J. Agric. Sci. Mansoura Univ., 34 (2): 1265 - 1273, 2009

GROWTH AND PRODUCTIVITY OF GIZA 80 COTTON CULTIVAR AS AFFECTED BY FOLIAR FEEDING WITH BORON AND ZINC.

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ABSTRACT

Two field experiments were carried out at Sids Agric. Res. Station, Beni-Suef Governorate, in 2007 and 2008 seasons. The experiment was conducted to evaluate the effect of foliar feeding with B and/or Zn on growth and productivity of the Egyptian cotton Giza 80 cultivar (*G. barbadense L.,*) to study response of growth, fruiting and yield. Besides the control treatment, two concentrations of both boron (85 and 170 ppm) and zinc (180 and 360 ppm) and their combinations were applied twice; at the start and peak of flowering. The experimental design was randomized complete blocks with four replications. Results revealed that, spraying boron and zinc either separately or in combination generally showed some positive effects on cotton growth, fruiting and yield in comparison with untreated control in both seasons, but such as some of their treatments significantly increased only plant height and number of fruiting branches/plant in 2007 season; number of open bolls/plant, boll weight and seed cotton yield/fad. in both seasons and seed index in 2008 season and significantly decreased fruit shedding % in 2008 season. Across the two studied seasons, the combined application of 85 ppm B and either 180 or 360 ppm Zn exerted the most consistently positive effects on cotton growth and fruiting and gave the highest seed cotton yield. The higher levels of either B or Zn (170 ppm B or 360 ppm Zn) showed no more benefits than those obtained of the lower ones (85 ppm B or 180 ppm Zn), rather than it tended to reduce them in case of boron. It could be concluded from this study that yield of Giza 80 cotton cultivar might be increased by spraying 85 ppm boron + 180 ppm zinc under the environmental conditions of this study or similar of them.

Keywords: Cotton, Foliar Feeding, Boron, Zinc, Micronutrients, Growth, Fruiting, Earliness and Yield.

INTRODUCTION

It has long been established that adequate and balanced nutrient supply is a major component of any successful cotton production system. Thus, a primary objective of efficient cotton nutrition management is that deficiencies of essential nutrients, both macro- and micro-ones, should be avoided. Otherwise, owing to intensive cultivation in consecutive years especially under unsustainable form of agriculture, like those dominated in Egypt, soil fertility is steadily declined due to continuous nutrients removal without balanced and efficient soil replenishment. Under such situations, the availability of micronutrients in the soil is liable to be reduced to level that may limit crop growth and productivity. This emphasizes the importance of the achievement of sustainable agriculture as a manager of the natural resources for future. Besides, some soil conditions in Egypt are perceived as being likely to induce micronutrients deficiencies such as high pH, low organic matter and high calcium carbonate, Hamissa & Abdel-Salam (1999) and El-Fouly (2006). In addition, taking in consideration also the increased use of the newly developed cultivars with high nutrients demand and the global climatic changes with their consequences on plant, soil and the whole agro ecosystem, the recommendations of a crop fertilization, therefore, should be regularly updated preferably on a site-specific basis to suit the current nutrient status in soil and the crop requirements for nutrients.

Adequate supply of micronutrients is essential for healthy plant growth and high crop productivity. Although, required by plants in small amounts, micronutrients are vital in terms of their significance in plant growth and development. Furthermore, their importance is growing at both local and global scales with mining of their reserves in soils and increasing crop demand for them. Micronutrients are involved in regulating plant physiology and in enhancing plant stress tolerance, El-Fouly (2006) and Dar (2004). Also, micronutrients have positive environmental impacts through increasing the use efficiency of macronutrients, Malakouti, (2006). Thus, micronutrients are a critical component of balanced plant fertilization management necessary for increasing and sustaining future crop production, Dar (2004) and Dell *et al.* (2006). In Egypt, El-Fouly & Fawzi (1995) emphasized that the use of micronutrients may help in obtaining higher and better crop yields with less environmental pollution. Among micronutrients, boron and zinc are of particular importance for cotton, and adequate supply of both to cotton can be of significant economic importance, Roberts *et al.* (2000) and Alloway (2008).

Boron (B) has been universally recognized as the most important micronutrient for cotton production, and cotton plant requires B in relatively large amounts as compared with other plants, Niaz *et al.* (2002) and Roberts *et al.* (2000). It is involved in many important biochemical and physiological functions in plants, most of which are related to its structural role in cell wall formation and in membrane functions, Blevins & Lukaszewski (1998). Boron helps in the biosynthesis of cell walls, and thereby cell division and elongation, in the rapidly growing, conductive and storage tissues; and also aids in sugars and nutrients translocation, resulting in promoting growth of vegetative growing tissues and developing storage sinks, Blevins & Lukaszewski (1998). Cotton plant shows a particular need for B during flowering and boll development stage owing to the central role of B in stimulating pollen germination and pollen tube growth, resulting in successful fruit setting, Niaz *et al.* (2002) and Zhao & Oosterhuis (2003). Many recent studies have demonstrated positive effects of foliar application of B on cotton growth, fruit retention, yield and yield components of cotton in Egypt, Saeed (2000); El-Shazly *et al.* (2005) and El-Menshawi & El-sayed (2007).

Zinc also is important for healthy and high yielding crops. The metabolic functions of zinc are mainly based on its role as a structural constituent or regulatory co-factor of enzyme systems involved in several key physiological pathways including; photosynthesis, sugar formation, protein synthesis, growth regulation and defense against disease, Rengel (2007) and Alloway (2008). It has a role in the maintenance of structural and functional integrity of biological membranes, El-Fouly (2006) and Alloway (2008). Thus, tolerance to environmental stresses has a high requirements for *Zn* and Zn-deficient plants are sensitive to stress conditions, Cakmak (2000). Cotton is regarded as being a particularly Zn-sensitive crop, Alloway (2008). Several workers documented favorable responses of cotton growth and productivity to foliar feeding with Zn, Wassel *et al.* (2000); Noval *et al.* (2002); El-Morsi (2005) and El-Menshawi & El-sayed (2007).

Thus, the main objective of this study was to evaluate the effect of foliar feeding with B and/or Zn on growth and productivity of Giza 80 cotton cultivar under the Egyptian soils environment.

MATERIALS AND METHODS

Two field experiments were conducted at Sids Agric. Res. Station, Beni Suef governorate, Middle Egypt, in 2007 and 2008 seasons, using the Egyptian cotton cultivar Giza 80 (*G. barbadense L.*). A randomized complete blocks design in four replications was used. Plot area was $12m^2$, including 5 ridges, 4m long and 60cm apart. Distances between hills were 25 cm and leaving two plants per hill at thinning (five weeks after sowing). Sowing date was in the last week of March in both seasons. The physical and chemical analysis of the experimental sites is presented in (Table 1).

Table (1): Physical and chemical analysis of the experimental soil.

Soil properties		2007	2008
Texture class		Clay loam	Clay loam
Organic matter	(%)	1.31	1.52
Ph		8.0	8.1
E.C.		0.45	0.59
$CaCO_3$	(%)	2.8	2.3
HCO_3^-		1.36	1.29
Available N	(ppm)	34.9	38.8
Available P	(ppm)	9.0	7.5
Available K	(ppm)	382	358
Available B	(ppm)	0.85	0.97
Available Zn	(ppm)	1.05	0.95
Available Fe	(ppm)	9.0	6.3
Available Cu	(ppm)	4.5	3.8
Available Mn	(ppm)	7.0	11.0

Boron in the form of boric acid (17% B) and zinc in the form of zinc sulphate (36% Zn) were used. Two concentrations of each of boron (85 and 170 ppm B) and zinc (180 and 360 ppm Zn) and their combinations were sprayed twice, at the start and peak of flowering stages. Standard agricultural practices were followed throughout the growing seasons.

At harvest, five representative hills were chosen by random from each plot to study the following traits;

Final plant height (cm), number of main stem nodes and number of fruiting branches per plant, number of open bolls per plant, number of non-open bolls per plant, numbers of aborted and total fruiting sites per plant. Fruit shedding % was calculated as (aborted fruiting sites ÷ total fruiting sites) x 100, boll weight (g). Earliness index (%) was calculated as (1^{st} pick yield ÷ total yield) x 100, lint percentage and seed index (g).

Seed-cotton yield per feddan in Kentars, estimated as the weight of seed cotton yield picked from the three middle rows, then converted to yield per feddan in kentar (Ken./fed.)

The collected data were subjected to statistical analysis according to Gomez and Gomez (1984), L.S.D. values at 5% level of significance were used for comparison between means.

RESULTS AND DISCUSSION

1- Effect on plant growth parameters:

Data present in Table (2) reveal that all foliar treatments of B and Zn either separately or in combination tended to increase plant growth parameters in comparison with the untreated control in both seasons. However, the significant effects were obtained on plant height and number of fruiting branches/plant in 2007 season only, when both traits were significantly increased by all treatments except for the higher level of B (170 ppm).

Table (2): Effect of boron (B) and zinc (Zn) foliar treatments on some growth parameters of cotton plant in 2007 and 2008 seasons.

Treatments	Plant height (cm)		No. of main stem nodes		No. of fruiting branches/plant	
	2007	2008	2007	2008	2007	2008
Control	120.4	136.7	24.2	25.0	13.1	14.2
85 ppm B	126.3	140.4	25.8	26.3	14.6	15.6
170 ppm B	124.5	137.5	24.8	25.5	13.9	14.7
180 ppm Zn	124.4	138.8	25.3	25.6	14.4	14.8
360 ppm Zn	126.6	140.7	25.6	26.2	14.8	15.4
85 ppm B + 180 ppm Zn	126.8	142.6	25.8	27.4	14.9	16.4
85 ppm B + 360 ppm Zn	127.5	141.4	26.0	26.7	15.0	16.0
170 ppm B + 180 ppm Zn	126.0	141.8	25.5	27.0	14.3	16.1
170 ppm B + 360 ppm Zn	125.7	140.7	25.3	26.8	14.3	15.6
L.S.D. at 5%	4.5	N.S	N.S	N.S	1.2	N.S

The lower B concentration (85 ppm) surpassed the higher one (170 ppm) in enhancing plant growth, while the two Zn concentrations gave comparable effects in this respect. In general, the combined application of 85 ppm B and either 180 or 360 ppm Zn produced the tallest plants with the highest fruiting branches, followed by 85 ppm B alone.

This enhancement in plant growth obtained by foliar B and Zn treatments may be a result of their roles in stimulating plant biological activities such as photosynthesis, enzyme activities, nutrient uptake and rate of translocation of photosynthetic products. In this concern, B has been reported to be essential for the biosynthesis and structure of cell walls in the rapidly growing tissues, which leads to a cascade of secondary effects on plant growth and production. It also increases endogenous level of IAA via antagonizing its oxidative degradation by IAA-oxidase enzyme, Blevins & Lukaszewski (1998) and Niaz *et al.* (2002). Likewise, Zn is a growth promoting element required for the synthesis of the amino acid tryptophan, the precursor for the biosynthesis of the natural auxin IAA responsible for stem elongation, Alloway (2008). Stunted and poor plant growth is common symptoms of B-deficiency, Blevins & Lukaszewski (1998) and Zn-deficiency, Alloway (2008). Many researchers obtained increases in cotton growth by foliar feeding with B, Zn or with both, Wassel *et al.* (2000); Noval *et al.* (2002) and El- Menshawy & El-Sayed (2007).

2- Effect on plant fruiting characteristics:

Results illustrate in Table (3) show that various treatments of B and Zn exhibited an increase in number of open bolls/plant and a reduction in fruit shedding % in comparison with the control in two seasons. However, the significant effects were obtained only by 85 ppm B alone or as combined with 180 or 360 ppm Zn on number of open bolls/plant in both seasons and on fruit shedding % in 2008 season. The treatment of 360 ppm Zn significantly increased number of open bolls/plant in 2007 season only.

Table (3): Effect of boron (B) and zinc (Zn) foliar treatments on some fruiting characteristics of cotton plant in 2007 and 2008 seasons.

Treatments	No. of open bolls/plant		No. of non-open bolls/plant		No. of aborted fruiting sites/plant		Total fruiting sites/plant		Fruit shedding%	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
Control	10.5	9.2	4.8	5.8	7.5	9.4	22.8	24.4	32.9	38.5
85 ppm B	12.1	11.5	4.6	5.9	7.1	8.6	23.8	26.0	29.8	33.1
170 ppm B	11.2	10.9	5.5	5.3	7.7	9.3	24.4	25.5	31.6	36.5
180 ppm Zn	11.9	10.7	5.3	6.0	7.7	9.5	24.9	26.2	30.9	36.3
360 ppm Zn	12.2	10.4	5.1	6.0	8.1	9.0	25.4	25.4	31.9	35.4
85 ppm B + 180 ppm Zn	12.4	12.5	4.6	5.3	7.2	8.6	24.2	26.4	29.6	32.6
85 ppm B + 360 ppm Zn	12.0	12.9	5.0	5.7	7.3	8.5	24.3	27.1	30.0	31.4
170 ppm B + 180 ppm Zn	11.5	10.6	4.9	6.9	7.3	9.1	23.7	26.6	30.8	34.2
170 ppm B + 360 ppm Zn	11.6	10.4	4.4	5.9	7.5	9.7	23.0	26.0	31.9	37.3
L.S.D. at 5%	1.5	2.1	N.S	N.S	N.S	N.S	N.S	N.S	N.S	5.1

Different tested treatments exerted no significant effects on numbers of non-open bolls/plant; aborted fruiting sites/plant and total fruiting sites/plant in both seasons.

The positive effects of foliar feeding with B on fruiting of cotton plant was more pronounced using the lower level (85 ppm), while similar effects for both Zn levels were noted. In general, the highest open bolls per plant and the lowest fruit shedding % were given by the combined application of 85 ppm B and either 180 or 360 ppm Zn followed by the treatment of 85 ppm B alone.

The obtained favorable effects for B and Zn on cotton fruiting performance may be owing to their well recognized roles in promoting reproductive growth of plants, El-Fouly (2006). Cotton plant shows a particular demand for B because its significance for pollen germination and pollen tube growth, resulting in successful fruit setting, Zhao & Oosterhuis

(2003) and B-deficiency considerably decreased leaf photosynthetic rate and carbohydrate transport from leaves to fruits resulting in high fruit abscission and small and deformed bolls, Roberts *et al.* (2000) and Zhao & Oosterhuis (2003). Also, Zn is important for pollen grains development and their fertility (Alloway, 2008). Similar results were reported by, El-Menshawy & El-Sayed (2007).

3- Effect on yield and yield components:

Results shown in Table (4) indicate that different treatments of B and Zn exhibited increases in boll weight and seed cotton yield per feddan (kentar/fad.) in the two seasons and seed index in 2008 season only, but the significant differences with the control were not always reached. Earliness index and lint percentage were not significantly affected in both seasons. Boll weight was significantly increased by all used treatments in 2008 season and by 85 ppm B alone or as combined with 180 or 360 ppm Zn in 2007 season.

Table (4): Effect of boron (B) and zinc (Zn) foliar treatments on cotton yield and some yield components in 2007 and 2008 seasons.

Treatments	Boll weight (gm)		Lint %		Seed index (gm)		Earliness index %		Seed cotton yield (kentar/fad.)	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
Control	2.65	2.45	40.17	39.76	10.4	9.6	57.7	58.3	9.03	6.62
85 ppm B	2.83	2.69	39.95	39.51	10.8	10.5	59.6	60.3	9.64	7.68
170 ppm B	2.77	2.66	39.74	38.67	10.6	10.5	59.6	61.4	9.28	7.51
180 ppm Zn	2.73	2.69	40.25	38.94	10.5	10.2	58.7	60.4	9.59	7.45
360 ppm Zn	2.74	2.64	40.21	40.32	10.8	10.7	59.9	58.6	9.55	7.41
85 ppm B + 180 ppm Zn	2.83	2.71	39.79	39.23	10.5	10.8	61.8	60.2	9.72	7.82
85 ppm B + 360 ppm Zn	2.82	2.62	39.65	40.43	10.5	10.2	59.4	61.4	9.58	8.07
170 ppm B + 180 ppm Zn	2.74	2.69	39.74	39.68	10.6	10.2	60.9	56.8	9.31	7.41
170 ppm B + 360 ppm Zn	2.77	2.68	39.90	39.88	10.7	10.1	59.4	59.9	9.48	7.12
L.S.D. at 5%	0.13	0.15	N.S	N.S	N.S	0.4	N.S	N.S	0.51	0.84

Seed cotton yield per feddan was significantly increased by B at 85 ppm alone or in combination with 180 or 360 ppm Zn in both seasons, by B at 170 ppm alone in 2008 season only and by Zn at both levels in 2007 season only. Seed index was significantly increased by various treatments in 2008 season only.

Again, B at 85 ppm showed more positive effects on cotton productivity than at 170 ppm, while the positive effects of the two Zn levels were almost the same. Across the two seasons, the heaviest bolls and the highest seed cotton yield were generally obtained by the combination between B at the lower concentration (85 ppm) and either Zn levels. Such improvements in yield and its components due to B and Zn foliar supply could be a result of their effects on fundamental metabolic activities which may be positively reflected on boll growth and seed and fiber development, leading to increasing boll production and retention, boll weight, seed index and seed cotton yield per feddan. These results are in general agreement with those of, Saeed (2000), Noval *et al.* (2002), El-Shazly *et al.* (2005), El-Morsi (2005) and El-Menshawy & El-Sayed (2007).

Referring to physical and chemical analysis of soils where the present study were conducted shown in Table (1), it seems that the experimental soils were relatively sufficient in their content of micronutrients including B and Zn, but they are characterized by a relatively high pH and calcium carbonate and low organic matter content. Such soil undesirable conditions may limit micronutrients availability for plants, Hamissa & Abdel-Salam (1999) and El-Fouly (2006). This could explain the obtained positive responses of cotton plant to spraying B and Zn. In this connection, it was reported that cotton is prone to B or Zn deficiency not only in soils deficient of them, but also in high pH, calcareous, low organic matter and highly leached soils, Niaz *et al.* (2002) and Alloway (2008). Besides, hidden micronutrients deficiency can reduce crop yields without the appearance of distinct symptoms, El-Fouly (2006) and Alloway (2008).

It could be concluded from the results of this study that some treatments of B and/or Zn induced improvement in cotton growth and productivity. The most consistent positive responses were given by the combined application of 85 ppm B + 180 or 360 ppm Zn. The use of higher levels of either B or Zn (170 ppm B or 360 ppm Zn) showed no more benefits than those obtained of the lower ones (85 ppm B or 180 ppm Zn), insteadly the reverse trend was noted in case of boron.

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تأثير التغذية الورقية بالبورون والزنك على نمو وإنتاجية صنف القطن جيزة ٨٠

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أقيمت تجربتان حقليتان بمحطة البحوث الزراعية بسدس، محافظة بني سويف، في موسمي ٢٠٠٧ و ٢٠٠٨، بهدف دراسة إستجابة نمو وإثمار ومحصول صنف القطن جيزة ٨٠ للرش بالبورون أو الزنك أو كلاهما. شملت الدراسة تسعة معاملات نتجت من كل التوافيق بين أثنين تركيز من البورون (٨٥، ١٧٠ جزء في المليون) ومثلهم من الزنك (١٨٠، ٣٦٠ جزء في المليون)، بالاضافة الي معاملة الكنترول بدون رش. وكانت مواعيد الرش هي عند بداية التزهير وقمة التزهير، وكان التصميم التجريبي المستخدم هو القطاعات الكاملة العشوائية فى أربعة مكرارت.

وتتلخص أهم النتائج المتحصل عليها فيما يلى:

١) أظهر الرش بالبورون أو الزنك أو كلاهما تأثيراً إيجابيا على نمو وإنتاجية نبات القطن مقارنة بالنباتات الغير معاملة فى كلا الموسمين، إلا أن بعض المعاملات فقط أعطت زيادة معنوية فى طول النبات و عدد الأفرع الثمرية للنبات فى موسم ٢٠٠٧، وعدد اللوز المتفتح للنبات ووزن اللوزة ومحصول القطن الزهر بالفدان فى كلا الموسمين، ومعامل البذرة فى موسم ٢٠٠٨، وإلى نقص معنوى فى النسبة المئوية لتساقط الثمار فى موسم ٢٠٠٨.

٢) أعطى الرش بخليط من البورون بتركيز ٨٥ جزء فى المليون مع الزنك سواء بتركيز ١٨٠ أو ٣٦٠ جزء فى المليون أعلى محصول من القطن الزهر و أفضل النتائج بشكل عام خلال موسمى الدراسة.

٣) لم يظهر إستخدام التركيز الأعلى سواء من البورون أو الزنك (١٧٠، ٣٦٠ جزء فى المليون، على التوالى) تأثيراً أفضل من تلك المتحصل عليها باستخدام التركيز الأقل منهما (٨٥، ١٨٠ جزء فى المليون، على التوالى) بل العكس كان صحيحاً بالنسبة للبورون.

٤) ومن النتائج المتحصل عليها والموضحة في هذه الدراسة فأنه يمكننا استخلاص توصية قد تكون مفيدة في زيادة أنتاج محصول القطن وهي أنه يمكن زيادة إنتاجية صنف القطن جيزة ٨٠ برش ٨٥ جزء فى المليون بورون + ١٨٠ جزء فى المليون زنك تحت الظروف البيئية لهذه الدراسة أو المشابهة لها.