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Okra growth, yield and aborted seed as affected by gibberellic acid using stem injection

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Abstract
The study was conducted to evaluate the effect of different concentration of gibberellic acid (GA3) on okra growth and development. The stem injection innovative method of application was used in this experiment rather than spray as common and traditional method. Stem injection method was applied on the stem of okra plant using GA3 at different concentrations. The higher concentrations (100 mg/l) of GA3 greatly increased the plant height compared to the control. GA3 application at 100 mg/l induced the highest value of stem girth over the control. The chlorophyll content in leaves was affected significantly by different concentrations of GA3. It was found that all concentrations of GA3 (25, 50, 100 and 200 mg/l) increased chlorophyll content per leaf by 37, 45, 60 and 55% compared to the control. The pod per plant, pod length, pod diameter, pod size, per pod weight and healthy seeds percentage per pod were significantly affected by different concentrations of GA3. The 100 and 200 mg/l concentrations of GA3 had increased the production of healthy seeds compared with control.

Keywords: conducted, gibberellic, production, evaluate

Introduction

Okra *(Abelmoschus esculentus*) is one of the important and popular vegetable crops in tropical and subtropical area in Asia (Grubben, 1977) [7] and Africa (Purseglove, 1974) [23]. Okra is also known as lady's finger, gumbo, bhindi in Malaysia and bamya in Arabic countries. It belongs to family Malvaceae, genus, *Abelmoschus and species, esculentus.* Cultivated okra is suitable for agriculture as garden crop as well as on commercial farms. It is one of the vegetables which grown commercially in many countries such as India, Westren Africa, Iraq, United States and other countries around the world. It was reported that total production of okra was 5.9 m tons in the world (USDA, 2010) [31]. The production was 1, 1.25, 1.26, 2.4, 8.1 and 38.5 m tons in USA, Ivory coast, Iraq, Sudan, Nigeria and India respectively.

Lee *et al*., (1990) [15], Adebooye and Opunta, (1996) [3] mentioned that okra pods are considered nutritious, providing some human supplementary vitamins such as vitamin C, A, B- complex, calcium, potassium, iron and other minerals. Okra pod contains many nutritional contents which important for human health. One hundred gram of fresh pod has around; moisture (89.6 percent). K (103 mg), Ca (90 mg), Mg (43 mg), P (56 mg), vitamin C (18 mg) and some important metals such as iron and aluminum (Markose and Peter, 1990) [17].

The application of plant growth regulartors are known as one of the most important treatments used nowadays in agriculture. Some horticulture crops production were increased by application of different growth regulartors (Jafarullahet *et al*., 2007) [10]. Growth regulators mainly regulate the plant physiological and biochemical processes. For example, play a major role in dormancy, organ size, crop improvement, flowering and fruit set, regulation of chemical composition of plants (Nickell, 1978) [21]. The phytohormone auxin affects approximately all developmental processes in plants, including fruit improvement. However, auxin is produced in meristems and young leaves and moved to other parts of the plant in a polar fashion (Leiser, O., 2006) [16].

There are more than 100 distinct gibberellins produced primarily in roots & young leaves but GA3 or gibberellic acid is the most popular available form. GA3 has many effects on plant growth such as enhance stem and internodes elongation, produce seed germination, enzyme production during germination and fruit setting and growth (Davies, 1995; Karssen *et al*., 1989) [12] and breaking of dormancy. Latimer, (1991) indicated that plant growth regulartors may be used to regulate the vegetative growth of plants. Application of GA3 increased the plant height, number of internodes, leaf area, dry weight of shoot and dry weight of Gram plant respectively (Khan and Rashid, 1983) [13]. However, work has been done on the use of GA3 to improve vegetative growth, pod size, and delay pod maturity in vegetables using spray method. But no studies have been conducted to evaluate the complete profile of vegetative growth, pod quality and seeds yield in response to GA3 application to okra using stem injection.

Objectives of the experiment were undertaken to

To investigate the effect of different concentration of applied GA3 at different concentrations on plant height, stem girth, leaves, chlorophyll content, maximum quantum yield (Fv/Fm), pod size and yield. Also to evaluate the efficacy of this injection method (treated stem) of application on seeds for inducing parthenocarpy or Stenospermocarpy (aborted seeds) in okra pod. In addition to that find cost effective methods reducing pollution of excessive use of plant growth regulator (GA3).

Materials and Methods

Study site and Climatic information

The present investigation was carried out in commercial farm in Banting, Selangor, Malaysia. The experiment field was located at 1º28´ N latitude and 111º20´E longitude at the height of 44.81 m above the sea level. The area of this study had a hot and humid tropical weather. The soil in this field was peat with a mean pH Of 6.6. Experiment were run for 2 years (2009-2011).

Plant materials, cultural operation and experimental design

The seeds of local *Abelmoschus esculentus* variety were sown in the experimental area of Banting. These seeds soaked in distilled water for 24 hours after which they were spread on moist filter paper in Petri-dish. The Petri-dish was kept in dark cupboard at room temperature of 30 ºC. Okra seeds were sown directly into the soil by hand in soil fertilized with NPK 19 g/hill 14-14-14 as basal fertilization. Thirty days after emergence, sidedress with 10g/hill 46-0-0 (Rodel at el., 2009) and plots were irrigated when necessary. The experiment was laid out in randomized block design having four replications. The whole area was divided into fifteen blocks and each block into 20 unit plots. The size of the unit plot was 1 x 1 m². The seeds were shown in rows made by hand plough. The gaps where seeds failed to germinate were filled up within two weeks after germination of seeds. After field preparation, seeds were sown in well-prepared seedbeds in line with a distance of 70 cm when germination completed thinning was done to maintain the plant to plant distance of 30 cm. The depth of planting was 1cm from the surface of the soil. Hoeing, weeding and other cultural practices were done uniformly (Fig. 1).

Fig 1: Partial view of experimental field at a glance

Preparation of plant growth regulators with their selected concentrations

The growth regulartors employed in the experiment were indole acetic acid (GA3). The concentrations of the growth regulators treatments were 25, 50, 100 and 200 mg/L. The GA3 was dissolved in 2ml of 1% ethanol to make desired concentration. Each rate of chemical GA3 was added with distilled water to make 100 ml of solutions. The control plants were injected with 100ml of water mixed with 2 ml of 1% ethanol.

Application

One and an half ml (1.5ml) of the various concentrations of GA3 (0, 25, 50, 100 and 200 mg/l) were applied on the stem by injected the plant stems with needle for a surgical purpose of 1 dose at the height of 3 cm above the ground level. While control was distilled water mixed with 2ml of 1% ethanol (Fig. 2).

Fig 2: Photo shows stem injection technique

Measurement of parameters

Data were recorded considering the following parameters:

Plant height and stem girth (cm)

Plant height was measured from above ground level up to the uppermost tip of the leaves at the end of harvesting. Both plant height and stem girth were measured using a meter rule with the aid of thread.

Leaves numbers

Number of leaves: number of leaves on each treated and control plants was counted.

Leaf chlorophyll content

The chlorophyll content in the leaves was measured by SPAD value meter (Minolta Japan).

Leaf chlorophyll fluorescence measurement

Fast chlorophyll fluorescence was evaluated on the upper surface of latest fully expanded leaf by using a Plant Efficiency Analyzer (PEA, Hansatech Instruments Ltd., England). A leaf clip was appended to the leaf and kept in the dark for 15 minutes for dark adaptation. After that the shutter plate was opened and light was applied on the leaf. The initial fluorescence intensity (Fo) when all reaction centers (RCs) are open, the maximal fluorescence intensity when all reaction are close (Fm), the variable fluorescence (Fv = Fm-Fo) and the time to reach the maximal fluorescence intensity (tmax), were calculated. The quantum yield was determined according to the equation Fv/Fm. Used the ratios Fv/Fm and which provide an estimation of the maximal photochemical efficiency of photosystem II (Ouzounidou *et al*., 2006) to evaluate alterations under our experimental conditions.

Pod parameters

Five pods were randomly chosen from each treatment to determine the following characters

Green pod length (cm)

Green pod diameter (cm)

Pod size (cm²)

Pod size was determined by measuring the length and diameter of pod per treatments with a Varnier caliper.

Single pod weight (Average)
Green pod weight (g) was determined with help of a digital UWE-ESP Digital Electric Balance and the average weight calculated.

Seed production
For the determination of healthy seeds from treated flowers, the number of health seeds and aborted seeds was counted after dry stage.
Healthy seeds/pod (%)
Seedless or Aborted seeds/pod (%Statistical analysis
The obtained data were statistically analysed using SPSS Computer Programme, Version16. The data were analyzed following Analysis of Variance (ANOVA) technique and mean differences were adjusted by using Duncan's Multiple Test (DMRT) at 5% level of significance.

Result and Discussion

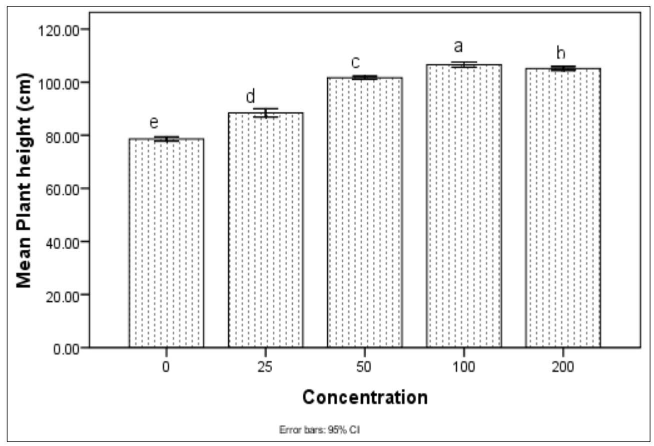
Plant height (cm), number of branches, stem girth, number of leaves and Chlorophyll content

Plant height was influenced by the application of GA3 (Figure 3). GA3 applied at different concentrations influenced the plant height significantly ($P<0.05$). The higher concentrations (100 and 200 mg/l) of GA3 greatly increased the plant height (106.60 and 105.02 cm) compared to the control (78.95). The lower concentrations had lesser plant height (88.42 and 101.63 cm) but higher than the control.
A significant variation was evident in the number of branches per plant, stem girth, number of leaves and leave area due to the application of gibberellic acid (GA3) at different concentrations (Table 1). The treated plants generated higher number of branches over control. Among the GA3 application, 100 mg/l of GA3 induced maximum number of branches (6.00) followed by 200 mg/l (4.75) and 50 mg/l (3.00) as compared to control (1.50). In the contrary, GA3 application at 200 and 100 mg/l induced the highest value of stem girth (2.44 and 2.64cm) over the control (2.20cm). The analysis of variance showed that GA3 application exerted highly varied influence on leaves number per plant. The highest number of leaves per plant (80) was obtained by 100 mg/l followed by 200 mg/l (64) and the lowest leaves number/plant (22) was observed with control treatment. The data indicated that the higher concentration of GA3 increased number of leaves more efficiently than the lower concentrations. Results in Figure (4) indicated that leaves content of chlorophyll was affected significantly by different concentrations of GA3. The results showed that all concentrations of GA3 (25, 50, 100 and 200mg/l) increased chlorophyll content per leaf by 37, 45, 60 and 55% of the control.

Pod production, Yield contributing characters and seeds yield percentage per pod

Results in table (2) indicated that total pod per plant, pod length, pod diameter, pod size, individual pod weight and healthy seeds percentage per pod were significantly affected by different concentrations of GA3.

Among the concentrations treatments, 100 mg/l had the maximum number of pod per plant (41) followed by 200 mg/l (37.50) and 50 mg/l (31.50) in comparison with control (9.50). The data revealed that 100 mg/l produced the longest pod (11.28cm) followed by 200 mg/l (11.12cm). Pod diameter was found maximum with 100 mg/l (3.67cm) and 200 mg/l (3.57cm) and followed by 50 mg/l (3.43cm) and 25 mg/l (3.33cm). Significantly highest pod size was obtained in 100 mg/l (41.46cm²) followed by 200 mg/l (40.56cm²). In this respect, pod weight recorded significantly highest in 100 mg/l (14.10g). Second heaviest pods were obtained in 200 mg/l (13.93g), 50 mg/l (13.74g) and 25 mg/l (11.25g). Pod harvested from 25 mg/l treated plants had significant highest aborted seeds percentage (4.85%) and it was followed by 50 mg/l (4.66%), control (4.64%), 200 mg/l (4.29%) and 100 mg/l (3.77%). 100 and 200 mg/l treatments had increasing the production of healthy seeds compared with control (Figure 5). 100 mg/l treatment which had maximum healthy seeds (96.21%) per pod followed by 200 mg/l (95.69%) while minimum healthy seeds was observed in 25 mg/l treatment (95.14%). However, 100 mg/l application produced the longer and heavier pods (Plate 4.8) than control (Plate 4.9).



Mean followed by same letter were not significantly different at $p \leq 0.05$ according to Duncan Multiple Range Test (DMRT).

Fig 3: Effect of different concentrations of GA3 on plant height of okra was under stem injection technique.

Table 1: Effect of stem injection method applied with various concentrations of GA3 on growth parameters of *Abelmoschus esculentus*.

Concentrations (mg/l)	No. of branches/plant	Stem girth (cm)	No. of leaves/plant
0	1.50±0.50d	2.20±0.02d	20.00±1.41e
25	2.50±0.57c	2.20±0.01d	46.75±2.06d
50	3.00±0.01c	2.23±0.01c	52.50±1.29c
100	a 02±0. 6.00	2.64±0.01a	80.00±1.41a
200	4.75±0.50b	2.44±0.03b	64.00±0.82b

Values are mean ± standard deviation
Mean followed by same letter were not significantly different at $p \leq 0.05$ according to Duncan Multiple Range Test (DMRT).

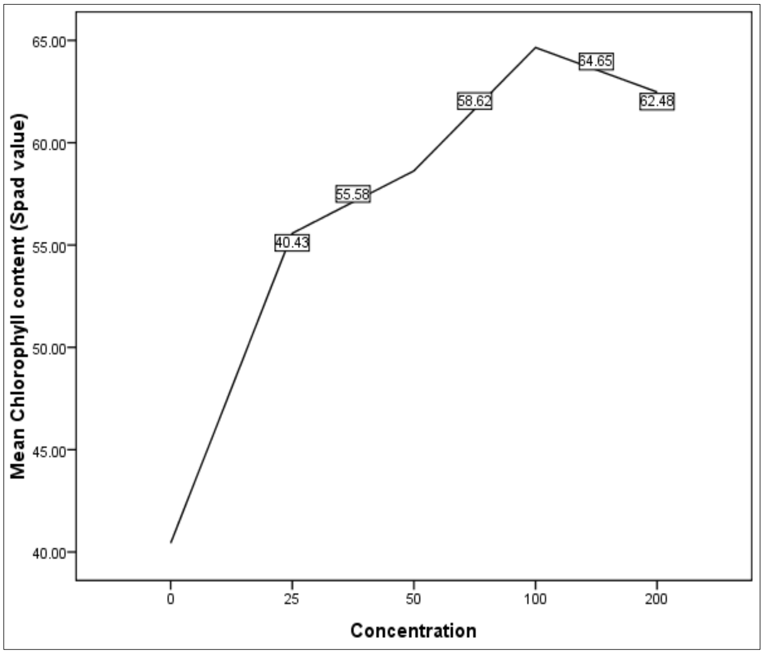
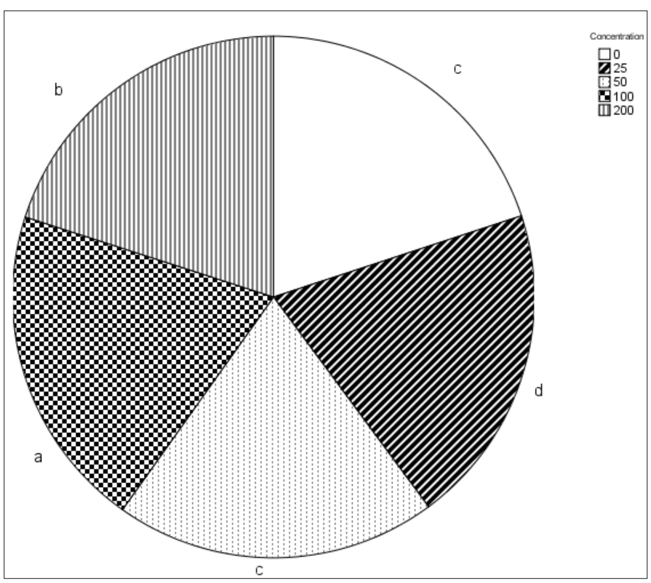


Fig 4: Effect of different concentrations of GA3 applied by stem injection method on chlorophyll content of okra leaves.

Table 2: Yield and yield contributing characters of okra as influenced by GA3 at different concentrations applied by stem injection technique.

Concentrations (mg/l)	No. of pods/plant	Pod length (cm)	Pod diameter (cm)	Pod size (cm²)	Individual pod weight (g)	Aborted seeds/pod (%)
0	9.50±1.29e	4.23±0.01e	1.23±0.02e	5.20±0.08e	2.72±0.02e	4.64±0.01c
25	26.75±0.96d	10.33 ±0.02d	3.33±0.02d	34.39±0.20d	11.25±0.02d	4.85 ±0.01a
50	31.50±1.29c	10.86±0.03c	3.43±0.05c	37.25±0.21c	13.74±0.05c	4.66±0.01b
100	41.00±1.41a	11.28±0.02a	02a±0. 3.67	41.46±0.03a	14.10±0.01a	3.77±0.03e
200	37.50±0.57b	11.12±0.03b	3.57±0.02b	40.56±1.58b	13.93±0.02b	4.29±0.01d

Values are mean ± standard deviation
Mean followed by same letter were not significantly different at $p \leq 0.05$ according to Duncan Multiple Range Test (DMRT).



Mean followed by same letter were not significantly different at $p \leq 0.05$ according to Duncan Multiple Range Test (DMRT).

Fig 5: Effect of various concentrations of GA3 on healthy seeds percentage per fruit (%) applied by stem injection.

Control (plant and fruit) GA3 (plant and fruit)

Fig 5: Photos show effect of 100 mg/l concentration of GA3 and control application on pod production and pod size applied by stem injection method.

Discussion

This study compared the bioavailability of different concentrations of GA3 for improving growth, yield and fruit quality when applied to okra crop by stem injection technique. The use of the plant growth regulators (PGRs) is becoming an increasingly important aspect in agricultural and horticulture practices for many cultivated plants (Monselise, 1979) [18]. Several reports which indicate that application of the plant growth regulators can provide germination, growth, fruit set, fresh vegetables weight and seed yields quality (Saimbhi, 1993)[25].

Olaiya and Osonubi, (2009) [22] informed that natural plant growth regulators or synthetic are controlled the plant activities and their productions by controlling one or more of one or more specific physiological processes within a plant. However, Gibberellic acid are safe for human health which can be used for different aims (Iknur *et al*., 2008). Plant growth regulators play a central role in morphology and physiology of the plants. The effect of growth regulator depends on plant species, variety, their growth stage, concentration of chemicals that used, application technique and frequency of application (Hilli *et al*., 2009)[9]. Application of GA3 at 25, 50 and 200 mg/l increased the plant height over control in applied by stem injection method. GA3 is concerned to enhance cell division and elongation (Harrington *et al*., 1996) [8]. Veer Kumar, (2002) [32] and Sreedhar, (2003) [30] stated that increased stem elongation might be due to stimulating action of GA3, which alleviate the cell wall by increasing its plasticity. The results confirm with those of Sarkar *et al*., (2002) [27] and Mukhtar, (2008) [19] who found that GA3 and IAA applications increased the plant height of soybean and Red sorrel, respectively. But both investigations found GA3 at 100 ppm was efficient than IAA. Also, earlier studies reported that GA3 increased plant height in various crops; soybean (Deotale *et al*., 1998), sesame (Sontakey *et al*., 1991) [29], rice (Awan and Alizai, 1989) [4] and some cowpea cultivars (Mukhtar, 2004) [20]. With GA3 at 100 and 200 mg/l concentrations, there was a significant differences in pod in comparison with control. GA3 increased leaves number per plant in Bell pepper (Abdul *et al*., 1988); (Shishido and Saito, 1984) [28]. Mukhtar, (2008) [19] found that GA3 and IAA treatment at 100 ppm increased leaves number and leaves area and chlorophyll content in Hibiscus sabdariffa L. Also, Salah *et al*., (1989) [26] mentioned a significant increase in the leaf length in onion by application of GA3. This may be attributed that GA3 and IAA increase the division and elongation of the cells led to better vegetative growth of plants. Also, Wanyama, (2006) [33] informed that GA3 application increases branches number by breaking apical dominance. Jordi *et al*., (1995) [11] informed that GA3 delay the loss of chlorophyll. GA3 at 100 and 200 mg/l had better effect than lower concentrations (25 and 50 mg/l) and control. GA3 and IAA developed yield and physiochemical characters of leafy vegetable (Deore and Bharud 1990) [6]. In addition, Deore and Bharud, (1990) [6] reported that increasing yield might be related to the plant height, leaf number, leaf area. Also, another important factor is number of branches / plant which offered a chance to the plant to carry more flowers therefore higher pods. Another reason might the physiological role of gibberellin and indole acetic acid in increasing cell division and elongation and stimulating the complete growth of plant which revealed in better pod setting by using of IAA and GA3. IAA and GA3 allow water to enter the cells of fruits and dissolved materials which lead naturally to increase fruit size by increasing the permeability of fruit cell wall (Abduljabbar *et al*., 2007)[2]. IAA and GA3 application at 100 ppm increased the yield of rice and soybean (Awan and Alizia, 1989; Reena *et al*, 1999) respectively. A significant decreased of seed abortion percentage was observed after GA3 treatment at 200 mg/l compared with control. The increase in seed yield due to GA3 application and other treatments maybe related to improved vegetative growth (leaf area and leaf number plant. The present observations was in confirmation with Sarkar *et al*., (2002) [27] who observed that GA3 application at 100 ppm to soybean produced the highest yield of seeds per plant

Summary and Recommendation

The higher concentrations (100 mg/l) of GA3 greatly increased the plant height compared to the control. The lower concentrations had lesser plant height but it was higher than the control. The treated plants generated higher number of branches over control. Among the GA3 application, 100 mg/l of GA3 induced maximum number of branches in 200 mg/l as compared to control. In the contrary, GA3 application at 50 mg/l induced the highest value of stem girth over the control. The highest number of leaves per plant was obtained by 100 mg/l and the lowest leaves number/plant was observed with control treatment. The chlorophyll content in leaves was affected significantly by different concentrations of GA3. It was found that all concentrations of GA3 (25, 50, 100 and 200mg/l) increased chlorophyll content per leaf by 37, 45, 60 and 55% of the control. The total pod per plant, pod length, pod diameter, pod size, individual pod weight and healthy seeds percentage per pod were significantly affected by different concentrations of GA3. Among the concentrations treatments, 100 mg/L had the maximum number of pod per plant in comparison with control. Pod diameter was found maximum with 100 mg/l. significantly highest pod size was obtained in 100 mg/L followed by 200 mg/l. In this respect, pod weight recorded significantly highest in 100 mg/L. Pod harvested from 25 mg/l treated plants had significant highest aborted seeds percentage followed by 50 mg/l. 100 and 200 mg/l treatments had increased the production of healthy seeds compared with control. 100 mg/L treatment had maximum healthy seeds per pod followed by 200 mg/l. However, 100 mg/l application produced the longest pods.

From the above discussion it can be concluded that 100 and 200 mg/l of GA3 concentrations were the best for okra growth and development. So it can be recommended that stem injection technique can be used commercially in the vegetable industry. The internal application stem injection can reduce the chemical and production cost without hazardous any environmental pollution.

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References

1. Abdul KS, MMS Saleh, Omer SJ. Effects of gibberellic acid and cycocel on the growth flowering and fruiting characteristics of pepper. Irgi. J Agril. Sci. JANCO. 1988; 6:7-18.
2. Abduljabbar IM, Abduljabbar I, Shukri S. Effect of sowing date, topping and some growth regulators on growth pod and seed yield of okra (*Abelmoschus esculentus* L.M.). African Crop Science Conference Proceedings, 2007; 8:473-478.
3. Adebooye CO, Opunta CO. Effect of galex on growth and fruit nutrient composition of okra (*Abelmoschus esculentus* L.). Ife J Agric, 1996; 18:1-9.

4. Awan I, Alizai HK. Effect of plant growth regulators on ripening, grain development and rice quality. Int. Rice Res. Newsletter, 1989; 149:30-31.
5. Davies PJ. The plant hormones: their nature, occurrence and function. *In*: P.J. Davies (editor). Plant Hormones; physiology, biochemistry and molecular biology. Kluwer Dordrecht, Netherlands, 1995, Pp.1-12.
6. Deore BP, Bharud RW. Growth yield and storability of fenugreek as influence by foliar spray of growth substances. Journal of Maharashtra Agricultural Universities, 1990; 15:208-210.
7. Grubben CJH. Okra In: Tropical vegetables and their genetic resources, IBPGR, Rome, 1977, pp. 111-114.
8. Harrington JF, Rappaport L, Hood KJ. The influence of gibberellins on stem elongation and flowering on endive. Science, 1996; 125:601.
9. Hilli JS, Vyakarnahal BS, Biradar D P, Ravihunje. Effect of growth regulators and stages of spray on growth, fruit set and seed yield of ridge gourd (*Luffa acutangula* L. Roxb). Karnataka J Agric. Sci. 2009; 23(2):239-242.
10. Jafarullahet MD, Abdul Fattah Q, Feroza H. Response of growth, yield attributes and yield to the application of KNP and NAA in Cowpea (*Vigna unguiculata L*. WALP.). Bangladesh J Bot. 2007; 36(2):127-132
11. Jordi W, Stoopen GM, Kelepouris K, vander Krieken WM. Gibberellin-induced delay of leaf senescence of *Alstroemeria* cut flowering stems is not caused by an increase in the endogenous cytokinin content. J Plant Growth Regul, 1995; 14:121-127.
12. Karssen CM, Zagorski S, Kepczynski J, Groot SPC. Key role for endogenous gibberellins in the control of seed germination. Annals Bot, 1989; 63:7180.
13. Khan KA, Rashid A. Effect of gibberellic acid on growth and yield of gram var.c-727. Pakistan Journal Sciences and Industrial Research. 26(1):27-30.
14. Latimer JG. Growth retardants affect landscape performance of Zinnia, Impatiens and Marigold. Hort Science, 1991; 26:57-560.
15. Lee KH, Cho CY, Yoon ST, Park SK. The effect of nitrogen fertilizer plant density and sowing date on the yield of okra. Korean Journal of Crop Science. 1990; 35(8):179-183.
16. Leiser O. Dynamic integration of auxin transport and signalling. Curr. Biol, 2006; 16:R424-R433.
17. Markose BL, Peter KV. Review of research on vegetables and tuber crops-okra. Kerala Agric. Univ. Mannuthy, India. Technical Bullerin, 1990; 16:109.
18. Monselise SP. The use of growth regulators in citric culture. A review. Sci. Hort, 1979; 11:151-162.
19. Mukhtar FB. Effect of Some Plant Growth Regulators on the Growth and Nutritional Value of Hibiscus sabdariffa L. (Red sorrel). Int. Jor. P App. Scs. 2008; 2(3):70-75.
20. Mukhtar FB, Singh BB. Growth response of photoperiod sensitive and photoperiod insensitive cowpea varieties to plant growth regulator treatments. Soil Environ. Sci. J Trops (BEST), 2004; 1:79-86.
21. Nickell LG. Plant growth regulators. Chemical Engineering News, 1978; 56:18-34.
22. Olaiya CO, Osonubi O. Effects of Pre-sowing Seed Treatments on Tomato *Lycopersicon esculentum* (L.) Mill. Seedling Emergence. Int. J Eng Technol. 2009; 1(4):321-323.
23. Purseglove JW. Tropical Crops: Dicotyledons. London Longman. Combined. 1974; 1(2):719.
24. Reena T, Deotale RD, Armarkar N, Chore CN. Influence of seed soaking in IAA and kinetin solutions on growth and yield of soybean. J Soils and Crops, 1999; 9:72-79.
25. Saimbhi M S. Growth regulators on vegetable crops. In: K. L. Chadha and G. Kallo (Eds.). Advances in Horticulture. Malhotra Publishing House, New Delhi, India. 1993; 6(1):619-642.
26. Salah MMS, Abd DJ. Effect of gibberellic acid and naphthalene acetic acid on growth, yield and quality of onion. Dirsat, 1989; 16:39-51.
27. Sarkar PK, Shahidul Haque MD, Abdul Karim M. Effects of GA and IAA and their Frequency of Application on Morphology, Yield Contributing Characters and Yield of Soybean. Pakistan Journal of Agronomy. 2002; 1(4):119-122.
28. Shishido Y, Saito T. Effects of plant growth regulators on low temperature induction of flower buds in onion plants. J. Japanese Soc. Hort. Sci, 1984; 53:45-51.
29. Sontakey PY, Belsore WV, Deotale RD, Takzure SC, Wankhede SZ. Relative influence of growth hormones on growth and yield performance of sesame (*Sesamum indicum* L.) New Agriculturist, 1991; 1:207-208.
30. Sreedhar RV. Assessment of genetic variability in Niger (*Guizotia abyssinica* Cass.) germplasm. M.Sc. (Agri.) Thesis, Univ. Agric. Sci., Dharwad, 2003.
31. USDA National Nutrient Data Base, 2010. http://www.buzzle.com/articles/okra-nutrition.html.
32. Veer Kumar GV. Studies on genetic variability, floral biology, auto gamy and histology of GA3 induced male sterility in Niger. *M.Sc. (Agri.) Thesis*, Univ. Agric. Sci., Bangalore, 2002.
33. Wanyama DO, Wamocha LS, Ngamau K, Ssonkko RN. Effect of gibberellic acid on growth and fruit yield of greenhouse-grown Cape gooseberry African Crop Science Journal. 2006; 14(4):319-323.