. 35:85-87.
Suresh J, Pappiah CM (1991). Growth and yield of bitter gourd as influenced by nitrogen, phosphorus and maleic hydrazide. South Indian Hort. 39(5):289-291.
Tomar I S, Ramgiry S R (1997) Effect of plant growth regulators on yield and yield attributes in tomato (*Lycopersicon esculentum* Mill.). Advance Plant Sci. 10(2):29-31.
Verma V K, Sirohi P S, Choudhury B (1980). Note on the response of chemicals to treatment of sex expression and fruiting in bitter gourd. Indian Journal of Horticulture 41: 113-115.
Verma VK, Sirohi PS, Choudhury B (1984). Chemical sex modification and its effect on yield in butter gourd. Progressive Hort. 16(1-2):52-54.
Vinning G (1995). Market Compendium of Asian Vegetables. RIRDC Research Paper No. 95/12. Canberra, Rural Industries Research and Development Corporation. p. 386.
Wang QM, Zeng GW (1996). Effects of gibberellic acid and cycocel on sex expression of *Momordica charantia.* J. Zhejiang Agric. Univ. 22(5):541-546.
Wareing PF, Phillips IDJ (1978). The control of growth and differentiation in plants, 2^{nd} edition. Oxford and New York: Pergamon. pp. 155-157.
Weaver RJ (1975). Plant growth substances in agriculture. W. H. Freeman and Company. San Francisco. pp. 2-3.