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THE PROSPECTIVE REQUIREMENTS OF ZINC AND MANGANESE FOR COTTON UNDER SOIL ZN AND MN DEFICIENCY

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ABSTRACT

Two field experiments were carried out at Kafr El-Dawar Center, El-Beheira Governorate, Egypt, during 2003 and 2004 seasons to study the response of the Egyptian extra long staple Giza 70 cotton cultivar, to tow foliar feedings with Zn and Mn at two levels (i.e. 1.5 g/L and 3 g/L) either alone or in combination in comparison with a control(spraying water) in view of soil testing where the experimental soil sites suffer from these two micronutrients deficiencies.

The results could be summarized as follows :

Foliar feeding with Zn and Mn had a significant effect on leaf N, K, Mn and Zn contents in both seasons in favour of foliar feeding with Zn+Mn mixture either at the high or low level. Also, these two treatments significantly increased plant height at harvest and number of fruiting branches/plant in both seasons as compared with the control. Moreover, these two traatments significantly incraased number of total bolls set/plant, boll setting % , earliness % , number of open bolls/ plant, boll weight , seed index , seed cotton yield/plant and/fed. in both seasons as compared with the control. Also, the results indicated that foliar feeding with Zn or Mn alone at the high level significantly increased most of the above traits as compared with the control

The results concluded that two foliar feedings with a mixture of 3 g/L zinc-EDTA (14% Zn), and of 3 g/L manganese-EDTA (14% Mn), at the beginning of flowering and 15 days later, as the soil suffer from Zn and Mn deficiencies is the best treatment for good growth and high productivity of cotton (cv. Giza 70).

INTRODUCTION

Crop growth and yield are often restricted by the fact that certain nutrient elements, or sometimes a single nutrient, are inadequate or unavailable. The soil is then said to be deficient in the nutrient (s) in question. In practice, such deficiencies are very common. Soils are very often unbalanced or impoverished because in the past there has been a failure to put back all nutrients that have been removed by the crop (Sement, 1988).

In Egypt, cotton (*Gossypium barbadense L*) is grown on flood-irrigated loamy or clayey soils with high pH (around 8). The crop is commonly preceded by Egyptian clover (*Trifolium alexandrinum L*) where two cuts of this preceding crop removes averages of 190 kg K_2O + 1.1 kg Fe + 0.25 kg from each of Mn and Zn/ha from the soil (El-Fouly *et al.*, 1987). In spite of high K and micronutrients depletion from soil, before cotton planting, farmers are not used to apply either K or any of micronutrients fertilizers. The wide spread possible deficiencies, of these nutrients, are possibly contribute to an imbalanced cotton nutrition which leads to low yield (Fawzy *et al.*, 1987). Above pH 7 ,soil zinc and manganese, become less available (Cardozier, 1957). Concerning the effect of Zn or Mn on cotton plants, Girgis (1982) found that spraying cotton plants with Mn increased boll weight, boll number, seed cotton yield/plant and/feddan. Darwish and Hegab (2000) found that foliar application of Zn to cotton plants significantly increased seed cotton yield/plant and/fed. compared with the control in two seasons, but seed index and lint % were not significantly affected. Nofal *et al.* (2002) found that numbers of total and open bolls/plant, boll weight, seed cotton yield/plant and/fed. were significantly increased when plants received two foliar sprayings with Mn+Zn mixture either at the high or low level.

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). Therefore a soil analysis of the experimental sites was made before sowing to study, in view of soil testing, the response of the Egyptian extra long staple Giza 70 cotton cultivar to foliar application of Zn and Mn.

MATERIALS AND METHODS

Two field experiments were carried out at Kafr El-Dawar District, El-Beheira Governorate, Egypt, during 2003 and 2004 seasons to study the response of the Egyptian extra long staple cotton (*Gossypium barbadense L*), Giza 70 cultivar to two foliar applications of Zn and Mn at two levels (i.e. 1.5 g/L and 3 g/L) either alone or in combination compared with a control (spraying tap water). The soil analysis(Table 1) shows that experimental soil sites suffer from these two micronutrients deficiencies. The experimental design was a randomized complete blocks with four replicates where each experiment included seven treatments, which were :

1- Control, spraying with tap water.
2- Spraying zinc-chelate 1.5 g/L , (Zn_1)
3- Spraying zinc-chelate 3 g/L , (Zn_2).
4- Spraying manganese-chelate 1.5 g/L , (Mn_1).
5- Spraying manganese-chelate 3 g/L , (Mn_2).
6- Spraying with mixture of zinc-chelate 1.5 g/L + manganese- chelate 1.5 g/L , (Zn_1 + Mn_1).
7- Spraying with mixture of zinc-chelate 3 g/L + manganese- chelate 3 g/L , (Zn_2 + Mn_2).

- The chelate compounds were : Zn-EDTA (14% Zn) and Mn-EDTA (14% Mn).
- The chelated compounds were applied as foliar sprays on cotton plants at the start of flowering stage followed by another spray, 15 days later using hand operated compressed at a low volume of 200 litre /fed.

In both seasons, the plot consisted of eight rows, eight meters long, 65 cm apart and the distance between hills was 25 cm. The planting date was 7 April in both seasons.

- The preceding crop was Egyptian clover (*Trifolium alexandrinum L*) berseem, from which two cuts were taken in both seasons.

Phosphorus fertilizer was add to the soil at the rate of 22.5 kg P_2O_5/ fed. as calcium superphosphate (15% P_2O_5) during land preparation. Nitrogen fertilizer was applied at the rate of 60 kg N/ fed. as ammonium nitrate (33.5% N) in two equal portions. The 1st portion was applied after thinning and the 2nd portion was applied 15days later. Potassium fertilizer was added at the rate of 24 kg K_2O/ fed. as potassium sulphate (48% K_2O) in one dose at the time of applying the 1st dose of nitrogen.

- All other cultural practices were followed as recommended in cotton fields.

Soil analysis :

Representative soil samples were taken from the experimental sites before planting in both seasons and prepared for analysis, according to Chapman and Pratt (1978). The results of soil analysis are shown in Table (1).

Table (1): Soil chemical analysis of the experimental site in the two seasons for the 40 cm soil depth.

Properties	2003	2004
Texture	Clay loam	Clay loam
pH	8.1	8.0
E.C. mmohs/cm	1.34	1.47
Organic matter %	1.85	1.90
CaCO3	13.8	16.3
Total N (mg/100 gm soil)	64.7	66.5
Available P (mg/100 gm soil)	1.16	1.23
Available K (mg/100 gm soil)	30.1	28.7
Available Ca (mg/100 gm soil)	450	455
Available Mg (mg/100 gm soil)	157.6	131.9
Available Na (mg/100 gm soil)	59.2	70.7
Available Fe (ppm)	15.0	16.2
Available Mn (ppm)	4.35	5.3
Available Zn (ppm)	1.09	1.2
Available Cu (ppm)	4.6	4.9

The data indicate that the two experimental soil sites had high pH values. Regarding soil micronutrients content, the soils of the two sites were high in available Fe but were poor in their available contents from Zn and Mn measured by the critical levels according to Ankerman and Large (1974).

Studied characters :

A- Leaf nutrient content :

120-days after planting, a representative leaf sample (20 leaves) was taken from the youngest fully matured leaf (4th leaf) on the main stem from each 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 and Mg were determined according to Chapman and Pratt (1978). Also the total N content was determined using Micro – Kjeldahl method as described by Allen (1953) and Ma and Zauzage (1942).

B- Growth traits :

At harvest, plants of five guarded hills were taken at random from the second row of each plot to determine plant height (cm) and number of fruiting branches/plant.

C- Boll setting attributes and earliness :

The forementioned five guarded hills were also used to determine the following attributes : number of fruiting positions/plant,

$$\text{boll setting \%} = \left(\frac{\text{Number of total bolls set/plant}}{\text{Number of fruiting positions/plant}} \times 100 \right)$$

and, $$\text{earliness \%} = \left(\frac{\text{Seed cotton yield of the first pick}}{\text{Total seed cotton yield}} \times 100 \right)$$

according to Richmond and Radwan (1962)

D- Seed cotton yield and its components :

The same five guarded hills were also used to determine the following yield components : numbers of total and open bolls/plant, boll weight (g), seed cotton yield/plant (g), lint % and seed index "100 seed weight".

Seed cotton yield/feddan* in kentars** was calculated from the yield of the six inner rows of each plot.

The obtained data were subjected to statistical analysis outlined by Snedecor and Cochran (1971). The treatments means were compared using L.S.D at 0.05 level of probability.

RESULTS AND DISCUSSION

A- Leaf nutrient content :

Foliar feeding with micronutrients had a significant effect on leaf N, K, Zn and Mn contents in both seasons (Tables 2 and 3). The highest leaf N and K contents were obtained from foliar feeding with Zn+Mn mixture either at the high or low level, followed by foliar feeding with Mn or Zn alone at the high level, while the lowest values were obtained from foliar feeding with Zn or Mn alone at the low level and from the control. Also, the foliar feeding with Zn+Mn mixture either at the high or low level gave the highest leaf Zn content followed by foliar feeding with Zn at the high or low level, while the lowest values of leaf Zn content were obtained from foliar feeding with Mn either at high or low level and from the control. The highest leaf Mn content was obtained from foliar feeding with Zn+Mn mixture either at the high or low level followed by foliar feeding with Mn either at the high or low level. while the lowest values of leaf Mn content were obtained from foliar feeding of Zn either at the high or low level and from the control. However, the tested treatments did not affect leaf P, Ca, Mg, Fe and Cu contents in both seasons (Tables 2 and 3)

In this concern, Ishag (1987) and (1992) found that foliar fertilizers encouraged the uptake of N, P and K and also increased the N content of leaves. Nofal *et al.* (2002) found that the effect of the different micronutrients on leaf N content was negative in the first season as compared with the control. However, the effect of the tested micronutrients was positive for leaf P-content in the first season and for leaf K and Mg contents in two seasons.

* One feddan = 4200.83 m^2.
** One kentar = 157.5 kg.

They add that the tested micronutrients significantly increased leaf Fe, Mn, Zn and Cu contents as compared with the control expecially when using complete mixture of Fe, Mn and Zn at the high level in two seasons.

B- Growth traits :

Data in Table (4) show that micronutrients treatments reflected significant differences in plant height at harvest and number of fruiting branches/plant in both seasons. The tallest plants were produced from foliar feeding with Zn+Mn mixture either at the high or low level and from foliar feeding with Zn or Mn at the high level, while the shortest plants were produced from the control.

1-The results indicate that any of the foliar Zn or Mn treatments produced longer plants than the control. The increase in the level of Zn application produced a further increase in plant height in the first season. This was not true for either Zn or Mn in the second season. However, the increase in the level of their combination was effective in this respect particularly in the first season.

2-Similar favourable effect was observed due to the foliar application of Zn, Mn and their combination on the number of fruiting branches / plant and hence the total number of bolls / plant (table 4). However, Mn had more favourable effect than Zn in this respect particularly in the second season where the increase in its level of application produced a further increase in this number. Therefore, the Zn and Mn combination at the high level produced the highest number .

The increase in plant height due to Zn application or its combination with Mn that has an influence on auxin level (Skoog, 1940) or to that Mn acts as an activator for many enzymes which promote plant growth.

In this concern, Abdel-Gawad *et al.* (1985) found that spraying cotton plants with combination of Zn and Mn gave taller plants than the control (without spraying) and they attributed this to the role of Zn on cell elongation and consequently the longitudinal growth in various plant parts. Darwish and Hegab (2000) found that zinc application exerted significant increase effects on final plant height and number of fruiting branches/ plant. Similar results were reported by Nofal *et al.* (2002) regarding the number of fruiting branches/plant.

C- Boll setting attributes and earliness :

Foliar feeding with Zn or Mn had a significant effect on number of total bolls set/plant, boll setting % and earliness % in both seasons (Table 4), where the foliar feeding with Zn+Mn mixture either at the high or low level significantly increased these traits followed by the foliar feeding with Zn or Mn at the high level. The lowest values of these traits were produced from foliar feeding with Zn or Mn at the low level and from the control. However, the number of fruiting positions/plant was not significantly affected by the tested treatments.

The increase of boll setting percentage due to the foliar application of Zn or Mn and their combination could be attributed to a possible increase of photosynthesis and hence the photosynthats available for boll set and development

Results of boll set in table (4) clearly indicated that foliar application of either Zn or Mn was effect to increase the percentage of boll setting compared with the control. Again Zn and Mn combination ot the high level recorded the highest averages in both seasons. Data of earliness show that this foliar application treatment played a great role in having about too – third of seed cotton yield in the first pick in the second season which did not vary significantly with the single application of Mn ot high level.

In this concem, Nofal *et al.* (2002) found that the highest values of earliness % were obtained from two foliar applications of Fe+Mn+Zn mixture either at the high or low level and from spraying Zn twice at the high level, however. the lowest value was obtained from untreated plants.

Table (2): Effect of foliar feeding with Zn and Mn on leaf macronutrients content in 2003 and 2004 seasons.

Treatments	N %		P %		K %		Ca %		Mg %	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
Control	3.8	3.3	0.18	0.16	1.82	2.08	1.07	1.0	0.37	0.40
Zn_1	3.9	3.6	0.22	0.17	1.99	2.16	1.13	1.01	0.41	0.38
Zn_2	4.2	4.0	0.21	0.17	2.08	2.27	1.95	1.13	0.40	0.37
Mn_1	3.9	3.8	0.21	0.15	2.06	2.16	1.36	1.02	0.38	0.31
Mn_2	4.2	4.6	0.22	0.15	2.08	2.68	1.08	1.40	0.42	0.30
Zn_1+Mn_1	4.4	4.7	0.20	0.16	2.09	2.88	1.39	1.18	0.46	0.27
Zn_2+Mn_2	4.4	4.8	0.23	0.17	2.52	3.10	2.09	1.29	0.41	0.26
F- test	*	**	NS	NS	**	**	NS	NS	NS	NS
$L.S.D_{0.05}$	0.4	0.3	---	---	0.20	0.14	---	---	---	---

*, ** and NS indicate $P < 0.05$, $P < 0.01$ and not significant, respectively.

Table (3): Effect of foliar feeding with Zn and Mn on leaf micronutrients content in 2003 and 2004 seasons.

Treatments	Fe (ppm)		Zn (ppm)		Mn (ppm)		Cu (ppm)	
	2003	2004	2003	2004	2003	2004	2003	2004
Control	97.1	122.3	26.2	27.2	35.5	36.3	8.8	10.5
Zn_1	82.1	120.1	34.0	41.6	38.7	37.6	9.8	10.9
Zn_2	97.1	119	41.0	43.0	45.6	40.8	10.5	9.1
Mn_1	90.5	119	28.9	33.5	47.6	41.6	10.2	10.2
Mn_2	93.5	122.1	33.1	34.6	49.5	43.5	9.1	10.9
Zn_1+Mn_1	90.5	118.4	44.2	48.7	52.7	46.4	10.5	10.3
Zn_2+Mn_2	95.2	124.7	45.3	49.7	54.4	48.3	9.8	9
F- test	NS	NS	**	**	**	*	NS	NS
$L.S.D_{0.05}$	---	---	8.9	4.7	7.2	7.2	---	---

*, ** and NS indicate $P < 0.05$, $P < 0.01$ and not significant, respectively

D- Seed cotton yield and its components :

The tested treatments had a significant effect on number of open bolls/plant, boll weight, seed index, seed cotton yield/plant and/fed. in both seasons (Table 5), where the highest values of these traits were obtained from plants receiving two foliar feedings with Zn+Mn mixture either at the high or low level followed by two foliar feedings with Zn or Mn alone at the high level, while the lowest values were obtained from plants receiving two foliar feedings with Zn alone at the low level and from the control. However , the tested treatments did not affect lint % in both seasons.

The high level of Zn+Mn mixture increased seed cotton yield/fed. by 38.74 and 20.16% over the control in the first and second seasons, respectively. This increment could be attributed to the following points :

1-Zn is critical for several key enzymes in the plant. Most notable are the enzymes that convert carbon dioxide to bicarbonate. Carbonic anhydrase has zinc at its active site and hence Zn deficient C_3 plants suffer from an enhanced photorespiration and a reduction in the availability of CO_2 at the sites of carboxylation (Seethambaram *et al*, 1985)

2-Historically Zn deficiny has been associated with low levels of IAA the hormone responsible for main stem growth (Oosterhuis *et al.*, 1991).

3-Mn acts as an activator for the enzymes nitrite reductase ahydroxylamine reductase. It is also required for the operation of some enzymes in the metabolism of the hormone indoleacetic acid. The most important role of manganese in photosynthesis is in the sequence of reactions by which electrons are derived from water and oxygen is liberated. It also has structural role in chloroplasts (Oosterhuis *et al.*, 1991).

4-Zn and Mn application increased leaf macronutrients (N and K) content and leaf micronutrients (Mn and Zn) content and this led to enhancing assimilation and encouraged more production of synthesized metabolites and hence caused a significant increase in boll weight and seed index.

5-The increase of open bolls number/plant as a result of increasing boll setting percentage.

In this concern, Burkalov (1969) found that spraying cotton leaves with Zn increased seed cotton yield by 14.4% and boll weight by 0.3 gram as compared with control plants given no micronutrients. Farghal (1973) reported that Mn was more effective in producing the highest average number of bolls as a direct result in producing the highest number of flowers with the lowest percentage of shedding when the plants were sprayed during the vegetative growth period. Also, Girgis (1982) found that spraying cotton plants with manganese increased boll weight, boll number, seed cotton yield/plant and/fed. However, Ibrahim *et al.* (1982) reported significant increases in seed cotton yield by 21.6 to 38.7% due to foliar application of manganese chelates. Abdel-Gawad *et al.* (1985) found that application of Mn at preflowering was among treatments that gave the highest number of open bolls/plant, seed cotton yield/plant and seed cotton yield/fed. as compared with the other treatments. Darwish and Hegab (2000) found that foliar application of zinc significantly increased boll weight, seed cotton yield/plant and/fed. compared with the control in two seasons, while it exerted insignificant effect on number of open bolls/plant, seed index and lint %. Nofal *et al.* (2002) found that two foliar sprayings with Mn+Zn mixture either at the high or low level significantly increased number of open bolls/plant, boll weight, seed cotton yield/plant and/fed. as compared with untreated plants.

Table (4): Effect of foliar feeding with Zn and Mn on cotton growth and setting attributes.

Treat-ments	Plant height at harvest (cm)		No. of fruiting branches/ plant		No. of fruiting positions/ plant		No. of total bolls set/plant		Boll setting %		Earliness %	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
Control	140.5	146.5	11.7	13.5	21.4	28.2	10.4	14.8	48.6	52.5	37	53
Zn_1	146 1	149.6	12.1	13.8	21	28.2	10.3	14.9	49	52.8	43.5	58.7
Zn_2	151.5	149.9	12.8	14.6	21.3	29.5	11.7	15.7	54.9	53.2	46.6	61.5
Mn_1	146.3	149.3	12.8	14.2	22.3	28.7	11.4	15.3	51.1	53.2	43.5	59.4
Mn_2	151.0	149.7	13.6	15.1	22.3	29.4	12	16.2	53.8	55.1	44.1	65.4
Zn_1+Mn_1	152.0	150.7	13.5	15.3	22.2	29.6	12.5	17.5	56.3	59.1	49.3	66.1
Zn_2+Mn_2	155.7	152.6	13.8	15.7	23.4	28.1	13.9	18.1	59.4	64.4	51.7	66.8
F- test	**	**	**	**	NS	NS	**	**	**	**	**	**
$L.S.D_{0.05}$	4.1	1.3	0.9	1.1	---	---	1.4	1.1	5.0	2.0	4.5	4.3

** and NS indicate $P < 0.01$ and not significant, respectively.

Table (5): Effect of foliar feeding with Zn and Mn on seed cotton yield and yield components in 2003 and 2004 seasons.

Treatments	No. of open bolls/plant		Boll/ weight (g)		Seed cotton yield/plant (g)		Lint %		Seed index (g)		Seed cotton yield/fed. (kentar)	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
Control	8.7	14.1	2.01	2.10	17.49	29.61	35.9	35.7	8.85	9 13	5.73	8.63
Zn1	9.1	14.2	2.05	2.24	18.65	31.81	35.6	35.8	9.50	9.5	6.43	8.69
Zn2	10.5	15	2.15	2.29	22.57	34.35	36.5	35.8	9.55	9.5	7.58	9.2
Mn1	9.9	14.8	2.09	2.33	20.69	34.48	36.5	36.1	9.45	9.48	6.48	9.4
Mn2	10.6	15.3	2.15	2.25	22.79	34.42	36.8	36.4	9.75	9.65	7.6	9.37
Zn1+Mn1	10.9	15.4	2.17	2.41	23.65	37.11	36.2	36.2	9.83	9.73	7.6	9.97
Zn2+Mn2	11	16.8	2.18	2.52	24.00	42.34	36.6	36.2	9.82	9.93	7.95	10.37
F- test	**	**	**	**	**	**	NS	NS	*	*	**	**
L.S.D0.05	1.1	0.9	0.10	0.11	2.6	3.4	---	---	0.52	0.46	0.62	0.88

* , ** and NS indicate $P < 0.05$, $P < 0.01$ and not significant, respectively.

CONCLUSION

It could be concluded that seed cotton yield of the extra long staple Giza 70 cultivar, grown in Kafr El-Dawar region could be increased by two foliar feedings with a mixture of 3 g/L zinc-EDTA (14% Zn), and of 3 g/L manganese-EDTA (14% Mn), at the beginning of flowering and 15 days later, as the soil suffer from Zn and Mn deficiencies.

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الإحتياجات المتوقعة من الزنك والمنجنيز للقطن تحت ظروف من نقص الزنك والمنجنيز بالتربة

محمد فتحى المصرى
قسم تغذية النبات – المركز القومى للبحوث – الدقى – الجيزة

أجريت تجربتان حقليتان بمركز كفر الدوار – محافظة البحيرة – مصر ، فى موسمى ٢٠٠٣ و ٢٠٠٤م لدراسة إستجابة صنف القطن المصرى فائق الطول جيزة ٧٠ إلى التغذية بالرش مرتين بالزنك والمنجنيز عند مستويين ١,٥جم/لتر و ٣جم/لتر سواء بمفردها أو فى مخاليط مقارنة بعدم المعاملة ككنترول فى ضوء إختبار التربة حيث أتضح أن مواقع التربة التجريبية تعانى من نقص هذين العنصرين .

ويمكن تلخيص النتائج كما يلى :

- أعطت التغذية بالرش بالزنك والمنجنيز تأثيرا معنويا على محتوى الورقة من النيتروجين ، البوتاسيوم ، المنجنيز و الزنك فى الموسمين لصالح التغذية برش مخلوط الزنك والمنجنيز سواء عند المستوى العالى أو المنخفض .
- أعطت هاتين المعاملتين زيادة معنوية في كل من طول النبات عند الجنى وعدد الأفرع الثمرية للنبات في الموسمين وذلك مقارنة بمعاملة المقارنة.
- أدت إضافة هاتين المعاملتين إلى زيادة معنوية في كل من عدد اللوز الكلى على النبات ، النسبة المئوية لعقد اللوز ، النسبة المئوية للتبكير وعدد اللوز المتفتح للنبات ومتوسط وزن اللوزة ومعامل البذرة ومحصول القطن الزهر للنبات وللفدان في الموسمين مقارنة بمعاملة المقارنة.

أشارت النتائج إلى أن التغذية بالرش بالزنك أو المنجنيز بمفردها عند المستوى العالى أعطت زيادة معنوية لمعظم الصفات السابقة مقارنة بمعاملة المقارنة(الرش بالماء)٠

وتوصى نتائج التجربة بالتغذية بالرش مرتين بمخلوط من ٣ جرام / لتر زنك مخلبى Zn - EDTA (١٤% زنك) و٣ جرام / لتر منجنيز مخلبى Mn - EDTA (١٤% منجنيز) عند بداية التزهير ثم بعد ١٥ يوم إذا كانت التربة تعانى من نقص الزنك والمنجنيز حيث أنها أعطت نموا جيدا وإنتاجية عالية لمحصول القطن صنف جيزة ٧٠ ٠