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GROWTH, YIELD AND SEED PRODUCTION OF OKRA AS INFLUENCED BY DIFFERENT GROWTH REGULATORS

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Plant growth regulators (PGRs) affect various aspects of plant physiology, mainly vegetative and reproductive traits including yield and seed production. Therefore, different concentrations (0, 50, 100 & 200 ppm) of gibberellic acid (GA_3) and naphthalene acetic acid (NAA), alone or in different combinations were sprayed on okra plants at 2-true leaf stage, to ascertain their impact on plant growth, pod production, seed yield and seed quality. All variables regarding vegetative and reproductive growth were significantly influenced by different concentrations of the growth regulators except number of days taken to flowering. Growth regulators were less effective when applied individually as compared to their combined use; however, performance of plants treated with individual PGR was better than the untreated plants. The number of leaves plant^{-1} and plant height was higher in plants when sprayed with GA_3 and NAA @ 200+100 ppm as well as with GA_3 and NAA @ 200+200 ppm. The number of pods plant^{-1}, pod length, pod fresh and dry weight, seed yield and seed quality (in terms of germination percentage and 1000-seed weight) was maximum in plants receiving foliar spray of both GA_3 and NAA @ 200+200 ppm. These results signify the role of GA_3 and NAA in okra pod production for fresh consumption as well as for seed yield.
Keywords: *Abelmoschus esculentus*, GA_3, NAA, vegetative growth, reproductive growth.

INTRODUCTION

Okra (*Abelmoschus esculentus* L.) is cultivated since ages, and extensively disseminated from Africa to Asia, southern Europe and America (Ariyo, 1993; Oyelade *et al*., 2003) and currently grown in many countries. Its total annual production in the world was about 4.8 million tonnes; and the share of India (4.528 M tonnes), Nigeria (0.826 M tonnes), Sudan (0.249 M tonnes), Pakistan (0.116 M tonnes), Cote d'Iviore (0.115 M tonnes), Egypt (0.100 M tonnes) and Iraq (0.153 M tonnes) in world production was 70, 15, 4.5, 2, 2, 1.7 and 1.7%, respectively, during year 2009 (FAOSTAT, 2009). It is one of the important summer vegetables in Pakistan.

Growth and yield of okra depends upon many factors including seed quality, nutrition, climatic conditions and cultural practices (Kusvuran, 2012). 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). 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). 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 agro-chemicals after fertilizers, insecticides and herbicides. Plant physiologists have recognized five well defined groups of plant growth substances viz., auxins, GA's, cytokinins, inhibitors (abscisic acid) and senescent hormone ethylene. The use of plant growth regulators has led to intensive scientific activity for their commercial exploitation. Since, 1949 several valuable effects of different plant growth regulators have been studied on a number of horticultural crops such as tomato (Khan *et al.*, 2006), spinach (Akhtar *et al.*, 2008), tuberose (Panwar *et al.*, 2006) and citrus (Nawaz *et al*., 2008). Among them, the use of GA_3, NAA and ethrel were of considerable interest in different field and horticulture crops (Briant, 1974).

The effects 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). For example, GA_3 @ 25 and 50 ppm increased specific leaf weight and leaf area duration in okra when applied as foliar spray after 80 days of sowing as compared to application after 40-60 days of sowing (Surendra *et al*., 2006). The seed treatment with GA_3 @ 100 ppm increased plant height, number of flowers plant^{-1}, fruit size and seed yield in groundnut (Lee, 1990). Moreover, uptake of foliar applied GA_3 was more at high relative humidity and also increased with rise in temperature from 5 to 35°C (Greenberg and Goldschmidt, 1988). Naphthalene acetic acid (NAA), a synthetic auxin, enhances ethylene synthesis in treated flowers and young fruits, which in turn induces abscission of those organs when applied to more mature tissues. However, auxins at low doses reduce abscission possibly by promoting tissue attachment through enhanced differentiation and development of vascular bundles (El-Otmani *et al*., 2000). NAA is also an ingredient of many commercial horticultural products used for rooting of cuttings, inhibition of flower drop, bud shedding and button shedding besides inhibiting sprouting and development of suckers (El-Otmani *et al*., 2000; Williams and Taji, 1989). Gibberellins (GAs) play important role in various features of plant growth and development, such as seed germination (Maske *et al*., 1997), flower development and stem elongation (Yamaguchi and Kamiya, 2000). The cells of developing seeds are stimulated by gibberellic acid to generate mRNA molecules, resulting in the regulation of hydrolytic enzymes (Bidwell, 1974).

Ilias *et al*. (2007) reported that stem and leaf dry masses and stem length were significantly enhanced by the application of exogenous GA. Asghar *et al*. (1997) reported increased pod length, pod diameter and pod yield of okra plants sprayed with GA_3 at different concentrations as compared with the control. But, the studies regarding the use of NAA and its use in combination with GA_3 on okra are lacking. Therefore, the present investigation was aimed to evaluate the effect of GA_3 and NAA alone and at their different combinations on pod and seed yield of okra.

MATERIALS AND METHODS

Seed of okra cultivar Sabz Pari was obtained from Ayub Agricultural Research Institute (ARRI) Faisalabad. Crop was sown on 23rd June 2010 at Vegetable Experimental Area, Institute of Horticultural Sciences, University of Agriculture, Faisalabad, during the year 2010-2011, keeping a net plot size of 600 x 75 cm for each treatment. Urea, di-ammonium phosphate (DAP) and sulphate of potash (SOP) were used to supply Nitrogen, Phosphorus and Potassium @ 125, 75 and 65 kg/ha. There were sixteen treatments and each treatment was replicated thrice. In each replication, 40 seeds (20 seeds on each side) were sown on both sides of raised beds with plant to plant and row to row distance of 30x75 cm. Different concentrations of plant growth regulators, i.e. GA_3 and NAA were applied at 2-leaf stage till run-off, either alone or in combination as mentioned below (Table 1).

Table 1. Concentrations of growth regulators sprayed on okra.

Treatments	Gibberellic Acid (GA_3)	Naphthalene Acetic Acid (NAA)
T_0	Control (No foliar Application)	
T_1	50	-
T_2	100	-
T_3	200	-
T_4	-	50
T_5	-	100
T_6	-	200
T_7	50	50
T_8	50	100
T_9	50	200
T_{10}	100	50
T_{11}	100	100
T_{12}	100	200
T_{13}	200	50
T_{14}	200	100
T_{15}	200	200

The experiment was laid out according to the Randomized Complete Block Design (RCBD). The data on different growth and yield attributes as well as seed germination percentage (AOSA, 1990) and 1000 seed weight were collected and statistically analyzed by using computer software MSTAT-C (Russel and Eisensmith, 1983). Analysis of variance technique was employed to test the overall significance of the data, while the Least Significant Difference (LSD) test ($P \leq 0.05$) was used to compare the differences among treatment means (Steel *et al*., 1997).

RESULTS AND DISCUSSION

***Changes induced by PGRs in vegetative growth of okra*:** The application of both PGRs, either alone or in combination significantly improved growth related traits. The maximum number of leaves (50.27) and branches (4.53) plant^{-1} as well as plant height were recorded in plants sprayed with solution containing both GA_3 and NAA @ 200 +100 ppm. However, it was statistically at par with either the combined application of both regulators @ 200+200 ppm, or when both regulators were mixed and sprayed @ 100+100 ppm (Table 2).

Surprisingly, application of GA_3 @ 100 ppm and 200 ppm and that of NAA @ 50 and 200 ppm, did not improve any plant growth related trait in this trial in comparison with GA_3 @ 50 ppm and NAA @ 100 ppm (Table 2). The induction of foliage and branching as well as increased plant height at maturity was more pronounced in plants treated with 100 ppm of NAA alone and/or in combination with different concentrations of GA_3. So, the synergistic effect of different concentrations of NAA (50 and 100 ppm) in combination with increasing dose

Table 2. Vegetative growth patterns of okra in response to PGRs.

Treatments	Number of leaves plant^{-1}	Number of branches plant^{-1}	Plant height at maturity (cm)
T_0 Control (No foliar Application)	28.9 f	2.3 h	39.1 j
T_1 50 ppm GA_3	37.6 de	3.6 cdef	43.6 ghi
T_2 100 ppm GA_3	37.4 de	3.4 defg	44.2 fghi
T_3 200 ppm GA_3	30.7 f	2.9 g	42.7 hi
T_4 50 ppm NAA	32.5 ef	3.1fg	48.1cde
T_5 100 ppm NAA	41.3 cd	3.8 bcde	46.9 efg
T_6 200 ppm NAA	32.9 ef	3.2 efg	45.3 fgh
T_7 50 + 50 ppm GA_3 + NAA	40.9 cd	3.9 abcd	49.9 bcd
T_8 50 +100 ppm GA_3 +NAA	40.4 cd	4.0 abcd	47.3 def
T_9 50 +200 ppm GA_3 +NAA	41.4 cd	4.2 abc	46.7 efg
T_{10} 100 +50 ppm GA_3 +NAA	39.8 cd	4.1 abcd	49.7 bcd
T_{11} 100+100 ppm GA_3+NAA	45.0 abc	4.0 abcd	48.5 cde
T_{12} 100+200 ppm GA_3+NAA	37.6 de	3.6 cdef	48.3 cde
T_{13} 200+50 ppm GA_3 + NAA	44.1bc	4.1abc	50.6 bc
T_{14} 200+100 ppm GA_3+NAA	50.3 a	4.5 a	54.8 a
T_{15} 200+200 ppm GA_3+NAA	48.7 ab	4.4 ab	51.6 ab

of GA_3 resulted in specific vegetative inductive response of okra. Moreover, it can be depicted that application of each chemical individually @ 200 ppm was inhibitory to foliage production, branching and plant height. But, the same dose (200 ppm) of both (GA_3 and NAA), when combined together, was stimulatory and resulted in 16 to 36% increase in these characters over the individual application of GA_3 or NAA @ 200 ppm (Table 2). Our results are in line with the findings of Pandita *et al*. (1980) and Yamgar and Desai (1987) in chilli and Sharma *et al.* (1988) in bottle gourd who reported that number of branches was increased by the application of plant growth regulators that might be due to enhanced photosynthetic activity and efficient assimilation of photosynthetic products but need further confirmation.

***Alteration in reproductive growth by PGRs*:** Foliar application of growth regulators minimized the number of days taken to first flowering in comparison with control (Table 3), but the results were non-significant. Minimum days to flowering (40.3) were recorded when GA_3 + NAA were applied @ 100+50 ppm, respectively, whereas, maximum days to flowering (42.7) were observed in control. Yield and factors contributing to yield viz., number of pods

Table 3. Reproductive growth patterns of okra in response to PGRs

Treatments	Number of days taken to first flowering	Number of pods plant^{-1}	Pod length (cm)	Pod fresh weight (g)	Pod dry weight (g)
T_0 Control (No foliar Application)	42.7 $^{(n.s)}$	7.4 e	7.6 g	108 h	0.7 g
T_1 50 ppm GA_3	41.0	9.1 abcde	8.7 f	119 gh	1.3 bcde
T_2 100 ppm GA_3	41.7	7.6 de	8.7 ef	12.8 efg	0.9 cdefg
T_3 200 ppm GA_3	41.7	7.5 de	8.9 cdef	12 0 gh	0.8 fg
T_4 50 ppm NAA	42.3	9.1 abcde	9.5 abcdef	13.8 cdefg	0.9 cdefg
T_5 100 ppm NAA	42.3	9.3 abcd	8.7 ef	15. 4 abc	0.9 defg
T_6 200 ppm NAA	42.0	8.1 cde	9.8 abc	12. 5 fgh	0.9 efg
T_7 50 + 50 ppm GA_3 + NAA	41.3	9.3 abcd	8.8 ef	14. 5 bcde	1.4 abc
T_8 50 +100 ppm GA_3 +NAA	42.3	8.4 bcde	8.9 def	13.2 defg	1.1 cdefg
T_9 50 +200 ppm GA_3 +NAA	41.7	9.4 abcd	9.3 bcdef	14.6 abcde	1.2 bcdef
T_{10} 100 +50 ppm GA_3 +NAA	40.3	7.9 de	9.4 abcdef	14.3 bcdef	1.2 cdefg
T_{11} 100+100 ppm GA_3+NAA	41.3	8.9 bcde	9.6 abcde	14.8 abcd	1.3 bcde
T_{12} 100+200 ppm GA_3+NAA	42.0	8.3 bcde	9.5 abcdef	14.9 abcd	1.4 abcd
T_{13} 200+50 ppm GA_3 + NAA	41.0	10.1 ab	9.9 ab	14.8 abcd	1.3 bcde
T_{14} 200+100 ppm GA_3+NAA	41.3	9.8 abc	9.8 abcd	15.8 ab	1.7 ab
T_{15} 200+200 ppm GA_3+NAA	41.3	10.8 a	10.2 a	16.6 a	1.8 a

n.s = results were statistically non-significant plant^{-1}, pod length, pod fresh and dry weights, in response to different treatments were also observed. Number of pods plant^{-1}, pod length and pod fresh as well as dry weight varied significantly among different treatments (Table 3), maximum in plants sprayed with solution containing both GA_3 + NAA @ 200+200 ppm . Both GA_3 and NAA, when applied separately, at 200 ppm were not as much stimulatory for these yield determining factors (except the effect of NAA on pod length) as other treatments comprising their combinations; this effect was more pronounced in plants treated with GA_3 at concentrations above 50 ppm. Moreover, it was observed that combination of GA_3 and NAA @ 50+50 ppm and 50 +100 ppm were not effective to increase length of pod. While, high dose of GA_3 (100 and 200 ppm) in combination with NAA (50, 100 and 200 ppm) accounted for improved pod length that could be ascribed to the role of GA_3 to promote cell division and cell elongation. It is worth mentioning that NAA or GA_3 applied individually @ 200 ppm reduced branching and number of pods of plants sprayed with in comparison with GA_3 + NAA @ 200+50 ppm, 200+100 ppm and 200 ppm, that reflects the need for balanced endogenous level of hormones and seemed to be done by the combined application of two PGRs, but need confirmation. The growth regulators play role in enhancing photosynthetic activity and subsequently the accumulation of photosynthates in plant organs to account for more fresh weight and dry weight. Gibberellins activate the growth mechanism, by efficient photosynthetic activity thereby increasing carbohydrate accumulation and thus dry matter contents (Yadava and Sreenath, 1975; Saleh and Abdul, 1980). Increase in fruit yield and contributing components in response to growth regulators (IAA, NAA, GA_3 and ethrel) was also observed by Ramarao *et al*. (1990) and Biradar (1999) in chilli, and Vadigeri and Madalageri (1989) in cucumber. The combined application of GA_3 (1.5 mM) and IAA (2.85 mM) significantly increased the length and number of internodes as well as the number of compound leaves in lentil (Naeem *et al*., 2004). Furthermore, increased pod fresh weight, as concluded by Srivastava and Sachan (1971) and Singh and Singh (1971), by applying plant growth regulators (IAA and GA_3) in okra strengthen our results. Recently, Ayyub *et al*. (2013) also reported enhanced vegetative and reproductive growth of okra in response to 100 ppm of GA_3, applied after three weeks of sowing. Moreover, it can be deduced from the results that different pod characters were correlated with number of pods plant^{-1} (results are not presented).

***Seed yield and quality in response to PGRs*:** Foliar application of gibberellic acid had been reported to affect number of seeds plant^{-1} as well as pods and seed yield plant^{-1} per unit area in several crops (Marie *et al*., 2007; Hoque and Haque, 2002). Therefore, impact of PGRs was also assessed on okra seed yield and quality.

Seed yield plant^{-1} was found maximum from plants sprayed with solution containing GA_3 and NAA @ 200+200 ppm and statistically it surpassed all other treatments (Fig. 1). While minimum seed yield was noted in control (T_0). It is clear from the results that treatments comprising of both GA_3 and NAA at high concentration improved seed yield significantly as compared to their application alone or in combination at low concentrations. Almost same trend was seen for seed quality indices i.e. 1000 seed weight and germination percentage (Fig. 2 and 3). The more seed yield seemed to correlate with number of pods per plant.

T_0 Control; T_1 50 ppm GA_3; T_2 100 ppm GA_3; T_3 200 ppm GA_3; T_4 50 ppm NAA; T_5 100 ppm NAA; T_6 200 ppm NAA; T_7 50+50 ppm GA_3 +NAA; T_8 50+100 ppm GA_3+NAA; T_9 50+200 ppm GA_3+NAA; T_{10} 100+50 ppm GA_3+NAA ; T_{11} 100+100 ppm GA_3+NAA; T_{12} 100+200 ppm GA_3+NAA ; T_{13} 200+50 ppm GA_3+NAA; T_{14} 200+100 ppm GA_3+NAA; T_{15} 200+200ppm GA_3+NAA

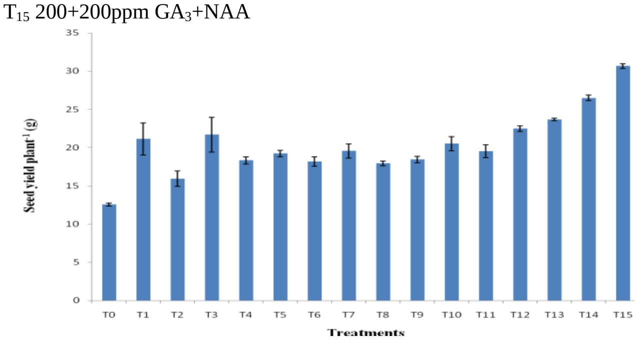

Figure 1. Effect of PGRs on seed yield of okra. Error bars indicate ± SE of means at P<0.05.

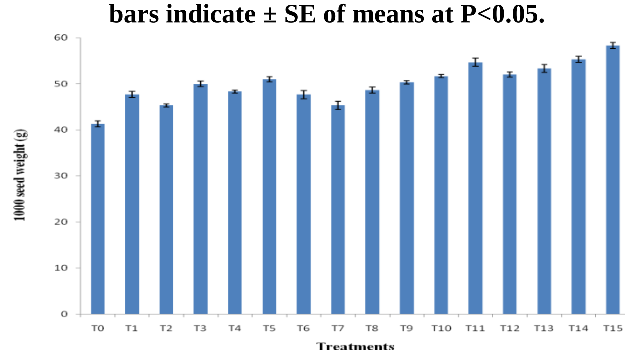

Figure 2.Effect of PGRs on 1000 seed weight of okra. Error bars indicate ± SE of means at P<0.05.

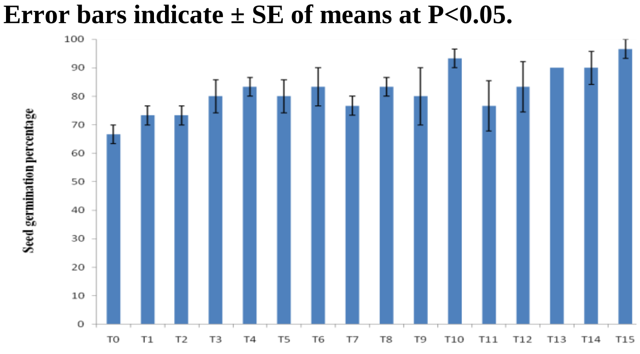

Figure 3. Effect of PGRs on seed germination percentage of okra. Error bars indicate ± SE of means at P<0.05.

The application of growth regulators might have improved the metabolism and resulted in accumulation of photosynthates ultimately yielding seeds of large size with better germination. The similar beneficial effects of growth regulators on enhancement of seed germination percentage were observed by Gedam *et al*. (1998) in bitter gourd and by Gondappalavar (2000) in tomato. The number of pods and seed yield plant^{-1} was increased in mustard and okra by foliar spray of GA_3 @ 50-75 ppm (Akter *et al.,* 2007; Marie *et al*., 2007). Moreover, Hoque and Haque (2002) reported that foliar application of GA_3 @ 100 ppm resulted into more number of pods plant^{-1}, seed yield plant^{-1}, 1000 seed weight and seed yield ha^{-1} of Mungbean. In addition, highest seed germination percentage and seedling vigor were recorded from chilli plants treated with 10 ppm NAA (Sultana *et al*., 2006). But, the studies on the combined application of both GA_3 and NAA on okra seed yield and quality were lacking. This report signifies the role of combined application of GA_3 and NAA at high concentration (200+200 ppm) in improving okra seed yield and quality. Moreover, our results confirmed the findings of von Denffer and Grfxndler (1950) that auxin at higher concentration inhibited vegetative growth and flowering not only in short-day plants but also in many long-day and day-neutral plant species. Furthermore, improvement in vegetative and reproductive growth in response to the application of GA_3 (@ 200 ppm) in combination with NAA (@ 100 and 200 ppm) depicts the compatibility of both PGRs at these concentrations and thus was in accordance to the findings of Gallasch (1984) who emphasized to ensure the compatibility of ingredients in foliar sprays.

REFERENCES

Akhtar, N., M. Ibrar and N. Aman. 2008. The effects of different soaking times and concentrations of GA_3 on seed germination and growth of *Spinacia oleracea* L. Pak. J. Plant Sci. 14:9-13.

Akter, A., E. Ali, M.M.Z. Islam, R. Karim and A.H.M. Razzaque. 2007. Effect of GA_3 on growth and yield of Mustard. Int. J. Sust. Crop Prod. 2:16-20.

Association of Official Seed Analysts (AOSA). 1990. Rules for testing seeds. J. Seed Technol. 12:1-112.

Ariyo, O.J. 1993. Genetic diversity in West African okra (*Abelmoschus caillei*): Stevels multivariate analysis of morphological and agronomic characteristics. Genetic Resour. Crop Evol. 40:25-32.

Asghar, S., S.A. Hussain and N. Ali. 1997. Effect of exogenous growth regulators on growth, flowering and yield of okra (*Abelmoschus esculentus* L.). Sarhad J. Agri. 13:449-453.

Ayyub, C.M., S. Ahmad and N. Akhtar. 2013. The effect of pre sowing magnetic treatment of okra seed on growth. Lambert Academic Publishing, Germany.

Biradar, B.R. 1999. Investigations of seed technology aspects in chilli (*Capsicum annuum* L.). Ph.D. Diss., University of Agricultural Sciences, Dharwad, India.

Briant, R.E. 1974. An analysis of the effects of gibberellic acid on tomato leaf growth. J. Exp. Bot. 25:764-771.

Bidwell, R.G.S. 1974. Plant Physiology. MacMillan Publishing Co., New York.

Das, B.C. and T.K. Das. 1995. Efficacy of GA_3, NAA and Ethrel on seed expression in pumpkin (*Cucurbita moschata* Poir.) cv. Guamala Local. Orissa J. Hort. 23:87-91.

von Denffer, D. and H. Grfxndler. 1950. Uber wuchsstoffinduzierte Bluhhemmung bei Langtagspflanzen. Biol. Zentr. 69:272.

El-Otmani, M., C.W. Coggins, M. Agusti and C.J. Lovatt. 2000. Plant growth regulators in citriculture: world current uses. Crit. Rev. Plant Sci. 19:395-447.

FAOSTAT. 2009. Food and Agriculture Organization of the United Nations. Available online with updates at http://faostat.fao.org./site/339/default.aspx

Gallasch, P.T. 1984. Practical aspects of the use of ethephon to control alternate cropping of Valencia orange. Proc. Int. Soc. Citriculture 1:285-288.

Gedam, V.M., R.B. Patil, Y.B. Suryawanshi and S.N. Mate. 1998. Effect of plant growth regulators and boron on flowering, fruiting and seed yield in bitter gourd. Seed Sci. Res. 26:97-100.

Gondappalavar, H.B. 2000. Effect of mother plant nutrition and chemical spray on seed yield and quality in tomato (*Lycopersicon esculentum* Mill.). M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad, India.

Greenberg, J. and E.E. Goldschmidt. 1988. The effectiveness of GA_3 application to citrus fruit. Proc. 6th Int. Citrus Congr. 1:339-342.

Hirose, K. 1981. Development of chemical thinners for commercial use for Satsuma mandarin in Japan. Proc. Int. Soc. Citriculture 1:256-260.

Hoque, M.M. and M.S. Haque. 2002. Effect of GA_3 and its mode of application on morphology and yield parameters of mungbean (*Vigna radiate* L). Pak. J. Biol. Sci. 5:281-283.

Ilias, I., G. Ouzounidou, A. Glannakoula and P. Papadopoulou. 2007. Effects of gibberellic acid and prohexadione-calcium on growth, chlorophyll fluorescence and quality of okra plant. Biol. Plant. 51:575-578.

Khan, M.M.A., C. Gautam, F. Mohammad, M.H. Siddiqui, M. Naeem and M.N. Khan. 2006. Effect of gibberellic acid spray on performance of tomato. Turk. J. Bot. 30:11-16.

Kusvuran, S. 2012. Influence of drought stress on growth, ion accumulation and antioxidative enzymes in okra genotypes. Int. J. Agric. Biol. 14:401-406.

Lee, I.I.S. 1990. Effects of pre-sowing seed treatments with GA_3 and IAA on flowering and yield components in groundnuts. Korean J. Crop Sci. 35:1-9.

Marie, A.I., A. Ihsan and S.H. Salih. 2007. Effect of sowing date, topping and some growth regulators on growth, pod and seeds yield of okra (*Abelmoschus esculentus* L.). Afr. Crop Sci. Soc. 8:473-478.

Maske, V.G., R.D. Dotale, P.N. Sorte, B.D. Tale and C.N. Chore. 1997. Germination, root and shoot studies in soybean as influenced by GA_3 and NAA. J. Soils Crops 7:147-149.

Naeem, M., I. Bhatti, R.H. Ahmad and M.Y. Ashraf. 2004. Effect of some growth hormones (GA_3, IAA and kinetin) on the morphology and early or delayed initiation of bud of lentil (*Lens culinaris* Medik). Pak. J. Bot. 36:801-809.

Nawaz, M.A., W. Ahmad, S. Ahmad and M.M. KHAN. 2008. Role of growth regulators on preharvest fruit drop, yield and quality in kinnow mandarin. Pak. J. Bot. 40:1971-1981.

Oyelade, O.J., B.I.O. Ade-Omowaye and V.F. Adeomi. 2003. Influence of variety on protein, fat contents and some physical characteristics of okra seeds. J. Food Eng. 57:111-114.

Pandita, M.L., S.C. Pandey, J.L. Mangal and G.P. Singh. 1980. Effect of various concentrations of planofix as foliar spray on plant growth and fruit yield of chillies. Haryana J. Hort. Sci. 9:170-174.

Panwar, R.D., S.S. Sindhu, J.R. Sharma and R.S. Saini. 2006. Effect of gibberellic acid spray on growth, flowering, quality and yield of bulbs in tuberose. Haryana J. Hort. Sci. 35:253-255.

Russel, D.F. and S.P. Eisensmith. 1983. MSTAT-C, Crop Soil Science Department. Michigan State University, USA.

Ramarao, G., G.V. Hanumantharao and T. Sujatha. 1990. Effect of NAA, IAA and 2,4-D on bud and fruit drop in chilli *(Capsicum annuum* L.). J. Res. Andhra Pradesh 18:349-354.

Saleh, M.M. and K.S. Abdul. 1980. Effect of gibberellic acid and CCC, on growth of tomato plants. Mesopotamia J. Agri. 15:137-166.

Sharma, N.K., S.K. Arora and B.S. Dhankhar. 1988. Effect of plant growth substances on growth, flowering, sex expression and fruit yield in bottle gourd [*Lagenaria siceraria* (Molina) Standl.]. Haryana Agri. Univ. J. Res. 18:291-297.

Singh, R.K. and K.P. Singh. 1971. Effect of seed treatment with plant growth substances on germination, vegetative growth and yield of okra. Proc. Bihar Acad. Agri. Sci. 25:24-27.

Solaimalai, A., C. Sivakumar, S. Anbumani, T. Suresh and K. Arumugam. 2001. Role of plant growth regulators in rice production. Agri. Rev. 22:33-40.

Srivastava, V.K. and S.C.P. Sachan. 1971. Effect of IAA and GA on growth and yield in okra. Indian J. Hort. 28:237-239.

Steel, R.G.D., J.H. Torrie and D.A. Dickey. 1997. Principles and Procedures of Statistics: A Biometrical Approach, 2nd ed. McGraw Hill Book Co., New York.

Sultana, W., Q.A. Fattah and M.S. Islam. 2006. Yield and seed quality of chilli (*Capsicum annuum* L.) as affected by different growth regulators. Bangladesh J. Bot. 35:195-197.

Surendra, P., C.M. NawalagattiChetti and S.M. Hiremath. 2006. Effect of plant growth regulators and micronutrients on morpho-physiological and biochemical traits and yield in Okra. Karnataka J. Agric. Sci. 19:694-697.

Vadigeri, B.G. and B.B. Madalageri. 1989. Response of cucumber genotypes to ethrel and GA_3. Karnataka J. Agri. Sci. 2:176-178.

Williams, R.R. and A.M. Taji. 1989. Auxin type, gel concentration, rooting and survival of *Cheiranthera volubilis in vitro*. J. Amer. Soc. Hort. Sci. 24:305-307.

Wilson, W.C., G.E. Coppock, and J.A. Attaway. 1981. Growth regulators facilitate harvesting of oranges. Proc. Int. Soc. Citriculture 1:278-281.

Yadava, R.B.R. and P.R. Sreenath. 1975. Influence of some growth regulators on growth, flowering and yield of cowpea. Indian J. Plant Physiol. 18:135-139.

Yamgar, V.T. and V.T. Desai. 1987. Effect of NAA and planofix on flowering, flower and fruit drop and fruit set in chilli. J. Maharashtra Agri. Univ. 12:34-38.

Yamaguchi, S. and Y. Kamiya. 2000. Gibberellin biosynthesis: Its regulation by endogenous and environmental signals. Plant Cell Physiol. 41:251-257.