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RESPONSE OF MAIZE *(ZEA MAYS* L.) TO BORON FOLIAR APPLICATION UNDER WATER STRESS CONDITIONS

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ABSTRACT

A field experiment was carried out at Agronomic Research Area, University of Agriculture, Faisalabad, Pakistan during the year 2013 to evaluate the response of maize (*Zea mays* L.) to foliar application of boron under water stress conditions. Maize hybrid FH-810 was selected as a test crop. The experiment was designed in RCBD with split plot arrangement. Two stress levels viz. no stress (S_1) and water stress of 15 days (S_2) were placed in main plots while three foliar sprays viz. no spray (F_1), simple water spray (F_2) and boron spray @ 100 ppm (F_3) were assigned to sub-plots. The crop was grown upto harvesting and data were recorded according to the standard procedures. The results showed that stress levels and foliar sprays significantly affected different yield related parameters. Maximum grain yield was obtained in no stress (S_1) crop when treated with F_3 (boron spray @ 100 ppm). Boron application significantly enhanced the plant height (194.63 cm), cop length (16.94 cm), 1000-grain weight (381.89 g), biological yield (16.89 t/ha) and harvest index (49.37%). However protein content (7.36%) and amylase contents (0.625 I.U/g) were found to be decreased due to boron application while stress levels had no significant effect on these parameters. The interaction of stress levels with foliar spray applications was found non-significant for all studied parameters.

KEYWORDS: ***Zea mays*; agronomic characters; ping; grain yield; water stress; boron; foliar sprays; Pakistan.**

INTRODUCTION

In Pakistan maize (*Zea mays* L.) has an important place in cropping pattern of irrigated areas of Pakistan. It is the third most important cereal crop after wheat and rice (15). Due to high yield potential and short duration this crop is gaining more popularity against other cereals. (11) In Pakistan, Punjab leads the KPK province in maize production. However, it is grown in almost

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all parts of the country, while only 5 percent maize production comes from Sindh and Baluchistan provinces. Maize is used as feed for poultry and livestock besides having a good consumption by human beings in the shape of food grain. Pakistan, has an area of 1.02 million hectares under maize cultivation with average grain production of 2893 kg per hectare with the annual grain yield of 2.96 million tons (5). Maize responds very well to various agro-management practices bearing high yield potential. Unfortunately in Pakistan maize is yield much less yield than other maize growing countries. Existing genotypes of maize are also producing under potential yields. This low and under potential yield of maize is not fully explored due to some management practices like agronomic, environmental and edaphic factors (4). Besides the other management practices, irrigation and nutrient management are also responsible for low yield of maize.

Crop production is mainly restrained by drought in addition to other environmental stresses like cold, salt, acid and high temperature stresses. The depressing effect of drought strain on yield performance has been well accredited (10, 13). In both tropical and temperate environments, drought stresses are mainly responsible for major yield losses. These areas provide maize for local as well as for worldwide consumption. Water stress effects depend on the duration, timing and magnitude of the stress. Almost all the plant expansion processes including photosynthesis are badly affected by water stress. However, water stress rate, duration of exposure, intensity and crop growth stage also mention the response of water stress (21). Water stress at tasseling stage reduced the yield as flowering delays silking and results in yield reduction and number of grains per cob. Early stages of maize plant are resistant against water stress than the final stages (8).

Boron is essential for plant growth as a micronutrient (2). Boron has an important role in accumulation of carbohydrates, lignifications, photosynthesis, cell wall structure, vegetative growth cell wall synthesis, and retention of flowers and fruits. It is also responsible indole and phenol acetic acid metabolism, membrane transportation and its insufficiency leads to brownish spots in plant tissues (photosynthesis retardation and speculations), stunting of the newly emerged plants (9). Boron is able to alleviate the drought effects and its use as micronutrient enhance the parameters of the major yield components, thus escalating yield level and enriching the chemical symphony of crops (23).

At present little is known about the physical and chemical effects of boron foliar application on growth and yield and yield components of maize under water stress conditions. Therefore, the present experiment was carried out to elucidate the influence of boron foliar application on growth and yield of maize (*Zea mays* L.) under water stress (drought) conditions.

MATERIALS AND METHODS

This study was conducted at Agronomic Research Area, University of Agriculture, Faisalabad Pakistan during the year 2013. Maize crop (cv. FH810) was sown during autumn under RCBD using split plot arrangements with three replications. Two stress levels (no stress and water stress of 15 days imposed at the onset of tasseling stage) were randomized in main plots keeping foliar sprays (no spray, simple water spray and boron spray @ 100 ppm at tasseling stage) in sub-plots. The net plot size of 8 m × 3.75 m was maintained for each replication. Soaking Irrigation (rouni) was applied earlier than seed bed preparation for the planting purpose. Land was set for sowing by using cultivator (2-3 cultivations followed by planking). The crop was sown with dibbler in 75 cm spaced rows maintaining plant to plant distance of 25 cm with seed rate of 25 kg per hectare. Fertilizer was applied @ 200-100-100 kg NPK per hectare. Half of N and P and all K were applied at sowing in the form of urea, diammonium phosphate (DAP) and sulphate of potassium (K_2SO_4), while remaining N was applied in splits. Furadon was applied @ 20 kg per hectare after first irrigation to control insect pests especially maize borer and shoot fly. The field was set aside free of unwanted vegetation and weeds by physical hoeing. At maturity, data on crop yield and yield components such as plant height (cm), cob lenght, 1000 grain weight (g), economic yield (kg/ha), biological yield (kg/ha) and harvest index (%) was recorded according to the standard procedures. The collected data were analyzed statistically using the Fisher analysis of variance technique and treatment means were compared by using least significance difference (LSD) test at 0.05% probability level (18).

RESULTS AND DISCUSSION

Yield parameters

The results (Table 1) showed that plant height was significantly affected among stress levels and maximum plant height (199.5 cm) was observed in S_1 (no stress) while minimum (185.17 cm) in S_2 (water stress of 15 days). The reduction in plant height due to water stress which is caused by the loss of turgor pressure, ultimately affects the cell growth and speed of cell formation. Wilson *et al*. (22) also confirm these findings. Regarding foliar sprays significantly maximum plant height (194.63 cm) was measured in F_3 (boron foliar application @ 100 ppm) followed by F_2 (191.37 cm) where water spray was applied. Smallest amount of plant height was recorded by the plants under F_1 where no spray was applied to plants. Similar findings were also described by Tombo *et al*. (20) who stated that plant height was positively and significantly affected by boron applications.

The comparison of treatments' means of cob length for stress levels revealed that greater cob length (19.18 cm) was recorded in S_1 (no stress) that was statistically different from S_2 (water stress of 15 days) (13.79 cm). For foliar sprays, maximum cob length (16.94 cm) was observed in F_3 (boron foliar application @ 100 ppm) that was statistically different from F_1 (no spray) (15.75 cm) and F_2 (water spray) where cob length was noted (15.75 cm). These findings are similar to those of Sposavoki *et al*. (17).

The weight of 1000-grains expresses the magnitude of grain development which is an important determinant of grain yield per hectare. Highest 1000-grain weight (410.8g) was recorded in S_1 (no stress) against S_2 (water stress of 15 days) planted crop (315.00g) was noted. The moisture stress reduced the grain weight as the water is much necessary for growth, development reproduction, and all metabolic processes take place in plant life. These results also confirm the earlier findings (7). In case of boron application maximum 1000-grain weight (381.89g) was observed in F_3 where (boron foliar spray @ 100 ppm), while minimum (353.3g) was recorded where F_1 (no spray). However, it was statistically in accordance with F_2 (water spray). These findings are in line with those of Tahir *et al*. (19) who mention that addition of boron to maize increased 1000-grain weight significantly.

Table 1. Effect of different stress levels and foliar sprays on yield components of maize (individual comparison of treatment means)

Treatments	Plant height (cm)	Cob length (cm)	1000 grain weight (g)	Grain yield (t/ha)	Biologica l yield (t/ha)	Harvest index (%)
A. Stress levels						
S_1= No stress	199.5a	19.18a	410.8a	7.66a	15.61a	49.07a
S_2= water stress of 15 days	185.1b	13.79b	315.0b	5.68b	13.11b	43.32b
LSD value	2.076	1.138	18.464	0.639	0.894	3.269
B. Foliar sprays						
F_1= No spray	191.00b	15.75b	353.30b	6.73b	15.28b	44.04b
F_2= Simple water spray	191.37b	15.27b	353.53b	6.93b	15.57b	44.50b
F_3= Boron spray @ 100 ppm	194.63a	16.94a	381.89a	8.34a	16.89a	49.37a
LSD value	1.264	0.681	10.872	0.433	0.824	2.981
interaction stress x foliar sprays	NS	NS	NS	NS	NS	NS

Means not having the same letter significantly differ at 0.05% probability level, NS = Non-significant.

The effectiveness of boron foliar spray and water stress (drought) is ultimately measured by the grain yield level, which is a result of function of collective behaviour of all yield parameters. Data in the (Table-1) showed that grain yield beneath different stress and foliar spray treatments was found to be highly significant. The plants under S_1 (no stress) produced more significantly high grain yield (9.67 t/ha) than noted in S_2 (water stress of 15 days) (5.68 t/ha). Sajedi *et al*. (16) also found that drought (water stress) decreased grain yield as compared with control. Maize crop treated with F_3 (foliar application of boron @100 ppm) produced high significantly economical yield (9.34 t/ha) than F_2 (water spray) and F_1 (no spray) (6.73 and 6.93 t/ha) that were statistically at par with each others. In the same way Rahim *et al*. (14) and Ahmad *et al*. (1) reported that boron application increased the grain yield significantly in maize as compared with no application.

The biological yield was also significantly affected by different stress and foliar spray treatments. Treatments means showed that more biological yield (19.98 ton/ha) was observed in S_1 (no stress) against S_2 (water stress of 15 days)(12.35 t/ha). These results agreed findings of Khan *et al*. (8). The statistically maximum biological yield (17.89 t/ha) was observed under F_3 where boron foliar application @ 100 ppm was applied followed by F_2 (15.57 t/ha) where water spray was applied to plants which was statistically at par with F1 (no spray). The results are closely related with Ziaeyan and Rajaie (24) as they described increased biological yield in maize by foliar application of boron.

Data pertaining to harvest index for stress levels revealed statistically maximum harvest index (49.07 %) in S_1 (no stress) as compared with S_2 (water stress of 15 days) (43.32%). It was assumed that harvest index of wheat crop was significantly decreased under reduced water conditions (12). For foliar sprays maximum harvest index (49.37%) was observed F_3 (foliar application of boron @ 100 ppm) and minimum (44.04%) in F_1 where no spray was applied. Same findings have been reported by Tombo *et al*., (20) that harvest index of crop was significantly affected by boron applications. The interaction between stress levels and foliar sprays for yield and yield components was non-significant in all parameters.

Biochemical responses

Data regarding biochemical characteristics (Table 2) showed that biochemical attributes like amylase and protein contents were statistically non-significant between two stress levels. However their values were higher

Table 2. Effect of different stress levels and foliar sprays on biochemical responses of maize (Individual comparison of treatment means)

Treatments	Parameters	
A. Stress levels	**Amylase (I.U/g)**	**Protein (%)**
S_1 = No stress	0.82 a	8.76 a
S_2 = Water stress of 15 days	0.79 a	9.33 a
LSD value	NS	NS
B. Foliar sprays		
F_1 = No spray	0.858 b	9.29 b
F_2 = Simple water spray	0.987 a	10.47 a
F_3 = Boron spray @ 100 ppm	0.625 c	7.36 c
LSD value	0.092	0.368
interaction stress x foliar sprays	NS	NS

Means not having the same letter significantly differ at 0.05% probability level, NS = Non-significant.

in S_2 plants where water stress of 15 days were given than S_1 treated plants where no stress was given. Ahmadi *et a*l. (3) also reported that protein concentration was highly increased by drought (water stress). In case of foliar sprays significant effect of foliar application of boron was observed on stem protein and amylase concentration. The comparison of experiment treatment means showed that maximum concentration of stem amylase

(0.987 I.U/g) was noted in F_2 where water spray was applied followed by F_1 (0.858 I.U/g) while minimum (0.625 I.U/g) was recorded in F_3 (boron foliar application @100 ppm). Similar data fashion were found in case of protein contents in which statistically highest protein content (10.47 %) was noted in F_2 (water spray) treatment whereas lowest concentration of protein (7.36 %) was measured in boron foliar application @ 100 ppm. Dwivedi *et a*l. (6) mentioned that protein contents of maize grains were highly increased with boron application which is contradictory to our findings. Interaction among the boron foliar application and stress levels was also non-significant for these traits.

CONCLUSION

The study concluded that water stress has a great impact on yield and yield components of maize (*Zea mays* L.) crop. Soil moisture stress produces less grain yield by inducing less plant height, cob length and 1000-grain weight. However, boron application has significant positive effect on these parameters. So under water stress conditions at tasseling stage of maize, boron application @ 100 ppm should be followed to attain maximum yield and benefits under the climatic conditions of Faisalabad.

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Saadia	**:**	**Contributed in results and discussion**
Muhammad Rizwan	**:**	**Helped in data analysis**