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The effects of plant growth promoting on some of traits in maize (cv. S.C.704) under drought stress condition

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ABSTRACT

Maize has now become an important staple food. In Iran, maize in its many forms is included as a part of the diet of many people. In order to study the effect of plant growth promoting on grain and biological yields of maize under drought stress condition, using three levels of drought stress including D_1 (100% plant water requirement-control), D_2 (80% plant water requirement) and D_3 (60% plant water requirement) as main plots and seven kinds of plant growth promoting as foliar spray (P_1= Marmaryn; P_2= Dalgin; P_3= Multi Purplex; P_4= Grofolan; P_5= Stimurel; P_6= HB-101; and P_7= control-without foliar spray) as sub plots, an experiment was conducted using a split block experiment based on completely randomized block design with four replications. The study was done at the Agricultural Research Station of Saatlo in Urmia, Iran during 2011 growing season. The results of this study showed that drought stress levels, various plant growth promoting and interaction of them had significant effects on all measured traits of maize. The mean comparison showed that, maximum grain yield (20.51 g m^{-2}) and biological yield (40.85 g m^{-2}) were obtained from D_1 (100% plant water requirement-control) and in the case of the plant growth promoting obtained from P_6= HB-101 and P_5= Stimurel, respectively. From the results, it can be concluded that, apply 100% plant water requirement for all measured traits with foliar spray of different plant growth promoting (depending to the desired trait) are recommended to increase function of maize.

Key Words: *Zea mays* L., grain, biological yield, ear, weight.

INTRODUCTION

Maize (*Zea mays* L.) is one of the important cereal crops in the world and Iran after wheat and rice [1]. Maize grain is extensively used for the preparation of corn starch, corn oil dextrose, corn flakes, gluten, grain cake, lactic acid and acetone which are used by various industries such as textile, foundry, fermentation and food industries [2]. Thus, the development and spread of this exceptional product is very important.

Among different environmental stresses, drought stress has become a critical problem worldwide due to its harmful effect on plant physiology and performance [3]. Drought, or more generally, confined water availability is the main factor limiting crop production [4, 5]. Iran, with a yearly rainfall of 240 mm, is classified as one of those dry areas [6]. The significant abiotic stress affecting maize production on a worldwide basis is drought [7]. Osborne et al. [8] showed that water stress in the vegetative stage, florescence and seed filling of maize plants could decrease grain yield 25, 50 and 21%, respectively. However, according to the upon plant species, specific stages such as germination, seedling or flowering were the most critical stages susceptible to water stress [9]. Exposure of plants to water stress causes many physiological changes within plant cells, including hormonal metabolism and proteomic changes [10, 11, 12]. Maize is very susceptible to drought damage due to the plants requirement for water for cell elongation and its inability to delay vegetative growth [13]. Yield is reduced when evapotranspiration request exceeds water supply from the soil at any time during the maize life cycle [14]. Maize yield is most susceptible to water stress during flowering and pollination, followed by seed filling and finally vegetative growth stages [14, 15]. However, significant yield devaluation was found when stress occurred during the pollination and seed filling stages [16].

Plant growth and development are controlled by both external cues and intrinsic growth regulators, such as hormones [17]. Eight significant classes of plant hormones have been characterized: abscisic acid, auxin, brassinosteroids, cytokinins, ethylene, gibberellins, jasmonates and strigolactones [18]. All of them have been related to growth adjustment in one way or another, sometimes in a tissues specific manner [17]. The use of hormones cause to stimulate plant growth. Among them, cytokinins adjust cell reproduction, while gibberellins promote cell elongation and auxin is involved in both processes. In addition, brassinosteroids are necessary for cell elongation, but might also have a role in cell proliferation [19, 20]. In one study, cytokinin was applied to soybean at initial flowering yet no difference in the pod number, seed number, seed weight, or grain yield resulted in comparison to an untreated control [21].

The aim of this experiment was to study the effect of different kinds of plant growth promoting on function of maize cultivar SC704 under drought stress condition.

MATERIALS AND METHODS

A field experiment was conducted in 2010, at Agricultural Research Station of Saatlo in Urmia, Iran (37°44'18"N latitude and 45°10'53"E longitude and 1338 m above sea level). The experiment was a split block experiment based on completely randomized block design with four replications. Three drought stress levels D_1 (100% plant water requirement-control), D_2 (80% plant water requirement) and D_3 (60% plant water requirement) were tested in the main plots and seven kinds of plant growth promoting as foliar spray (P_1=Marmaryn; P_2=Dalgin; P_3=Multi Purplex; P_4=Grofolan; P_5=Stimurel; P_6=HB-101; and P_7=control-without foliar spray) were tested in sub plots. After selecting the land, it was prepared (plowed, disked, and leveled), and soil analysis was done before the beginning of the study from the depth of 0-50 cm (Table 1).

Before implementing the project, 84 plots were created with 5 × 2 m^2 area and each plot consisted of 3 rows, inter row spacing was 50 cm and inter plant spacing was 20 cm. By manually using the maize seeds (cv. SC. 704) were sown. Immediately after planting the first irrigation was performed according to the soil moisture compensation (D_1=100% plant water requirement-control) and the other levels of irrigation were performed according to the evaporation and transpiration estimated, weather statistics, and by calculated using the following formulas:

Formula 1: $\mathrm{ETo} = 0.032\mathrm{EP}^{0.8521}$
Which in the formula, ET_0 is evaporation and transpiration of maize (mm), EP is the evaporation from pan.

Formula 2: $\mathrm{IR}_{100} = \frac{(\mathrm{K_c} \sum ET_0) \times \mathrm{A}}{\mathrm{Ea}}$
Which in the formula, IR_{100} is complete amount of irrigation water (liters per plot), K_C is crop coefficient, A is area (m^2), and Ea is efficiency (%).

Foliar spraying of plant growth promoting (PGP) was performed in two stages (before and after the pollination) by handsprayer (one atmospheric pressure). At the end of the growing season, some traits such as grain yield, biological yield, plant height, number of grain per ear and grain weight per ear in maize were measured.

Analysis of variance of the obtained data using the statistical software MSTATC was done and the significant interaction effects of the factors in the experiment, and comparison of the means were conducted using Duncan′s test.

RESULTS AND DISCUSSION

Plant height

Statistical analysis of variance results (Table 2) demonstrated that, maize plant height significantly affected by drought stress, plant growth promoting and interaction of them (D × P) ($p < 0.01$). Mean comparison of the interaction of two factors (drought stress and plant growth promoting) indicated that, the highest plant height of maize (296.07 cm) was obtained from first level of drought stress (D_1=100% plant water requirement-control) and foliar spray of Marmaryn (P_1), and the shortest plant height of maize was obtained from third level of drought stress (D_3=60% plant water requirement) and without foliar spray of plant growth promoting (P_7=control) (Figure 1).

Pandy et al. [22] reported that, deficit irrigation in early vegetative growth of maize, slightly reduced leaf area index and plant height, but deficit irrigation in reproductive stage plenty reduced these traits. In drought stress conditions because of reduction in cytokinin transport from root to shoot or because of increased amount of abscisic acid in leaves, flexibility of the cells wall decreased, so plant growth is reduced [23]. Whitty and Chambliss [24] expressed that, leaf consumption of micronutrients (i.e. iron, zinc and manganese) by addition of stem height cause to increase dry matter yield of maize. Pula Kumar et al. [25] reported that, foliar application of gibberellin (concentration of 100 ppm) in soybean increased stem and lateral branches length.

Grain yield

Statistical analysis of variance results (Table 2) demonstrated that, maize grain yield significantly affected by drought stress, plant growth promoting and interaction of them (D × P) (p < 0.01). Mean comparison of the interaction of two factors (drought stress and plant growth promoting) indicated that, the higher amount of grain yield (20.51 g m^{-2}) was obtained from first level of drought stress (D_1=100% plant water requirement-control) and foliar spray of HB-101 (P_6), and the lowest amount of grain yield was obtained from third level of drought stress (D_3=60% plant water requirement) and without foliar spray of plant growth promoting (P_7=control) (Figure 2).

Payero et al. [26] showed that drought stress significantly decreases the maize grain yield. Frederick et al. [27] reported that, drought stress happening between initial flowering and grain fill decreases total grain yield primarily by reducing branch vegetative growth, which reduces branch grain number and branch grain yield. Potarzycki and Grzebisz [28] expressed that, particular zinc foliar application can increase the length of cob as a component of yield structure significantly shaping the final maize grain yield. Berglund [29] reported that foliar spray of zinc on soybean (especially in vegetative stages of plant) significantly decreases the grain yield. Results showed that, of various compounds of zinc and auxin foliar application were increased level of anti-oxidant enzymatic activities, so it seems that foliar application of zinc and auxin enhance maize tolerance against drought stress via promoting of root growth [30]. Dubey and Sharma [31] realized significant increase in grain yield of wheat by the application of irrigation.

Biological yield

Study of the results obtained in analysis of variance table (Table 2) show that, the maize biological yield significantly affected by drought stress, plant growth promoting and interaction of them (D × P) (p < 0.01). Mean comparison of the interaction of two factors (drought stress and plant growth promoting) indicated that, the maximum biological yield (40.85 g m^{-2}) was obtained from first level of drought stress (D_1=100% plant water requirement-control) and foliar spray of Stimurel (P_5), and the minimum biological yield was obtained from third level of drought stress (D_3=60% plant water requirement) and without foliar spray of plant growth promoting (P_7=control) (Figure 3).

Mojdam [32] reported that, the maximum grain and biological yields of maize in Ahwaz weather condition (dry and warm climate) were obtained from optimal irrigation treatment. Thanna et al. [33] expressed that biological yield was reduced in all the wheat genotypes under water stress conditions. Water stress significantly decreased wheat genotypes' biological yield m^{-2} (g) and grain yield m^{-2} (g) [34].

Number of grain per ear

Study of the results obtained in analysis of variance table (Table 2) show that, number of grain per ear in maize significantly affected by drought stress, plant growth promoting and interaction of them (D × P) (p < 0.01). Mean comparison of the interaction of two factors (drought stress and plant growth promoting) indicated that, the maximum number of grain per ear (885.62) was obtained from first level of drought stress (D_1=100% plant water requirement-control) and foliar spray of Multi Purplex (P_3), Stimurel (P_5) and HB-101 (P_6) and the minimum number of grain per ear was obtained from third level of drought stress (D_3=60% plant water requirement) and without foliar spray of plant growth promoting (P_7=control) (Figure 4).

Number of grain per ear reduction may be due to embryo abortion or delay in appearing silk because of the carbohydrates shortage in drought stress condition [35]. Li et al. [36] concluded that plants under normal irrigation condition produced more number of grains per ear, because during the granulation phase (the most sensitive stage of drought stress) plant has received water. Early grain filling is the most sensitive to water stress as compared with pre flowering and late grain-filling growth stages [37]. Setter et al. [38] expressed that, maize granulation is determined by leaf photosynthesis, amount of sugars, starch, abscisic acid and cytokinin and shortage of water in five days before pollination and in pollination stage reduced the gradation in end of the ear.

Grain weight per ear

Statistical analysis of variance results (Table 2) demonstrated that, grain weight per ear in maize significantly affected by drought stress, plant growth promoting and interaction of them (D × P) (p < 0.01). Mean comparison of the interaction of two factors (drought stress and plant growth promoting) indicated that, maximum grain weight per ear (310.75 g) was obtained from first level of drought stress (D_1=100% plant water requirement-control) and foliar spray of HB-101 (P_6), and the minimum grain weight per ear was obtained from third level of drought stress (D_3=60% plant water requirement) and without foliar spray of plant growth promoting (P_7=control) (Figure 5).

Water stress in maize because of the leaves wilting, cause to reduced photosynthesis and photosynthetic material transfer. This action by prevent from grain development, finally reduced grain weight [39].

Table 1: Analysis of Soil physico-chemical characteristics.

P	K	pH	EC×10^{-3}	Lime	N	Clay	Sand	Silt	OC
Mg.kg^{-1}				%					
12	425	8	0.8	16	12	43	16	43	1.2

Table 2: Analysis of variance for experimental characteristics.

S.O.V.	d.f	Plant height	Grain yield	Biological yield	Number of grain per ear	Grain weight per ear
Rep	3	189.22	0.415 $^{n.s}$	2.342 $^{n.s}$	14401.455	108.679
Drought stress (D)	2	8397.510**	318.214**	458.659**	145597.04**	72555.619**
Error (a)	6	17.814	0.428	1.479	1242.992	91.333
Plant growth promoting (P)	6	278.901**	15.830**	20.848**	12526.882**	3637.496**
Error (b)	18	4.721	0.071	0.167	493.991	9.253
A × B	12	33.534**	0.539**	1.345**	2248.121**	110.258**
Error (a×b)	36	11.789	0.090	0.317	327.340	14.491
CV (%)		1.25	1.91	1.63	2.31	1.59

**, **, ns, Significant at P=0.05, P=0.01 and non-significant, respectively.*

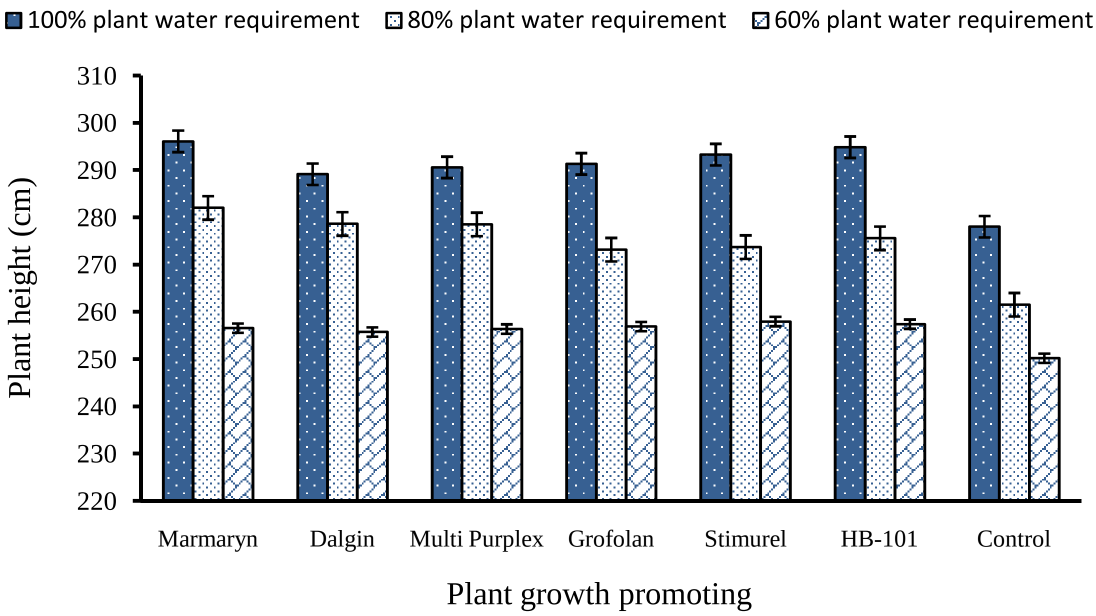

Figure 1: Comparison of interaction of drought stress and plant growth promoting on plant height.

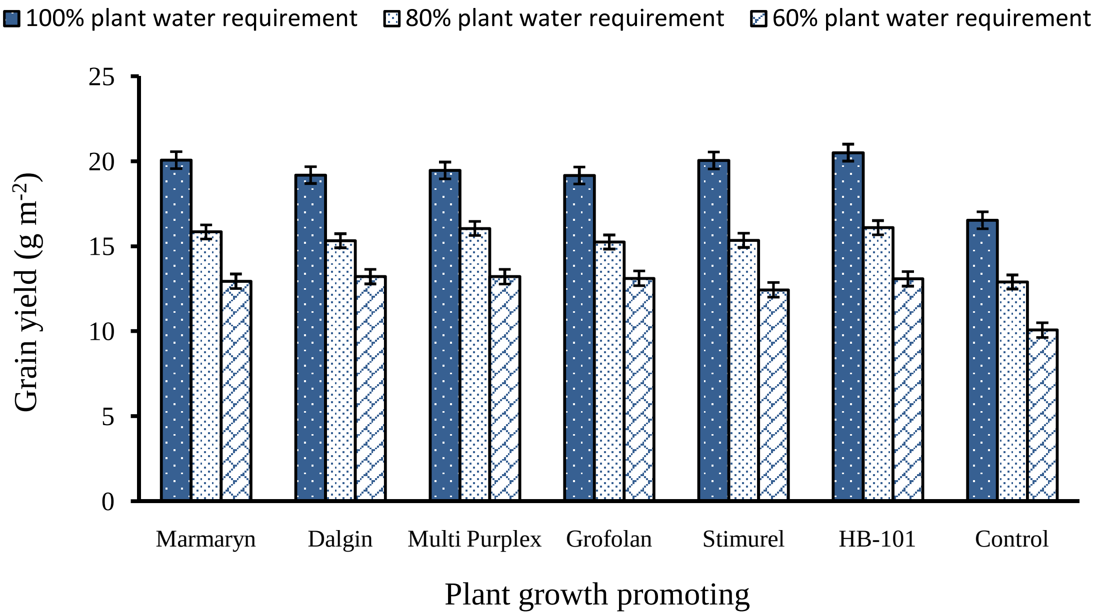

Figure 2: Comparison of interaction of drought stress and plant growth promoting on grain yield.

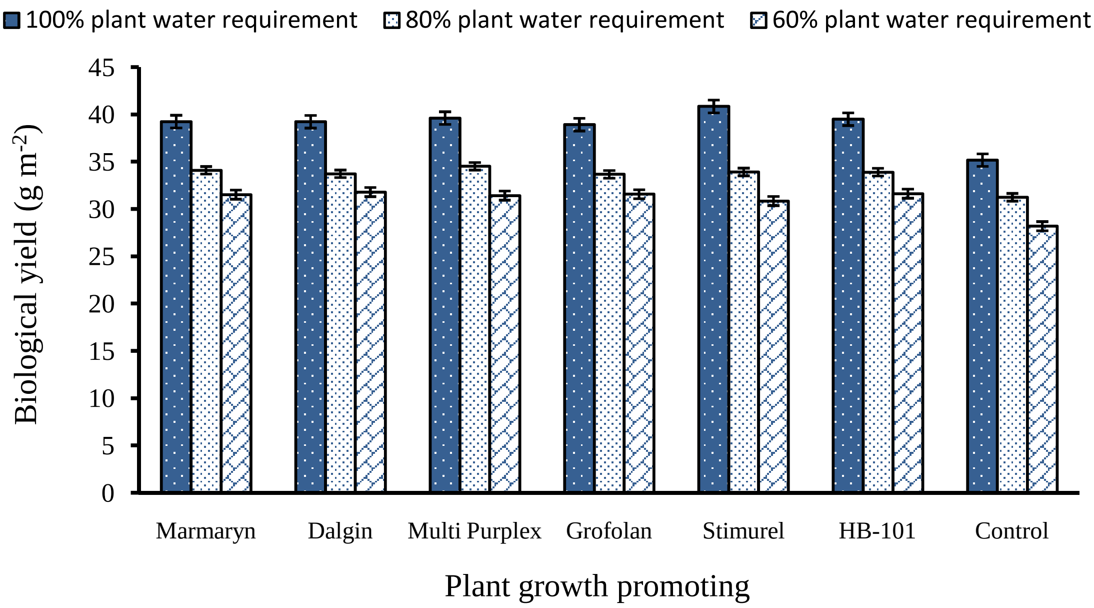

Figure 3: Comparison of interaction of drought stress and plant growth promoting on biological yield.

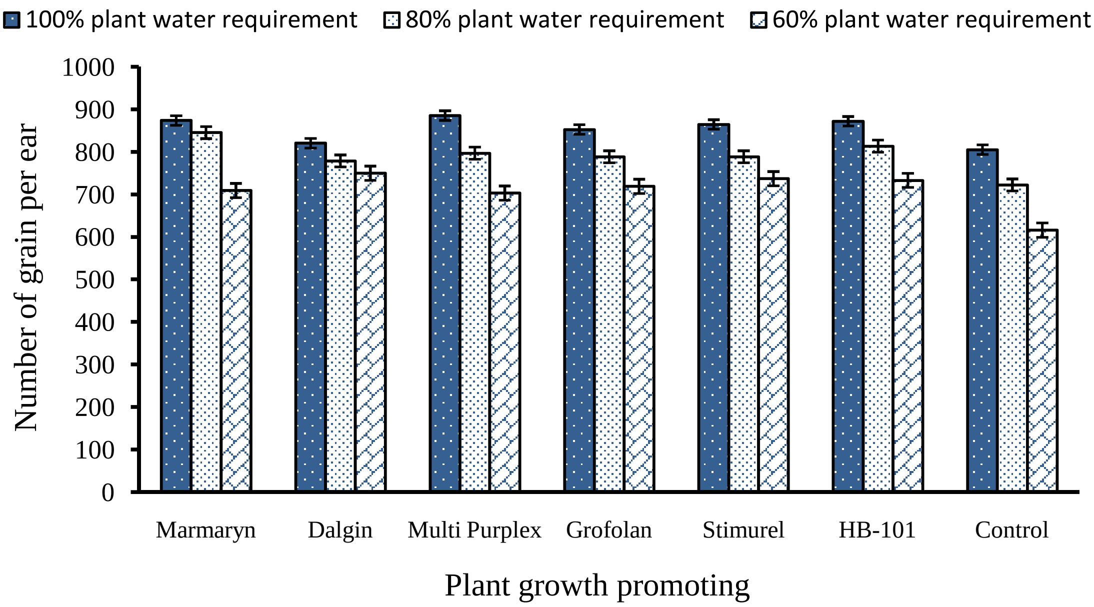

Figure 4: Comparison of interaction of drought stress and plant growth promoting on number of grain per ear.

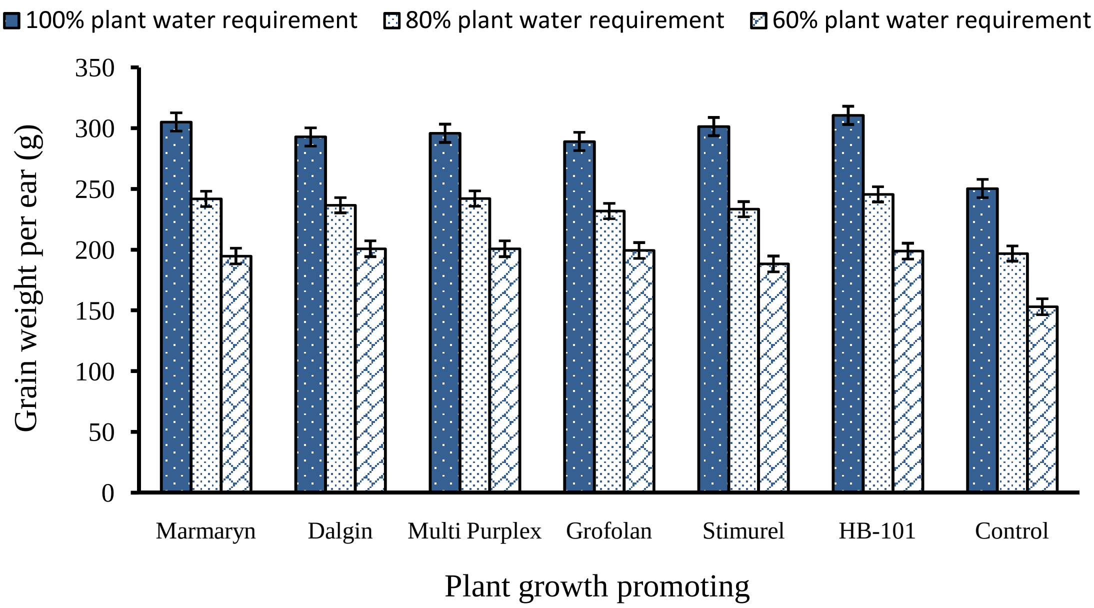

Figure 5: Comparison of interaction of drought stress and plant growth promoting on grain weight per ear.

CONCLUSION

Different plant growth promoting like Marmaryn, HB-101, Stimurel and Multi Purplex showed significant increase under drought stress condition in maize function. From the results, it can be concluded that, apply 100% plant water requirement with foliar spray of different plant growth promoting (depending to the desired trait) are better in maize.

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