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EFFECT OF DECAPITATION AND FOLIAR SPRAY WITH Zn AND Mn ON GROWTH, FLOWERING, GREEN POD YIELD AND SEED PRODUCTION OF OKRA PLANTS

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ABSTRACT

Two field experiments were carried out at Gemmeiza Agric. Res. Station, Gharbia Governorate during the two successive seasons of 2003 and 2004 to study the effect of okra plants "cv. Balady" decapitation treatments (early and late decapitation (removal apex) after 30 and 45 days of seed sowing, respectively), and foliar spray with Zn and Mn at 300 ppm either alone or in combination [300 ppm Zn, 300 ppm Mn, 300 ppm Zn + 300 ppm Mn] in comparison with control (sprayed with tap water), as well as their interaction on growth, flowering, leaf nutrient content, green pods yield and seed production.

The results can be summarized as follows:-

1- Decapitation of okra plants led to significant increments in vegetative growth characters except for plant height, it increased number of flowers per plant, as well as, delayed flowering time. Early decapitation, significantly increased number of green pods per plant, total green pod per plant and per fed. Meanwhile, early green yield per plant and per fed were decreased. Decapitation, significantly decreased average green pod weight. Early and late decapitation significantly increased N, P, K, Ca, Mg and Na. Furthermore, early decapitation significantly increased Fe, Mn, and Cu. Meanwhile, late decapitation significantly increased Zn and reduced Fe compared with undecapitation. Generally, it was noticed that early decapitation was effective than the late one. Significant increases in number of dry pods per plant, seed yield per plant, seed yield per fed and seed index were noticed due to late decapitation and undecapitation compared with early decapitation.
2- Foliar application with 300 ppm Zn, 300 ppm Mn and 300 ppm Zn + 300 ppm Mn significantly increased vegetative growth characters in both seasons. The highest values were obtained by spraying okra plants with 300 ppm Zn + 300 ppm Mn. Moreover, these treatments significantly increased number of flowers per plant and fruit setting % as well as were associated with a significant increase in green pods yield per plant, early and total yield per fed. Also, these treatments significantly increased N, P, K, Ca, Mg and Na in okra leaves. Meanwhile, foliar feeding with 300 ppm Mn gave a significant increase in content of leaf Mn in both seasons and Fe on the first season. Also, foliar spray with Zn or Zn + Mn at 300 ppm had a significant effect on leaf Zn and Cu in both seasons and leaf Fe in the second season. However, foliar feeding with 300 ppm Zn + 300 ppm Mn significantly increased Na of dry pods per plant, seed yield per plant and per fed and seed index in both seasons.
3- Decapitation of okra plants after 30 days from seed sowing and foliar nutrition with 300 ppm Zn + 300 ppm Mn was suitable the most efficient combination treatment, which assured a good vegetative growth and gave a higher green pods yield of okra plants. Also, for seed production the highest values of Number of dry pods, seed yield per plant, seed yield per fed and seed index were obtained by spraying okra plants with 300 ppm Zn + 300 ppm Mn and late decapitation treatment.

INTRODUCTION

Okra (*Abelmoschus elsculentus* L., Monch) is important vegetable crop in Egypt and popular among all classes of people. It has attracted attention due to its multifarious fresh, dried, canned or frozen. The edible portion of the pod is rich in protein, carbohydrate, fiber and ash. In Egypt, due to the limiting cultivated area, more efforts must be directed toward increasing yield potential per unit area to meet consumer's necessity.

Decapitation (Topping) or removal the main stem growing point of plant is done to encourage basal branching and accelerated branch growth. This removal also reduces the seed crops range of maturity period (George, 1985).

Few studies were carried out to determine the effect of decapitation on growth and quality of vegetable crops. The positive or negative effects depend on the time of topping. The earlier or later topping leads to significant reduction in plant height, highest value of number of fruiting branches per plant, significantly lower yield of seed cotton as well as heaviest seed index or insignificant effect (Abdalla and Shalaby, 1981; El-Halwani *et al.*, 1988; Ghaly *et al.*, 1988 and Hosney *et al.*, 1991). Wein and Minttoni (1988) reported that apex removal of tomato plants accelerated branch growth and stimulated basal branching. El-Assiouty (1998) reported that decapitation of okra plants increased number of branches, however, plant height, number of leaves, fresh and dry weights, seed yield and quality were reduced. The positive or negative effects of decapitation depend largely, on time of decapitation performance.

Ghoneim (2000) reported that early decapitation of okra plants significantly increased vegetative growth characters, except plant height, increased number of flowers per plant, total yield and reduced seed yield.

Micronutrients may perform essential in vital process in plants, so, application of this micronutrients may leads to higher yield and better quality crops. Manganese has a role as an activator of several enzymes system, it is related to chlorophyll synthesis and affects fruit bearing (Yagodin, 1984). The same author reported that zinc is important in nitrogen assimilation in plants. Above pH 7, soil zinc and manganese become less available (Cardozier, 1957).

Concerning the effect of Zn and Mn on okra plants, Ragheb (1994) found that Zn + Mn + Fe with 300 ppm from each as a foliar spray gave the best results for seed yield, number of pods per plant and plant height. Also, El-Assiouty (1998) found that soaking of okra seeds for 24 hr in 150 ppm Mn + 100 ppm Cu or 100 ppm Zn + 100 ppm Cu gave the highest values of number of dry pods per plant, seed yield per fed and seed index.

El-Masri (2005) on cotton, found that foliar feeding with Mn + Zn at 3 gm / L had a significant effect on leaf N, K, Mn and Zn. Also, these treatment increased plant height, number of branches, seed index, boll setting and seed cotton yield / plant and / fed.

The experimental sites under study had clay soil with high pH, such conditions are known to reduce the availability of micronutrients to plants (El-Fouly, 1983).

The objective of this research was to study the role of decapitation and foliar application with Zn and Mn on growth, flowering, leaf nutrient content, green pods yield and seed yield and quality of okra plants.

MATERIALS AND METHODS

Two field experiments were conducted at Gemmeiza Agric. Res. Station, Gharbiys Governorate during 2003 and 2004 seasons to study the effect of decapitation application and foliar nutrition with Zn and Mn on growth, flowering, green pods yield, leaf chemical composition and seed yield production of okra plants. The soil was analyzed by using standard method described by Jackson (1976) (Table 1) and shows that experimental soil sites suffer from these two micronutrients deficiencies.

Table 1. Soil physical and chemical analysis of the experimental site in the two seasons.

Properties	Season	
	2003	2004
Texture	Clay	Clay
OM (%)	1.23	1.18
$CaCO_3$	2.90	3.50
pH (1 : 2.5 suspension)	8.10	8.20
EC (mmhos/cm)	1.40	1.30
Available N (ppm)	24.0	23.5
Available P (ppm)	6.80	5.90
Available K (ppm)	470	485
Available Fe (ppm)	15.0	16.3
Available Mn (ppm)	4.25	5.20
Available Zn (ppm)	1.10	1.00
Available Cu (ppm)	4.60	4.90

Each experiment included twelve treatments, which were the combinations of three treatments decapitation and four treatments of foliar spray with Zn and Mn as follows:-

A. decapitation treatments:

1. Decapitation after 30 days of seed sowing (D_1).
2. Decapitation after 45 days of seed sowing (D_2).
3. Without decapitation (D_0).

B. Foliar application with Mn and Zn:

1. Zn at 300 ppm.
2. Mn at 300 ppm.
3. Zn at 300 ppm and Mn at 300 ppm.
4. Control (Sprayed with tap water).

The source of micro-nutrients were chelate compounds of Zn-EDTA (12% Zn) and Mn-EDTA (12% Mn). The plants of okra plants were sprayed twice after 25 and 40 days after seed sowing.

A split-plot design was followed using randomized complete blocks with three replication was used, decapitation treatments occupied the main plots and foliar application treatments were allocated at random in sub-plots.

Seeds of okra cv. Balady (obtained from Hort. Res. Institute) were sown on 16^{th} of April, 2003 and 14^{th} of April, 2004 in ridges 3m long and 70 cm wide within row spacing averaged 30 cm apart.

Each experimental plot contained 5 rows (plot area was 10.5 m^2). The normal practices of okra production were followed. Plants were thinned at one plant per hill after 20 days of seed sowing.

In each sub-plot, plants of the outer two rows were allocated to measure the vegetative growth characters, flowering and fruit setting traits as well as chemical composition of leaves. Plants of the inner two rows were assigned to determine green pods yield. While, the middle row was allocated to record seed yield and quality.

I. Vegetative growth characters:

Hundred days after seed sowing, random sample of five plants from each sub-plot was collected. Number of leaves per plant, number of branches, plant height (cm), plant fresh weight (kg), and leaf area / plant (cm^2), which was determined for each sample by the disk method (Bremner and Taha, 1960).

II. Flowering characters:

Ten plants were labelled in each sub-plot to record flowering time from seed sowing till 25% of anthesis and number of flowers per plant till the termination of the experiment. Fruit setting was calculated according to the following formula:-

$$\text{Fruit setting (\%)} = \frac{\text{Number of set fruits / plant}}{\text{No. of flowers / plant}} \times 100$$

III. Green pods yield:

At harvest stage, picking of green pods achieved at 3 days interval. Number of green pods per plant, average pod weight (gm), early yield per plant and per fed, weight of harvested pods were determined throughout the first four pickings. Total yield per plant and per fed were also determined throughout entire season.

IV. Leaf nutrient content:

100-days after planting, a representative leaf sample (20 leaves) was taken from the youngest fully matured leaf (4^{th} leaf) on the main stem from each sub-plot. After sample preparation for analysis, concentrations of Fe, Zn, Mn and Cu were determined with an atomic absorption spectrophotometer and contents of total P, K, Ca, Mg and Na were determined according to Chapman and Pratt (1978). Also, the N content was determined using microkjeldahl methods as described by Allen (1953) and Ma and Zauzage (1942).

V. Seed yield and quality:

At the end of the experiments, dry pods were picked from the plants and seeds were manually extracted. Number of dry pods per plant, seed yield per plant and per fed and weight of 1000 seeds (seed index) were recorded.

All obtained data were statistically analyzed according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

I. Vegetative growth:

a. Effect of decapitation:

The results represented in Table 2 reveal that decapitation leads to significant increments in number of leaves and branches, plant fresh weight (kg) and leaf area per plant (cm^2) compared with undecapitation plants in both year of the study. The reverse was true for plant height. However, the effect of decapitation depends, largely, on time of its performance.

Generally, early decapitation was more effective than the late one. The obtained results can be discussed on the basis that removal the apical meristem of the main stem terminated the apical dominance and inhibited the vertical growth, which in turn promoted the lateral branches to grow strongly (Rubinstein and Nagao, 1976). Olasantan (1986) mentioned that decapitation of okra plants, strongly increased the vegetative growth, except plant height.

Similar results were also recorded by El-Assiouty (1998) and Ghoneim (2000) on okra.

b. Effect of foliar application with Zn and Mn:

Data in Table 2 indicate that number of leaves and branches, plant height, plant fresh weight and leaf area (cm^2) per plant were significantly increased by foliar feeding with Zn, Mn and Zn + Mn at 300 ppm from each compared with the control (tap water) in both seasons. The highest values were obtained from foliar feeding with a mixture of Zn + Mn.

Such favourable effect of these treatments may be attributed to the important role of two micronutrients within the plants. Zn is recognized as an essential component of number of enzymes as dehydrogenase, proteinase and peptidase. The roles, zinc can exert an influence on electron transfer reactions including these in Kreb's cycle and subsequently on energy production in plant (Gomaa *et al.*, 1986).

It is well known that activity of peptidases and some enzymes of the citric acid cycle depends on Mn and this contributes much to its favourable effect on growth.

These results agree with those of Randhawa *et al.* (1977), Farag *et al.* (1991), Bin Ishaq (1992), El-Seifi and Anisa (1997) and El-Assiouty (1998) on okra.

c. Effect of decapitation and foliar application with Zn and Mn interaction:

It is evident from data presented in Table 3 that the interaction between decapitation of okra plant and foliar feeding with Mn + Zn gave the best results of number of leaves, number of branches, plant height, plant fresh weight and leaf area per plant as compared with the control. The differences were significantly in both seasons.

Table 2. Effect of decapitation and foliar nutrition with Zn and Mn on growth characteristics of okra plants during the summer seasons of 2003 and 2004.

Treatments	No. of leaves / plant		No. of branches / plant		Plant height (cm)		Plant fresh weight (kg)		Leaf area / plant (cm^2)	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
D_1	38.83	36.83	4.00	3.50	134.17	133.58	2.58	2.49	1087.60	1098.13
D_2	45.75	43.83	3.33	4.08	131.83	129.67	2.52	2.38	980.18	981.42
D_0	32.92	33.75	2.00	2.33	152.67	150.17	1.83	1.76	749.37	751.92
LSD at 5%	4.39	3.14	0.62	0.47	4.80	3.96	0.15	0.15	6.21	10.52
1%	5.98	4.27	0.80	0.64	6.58	5.39	0.19	0.19	8.45	14.32
Zn*	39.56	37.67	3.44	3.78	138.56	137.56	2.51	2.38	975.26	977.22
Mn	43.00	41.00	3.00	3.33	132.00	132.44	2.38	2.31	908.58	910.78
Zn + Mn	47.44	46.11	3.89	3.89	159.89	154.90	2.40	2.32	1053.96	1057.83
Control	26.67	27.78	2.11	2.22	127.78	126.33	1.96	1.83	818.32	829.44
LSD at 5%	5.07	3.60	0.70	0.93	5.57	0.18	0.18	0.18	7.71	12.13
1%	6.90	5.27	0.96	1.28	7.58	0.24	0.24	0.24	9.76	16.52

Decapitation; D_1, D_2 were done after 30 and 45 days of seed sowing and D_0 (without decapitation).
* Zn and Mn as foliar application with 300 ppm from each.

Table 3. Effect of interaction between decapitation and foliar nutrition with Zn and Mn on growth characteristics of okra plants during the summer seasons of 2003 and 2004.

Treatments		No. of leaves / plant		No. of branches / plant		Plant height (cm)		Plant fresh weight (kg)		Leaf area / plant (cm^2)	
Decapitation	Foliar nutrition	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
D_1	Zn	36.33	34.00	4.33	3.67	135.67	135.67	2.60	2.47	1121.90	1123.00
	Mn	41.67	39.00	4.00	4.00	126.00	127.33	2.73	2.70	1062.00	1071.67
	Zn + Mn	50.00	45.00	5.00	4.00	159.00	155.67	3.10	3.00	1136.83	1151.83
	Control	27.33	29.00	2.67	2.33	116.00	115.67	1.90	1.80	1029.67	1046.00
D_2	Zn	50.00	46.00	4.00	4.67	125.00	123.00	2.90	2.80	1034.00	1031.67
	Mn	48.33	44.33	3.00	4.00	115.00	120.00	2.67	2.53	947.17	939.00
	Zn + Mn	52.33	52.33	4.00	5.00	155.67	149.00	2.20	2.10	1133.33	1141.67
	Control	32.33	32.67	2.33	2.67	131.67	126.67	2.30	2.10	805.97	813.33
D_0	Zn	32.33	33.00	2.00	3.00	155.00	154.00	2.33	1.87	769.87	777.00
	Mn	39.00	39.67	2.00	2.00	155.00	150.00	1.73	1.70	716.57	721.00
	Zn + Mn	40.00	41.00	2.67	2.67	165.00	160.00	1.90	1.87	891.70	880.00
	Control	20.33	21.33	1.33	1.67	135.67	136.67	1.67	1.60	619.33	629.00
LSD at 5%		8.76	6.27	0.20	0.93	9.63	7.97	0.29	0.29	12.41	21.00
1%		11.93	8.54	0.64	1.28	13.13	10.85	0.39	0.39	16.90	28.60

Decapitation; D_1, D_2 were done after 30 and 45 days of seed sowing and D_0 (without decapitation).
* Zn and Mn as foliar application with 300 ppm from each.

II. Flowering:

a. Effect of decapitation:

Table 4 demonstrates the influence of decapitation on number of flowers per plant and fruit setting were significant in both seasons. Flowering time was significantly reduced by decapitation treatments. Moreover, the early decapitation delayed flowering time than the late one. The promoting effect of decapitation on number of flowers per plant may be resulted from the stimulating effect on basal branching, as it was noticed from Table 2, which contain most of fruit bearing nodes (Ariyo, 1990). Barakat and Abdel-Razik (1990) reported that decapitation of tomato seedling, significantly enhanced basal branching and gave more number of flower clusters.

Results of Olasantan (1986) coincided the delaying effect of decapitation on flowering time. Also, Ghoneim (2000) on okra found that early decapitation significantly increased number of flowers per plant.

Table 4. Effect of decapitation and foliar nutrition with Zn and Mn on flowering characters of okra plants during the summer seasons of 2003 and 2004.

Treatments	Flowering time (days)		No. of flowers / plant		Fruit setting (%)	
	2003	2004	2003	2004	2003	2004
D_1	59.33	58.75	69.50	75.50	95.58	95.64
D_2	56.60	54.33	54.83	56.92	93.62	93.74
D_0	52.00	51.42	46.17	49.92	92.28	86.43
LSD at 5%	1.67	0.87	2.28	1.26	1.81	NS
1%	2.27	1.19	3.07	1.72	2.19	NS
Zn*	55.00	54.11	59.67	63.56	94.35	95.20
Mn	57.44	55.44	57.44	60.11	94.52	94.53
Zn + Mn	53.22	51.78	60.11	67.78	95.01	86.70
Control	58.11	58.00	50.11	51.67	91.43	91.31
LSD at 5%	1.93	0.99	2.64	1.50	1.88	NS
1%	2.63	1.36	3.59	1.99	2.55	NS

Decapitation; D_1, D_2 were done after 30 and 45 days of seed sowing and D_0 (without decapitation).

*** Zn and Mn as foliar application with 300 ppm from each.**

b. Effect of foliar spray with Zn and Mn:

The effect of foliar nutrition with Zn and Mn on flowering time and number of flowers per plant was significantly increased in both seasons compared with control (Table 4). Fruit setting was significantly affected in the first season only. The highest values were obtained from foliar feeding with a mixture of Zn + Mn.

The promoting effect of foliar feeding with Zn and Mn on number of flowers, may be resulted from the stimulating effect of vegetative growth (Table 2) especially stimulating effect on basal branching which contain most of fruit bearing. Mn has role as an activator of several enzymes system, it is also related to chlorophyll synthesis and affect fruit bearing (Yagodin, 1983).

c. Effect of interaction:

The interaction effect of decapitation treatments by foliar spray with Zn and Mn on number of flower per plant was significant in both seasons (Table

5). However, fruit setting was significant in the first season only. The highest values of number of flowers per plant and fruit setting were from early decapitation and foliar nutrition with a mixture of Zn + Mn. Undecapitation treatment by foliar spray with Zn + Mn significantly decreased flowering time (days) in both seasons.

Table 5. Effect of Interaction between decapitation and foliar nutrition with Zn and Mn on flowering characters of okra plants during the summer seasons of 2003 and 2004.

Treatments		Flowering time (days)		No. of flowers / plant		Fruit setting (%)	
Decapitation	Foliar nutrition	2003	2004	2003	2004	2003	2004
D_1	Zn	58.33	58.33	71.00	78.00	95.59	96.28
	Mn	59.57	59.00	68.33	74.67	96.00	95.93
	Zn + Mn	57.67	56.67	72.67	82.67	95.83	97.17
	Control	61.67	61.00	66.00	66.67	94.90	93.17
D_2	Zn	55.00	53.00	60.33	60.00	94.34	94.34
	Mn	59.33	54.67	60.00	57.67	95.07	94.10
	Zn + Mn	53.67	51.67	56.67	62.67	85.80	95.70
	Control	58.00	58.00	42.33	47.33	89.20	90.73
D_0	Zn	51.67	51.00	47.66	52.67	93.03	94.87
	Mn	53.33	52.67	44.00	48.00	92.50	93.57
	Zn + Mn	48.33	47.00	51.00	58.00	93.40	67.23
	Control	54.67	55.00	42.00	41.00	90.20	90.03
LSD at 5%		3.34	1.73	4.57	2.52	3.22	NS
1%		4.54	2.35	6.22	3.43	4.39	NS

Decapitation; D_1, D_2 were done after 30 and 45 days of seed sowing and D_0 (without decapitation).
*** Zn and Mn as foliar application with 300 ppm from each.**

III. Green pods yield:

a. Effect of decapitation:

Table 6 show that decapitation had significant effects on green pods yield during both seasons. Early and late decapitation, i.e., 30 and 45 days of seed sowing significantly increased number of green pods per plant, total yield per plant and per fed and significantly reduced average pod weight compared with undecapitation. Early yield per plant and per fed was significant increased by undecapitation.

The favourable effect of decapitation on number and yield of green pods could be related to the stimulatory effect of decapitation on number of lateral branches, which contain most of fruits bearing nodes (Ariyo, 1990). Reducing of average pod weight due to decapitation was in harmony with those of Olasantan (1986) and Ghoneim (2000) reported that decapitation of okra plants reduced size of green pods.

b. Effect of foliar spray with Zn and Mn:

Foliar feeding with Zn and Mn had a significant effect on number of pods per plant, early yield per plant and per fed, total yield per plant and per fed and average pod weight during 2003 and 2004 seasons (Table 6), where the foliar feeding with Zn + Mn mixture significantly increased these traits. The lowest values of these traits were obtained from the control.

Table 6. Effect of decapitation and foliar nutrition with Zn and Mn on green pods yield potential of okra plants during the summer seasons of 2003 and 2004.

Treatments	No. of green pods / plant		Early yield / plant (gm)		Early yield / fed. (ton)		Total yield / plant (gm)		Total yield / fed. (ton)		Average weight of green pod (gm)	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
D_1	56.50	72.42	45.84	45.10	0.871	0.856	364.59	360.20	6.93	6.85	5.47	4.98
D_2	51.50	53.50	46.42	44.50	0.882	0.856	301.60	289.03	5.60	5.44	5.82	5.36
D_0	42.67	46.75	51.67	55.40	0.981	1.05	258.80	277.17	5.15	5.27	6.04	5.92
LSD at 5%	2.29	1.37	2.26	1.49	0.04	0.02	15.12	8.79	0.49	0.17	0.15	0.12
1%	3.11	1.87	3.07	2.03	0.05	0.04	20.58	11.97	0.69	0.24	0.19	0.15
Zn*	56.44	60.56	50.49	51.73	0.959	0.983	326.37	327.84	6.54	6.24	5.79	5.51
Mn	53.78	57.00	48.66	47.00	0.924	0.893	312.96	301.53	5.90	5.64	5.84	5.39
Zn + Mn	57.90	65.11	55.38	59.46	1.05	1.13	353.21	378.44	6.96	7.21	6.22	5.90
Control	46.11	47.56	37.39	35.10	0.709	0.679	240.60	277.37	4.58	4.32	5.27	4.84
LSD at 5%	2.67	1.58	2.61	1.73	0.05	0.04	17.43	10.37	0.56	0.20	0.17	0.12
1%	3.63	2.16	3.55	2.35	0.07	0.05	23.74	13.84	0.76	0.28	0.23	0.16

Decapitation; D_1, D_2 were done after 30 and 45 days of seed sowing and D_0 (without decapitation).
* Zn and Mn as foliar application with 300 ppm from each.

The improvement of okra yield by foliar application of Mn, Zn and Zn + Mn may be due to the low availability of these elements in soil owing to its relatively high pH (Table 1). Generally, it could be concluded that foliar spraying of okra plants with Zn + Mn increased productivity. Such result could be attributed to the enhancing effect of these micronutrients on different metabolic aspects such as enzymes activation photosynthetic assimilation, carbohydrate accumulation and role of such micronutrients in bio-synthesis of some plant hormone.

c. Effect of decapitation and foliar application interaction:

The interaction effect of decapitation with foliar application with Zn and Mn was significant in both seasons (Table 7). Early decapitation and foliar spray with Zn + Mn significantly increased number of green pods per plant and total yield per plant and per fed. Meanwhile, the interaction of untopping and foliar spray with Zn and Mn resulted in the maximum magnitudes of early green pod per plant and per fed and average weight of green pod in both seasons.

VI. Leaf nutrient content:

a. Effect of decapitation:

Table 8 show that decapitation had a significant effect on leaf nutrient content (N, P, K, Ca, Mg and Na) during both seasons compared of untopping treatment. Also, decapitation significantly increased Mn, Zn, Cu in both seasons (Table 9). Early decapitation had significant effect compared with late and unstopping. On the other hand, Ghoneim (2000) reported that decapitation of okra plants significantly reduced N contents of leaves and pods and protein contents in pods.

b. Effect of foliar application with Zn and Mn:

Table 8 shows that foliar feeding with Zn, Mn and Zn + Mn had a significant effect on nutrient content (N, P, K, Mg and Na) during both seasons compared with control. Meanwhile, foliar spray with Zn or Zn + Mn significantly increased leaf content of Zn and Cu in both seasons and Fe content in the second season. Foliar spray with Mn increased significantly Mn in both seasons and Fe in the first season (Table, 10).

Bin Ishaq (1992) stated that application of Fe, Mn or Fe + Mn combination increased Fe concentration in leaves of okra. It was also reported that application of Mn increased Fe concentration (Kumar *et al.*, 1981 and Gupta, 1972). But, Oki (1975) showed that application of Mn decreased Fe concentration.

On the other hand, Tylor and Joner (1963) said that Fe was linearly decreased by Zn. However, Kumar *et al.* (1981) stated that Mn application may decrease zinc concentration. Also, Ragheb (1994) found that spraying okra plants with Mn significantly increased Mn and Fe concentration in leaves and decrease Zn concentration.

Regarding zinc concentration, Ragheb (1994) reported that foliar spraying okra plants with Zn, Zn + Mn + Fe and Zn + Mn, respectively gave the highest values in either leaves or in seeds. Also, Noval *et al.* (2002) found that spraying of cotton plant with Mn + Zn + Fe significantly increased leaf Fe, Mn, Zn and Cu. El-Masri (2005) reported that spraying cotton plants with Zn + Mn significantly increased N, K, Zn and Mn contents on leaves.

Table 7. Effect of interaction between decapitation and foliar nutrition with Zn and Mn on green pods potential of okra plants during the summer seasons of 2003 and 2004.

Treatments		No. of green pods / plant		Early yield / plant (gm)		Early yield / fed. (ton)		Total yield / plant (gm)		Total yield / fed. (ton)		Average weight of green pod (gm)	
Decapitation	Foliar nutrition	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
D_1	Zn	68.00	75.00	48.53	45.00	0.922	0.855	385.70	359.73	7.34	6.84	5.67	4.80
	Mn	65.67	71.67	44.60	44.80	0.847	0.851	354.63	359.40	6.74	6.83	5.40	5.10
	Zn + Mn	69.67	80.33	50.83	54.43	0.966	1.03	404.37	433.53	7.68	8.24	5.80	5.40
	Control	62.66	62.67	39.40	36.03	0.748	0.684	313.13	288.13	5.96	5.48	5.00	4.60
D_2	Zn	57.00	56.67	51.60	48.93	0.980	0.930	336.27	317.13	6.40	6.10	5.90	5.60
	Mn	55.00	54.33	50.63	43.60	0.962	0.828	329.47	282.13	6.11	5.10	5.87	5.20
	Zn + Mn	56.33	60.00	52.50	45.00	0.997	1.03	341.07	352.60	6.48	6.75	6.20	5.87
	Control	37.67	43.00	30.97	31.47	0.588	0.638	199.60	204.97	3.80	3.90	5.30	4.77
D_0	Zn	44.33	50.00	51.33	61.27	0.975	1.16	257.13	306.67	5.88	5.83	5.80	6.13
	Mn	40.67	45.00	50.73	52.60	0.964	1.00	254.80	263.20	4.84	5.00	6.27	5.87
	Zn + Mn	47.67	55.00	62.80	69.93	1.19	1.33	314.20	349.82	5.90	6.67	6.60	6.50
	Control	38.00	37.00	41.80	37.80	0.790	0.714	209.07	189.00	3.97	3.60	5.50	5.17
LSD at 5%		4.60	2.75	4.51	3.02	0.09	0.06	30.18	17.58	0.99	0.35	0.26	0.21
1%		6.26	3.75	6.14	4.10	0.11	0.08	41.09	23.94	1.36	0.47	0.36	0.28

Decapitation; D_1, D_2 were done after 30 and 45 days of seed sowing and D_0 (without decapitation).
* Zn and Mn as foliar application with 300 ppm from each.

Table 9. Effect of interaction between decapitation and foliar nutrition with Zn and Mn on leaf macronutrients content of okra plants during the summer seasons of 2003 and 2004.

Treatments		N (%)		P (%)		K (%)		Ca (%)		Mg (%)		Na (%)	
Decapitation	Foliar nutrition	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
D_1	Zn	3.17	3.67	0.300	0.427	2.10	2.53	3.67	2.90	1.23	1.40	0.300	0.400
	Mn	3.50	4.20	0.300	0.260	2.17	2.30	3.00	3.13	1.33	1.23	0.330	0.400
	Zn + Mn	2.87	3.20	0.300	0.457	2.60	2.20	3.23	3.13	1.33	1.33	0.400	0.400
	Control	2.20	2.90	0.300	0.203	1.97.	1.60	3.00	2.63	0.93	1.23	0.330	0.233
D_2	Zn	2.33	3.50	0.300	0.363	2.03	2.43	3.00	3.20	1.13	1.20	0.300	0.400
	Mn	2.60	3.90	0.270	0.287	1.93	1.63	3.00	3.13	1.20	1.07	0.270	0.300
	Zn + Mn	3.23	3.27	0.300	0.257	1.37	1.33	3.13	3.13	0.93	1.00	0.270	0.300
	Control	2.03	2.83	0.270	0.350	2.00	2.10	3.00	2.57	0.83	1.33	0.230	0.400
D_0	Zn	2.33	2.47	0.230	0.270	1.97	2.13	2.60	2.67	0.900	0.833	0.270	0.200
	Mn	2.63	3.50	0.300	0.307	1.90	1.73	2.83	2.83	0.900	0.900	0.300	0.300
	Zn + Mn	2.73	3.30	0.370	0.323	2.20	2.33	3.07	3.13	0.830	0.833	0.200	0.200
	Control	2.57	2.80	0.130	0.397	1.53	1.83	2.97	2.17	0.530	0.833	0.200	0.200
LSD at 5%		0.09	0.08	0.06	0.018	0.210	0.05	0.09	0.40	0.11	0.070	0.060	0.028
1%		0.13	0.10	0.08	0.025	0.280	0.07	0.12	NS	0.16	0.100	0.090	0.038

Decapitation; D_1, D_2 were done after 30 and 45 days of seed sowing and D_0 (without decapitation).

*** Zn and Mn as foliar application with 300 ppm from each.**

Table 8. Effect of decapitation and foliar nutrition with Zn and Mn on leaf macronutrients content of okra plants during the summer seasons of 2003 and ∠004.

Treatments	N (%)		P (%)		K (%)		Ca (%)		Mg (%)		Na (%)	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
D_1	2.93	3.44	0.300	0.337	2.21	2.13	3.23	2.95	1.21	1.30	0.275	0.358
D_2	2.75	3.38	0.283	0.341	1.83	1.89	3.03	3.01	1.03	1.10	0.292	0.350
D_0	2.54	3.03	0.258	0.324	1.90	2.01	2.87	2.70	0.80	0.85	0.283	0.225
LSD at 5%	0.05	0.04	0.030	0.008	0.12	0.02	0.04	0.20	0.06	0.04	0.030	0.014
1%	0.06	0.05	0.040	0.011	0.13	0.03	0.06	0.27	0.08	0.05	0.050	0.019
Zn*	2.58	3.14	0.278	0.353	2.03	2.37	3.09	2.92	1.09	1.14	0.290	0.333
Mn	2.91	3.87	0.289	0.284	2.00	1.89	2.94	3.03	1.14	1.07	0.300	0.333
Zn + Mn	2.94	3.26	0.322	0.346	2.06	1.96	3.14	3.13	1.03	1.06	0.290	0.300
Control	2.53	2.86	0.233	0.317	1.83	1.84	2.99	2.46	0.77	1.07	0.260	0.278
LSD at 5%	0.05	0.04	0.040	0.011	0.12	0.03	0.05	0.23	0.11	0.04	0.04	0.016
1%	0.07	0.06	0.050	0.014	0.16	0.04	0.07	0.32	0.16	0.06	NS	0.022

Decapitation; D_1, D_2 were done after 30 and 45 days of seed sowing and D_0 (without decapitation).

* Zn and Mn as foliar application with 300 ppm from each.

c. Effect of decapitation and foliar application interaction:

The effect of decapitation and foliar application interaction of N, P, K, Ca, Mg and Na was significant in both seasons (Table 9). Early and late decapitation significantly increased nutrient contents compared with undecapitation treatment. Data in Table 11 show that foliar application with Mn with early decapitation significantly increased Mn and Mn with early decapitation significantly increased Fe concentration in the second season. Also, foliar application with Zn significantly increased Zn and Cu concentration in both seasons.

Table 10. Effect of decapitation and foliar nutrition with Zn and Mn on leaf micronutrients content of okra plants during the summer seasons of 2003 and 2004.

Treatments	Fe (ppm)		Mn (ppm)		Zn (ppm)		Cu (ppm)	
	2003	2004	2003	2004	2003	2004	2003	2004
D_1	366.67	482.67	97.75	138.67	69.25	68.42	23.00	27.42
D_2	319.33	380.25	97.42	131.25	70.50	79.67	15.67	19.00
D_0	330.58	386.33	84.00	110.33	65.33	71.66	12.67	15.08
LSD at 5%	1.69	2.72	0.82	4.81	1.49	0.46	0.41	0.39
1%	2.31	3.71	1.12	6.54	2.03	0.63	0.56	0.54
Zn*	331.44	426.78	88.22	112.89	78.22	85.33	19.56	25.00
Mn	391.67	395.11	109.33	148.44	63.00	59.89	16.11	17.33
Zn + Mn	300.44	428.78	98.44	139.67	67.44	82.00	16.44	21.44
Control	331.89	415.00	76.22	106.00	64.78	65.78	16.33	18.22
LSD at 5%	1.96	3.14	0.94	5.55	1.73	0.53	0.47	0.46
1%	2.67	4.28	1.28	7.56	2.35	0.72	0.64	0.62

Decapitation; D_1, D_2 were done after 30 and 45 days of seed sowing and D_0 (without decapitation).
*** Zn and Mn as foliar application with 300 ppm from each.**

Table 11. Effect of interaction between decapitation and foliar nutrition with Zn and Mn on leaf micronutrients content of okra plants during the summer seasons of 2003 and 2004.

Treatments		Fe (ppm)		Mn (ppm)		Zn (ppm)		Cu (ppm)	
Deca.	Foliar nutrition	2003	2004	2003	2004	2003	2004	2003	2004
D_1	Zn	343.76	475.67	93.67	130.33	78.67	88.33	25.67	32.33
	Mn	402.00	495.00	133.0	150.00	66.00	43.00	23.00	24.00
	Zn + Mn	327.33	505.67	99.33	162.00	67.67	88.67	23.67	30.33
	Control	393.67	454.33	65.00	112.33	64.67	53.67	19.67	23.00
D_2	Zn	286.67	400.67	92.33	118.67	87.00	91.33	17.33	24.33
	Mn	360.67	362.67	112.00	151.67	59.00	67.33	15.33	15.67
	Zn + Mn	257.33	382.67	97.67	144.00	69.33	85.00	12.67	19.33
	Control	372.67	375.00	87.67	110.67	66.67	75.00	17.33	16.67
D_0	Zn	346.06	404.00	78.67	89.67	69.00	76.33	15.67	18.33
	Mn	412.33	327.67	83.00	143.67	64.00	69.33	10.00	12.33
	Zn + Mn	316.67	398.00	98.33	113.00	65.33	72.33	13.00	14.67
	Control	229.33	415.67	76.00	95.00	63.00	68.67	12.00	15.00
LSD at	5%	3.39	5.45	1.61	9.51	2.99	0.92	0.82	0.79
	1%	4.63	7.42	2.19	13.09	4.07	1.25	1.12	1.08

Decapitation; D_1, D_2 were done after 30 and 45 days of seed sowing and D_0 (without decapitation).
*** Zn and Mn as foliar application with 300 ppm from each.**

V. Seed yield and quality:

a. Effect of decapitation:

Data illustrated at Table 12 show the effect of decapitation treatments on number of pods per plant, seed yield per plant, seed yield (kg) / fed and seed index. It is obvious that late decapitation and undecapitation significantly increased these traits compared with early decapitation in both seasons. The highest values were obtained from undecapitation treatment compared with early decapitation.

Similar results were obtained by El-Halwaney *et al.* (1988), Hosney *et al.* (1991), on cotton, found that the topping gave significant lower yield of seed cotton / fed, and El-Assiouty (1998) reported that decapitation of okra plants led to significant reduction in number of pods per plant, seed yield per plant and per fed and seed index.

On the other hand, Abdalla and Shalaby (1981), Ghaly *et al.* (1988) pointed out that higher values of cotton seed and seed index were obtained when plants were topped and Ghoneim (2000) found that decapitation of okra plants significantly increased number of dry pods per plant, seed yield per plant and per fed.

b. Effect of foliar application with Zn and Mn:

The results shown in Table 12 demonstrated that foliar feeding with Zn, Mn and Zn + Mn had significant effect on number of dry pods, seed yield per plant and per fed and seed index compared with control in both seasons. The highest means of the previously mentioned traits were produced by foliar feeding okra plants with Zn + Mn combination at 300 ppm for each.

Table 12. Effect of decapitation and foliar nutrition with Zn and Mn on seed yield and quality of okra plants during the summer seasons of 2003 and 2004.

Treatments	No. of dry pods / plant		Seed yield / plant (gm)		Seed yield / fed (Ton)		Seed Index	
	2003	2004	2003	2004	2003	2004	2003	2004
D_1	16.67	17.00	57.80	57.00	1.10	1.07	62.75	62.75
D_2	19.58	19.75	60.60	61.17	1.16	1.16	63.50	62.83
D_0	19.42	19.17	63.00	62.00	1.20	1.18	62.25	62.00
LSD at 5%	0.62	0.70	0.32	1.11	0.17	0.03	0.85	NS
1%	0.84	0.95	0.44	1.52	0.23	0.04	1.15	NS
Zn*	18.56	18.78	61.06	61.00	1.16	1.16	63.56	62.89
Mn	17.56	18.00	58.90	58.44	1.13	1.11	62.11	62.00
Zn + Mn	20.67	21.00	64.11	63.56	1.22	1.19	64.67	64.56
Control	16.20	16.78	27.70	57.22	1.10	1.09	61.00	61.33
LSD at 5%	0.73	0.82	0.38	1.29	0.01	0.03	0.99	1.27
1%	0.99	1.21	0.52	1.75	0.03	0.04	1.36	1.73

Decapitation; D_1, D_2 were done after 30 and 45 days of seed sowing and D_0 (without decapitation).

*** Zn and Mn as foliar application with 300 ppm from each.**

Ragheb (1994) found that spraying okra plants with 300 ppm Zn or 300 ppm Zn + 300 ppm Mn + 300 ppm Fe increased seed yield per plant and number of pods per plant. Also, El-Assiouty (1998) found that Cu, (Mn + Cu) or (Cu + Zn) significantly increased No. of dry pods / plant, No. of seeds / pod, seed yield per plant and per fed and seed index. El-Masri (2005) found that spraying cotton plant with Zn + Mn at 3 gm/L for each significantly increased seed cotton yield and seed index.

c. Effect of decapitation and foliar application with Zn and Mn interaction:

The interaction effect between the two studied factors had significant effect on number of pods per plant, seed yield per plant and per fed and seed index. It is clear from Table 13 that the combined treatment of late decapitation x (Zn + Mn) produced the highest values for all seed yield components and quality in both seasons. The lowest values were obtained by the combined treatment of early decapitation x control (sprayed with tap water) in both season.

Table 13. Effect of interaction between decapitation and foliar nutrition with Zn and Mn on seed yield and quality of okra plants during the summer seasons of 2003 and 2004.

Treatments		No. of dry pods / plant		Seed yield / plant (gm)		Seed yield / fed (Ton)		Seed Index	
Deca.	Foliar nutrition	2003	2004	2003	2004	2003	2004	2003	2004
D_1	Zn	17.00	17.33	58.50	58.67	1.11	1.11	64.00	63.00
	Mn	16.00	16.33	57.00	56.00	1.08	1.06	62.00	62.67
	Zn + Mn	19.00	19.33	60.67	60.33	1.15	1.10	64.00	63.67
	Control	14.67	15.00	55.00	53.00	1.05	1.01	61.00	61.67
D_2	Zn	20.00	20.00	61.33	62.00	1.17	1.18	65.00	63.33
	Mn	18.33	19.00	59.00	59.67	1.15	1.13	62.33	61.67
	Zn + Mn	23.00	22.67	65.00	65.33	1.24	1.24	66.33	65.33
	Control	17.00	17.33	57.00	57.67	1.10	1.10	60.33	61.00
D_0	Zn	18.67	19.00	63.33	62.33	1.20	1.19	61.67	62.33
	Mn	18.33	18.67	60.83	59.67	1.16	1.13	62.00	61.67
	Zn + Mn	20.00	21.00	66.67	65.00	1.27	1.24	63.67	64.67
	Control	17.00	18.00	61.17	61.00	1.16	1.16	61.67	61.33
LSD at	5%	1.26	1.42	0.64	2.23	0.03	0.05	1.73	2.21
	1%	1.72	1.94	0.88	3.04	0.04	0.07	2.35	3.01

Decapitation; D_1, D_2 were done after 30 and 45 days of seed sowing and D_0 (without decapitation).

* Zn and Mn as foliar application with 300 ppm from each.

Conclusion:

It could be concluded that early decapitation after 30 days of seed sowing combined with foliar spray with 300 ppm Zn + 300 ppm Mn gave the highest values of growth flowering and green pods yield of okra plants. For seed production, late decapitation after 45 days of seed sowing combined with foliar application with 300 ppm Zn + 300 ppm Mn gave the highest values of these results.

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تأثير تطويش القمة النامية والرش بالزنك والمنجنيز على النمو ، الإزهار ، المحصول الأخضر للقرون وإنتاج بذور الباميا وجودته

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** قسم تغذية النبات - المركز القومى للبحوث - الدقى - مصر

أجريت تجربتان حقليتان بمحطة البحوث الزراعية بالجميزه - محافظة الغربية ، خلال الموسم الصيفى لعام ٢٠٠٣ ، ٢٠٠٤ لدراسة تأثير معاملات تطويش (إزالة) القمة النامية لنباتات الباميا (صنف بلدى) (تطويش مبكر ومتأخر بعد ٣٠ ، ٤٥ يوم من زراعة البذور على التوالى وغير مطوشة "كنترول") والرش بالزنك والمنجنيز فى صورة مخلبية ١٢% زنك ، ١٢% منجنيز (٣٠٠ جزء فى المليون زنك ، ٣٠٠ جزء فى المليون منجنيز ، ٣٠٠ جزء فى المليون زنك + ٣٠٠ جزء فى المليون منجنيز ، الكنترول "رش بماء الصنبور")٠

إستخدم تصميم القطع المنشقة مرة واحدة فى قطاعات كاملة العشوائية فى ثلاث مكررات ، حيث وزعت معاملات التطويش فى القطع الرئيسية ومعاملات الرش بالزنك والمنجنيز فى القطع المنشقة٠ وتتلخص أهم النتائج فيما يلى:-

١- تأثير التطويش: أثرت معاملات تطويش القمة النامية لنباتات الباميا معنوياً على جميع الصفات المدروسة فى كلا الموسمين٠ حيث أدى تطويش القمة النامية إلى زيادة معنوية فى صفات النمو الخضرى فيما عدا إرتفاع النبات وعدد الأزهار على النبات وتأخير ميعاد الإزهار٠ أدى التطويش المبكر بعد ٣٠ يوم من زراعة البذور إلى زيادة عدد القرون الخضراء على النبات والمحصول الأخضر على النبات ومحصول الفدان ونقص فى المحصول المبكر٠

- كما وجد أنه كلما كان التطويش مبكراً كلما كانت القرون صغيرة الوزن٠ كما أدى التطويش إلى زيادة محتوى الأوراق من النيتروجين والفوسفور والبوتاسيوم والكالسيوم والمغنسيوم والصوديوم مقارنة بعدم التطويش وكذلك محتوى الأوراق من المنجنيز والزنك والنحاس٠ كما أدى التطويش المبكر إلى زيادة محتوى الأوراق من الحديد٠
- وقد لوحظ أن التطويش المبكر كان أكثر تأثيراً وفعالية مقارنة بالتطويش المتأخر٠ وقد أثبتت النتائج أن التطويش المتأخر وعدم التطويش كان أكثر فعالية من حيث إنتاج البذور عن التطويش المبكر٠

٢- تأثير الرش بالزنك والمنجنيز: أعطت التغذية بالزنك والمنجنيز تأثيراً معنوياً على جميع الصفات المدروسة فى كلا الموسمين٠ وكانت أعلى القيم تم الحصول عليها من رش نباتات الباميا بمخلوط ٣٠٠ جزء فى المليون زنك + ٣٠٠ جزء فى المليون منجنيز مقارنة بمعاملة المقارنة الرش بالماء (زيادة النمو الخضرى - زيادة محتوى الأوراق من العناصر الغذائية - زيادة عدد القرون على النبات - زيادة المحصول المبكر والكلى وزيادة محصول البذور)٠

٣- تم مناقشة تأثير التفاعل والرش بالزنك والمنجنيز٠

وتوصى الدراسة بتطويش نباتات الباميا مبكراً بعد ٣٠ يوم من زراعة البذور والرش مرتين (بعد ٢٥، ٤٠ يوم من زراعة البذور) بمخلوط ٣٠٠ جزء فى المليون زنك مخلبى Zn-EDTA ١٢% زنك + ٣٠٠ جـزء فى المـليون منجنيز مخلبى Mn-EDTA ١٢% زنك وذلك للحصول على أعلى محصول من القرون الخضراء٠

وفى حالة إنتاج البذور توصى الدراسة بالتطويش المتأخر مع الرش بـ ٣٠٠ جزء فى المليون زنك مخلبى + ٣٠٠ جزء فى المليون منجنيز مخلبى٠