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Study on effect of plant growth regulators on vegetative growth of summer okra (*Abelmoschus esculentus* L. Moench) Var. Varsha Uphar

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Abstract
Growth and fruiting pattern of okra (*Abelmoschus esculentus* L. Moench) CV. Varsha Uphar as affected by the growth regulators cycocel (CCC), paclobutrazol (PBZ) and ethrel were evaluated in field studies. High temperature and high humidity resulting more vegetative growth as compare to reproductive growth. Growth retardant suppresses the vegetative growth and promotes reproductive traits. Therefore, different concentrations of CCC (200, 400 & 600 ppm), PBZ (150, 250 & 300 ppm) and ethrel (150, 250 & 300 ppm) were sprayed on okra plants at 30 DAS stage, to ascertain their impact on plant growth. Observations were recorded on various traits and concluded that the lowest plant height, internodal length, highest number of leaves, leaf area, and petiole length of leaves per plant were recorded most in CCC @ 600 ppm while maximum number of nodes, lowest absolute growth rate (AGR) and relative growth rate (RGR) of plant, fruit length and ascorbic acid were higher in ethrel @ 300 ppm.

Keywords: Okra, CCC, PBZ, Ethrel, foliar spray, growth and yield

Introduction

Okra (*Abelmoschus esculentus* (L.) Moench, 2n=130) is considered to be one of the most important vegetables in India and many countries, especially during summer season. India is a largest producer (72.9%) of okra (Bhindi) in the world (Anonymous, 2014) [1]. It's green fruits has high food value, and rich in some nutritional elements (*i.e.* Ca, Mg & P). Also it contains some vitamins with medium percentages (Riboflavin, Thiamin, Vitamin-C & Vitamin-A) (Matloob *et. al.*, 1989) [16], which can help in minimizing their deficiency in the daily diet. Furthermore, okra is used in food processing, oil (the ripe seeds contain about 20% edible oil), paper and sugar industry (Reddy *et. al.*, 1997) [25].

All over India, its immature tender fruits which are botanically called capsules are used as vegetable. The roots and stems of okra are used for clearing the sugar cane juice while preparing jaggery and sugar. Its ripe black or brown white-eyed seeds are sometimes roasted, ground and used as a substitute for coffee in Turkey (Mehta, 1959) [17].

Generally, an okra plant produces one flower in a different leaf axil each day (Tanda, 1985) [29]. The immature fruits are ready for fresh-market harvest between 4 and 7 days after anthesis (Kolhe and Chavan, 1964; Sistrunk *et al.*, 1960) [12, 26]. After the 7th day, fibrousness of the pods increases rapidly, rendering them inedible. The extended period of fruit set makes okra harvesting labor intensive.

Growth and yield of okra depends upon many factors including seed quality, nutrition, climatic conditions and cultural practices (Kusvuran, 2012) [13]. Chemical substances like plant growth regulators can bring changes in the phenotypes of plants and affect growth either by enhancing or by stimulating the natural growth regulatory systems from seed germination to senescence (Das and Das, 1995) [5]. These can improve physiological efficiency of plants including photosynthetic capacity and effective partitioning of assimilates. The productivity in field crops can be increased by stimulating the translocation of photo-assimilates (Solaimalai *et al.*, 2001) [27].

Although plant growth regulators have great potential for growth improvement but their application has to be planned sensibly in terms of optimal concentration, stage of application, species specificity and seasons. These are considered as new generation of agrochemicals after fertilizers, insecticides and herbicides. Plant physiologists have recognized two well defined groups of plant growth substances viz., cycocel, paclobutrazol (growth retardents) and senescent hormone ethylene. The use of plant growth regulators has led to intensive scientific activity for their commercial exploitation. The effects of plant growth regulators vary with the stage of plant development, weather conditions (temperature and light intensity) and time of the year (Hirose, 1981; Wilson *et al.,* 1981) [10, 32].

Materials and Methods

The study was conducted to see the effect of plant growth regulators on growth and yield of summer okra cv. Varsha Uphar during the summer season in 2014 at nursery No. 4, Department of Horticulture, College of Agriculture. The experiment was laid out in Randomized Block Design with ten treatments having three replication. The treatments comprising different concentrations of CCC (200, 400 & 600 ppm), PBZ (150, 250 & 300 ppm), Ethrel (150, 250 & 300 ppm) and control. All foliar spray was given at 30 days after sowing. One week before final cultivation, pre-emergence chemical weed control was with Tok E-25 (5L/ha) for all plots. During the season two hoeing were done. All plots were irrigated six times. The seeds were sown in the plots maintaining a distance of 60 cm apart of row and 20 cm between plants. After 15 days of sowing seedlings were thinned out leaving only one seedling $hole^{-1}$. Intercultural operations were done as and when necessary. Insecticide for control of White Fly at 25 days interval was sprayed. Ten plants were selected for data collection. The observation were recorded at 30, 60, 90 DAS and at last harvest. The data were analyzed statistically with standard procedure. The data recorded on different characteristics were plant height (cm), number of nodes per plant, intermodal length, number of leaves per plant, petiole length of leaves, absolute growth rate and relative growth rate etc. The mean values of all the recorded characteristics were evaluated and analysis of variance was performed using the 'F' (variance ratio) test.

Results and Discussion

Effect of plant growth regulators on vegetative growth of okra

The foliar application of plant growth regulators significantly improved growth related traits.

Plant height (cm)

The data presented in Table 1 revealed that the concentration and application method of regulators *viz.,* CCC, PBZ and ethrel was found to be significant and decreased the plant height significantly as compare to control. The lowest height of plant at last harvest was recorded in treatment T_3 *i.e.* CCC @ 600 ppm (84.17cm) followed by T_2 (86.38 cm), T_6 (89.56 cm), T_5 (91.63 cm) and T_1 (91.69 cm). Significantly the highest plant height (124.13 cm) was noticed in T_{10} (control). The reason for reduction in height of plant might be that cycocel produced shorter stem length through inhibition of cell division. Cycocel interact with gibberellins or lower the levels of diffusible auxin and thereby suppress vegetative growth (Gowda and Gowda, 1983) [8]. These results are in conformity with that of Pateliya *et al.* (2008) [20] with CCC and ethrel and Chutichudet *et al.* (2007) [4] in okra with PBZ.

Number of nodes per plant

Significantly the highest number of nodes per plant was noticed in treatment T_9 *i.e.* ethrel @ 300 ppm (20.96) followed by T_8 (19.86) and T_3 (19.42). Cycocel reduced intermodal length by restricting the cell division hence, it increase the number of internodes (Tosh *et al.,* 1978) [31]. The findings were closely in confirmation with the results observed by Prasad and Srihari (2008) [23] with CCC and ethrel.

Intermodal length (cm)

The lowest internodal length (4.44 cm) was noticed in T_3 *i.e.* CCC @ 600 ppm followed by T_9 (4.76 cm), T_2 (4.81 cm), T_6 (4.83 cm) and the highest internodal length (7.44 cm) was noticed in T_{10} (control). The length of internodes was decreased with increased in concentration of cycocel, the growth of intemodes was short mainly due to cycocel which restricted cell division and elongation in the apical meristem, hence, length of intemodes was decreased (Patil *et al.,* 2008) [21]. Reduction in internodal length with increasing concentration in present study have been found by Nawalkar *et al.* (2007) [18], Mandal *et al.* (2012) [14] with respect to CCC in okra, Rai *et al.* (2006) in tomato regarding with PBZ and Ouzounidou *et al*. (2010) [19] with ethrel in capsicum.

Leaves per plant

Significantly the highest number of leaves per plant were recorded in treatment T_3 *i.e.* CCC @ 600 ppm (27.72). Whereas, lowest was in control (21.78). The number of leaves was increased with increased in concentration of cycocel. It might be due to cycocel effective in suppressing apical dominance, there by promote the growth of lateral buds in to new shoots (Arora and Dhankhar, 1992) [2]. Similar trends of results also obtained Mandal *et al.* (2012) [14] with CCC in okra and Marsh *et al.* (1990) [15] with ethrel in okra.

Petiole length of leaves (cm)

The highest (20.40 cm) petiole length of leaves was recorded in T_7 *i.e.* ethrel @ 150 ppm and was significantly superior over all except T_1 (20.05 cm).The treatment T_3 *i.e.* CCC @ 600 ppm recorded the lowest (16.69 cm) petiole length of leaves.

Total leaf area (dm^2)

Significantly the highest leaf area (33.22 dm^2) was produced by T_3 *i.e.* CCC 600 ppm. Whereas, the lowest leaf area (26.72 dm^2) was produced by T_{10} *i.e.* control. The result obtained in present investigation as regards to leaf area increased with increase in concentration of CCC. It might be due to CCC have the ability to delay senescence of leaf, arresting the chlorophyll degradation and promoting the synthesis of soluble protein and enzyme (Srivastava and Goswami, 1988) [28]. Similar findings were also recorded by Bhagure and with CCC in okra, Joshi (2001) [11] in capsicum, Faten (2003) in okra regarding with PBZ and Deepak *et al.* (2007) [6] with respect to ethrel in okra.

Absolute and relative growth rate (cm/day)

At last harvest, significantly the lowest (0.506 cm) absolute growth rate (AGR) was noticed in T_9 *i.e.* ethrel @ 300 ppm, whereas the highest absolute growth rate (0.760 cm) was noticed in T_{10} *i.e.* control plants. The lowest (0.00255 cm) relative growth rate (RGR) was produced by T_9 *i.e.* ethrel @ 300 ppm followed by T_8 (0.00273) and T_7 (0.00288). The highest (0.00393 cm) relative growth rate was noticed in T_6 *i.e.* PBZ @ 300 ppm followed by T_3 (0.00381 cm) and T_2 (0.00357 cm).

It was found that in the present study that AGR and RGR declined with advancement in the crop growth. The decrease in AGR and RGR due to growth regulators could be due to the effectiveness of these growth regulators in decreasing not only dry matter production but also the rate of increment in total dry matter. The similar effect of growth regulators on AGR and RGR as observed in investigation are accordance with observed by Patil (1994) [22] with CCC in soybean, Hanchinmath (2005) [9] with the application of Lihocin in cluster bean and Tekalign and Hammes (2005) [30] with PBZ in potato.

Table 1: Effect of plant growth regulators on vegetative growth of okra cv. Varsha Uphar

Sr. No.	Treatments	Plant height (cm)	Nodes per plant	Internodal length (cm)	Leaves/plant	Leaf area (dm^2)	Petiole length (cm)	AGR (cm/day)	RGR (cm/day)
1	T_1 – CCC 200 ppm	91.69	16.98	5.41	24.49	30.81	20.05	0.601	0.00337
2	T_2 – CCC 400 ppm	86.38	17.97	4.81	26.20	31.95	18.95	0.594	0.00357
3	T_3 – CCC 600 ppm	84.17	19.42	4.44	27.72	33.22	16.69	0.612	0.00381
4	T_4 – PBZ 150 ppm	98.15	16.56	5.93	23.06	30.71	18.85	0.649	0.00338
5	T_5 – PBZ 250 ppm	91.63	17.79	5.15	24.72	29.91	17.97	0.598	0.00335
6	T_6 – PBZ 300 ppm	89.56	18.53	4.83	25.81	29.58	17.08	0.664	0.00393
7	T_7 – Ethrel 150 ppm	108.27	18.36	5.90	23.64	32.22	20.40	0.621	0.00288
8	T_8 – Ethrel 250 ppm	105.38	19.86	5.30	25.28	31.91	18.23	0.581	0.00273
9	T_9 – Ethrel 300 ppm	97.29	20.96	4.76	26.49	31.07	16.87	0.506	0.00255
10	T_{10} – Control	124.13	16.22	7.44	21.78	26.72	18.68	0.760	0.00311
	S.Em. ±	3.91	0.29	0.20	0.33	0.21	0.26	0.0041	0.00014
	CD (p=0.05)	11.62	0.86	0.59	0.98	0.62	0.78	0.0122	0.00042

AGR (absolute growth rate), RGR (relative growth rate)

Conclusion

On the basis of different characteristics in present investigation, it could be concluded that foliar application of growth regulators like CCC, PBZ and ethrel have the ability to reduce the vegetative growth and enhance shoots and nodes per plant in okra cv. Varsha Uphar. Among the various plant growth regulator treatments tested, the foliar spraying on the okra variety Varsha Uphar with CCC @ 600 ppm, ethrel @ 300 ppm and PBZ @ 150 ppm at 30 days after sowing found to be optimum to reduce plant height and increase nodes and leaves par plant by increasing side shoot growth.

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