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Effect of plant growth regulators on vegetative and phenological characters of okra (*Abelmoschus esculentus* L. Moench)

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ABSTRACT

A field experiment was conducted at Department of Vegetable Science, Odisha University of Agriculture and Technology, Bhubaneswar, consecutively for two years during kharif 2020 & 2021. Foliar spray of PGRs at various concentrations were given to okra crop cv. Utkal Gourav. The experiment was laid out in RBD with three replications and eleven treatments viz.,GA_3 (100 ppm) (T_1), GA_3 (150 ppm) (T_2), NAA (150 ppm) (T_3), NAA (200 ppm) (T_4), Thiourea (250 ppm) (T_5), Thiourea (500 ppm) (T_6), Cycocel (200 ppm) (T_7), Cycocel (250 ppm) (T_8), Paclobutrazol (100 ppm) (T_9), Paclobutrazol (200 ppm) (T_{10}) and Control (T_{11}). The foliar sprays were done at 15 DAS and 30 DAS. All growth parameters significantly performed better as compared to the control. The result revealed that NAA showed higher result with respect to plant height (144.56 cm) and internodal length (8.84 cm).Cycocel 250 ppm recorded significantly better with respect to no. of nodes per plant (21.66), no. of primary branches per plant (3.48), no. of leaves (32.81), leaf area (238.40 cm^2), leaf chlorophyll content (1.396 mg/100 g), days to 50 % flowering (35.00).

***Key words**: Vegetative growth, Yield, Growth promoters, Growth retardants*

Introduction

Okra (*Abelmoschus esculentus* L.) belongs to the family Malvaceae, suitably grown in both Summer and Kharif season. Its centre of origin is Ethiopia. It's a continuous flowering and fruiting crop producing fruit in leaf axil. Flowering and fruiting are the daily phenomenon for this crop. So after 5 to 7 days of anthesis the tender and immature fruit is suitable for consumption (Sistrunk *et al*., 1960). After the 7th day, dietary fibre converted into crude fibre and henceforth the entire pod become inedible. It is often cross pollinated crop (5-12%) (Chadha, 2001). It is an important source of iodine which ultimately controls goiter.

Plant growth regulators created a revolutionary history in both agriculture and horticulture production. They are the organic compound which stimulates different plant physiological processes and plant biochemical processes. They produce in one part of the plant and hence translocated to another part. Some of them enhance the growth and development so that they are called growth promoters and those who retard the growth are known as retardants. In this context GA_3, NAA, Thiourea are growth promoters, whereas cycocel and paclobutrazol are growth retardants.

GA_3 helps in early seed germination, enzyme

production and photosynthates mobilization (Bewley and Black, 1983). Foliar application of GA_3 synchronize flowering and fruit set (Briant, 1974) enhances photosynthesis. It increases number of pods per plant and weight of the seed. NAA helps in cell elongation, cell division, cell enlargement, vascular tissue differentiation and create apical dominance. It increases supply of photosynthates and their efficient mobilization in plants leading to higher fruit length and fruit weight. In case of NAA and GA_3 more metabolic activity of plants with more meristematic activity which resulted higher vegetative growth. Cycocel and Paclobutrazol which are growth retardants induce early flowering, retard vegetative growth so that there will be broader reproductive cycle as well as it reduces duration of the crop. It is a type of cytokinin which suppresses vegetative growth, reduce apical dominance and also reduce lodging effect. So it has a less demand of food material for vegetative growth. Hence after metabolic utilization of photosynthates, excess carbohydrate reserves induces early flowering and accelerate reproductive phase of the plant. which ultimately reduces plant height, increases no. of branches, reduce flower and fruit drops. Keeping pace with the influence of PGRs on growth behaviour of plants, present experiment was designed to study the effect of promoters and retardants on growth traits both phonological and pod characters of okra cv Utkal Gourav.

Materials and Methods

The research work was conducted in the Department of Vegetable Science, Odisha University of Agriculture and Technology, Bhubaneswar, during kharif 2020 and 2021. Foliar spray of PGRs at various concentrations were given to okra crop cv. Utkal Gourav. The experiment was laid out in RBD with three replications and eleven treatments viz., GA_3 (100 ppm) (T_1), GA_3 (150 ppm) (T_2), NAA (150 ppm) (T_3), NAA (200 ppm) (T_4), Thiourea (250 ppm) (T_5), Thiourea (500 ppm) (T_6), Cycocel (200 ppm) (T_7), Cycocel (250 ppm) (T_8), Paclobutrazol (100 ppm) (T_9), Paclobutrazol (200 ppm) (T_{10}), Control (T_{11}). The foliar spray were done at 15 DAS and 30 DAS. In Control, equal quantity of water (without any PGR) was sprayed as in case of other treatments. The foliar spraying was carried out with the help of hand sprayer.

Vegetative Parameters

Plant height (Cm)

The results presented in Table 1 and Figure 1 revealed that during 2020, the application of NAA (200 ppm), T_4 was the best increasing the plant height to maximum (144.56 cm) and is statistically at par with T_3, NAA (150 ppm)(141.21 cm); T_2, (GA_3 150 ppm) (138.78 cm), T_1, GA3 (100 ppm) (133.77 cm). The untreated control plot recorded plant height of 108.27 cm, which significantly lower than T_4, NAA (200 ppm) and T_3 ,NAA (150 ppm). However among the growth retardants T_8 (cycocel 250 ppm) was the best in lowering the plant height up to (87.10 cm) cm and also found statistically at par with T_7, cycocel (200 ppm) (91.29cm), T_{10} (paclobutrazol 200 ppm) (92.18 cm) and T_9 (paclobutrazol 100 ppm) (92.81 cm). However T_8, cycocel (250 ppm) and $T_{10,}$ paclobutrazol (200 ppm) expressed significant height reduction as compared to the control.

No. of branches per plant

Effect of growth regulators on branches also expressed significant effect with T_8 cycocel (250 ppm) and T_{10} paclobutrazol (200 ppm) with number of branches being 3.48 and 3.30 in kharif 2020 which are statistically at par.

Internodal length (Cm)

The effect of growth promoters and growth retardants were studied on internodal distance which is presented in Table 2 and Fig. 2. During first year (2020) the internodal distance was found the highest in $T_{4,}$ NAA (200 ppm) which was statistically at par with $T_{3,}$ NAA (150 ppm). T_8 cycocel (250 ppm) was recorded the lowest internodal length (4.44 cm) which was statistically at par with T_7, cycocel (200 ppm) 4.65 cm and T_9, paclobutrazol (100 ppm) and $T_{10,}$ paclobutrazol (200 ppm) recording internodal length of 5.01 cm and 4.72 cm respectively.

No. of nodesper plant

Observations on no. of nodes per plant was the highest in $T_{8,}$ cycocel (250 ppm) (21.66 cm) followed by T_{10} paclobutrazol 200 ppm (20.43 cm), T_7, cycocel (200 ppm) (19.25 cm) and T_9, paclobutrazol (100 ppm) which are at par and significantly higher than control and all other growth regulators under test during kharif ,2020.

No. of leaves per plant

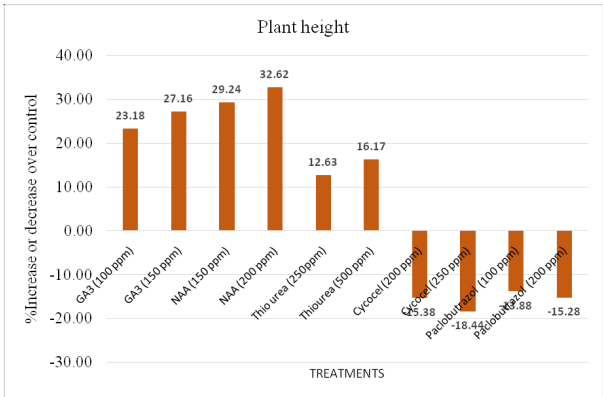
Data presented in Table 2 represented the effect of PGRs on leaves per plant. During kharif 2020, highest number of leaves recorded in T_8, i.e cycocel (250 ppm) (32.81) followed by T_2 GA_3 (150 ppm) (30.39). T10 paclobutrazol (200 ppm) (29.41), T_7 cycocel (200 ppm) (29.33) and T_1 GA_3 (100 ppm) (18.71 cm) and they are statistically at par and significantly higher when compared to T_{11} control (21.88).

Leaf area (Cm^2)

Effect of PGRs demonstrated significantly increase in leaf area with spray of all growth promoters being highest in T_4 NAA (200 ppm)(238.4 Cm^2)closely followed by T_2 GA_3 (150 ppm) (229.66 Cm^2) and T_3NAA (150 ppm) (229.59 Cm^2) are statistically at par in experiment compared to T_{11} control (170.65 Cm^2). T_8 cycocel (250 ppm) was recorded the lowest internodal length (175.71Cm^2) which was statistically at par with T_7, cycocel (200 ppm) (179.88 $Cm^{2)}$ and T_9, paclobutrazol (100 ppm) (189.29Cm^2) and T_{10}, paclobutrazol (200 ppm) (185.29$Cm^{2)}$ which are statistically at par.

Leaf Cholorophyll content (mg/100g)

Data presented in Table 2 revealed the influence of PGRs on chlorophyll content of okra leaf which expressed the superiority of T_8 cycocel 250 ppm in increasing the chlorophyll content (1.396 mg/100g) and found to be statistically significant from all other treatments in Kharif 2020.



Days to 50% flowering

The PGRs effect on various phenological parameters were also studied and data represented in Table 2 and Fig. 2. The data presented in Table 2 represented the superiority of all growth regulators in

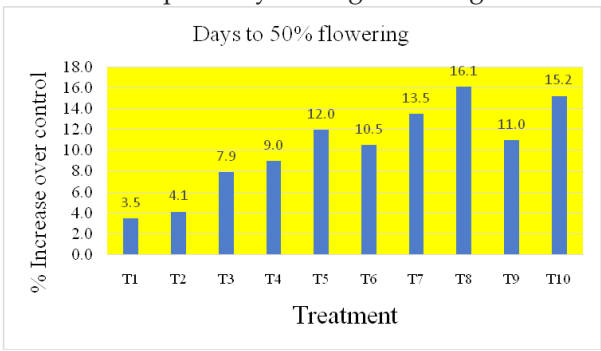


Fig. 2. Percent increase over control in Days to 50% flowering in seed crop of okra cv. Utkal Gourav as influenced by foliar application of growth regulators

Table 1. Effect of foliar spray of plant growth regulators on plant height, no, of branches, no. of nodes and internodal length per plant grown in *kharif* season at peak fruiting stage in cv. Utkal Gourav

Treatments		Plant height (cm)	No.of branches	No. of nodes	Internodal length (cm)
T_1	GA_3 (100 PPM)	133.77	2.74	17.20	6.29
T_2	GA_3 (150 ppm)	138.78	3.17	18.14	6.46
T_3	NAA (150 ppm)	141.21	2.77	16.25	8.58
T_4	NAA (200 ppm)	144.56	2.91	17.33	8.84
T_5	Thio urea (250 ppm)	121.91	2.58	15.24	7.32
T_6	Thiourea (500 ppm)	126.31	2.64	15.53	7.42
T_7	Cycocel (200 ppm)	91.29	2.94	19.25	4.65
T_8	Cycocel (250 ppm)	87.10	3.48	21.66	4.44
T_9	Paclobutrazol (100 ppm)	92.81	2.75	18.71	5.01
T_{10}	Paclobutrazol (200 ppm)	92.18	3.30	20.43	4.72
T_{11}	Control	108.27	1.87	14.11	5.11
	Grand mean	116.19	2.83	17.62	6.25
	S.E.m (±)	5.83	0.13	0.73	0.26
	CD (5%)	17.19	0.39	2.17	0.77

reducing days to 50% flowering. The lowest days to 50% flowering was recorded with cycocel as (35.0) during *kharif*, 2020.

Discussion

PGRs have significant influence on plant height. Generally the growth promoters increase the height and retardants decrease it. The present study resulted highest plant height with NAA (200 ppm) (144.56 cm). The growth retardants Cycocel (250 ppm) recorded lowest plant height (87.10 cm). Significant increase of plant height was also recorded by Baraskar *et al*. (2018), Gadade *et al*. (2017). The present study resulted GA_3 as a second best performer in increasing plant height.

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). These results are in conformity with that of Pateliya *et al*. (2008) with CCC and ethrel and Chutichudet *et al*. (2007) in okra with PBZ.

The no. of nodes per plant was found the maximum with growth retardants Cycocel (250 ppm) (21.56) and paclobutrazol 200 ppm (20.43). This result is corroborated with findings of Moulana *et al*. (2020) who revealed maximum number of nodes per plant (27.21) observed with foliar spray of cycocel (400 ppm). The increased number of nodes might be due to additional availability of cycocel to the plant as foliar application. The increased number of nodes also found with increased concentration of growth retardants which confirmed the present research as revealed with increase in concentration of cycocel and paclobutrazol when the doses increase from 200 to 250 ppm and 100 to 200 ppm respectively. Maharkar *et al*. (2007) and Praveen *et al*. (2018) supported the present result. Cycocel reduced intermodal length by restricting the cell division hence, it increase the number of internodes (Tosh *et al*., 1978). The findings were closely in confirmation with the results observed by Prasad and Srihari (2008) with CCC and ethrel.

The highest internodal length was also recorded with NAA (200 ppm) (8.58 cm) and lowest in Cycocel (250 ppm) (4.44 cm) when compared to control (5.11cm). The foliar spray of cycocel also has been found to promote reduce plant height by reducing the internodal length which simultaneously induce the enhancement of reproductive phase thus giving higher yield Shaik Moulana *et al*. (2020). NAA application might be attributed to enhance auxin activity where GA_3 foliar spray attributed to cell enlargement and internodal elongation which ultimately leads to enhanced growth and development. These two concepts of growth hormone influence on internodal elongation and reduction as agreement with the present findings. Reduction in internodal length with increasing concentration in present study have been found by Nawalkar *et al*. (2007), Mandal *et al*. (2012) with respect to CCC in

Table 2. Effect of foliar spray of plant growth regulators on no. of leaves, leaf area, leaf chlorophyll content and days to 50% flowering grown in *kharif* season at peak fruiting stage in cv. Utkal Gourav

Treatments		No. of leaves	Leaf area (Cm^2)	Chlorophyll content	Days to 50% flowering
T_1	GA_3 (100 PPM)	28.77	219.51	1.198	40.41
T_2	GA_3 (150 ppm)	30.39	229.66	1.382	40.29
T_3	NAA (150 ppm)	27 .00	222.59	1.266	39.00
T_4	NAA (200 ppm)	27.31	238.40	1.304	38.30
T_5	Thio urea (250 ppm)	26.72	207.89	1.171	37.00
T_6	Thiourea (500 ppm)	25.20	206.68	1.253	37.98
T_7	Cycocel (200 ppm)	29.33	179.88	1.380	36.30
T_8	Cycocel (250 ppm)	32.81	175.71	1.396	35.00
T_9	Paclobutrazol(100 ppm)	28.02	189.86	1.243	37.30
T_{10}	Paclobutrazol(200 ppm)	29.41	185.29	1.280	35.31
T_{11}	Control	21.88	170.65	1.053	43.08
	Grand mean	27.98	202.37	1.266	38.18
	S.E.m (±)	1.59	6.03	0.004	1.37
	CD (5%)	4.69	17.79	0.011	4.04

okra, and Ouzounidou *et al*. (2010) with ethrel in capsicum.

The present study revealed the highest number of leaves (32.81) with cycocel (250 ppm) followed by GA_3 (30.39) when compared to control (21.88). Ayubb *et al*. (2013) and Bhagure and Tambe (2013) worked on influence of PGRs on okra also demonstrated the same result. Bhagure and Tambe (2013) reported highest number of leaves and leaf area when seeds of okra soaked with GA_3@100 ppm and foliar spray of cycocel @750 and 1000 ppm sprayed at 30 &45 days respectively. These two PGRs also performed better than others when when experimented with okra cv. Utkal Gourav. Ayubb *et al*. (2013) recorded increase number of leaves with application of GA_3 along with others vegetative and reproductive parameters which supports the better performance of GA_3 in the present findings. 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). Similar trends of results also obtained Mandal *et al*. (2012) with CCC in okra and Marsh *et al*. (1987) with ethrel in okra.

The result obtained in present investigation recorded highest leaf area of (238.40 Cm^2) and (229.66 Cm^2) in NAA (200 ppm) and GA_3(150 ppm) respectively which is being supported by result of Barskar *et al*. (2018) and Kokare *et al*. (2006) 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. Under the influence of plant growth regulators like GA_3, NAA, chitosan and salicylic acid, elongation and multiplication of cell takes place and it may have resulted in large and broader blade size of leaf. It is observed fact, that GA_3 act in cell elongation or cell enlargement resulting in increased in size of leaves. Similar result was also reported by Kokare *et al*. (2006).

The present study revealed maximum chlorophyll content (1.39 mg/100g) with cycocel (250 ppm) foliar spray closely followed by GA_3 (150 ppm) (1.382 mg/100 g) compared to control (1.062 mg/100g). Kokare *et al*. (2006) also reported Cycocel (400 ppm) to increase total chlorophyll content in both leaf and fruit and also decrease the days to 50% flowering. 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. Similar findings were also recorded by Bhagure and with CCC in okra, Joshi (2001) in capsicum, Faten (2003) in okra regarding with PBZ and Deepak *et al*. (2007) with respect to ethrel in okra.

The number of primary branches per plant was found highest with Cycocel (250 ppm) (3.47) followed by paclobutrazol (200 ppm)(3.21), whereas control plot recorded only (1.76) no. of primary branches per plant. Pateliya *et al*. (2008) reported improvement and increase in fruit yield might be due to Cycocel which reduces plant height and increases no. of branches, so that the flow of food materials are diverted for improvement of flowering and fruiting. Jyotsna *et al*. (2022) recorded highest primary branches with growth retardant paclobutrazol. The present findings also recorded more number of branches with cycocel and paclobutrazol.

Days to 50% flowering is one of the important phenological character which expressed earlyness in flowering with cycocel (250 ppm) (35.75) and paclobutrazol (200 ppm) (36.11). Earlier the researchers also reported earliness in flowering due to spray of growth retardants like cycocel & paclobutrazol. Shaik Moulana *et al*. (2020), Kokare *et al*. (2006) and Pateliya *et al*. (2008). Pateliya *et al*. (2008) reported that cycocel (300 ppm) influence early flowering (37.26 days) with a lengthy reproductive phase (67.20 days). The excessive carbohydrate reserve might have induced early flowering and accelerated reproductive phase of the plant. This result is similar to findings of present research where cycocel (250 ppm) is the best performance with respect to early flowering and fruit yield.

Conclusion

The results obtained during the present investigation reveals that the effective concentration of plant growth regulators can be used to improve the growth and yield parameters of okra especially treatment with foliar application of Cycocel and GA_3. So it can be concluded that foliar application of Cycocel (250 ppm) and GA_3(150 ppm) was most effective in enhancing the vegetative parameters and phenological parameters of okra of okra. The yield attributing characters like leaf chlorophyll content, no. of leaves and days to 50% flowering is earlier in T_8 (Cycocel 250 ppm).

References

Arora, S.K., Dhankar, B.S. and Sharma, N.K. 1992. Effect of cycocel and NAA on vegetative growth in flowering, fruit set and incidence of YVMV in okra. *Research and Development Reporter*. 7: 123-129.

Ayubb, C.M., Ahmad, S. and Akhtar, N. 2013. The effect of pre sowing magnetic treatment of okra seeds on growth. Lambert Academic publishing, Germany.

Baraskar, T.V., Gawande, P.P., Kayande, N.V., Lande, S.S. and Naware, M.S. 2018. Effect of plant growth regulators on growth parameters of okra (*Abelmoschus esculentus* L. Moench). *International Journal of Chemical Studies.* 6(6): 165-168.

Bewley, J.D. and Black, M. 1983. Physiology and Biochemistry of seeds in relation to germination. New York: Springer -Verlag.

Bhagure, Y.L. and Tambe, T.B. 2013. Effect of seed soaking and foliar sprays of plant growth regulators on germination, growth and yield of okra *Abelmoschus esculentus* (L.) Moenchvar. Parbhani Kranti. *The Asian Journal of Horticulture.* 8(2): 399-402.

Briant, R.E. 1974. An analysis of the effects of gibberellic acid on tomato leaf growth. *Journal of Experimental Botany.* 25: 764-771.

Chadha, K.L. 2001. *Hand Book of Horticulture* ICAR Pub, 422.

Chutichudet, B., Chutichudet, P. and Chanaboon, T. 2007. Effect of Chemical Paclobutrazol on Growth, Yield and Quality of Okra (*Abelmoschus esculentus* L.) Har Lium Cultivar in Northeast Thailand. *Pak. J of Biol. Sci*. 10: 433-438.

Deepak, K.D., Deshpande, V.K. and Hosamani, R.M. 2007. Chemichal induction of male sterility and histological studies in okra. *Karnataka J. Agric. Sci*. 21(2): 202-205.

Gadade, B.S., Shinde, V.S., Deosarkar, D.B. and Shinde, S.S. 2017. Effect of plant growth regulators on growth and yield of okra (*Abelmoschus esculentus L.*). *Plant Archives*. 17 (1) : 177-180.

Gowda, N.C. and Gowda, P.M. 1983. Effect of inter row spacings and cycocel on growth and yield of bhendi. *South Indian J Hort*. 31(4-5): 210-214.

Jyothi, M. and Tambe, T.B. 2019. Effect of Plant Densities and Cycocel on Fruit and Yield Attributes of Okra, (*Abelmoschus Esculentus.* (L.) Moench) Cv. Parbhani Kranti. *Int. J. Curr. Microbiol. App. Sci.* 8(10): 859-863.

Jyothsna, J., Shanthi, A. and Nadaradjan, S. 2022. Paclobutrazol increases pod yield of okra by altering plant architecture: A case of a growth retardant that outperformed the growth promoters. *The Pharma Innovation Journal*. 11(3): 1568-1576.

Kokare, R.T., Bhalerao, R.K., Prabu, T., Chavan, S.K., Bansode, A.B. and Kachare, G.S. 2006. *Agric. Sci. Digest*. 26 (3): 178–181.

Mahorkar, V.K., Chaitali, T. and Gomase, D.G. 2007. Effect of growth retardant and spacing on growth of summer okra cv. Parbhani Kranti. *The Asian Journal of Horticulture*. 2 (2): 195-198.

Mandal, P.N., Singh, K.P. and Singh, V.K. 2012. Effect of production and plant growth regulators on quality and economics of hybrid okra. *Res. J. Crop Improve.* 3(1): 5-7.

Marsh, L. and Jones, R. 1987. Effect of ethrel on growth and fruiting of okra. *Hort Science.* 22(5): 1037.

Moulana, S., Prasad, V.M. and Bahadur, V. 2020. Effect of different levels of cycocel (CCC) on two different cultivars of okra under Prayagraj Agro climatic conditions (*Abelmoschus esculantus* L. *International Journal of Chemical Studies*. 8(4): 133-136.

Nawalkar, L.R., Khiratkar, S.D., Badge, S.A., Chopde, N.K. and Dadgal, S.S. 2007. Effect of bio-fertilizers and growth regulator with reduced doses of NPK on growth and yield of okra (*Abelmoschus esculentus* (L.) Moench.) cv. Akola Bahar. *J Soil and Crop*. 17(1): 145-149.

Ouzounidoul, G., Ilias, L., Giannakoula, A. and Papadopoulou, P. 2010. Comparative study on the effects of various plant growth regulators on growth, quality and physiology of C*apsicum annuum* L. cv. Standar. *Pak. J. Bot*. 42(2): 805-814.

Pateliya, C.K., Parmar, B.R., Tandel, Y.N. 2008. Effect of different growth retardants on flowering, yield and economics of okra (*Abelmoschus esculentus* L. Moench) cv. go-2 under South Gujarat conditions. *Asian J Hort*. 3(2): 317-318.

Prasad, K.R. and Srihari, D. 2008. *Effect of seed soaking and foliar spray of Cycocel on germination, growth and yield of okra*, Department of Horticulture, College of Agriculture, Rajendranagar, Hyderabad. 36(2): 23-27

Praveen, K., Haldankar, P.M. and Haldavanekar, P.C. 2018. study the effect of plant growth regulators on vegetative growth of summer okra var. Varsha Upahar. *International Journal of Chemichal Studies.* 6(3): 2489-2492

Sistrunk, W.A.L.G. and Miller, J.C. 1960. Okra pod growth habits. *Proc. Amer. Soc. Hort. Sci.* 76: 486-491.