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A Comparison of the Effectiveness of Chlormequat Chloride (CCC) Application and Terminal Apex Excision to Restrict Plant Height in Okra (*Abelmoschus esculentus* [L.] Moench.) and Optimize Yield

Charalampos Thanopoulos[1], Spyridon A. Petropoulos[2], Alexios A. Alexopoulos[3], Ioannis C. Karapanos[1], Ebrahim M. Khah[2], Konstantinos A. Akoumianakis[1] & Harold C. Passam[1]

[1] Agricultural University of Athens, Laboratory of Vegetable Production, 75 Iera Odos, Athens 11855, Greece

[2] School of Agricultural Sciences, Department of Agriculture, Crop Production and Rural environment, University of Thessaly, Fytokou Street, N.Ionia, Volos 384 46, Greece

[3] Technological Educational Institute of Kalamata, Department of Plant Production Antikalamos, Kalamata 24100, Greece

Correspondence: Spyridon A. Petropoulos, School of Agricultural Sciences, University of Thessaly, Volos, Fytokou Street, N. Ionia, Volos 384 46, Greece. Tel: 30-242-1093-196. E-mail: spetropoulos@uth.gr

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Abstract

Two methods for restricting plant height (CCC application and excision of the main shoot apex) were applied to okra cv. 'Boyiatiou' with the aim of assisting crop management and optimizing yield. Apex excision 26 or 40 days after transplantation (DAT) effectively restricted plant height, but either had no effect (40 DAT) or reduced the number of side shoots per plant (26 DAT). Moreover, although the length of side shoots increased after apex excision, the number of nodes per side shoot was not affected. Hence pod number and weight was less than in the control (untreated). CCC application (500 and 2000 ppm) reduced plant height due to a reduction in internode length; however, when applied at the time of transplantation (0 DAT) (both concentrations) or 26 DAT (2000 ppm) it also caused a reduction in node number on the main stem. CCC did not affect the number of side shoots or the number of nodes per shoot, and side shoot length decreased due to shorter internode lengths. The number and weight of pods per plant was reduced by 2000 ppm CCC irrespective of the time of application, but was not affected by 500 ppm CCC at 0 DAT (pod number) or 40 DAT (pod weight and number). We conclude that the application of 500 ppm CCC at 40 DAT may aid okra cultivation since it reduces overall plant size (height and diameter) without adversely affecting yield, and may thus assist crop management (e.g. easier hand-harvesting) and permit an increase in plant density.

Keywords: *Abelmoschus esculentus* L., growth stage, growth retardant, pruning

1. Introduction

World production of okra (*Abelmoschus esculentus* [L.] Moench., syn. *Hibiscus eculentus* L.) is estimated to be about 6.4 million tonnes of which 65% (4.1 million tonnes) is produced in India alone (FaoStat, 2008). Although okra is a popular vegetable within the Mediterranean region, production is nevertheless minor and amounts to only 170,000 tonnes, i.e. about 3% of the world's total. In Greece, 1366 hectares of land were cultivated with okra in 2009, with a total production of 7,378 tonnes, representing a yield of 5,400 kg ha-1 (Ministry of Rural Development and Food, Greece, 2010).

Five domestic okra cultivars are recognized in Greece (Koutsos, 2009) in addition to which there are a number of local populations (landraces). Although the majority of Greek cultivars are day neutral (Koutsos, 2009), flowering is generally promoted by short days (Arulrajah & Ormrod, 1973). Pod bearing occurs predominantly on the main stem but also on lateral shoots (Bhatt & Srinivasa Rao, 2009). Flowers form singly at the nodes and flower induction is promoted by regular harvest of the young, immature pods, which are considered to have the highest quality (Iremiren et al., 1991).

Although okra is frequently cultivated without irrigation, soil moisture affects plant growth and yield (Singh & Rajput, 2007) and the crop responds positively to water (Olasantan, 1985). Thus for satisfactory yield 460 mm has been recommended for the period May-end September (Spartsis & Kokaras, 2001). However, a problem that may arise with irrigated crops, especially under periods of long photoperiod, is the rapid increase in plant height which can make hand harvesting difficult within 2-3 months of planting (Passam & Rekoumi, 2009).

In other crops, e.g. tomato, plant height may be restricted genetically and farmers can select between determinate and indeterminate cultivars according to their production systems. In addition, in soybean (Glycine max) the application of growth regulators (e.g. Ethrel) resulted in higher vegetative growth and pod yield when applied at 40 and 60 days after sowing (Devi et al., 2011). Although dwarf okra cultivars are commercially available, these are mainly cultivated for okra used in processing rather than for fresh consumption. Previous studies of large-fruiting cultivars have reported that the application of growth retardants, e.g. chlormequat chloride (CCC) (Zayed et al., 1985) or paclobutrazol (Syed et al., 1997) may restrict plant height and even increase the number of pods produced per plant (Bhatt & Srinivasa Rao, 2009), perhaps by changing the level of hormones involved in floral induction and differentiation (Jiang et al., 2010). In the present paper we compare two methods for restricting plant height (CCC application and excision of the main shoot apex) on the growth and yield of cv. 'Boyiatiou', a major day-neutral, small-fruiting Greek cultivar (Koutsos, 2009) with the aim of assisting okra crop management and optimizing yield.

2. Materials and Methods

Seeds of okra (*Abelmoschus esculentus* [L.] Moench. cv. 'Boyiatiou') were scarified in H_2SO_4 for 20 min to facilitate germination as recommended by Passam & Polyzou (1997). Seeds were sown on 30 March 2005 in seed trays containing a commercial peat-based substrate (KTS2, Klasmann-Deilmann GmbH, Germany) and placed in an unheated greenhouse at 15-25 ^oC. At the two leaf stage (30 days after sowing) the plants were transferred to 0.1 l pots containing the same substrate and retained at the same temperature, while at the 6-8 leaf stage plants (45 days after sowing) they were transferred outdoors and transplanted to substrate containing 1:1 (v/v) peat (KTS2) and perlite (P4, Perloflor, Isocon SA, Athens, Greece). The experimental field consisted of six double rows (50 x 50 cm) separated by paths (1.0 m) and covered with black/white plastic to control weeds. Each plant was individually irrigated with a standard nutrient solution and the stems trained on vertical cordons to wires 1.6 m above the plants.

The following treatments were applied: The main shoot apex was excised 50 cm (1) or 80 cm (2) above the soil; plants were sprayed once with 500 ppm chlormequat chloride (CCC) at the 6-leaf stage, 46 days after sowing (3), or at a height of 50 cm, 72 days after sowing or 26 days after transplantation (4), or at a height of 80 cm, 86 days after sowing or 40 days after transplantation (5); plants were sprayed once with 2000 ppm CCC at the 6-leaf stage (6), or at a height of 50 cm (7), or at a height of 80 cm (8); plants were not treated with CCC and the main shoot apex was not excised (9, control). The concentrations of CCC were selected on the basis of previous work with large-fruiting okra (Zayed et al., 1985). Each treatment was replicated six times and arranged in a completely randomized design. Side shoots were permitted to develop without pruning. Morphological characteristics recorded throughout cultivation included: plant height, the number of nodes per plant, mean internode distance, the number and length of side shoots. Fruit were harvested regularly at the stage of market acceptability (4-8 cm) and weighed. The experiment was terminated on 2 September (156 days after sowing, or 121 days after transplantation, DAT).

The experiment was carried out in a completely randomized experimental design with two factors [factor 1: CCC application at concentrations of 500 or 2000 ppm or shoot apex excision; factor 2: stage of plant development at the time of treatment]. Due to the statistically significant interaction between these factors, the analysis of variance was carried out separately for the treatments at each stage of plant development. All results were subjected to analysis of variance (ANOVA) and where the F-test proved significant ($p=0.05$) means were compared by Duncan's multiple range test using the statistical programme StatGraphics 5.1.

3. Results

CCC induced a statistically significant reduction in mean plant height in comparison with the control, irrespective of the time of application (Table 1). The reduction in plant height by 2000 ppm CCC was similar for all application times (29-32%) and was significantly more than that induced by 500 ppm CCC (15-23%). In contrast, 500 ppm CCC had less effect on plant height when applied 26 DAT than at 0 DAT or 40 DAT (Table 1). Removal of the apex of the main shoot at 26 or 40 DAT terminated the growth of the main stem at a height of 50 and 80 cm respectively.

Table 1. The effect of CCC concentration and application time on the final plant height (cm) of okra cv. 'Boyiatiou'

Treatment	0 DAT	26 DAT	40 DAT
Control	202.3 a	202.3 a	202,3 a
CCC 500 ppm	160.7 b (b)	173.0 b (a)	155.4 b (b)
CCC 2000 ppm	140.3 c (a)	144.3 c (a)	137.7 c (a)

Mean values in the same column that are followed by the same letter do not differ significantly according to the Duncan test (p=0.05).

Mean values in the same row that are followed by the same letter in parenthesis do not differ significantly according to the Duncan test (p=0.05).

DAT: Days After Transplantation.

The number of nodes on the main stem was significantly lower when plants were sprayed with 500 or 2000 ppm CCC at the time of transplantation (0 DAT) as well as when 2000 ppm CCC was applied 26 DAT, but not at 40 DAT (Table 2), indicating that the effect of CCC relates to the stage of plant development at the time of application. When the main stem apex was excised 26 or 40 DAT the mean number of nodes was low because excision prevented subsequent node induction.

Mean internode length of the main stem was significantly reduced by CCC application. At the time of transplantation (0 DAT), 2000 ppm CCC caused a greater reduction of internode length than 500 ppm CCC, but at 26 and 40 DAT there was no significant difference between the two CCC concentrations (Table 2). In contrast, excision of the main stem apex caused an increase in mean internode length compared with the control, irrespective of the stage of plant development at the time of excision (26 or 40 DAT).

Table 2. The effect of CCC application, application time and main shoot apex excision on the number of nodes and internode length (cm) of the main shoot of okra cv. 'Boyiatiou'

Treatment	Number of nodes			Internode length (cm)		
	0 DAT	26 DAT	40 DAT	0 DAT	26 DAT	40 DAT
Control	61.2 a	61.2 a	61.2 a	3.3 a	3.3 b	3.3 b
CCC 500 ppm	55.0 b (b)	60.7 a (a)	61.0 a (a)	2.9 b (a)	2.9 c (a)	2.5 c (a)
CCC 2000 ppm	57.0 b (a)	52.7 b (a)	57.2 a (a)	2.5 c (a)	2.7 c (a)	2.4 c (a)
Shoot apex excision	-	10.3 c (b)	15.8 b (a)	-	5.0 a (a)	5.1 a (a)

Mean values in the same column that are followed by the same letter do not differ significantly according to the Duncan test (p=0.05).

Mean values in the same row that are followed by the same letter in parenthesis do not differ significantly according to the Duncan test (p=0.05).

DAT: Days After Transplantation.

Application of 500 ppm CCC at the time of transplantation (0 DAT) caused an increase in the number of side (lateral) shoots per plant but not thereafter, whereas 2000 ppm CCC had no effect on the number of side shoots irrespective of the time of application (Table 3). The mean length of the side shoots was not affected by the application of 500 ppm CCC at transplantation (0 DAT), but was reduced by 27-31% when this concentration of CCC was employed at 26 or 40 DAT. The higher concentration of CCC (2000 ppm) caused a significant reduction in side shoot length at all times of application, and as high as 60% at 26 DAT. Early excision of the terminal apex of the main shoot (26 DAT), but not later (40 DAT), caused a significant reduction in the number of side shoots per plant. Irrespective of the time of excision, a significant increase in side shoot length was observed (Table 3).

Table 3. The effect of CCC application, application time and main shoot apex excision on the number and length (cm) of side shoots of okra cv. 'Boyiatiou'

Treatment	Number of side shoots			Length (cm) of side shoots		
	0 DAT	26 DAT	40 DAT	0 DAT	26 DAT	40 DAT
Control	8.7 b	8.7 a	8.7 a	66.2 a	66.2 b	66.2 b
CCC 500 ppm	11.3 a(a)	6.8 a (b)	8.7 a (b)	70.9 a (a)	45.6 c (b)	48.5 c (b)
CCC 2000 ppm	7.7 b(a)	8.3 a (a)	9.0 a (a)	50.6 b (a)	27.2 d (c)	38.3 c (b)
Shoot apex excision	-	4.0 b (b)	7.2 a (a)	-	103.0 a (a)	104.9 a (a)

Mean values in the same column that are followed by the same letter do not differ significantly according to the Duncan test (p=0.05).

Mean values in the same row that are followed by the same letter in parenthesis do not differ significantly according to the Duncan test (p=0.05).

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Table 4. The effect of CCC application, application time and main shoot apex excision on the number of nodes and internode length (cm) of side shoots of okra cv. 'Boyiatiou'

Treatment	Number of nodes			Internode length (cm)		
	0 DAT	26 DAT	40 DAT	0 DAT	26 DAT	40 DAT
Control	17.7 a	17.7 ab	17.7 ab	3.7 a	3.7 b	3.7 b
CCC 500 ppm	16.8 a (a)	16.4 ab (a)	15.8 b (a)	4.0 a (a)	2.8 c (b)	3.1 c (b)
CCC 2000 ppm	16.3 a (a)	13.6 b (a)	16.1 b (a)	3.1 b (a)	2.0 d (b)	2.4 d (b)
Shoot apex excision	-	20.9 a (a)	23.2 a (a)	-	4.9 a (a)	4.6 a (a)

Mean values in the same column that are followed by the same letter do not differ significantly according to the Duncan test (p=0.05).

Mean values in the same row that are followed by the same letter in parenthesis do not differ significantly according to the Duncan test (p=0.05).

DAT: Days After Transplantation.

The mean number of pods per plant decreased when the main shoot apex was excised 26 or 40 DAT or by the application of 2000 ppm CCC at all stages of plant development (Table 5). However, 500 ppm CCC caused a decrease in the number of pods per plant only when applied at 26 DAT. Between 45 and 55% of the total number of pods per plant were formed on the main stem, irrespective of the time and concentration of CCC applied. However, when the main shoot apex was excised, subsequent pod induction occurred solely on the side shoots, thus accounting for the low percentage of pods (10-12%) formed on the main stem in this treatment.

Table 5. The effect of CCC application, application time and main shoot apex excision on the number and weight (g) of pods per plant of okra cv. 'Boyiatiou'

Treatment	0 DAT	26 DAT	40 DAT
		Mean number of pods per plant	
Control	96.7 a	96.7 a	96.7 a
CCC 500 ppm	90.2 a (a)	82.0 b (b)	91.0 ab (a)
CCC 2000 ppm	75.0 b (a)	77.8 c (a)	60.8 c (b)
Shoot apex excision	-	77.7 c (b)	88.5 b (a)
		Mean weight of pods per plant (g)	
Control	483.42 a	483.42 a	483.42 a
CCC 500 ppm	414.69 b (b)	415.11 b (b)	490.51 a (a)
CCC 2000 ppm	357.81 c (b)	416.75 b (a)	335.43 c (b)
Shoot apex excision	-	343.84 c (b)	429.53 b (a)

Mean values in the same column that are followed by the same letter do not differ significantly according to the Duncan test (p=0.05).

Mean values in the same row that are followed by the same letter in parenthesis do not differ significantly according to the Duncan test (p=0.05).

DAT: Days After Transplantation.

All treatments, with the exception of 500 ppm CCC applied at 40 DAT, caused a reduction in the weight of pods per plant; moreover the reduction in weight tended to be greater when treatments were applied at early stages of plant development (0 and 26 DAT) (Table 5). For treatments at 26 DAT, the reduction in pod weight was highest for plants the main apex of which was excised, whereas at 40 DAT the reduction was highest for the 2000 ppm CCC treatment.

4. Discussion

Naturally, excision of the main shoot apex is the most effective way of restricting plant height. However, application of this method at the stages of plant development used in the present experiment is not beneficial because the subsequent induction of side shoots was either inhibited (26 DAT) or not affected (40 DAT), and although side shoot length increased, particularly in the first formed side shoots due to an absence of competition, the number of nodes per shoot did not differ from the control. Since pods form singly at the nodes (Swamy Rao & Ramus, 1975), the loss of pod formation on the main shoot due to apex excision was not compensated for by an increase in pod production on the side shoots (Olasantan, 1986); hence pod number and weight per plant decreased significantly in comparison with the control. In consequence, although hand harvesting might be easier due to the restriction of plant height, the increased length of the side shoots would not favour an increase in plant density to compensate for yield loss, as proposed by Shrestha (1983). Alternatively, it may be preferable to terminate main shoot growth at a later stage (e.g. 1.0-1.5 m) even though this may be less convenient for hand harvesting.

The application of CCC at two concentrations (500 and 2000 ppm) caused a reduction in the height of the main stem of okra, as in sunflower (Dorrell, 1973) and wheat (Lowe & Carter, 1972), which resulted from a reduction in internode length probably due to the inhibition of gibberellin synthesis by CCC (Kozlowski et al., 1991) and in particular GA1, which is considered to be responsible for internode length (Brown et al., 1997). In okra, however, CCC application at an early stage of plant development (500 ppm CCC at 0 DAT, or 2000 ppm CCC at 0 or 26 DAT) caused a reduction in the number of nodes, which may indicate toxicity (Mastalerz, 1977). The reduction in node number is especially serious for okra because only one pod is formed per node, and therefore a reduction in yield occurs.

In okra, CCC application reduces the mean length of the side shoots, also via a reduction in internode length. However, because side shoots develop at a later stage of growth (i.e. after CCC application in the present experiment) the number of nodes on the side shoots is unaffected by CCC, irrespective of the concentration or time of application. This effect of CCC is significant because the reduction of plant height assists hand harvesting while the reduction in side shot length permits an increase in plant density, thus counteracting the reduction in pod number and weight per plant.

From the present experiment it is clear that although the higher concentration of CCC (2000 ppm) caused a greater reduction in plant height compared to the lower concentration (500 ppm) and to the control, it cannot be proposed for use on okra because of the significant reduction in yield. Studies elsewhere have shown that the efficacy of CCC as a growth retardant may be affected not only by CCC concentration but also by factors such as plant species, the stage of growth at application and the growth environment (Cathey, 1964; Alexopoulos et al., 2006). In okra, the application of 500 ppm at transplantation (0 DAT) caused an increase in the number of side shoots, as observed for roses (Rosa hybrida cv. 'Raktagandha') (Bhattacharjee & Singh, 1995). Thus, the plants produced totally the same number of pods as the control, although mean pod weight was lower probably due to competition between shoots for nutrients, but also possibly as a result of leaf shading due to the shorter internode distances on the side shoots. Although the flowering of many okra cultivars is promoted by short days (Ghanti et al., 1991), all Greek cultivars including cv. 'Boyiatiou', are day neutral (Koutsos, 2009). This may explain the apparent lack of effect of CCC on flower induction, in contrast to foreign cultivars (cv. 'Clemson spineless' and 'Better Five') (Zayed et al., 1985; Rahman et al., 1994). The application of 500 ppm CCC at a later stage of plant development (40 DAT) caused a greater reduction in plant height than the treatment at transplantation and also, because it caused an increase in side shoots without affecting the number of nodes per shoot, it did not affect pod number or weight. Thus the application of 500 ppm CCC 40 DAT is considered to be the preferred treatment to assist crop management (particularly pod harvesting at a more convenient height) and permit increased plant density within the field.

References

Alexopoulos, A. A., Akoumianakis, K. A. & Passam, C. H. (2006). Effects of plant growth regulators on the tuberisation and physiological age of potato (*Solanum tuberosum* L.) tubers grown from true potato seed. *Canadian Journal of Plant Science, 86*, 1217-1225. http://dx.doi.org/10.4141/P05-227

Arulrajah, T., & Ormrod, D. P. (1973). Response of okra (*Hibiscus esculentus* L.) to photoperiod and temperature. *Annals of Botany, 37*, 331-340.

Bhatt, R. M., & Srinivasa Rao, N. K. (2009). Physiology. Crop growth, development and yield. In B. S. Dhankhar & R. Singh (Eds.) (pp 37-60), *Okra Handbook: Global Production, Processing and Crop Improvement,* HNB Publishing, New York.

Bhattacharjee, S. K., & Singh, U. C. (1995). Growth and flowering response of Rosa hybrida cv. Raktagandha to certain growth regulator sprays. *The Orissa Journal of Horticulture, 23*, 21-25.

Brown, R. G. S., Kawaide, H., Yang, H., Rademacher, W., & Kamiya, Y. (1997). Daminozide and prohexadione have similar modes of action as inhibitors of the late stages of gibberellin metabolism. *Physiologia Plantarum, 101*, 309-313. http://dx.doi.org/10.1111/j.1399-3054.1997.tb01001.x

Cathey, H. M. (1964). Physiology of growth retarding chemicals. *Annual Review of Plant Physiology, 15*, 271-302. http://dx.doi.org/10.1146/annurev.pp.15.060164.001415

Devi, K. N., Vyas, A. S., Singh, M. S., & Singh, N. G. (2011). Effect of bioregulators on growth, yield and chemical constituents of soybean (*Glycine max*). *Journal of Agricultural Science, 3*(4), 151-159. http://dx.doi.org/10.5539/jas.v3n4p151

Dorrell, D. G. (1973). Controlling plant height in sunflowers with growth retardants. *Canadian Journal of Plant Science, 53*, 417-418. http://dx.doi.org/10.4141/cjps73-081

FaoStat, (2008). Production data for okra for 2008. Retrieved from http://www.fao.org/corp/statistics.

Ghanti, P., Sounda, G., & Verma, P. K. (1991). Effect of sowing dates on growth and yield of different bhindi (*Abelmoschus esculentus* L. Moench) varieties. *Environment & Ecology, 9*, 176-179.

Iremiren, G. O., Osara, A. W., & Okiy, D. A. (1991). Effects of age of harvesting after pod set on the growth, yield and quality of okra (*Abelmoshus esculentus*). *Experimental Agriculture, 27*, 33-37. http://dx.doi.org/10.1017/S0014479700019177

Jiang, B. B., Chen, S. M., Miao, H. B., Zhang, Sh. M., Chen, F. D., & Fang, W. M. (2010). Changes of edogenous hormone levels during short-day inductive floral initiation and inflorescence differentiation of *Chrysanthemum morifolium* 'Jingyun'. *International Journal of Plant Production, 4*, 149-157.

Koutsos, T. V. (2009). Greek okra cultivars. Sustainable agricultural systems. In B. S. Dhankhar & R. Singh (Eds.) (pp 361-373), *Okra Handbook: Global Production, Processing and Crop Improvement*. New York: HNB Publishing.

Kozlowski, T. T., Kramer, P. J. & Pallardy, S. G. (1991). *The Physiological Ecology of Woody Plants*. London: Academic Press.

Lowe, L. B., & Carter, O. G. (1972). The influence of CCC (2-chloroethyltrimethyl ammonium chloride) and temperature on dry matter and assimilate accumulation in wheat. *Australian Journal of Agricultural Research, 23*, 573-583. http://dx.doi.org/10.1071/AR9720573

Mastalerz, J. W. (1977). *The Greenhouse Environment*. N.Y.: John Wiley & Sons.

Ministry of Rural Development and Food, Greece. (2010). Statistical data. Retrieved from http://www.minagric.gr/greek/agro_pol/bamies.htm.

Olasantan, F. O. (1985). Effects of inercropping, mulching and staking on the growth and yield of tomatoes. *Experimental Agriculture, 21*, 135-144. http://dx.doi.org/10.1017/S0014479700012412

Olasantan, F. O. (1986). Effect of apical debudding on growth and yield of okra (*Abelmoschus esculentus*). *Experimental Agriculture, 22*, 307-312. http://dx.doi.org/10.1017/S0014479700014484

Passam, H. C., & Polyzou, P. (1997). Improvement of okra seed germination by acid, osmoconditioning and hot water treatments. *Plant Varieties and Seeds, 10*, 135-140.

Passam, H. C., & Rekoumi, K. (2009). In B. S. Dhankhar, & R. Singh (Eds.), *Okra Handbook: Global Production, Processing and Crop Improvement* (pp. 347-359). New York: HNB Publishing.

Rahman, S. M., Sarker, S. C., & Muhsi, A. A. A. (1994). Effects of phytohormone on growth development and yield of okra (*Abelmoschus esculentus* L. Moench). *Bangladesh Journal of Botany, 23*, 161-165.

Shrestha, G. K. (1983). Effects of spacing and nitrogen fertilizer on 'Pusa Sawani' okra (*Abelmoshus esculentus*) in Nepal. *Experimental Agriculture, 19*, 239-242. http://dx.doi.org/10.1017/S0014479700022754

Singh, D. K., & Rajput, T. B. S. (2007). Response of lateral placement depths of subsurface drip irrigation on okra (*Abelmoschus esculentus*). *International Journal of Plant Production, 1*, 73-84.

Spartsis, N. I., & Kokaras, E. K. (2001). *Okra (Abelmoschus esculentus* [L.] *Moench former name Hibiscus esculentus* L.). Spartsis, Thessaloniki, Greece.

Swamy Rao, T., & Ramu, P. M. (1975). A study of correlation and regression coefficients in bhindi (*Abelmoschus esculentus* L.). *Current Research, 4*, 135.

Syed, A., Hussain, S. A., Nawab, A., Asghar, S., & Ali, N. (1997). Effect of exogenous growth regulators on growth, flowering and yield of okra (*Abelmoschus esculentus* L.). *Sarhad Journal of Agriculture, 13*, 449-453.

Zayed, A. E., El-Zawily, I. A., & Ibrahim, A. S. (1985). Growth, yield and chemical composition of okra plants as affected by some growth regulators. *Angewandte Botanik, 59*, 199-208.