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Effect of Biological Fertilizer on Yield and Yield Components of Corn (Zea mays) CV. S.C. 504 in Drought Condition

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ABSTRACT

To evaluate the effects of biologic fertilizer (biosuper) on corn yield and yield components at different irrigation regimes a research was conducted in split plot experiment with three replications based on completely randomized block design at Research Field of Islamic Azad University Tabriz Branch in the spring of 2010. Irrigation levels (irrigation after 50, 100, 150, 200 and 250 mm evaporation from class A pan) were considered as a main factor and biologic fertilizer levels (control and biosuper) as sub factors respectively. The results showed that biosuper biologic fertilizer reduced drought stress effects and increased yield with positive effects on measured traits and also seed yield and yield components such as grain in row, row in ear, 100 kernel weight, and biological yield. Highest yield was in irrigation after 50 mm evaporation from pan by the average 1474 g/m^2. Delay in irrigation with subsequent increase in drought stress severity resulted in a significant decrease in grain yield. As irrigation after 100, 150, 200, 250mm evaporation from pan related to 50 mm evaporation led to decrease by 15.4, 24.83, 34.02, and 45.69% respectively. While with biosuper bio fertilizer application yield increased by 7% in maximum drought conditions (irrigation after 250 mm evaporation from pan). So, CV. 504 of corn cultivation under drought stress and biosuper bio fertilizer application can improve the grain yield.
Key words: Biosuper, Biologic fertilizer, Corn.

INTRODUCTION

Population and economic increasing rate resulted in broad demand for food at last two decades. To meet this demand might be difficult, because current fields are not accountable and yield loss clearly appears. Under these conditions, agriculture could not supply growing global requirement to food. Corn is one of the high yielding cereals that ranked as third cereal crop after wheat and rice to supply global population consumption [2]. Drought is one of the principal abiotic factors that strongly limit productions. Nevertheless, expected that drought might be more comprehensive than now [1]. Drought stress in corn can directly or indirectly affect seed yield; direct effects include whole plant death, interfering in pollen production, pest induced ear rot, and indirect effects include the harms that decrease yield and crop harvest ability [8]. Experimental results of researches illustrated that irrigation regimes (Irrigation after 40, 70, 100, and 120 mm evaporation from class A pan) and increase irrigation intervals and subsequent drought stress cause a biomass loss from 21.5 to 18.5 ton per hectare and yield loss from 10.5 to 8 ton per hectare in second and fourth treatments respectively (Singh and Usha, 2003). Also, another research on drought stress effect with respect to corn yield components indicated negative effects of drought stress to growth and development of reproductive organs with subsequent reduction in yield components include ear in area, grain in row, and 100 kernel weight and at last seed yield [10].

In sustainable agriculture system, biological fertilizers play an important role in crop production and increasing soil fertility conservation [13]. The term of biological fertilizer is not particularly for organic matters from manure, crop residue, green manure, etc., but also includes bacterial and fungus micro organisms, specially PGPRs and compounds from their activity [6]. This types of bacteria, in addition to increasing mineral elements of soil through biological N fixation, phosphate and potassium solubulizing and inhibition of pathogens, also by growth regulator hormones produce affect crop yield [15]. Overall, biological fertilizers term refers to fertile materials that involve one or more beneficial soil organism within a suitable preservative. In fact, this fertilizers include different types of micro organisms [3, 17] that could converse nutrients from unavailable form to available form during a biological process [11], and resulted in develop root system and increase seed germination rate [3].

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Based on this the main objective the present study was assess effects of biosuper biologic fertilizer application that containing Azotobacter, Azosprillum, tillobassillus, and Pseudomonas bacteria on reduction of drought stress induced loss in corn CV. S.C.504.

MATERIALS AND METHODS

To investigate the effects of biosuper as biofertilizer, under irrigation and deficit irrigation, a research was carried out at Research Field of Islamic Azad University, Tabriz Branch 15 kilometers east of Tabriz, Iran, during growing season of 2010 summary, which based on Domarton's classification is representative of semiarid cold climate with warm summers and cold winters. Annual temperature average is about 10 ^{0}c, maximum temperature average is about 16 ^{0}c, minimum is 2.2 ^{0}c in last 10 years, and annual rainfall average is about 271.3 mm in this area. Analysis of soil indicated that pH is about weak alkaline (About 7.67).

This study was performed in a split plot experiment with three replications , five irrigation levels and two levels of biofertilizer arranged in a randomizes complete block design with using single cross 504 of corn. Treatments include five irrigation levels (Irrigation after 50,100,150,200, and 250 mm evaporation from class A pan) and two levels of biologic fertilizer application (control and biosuper). This experiment constituted from 30 plots in three repetitions, each plot's length was 3 m and 2.4 m width with four planting row and 60 cm distance between rows. Seeds were planted with 20 cm distance between each other. Distance between main plots was 120 cm and distance between sub plots was 60 cm and also distance between experimental repetitions was 250 cm. In this experiment biosuper fertilizer applied that is a biological fertilizer containing Azotobacter, Azosprillum, Tillobasillus, and Pseudomonas. In the biosuper applied treatments, first at planting time seed mixed with this fertilizer (as manufacturers recommended rate) and then, when the plant had 6-8 leaves, this fertilizer used through mixing with irrigated water. Irrigation was performed once a week and up to last stage of plant vegetative growth. After tasseling stage, irrigation performed according to evaporation levels from class A pan and experimental treatments, up to last stage of plant growth. After emergence and establishment of plants in 10-15 cm height stage, thinning was done to maintain a stronger plant and desirable density. After harvesting, on five randomized selected plants assessed traits include grain in ear, row in ear, ear weight, 100 kernel weight, grain in row, harvest index, and biological yield. Grain yield was calculated by all of plants in 1.5 m^2. Analysis, include analysis of variance and mean square was performed through MSTAT-C and SPSS software and Danken's multiple range test at 5% level of probability, and charts was performed by Excel software.

RESULTS AND DISCUSSION

Grain in row

Irrigation/biofertilizer mean square results (Figure 1) indicated that drought stress in no applied fertilizer condition led to significant decrease in grain in row, while biosuper application even in drought stress condition have not any significant effect on this trait. Delay in irrigation rate per each mm evaporation from basin with no fertilizer application, reduced this trait by 3.47 unit and with fertilizer application, grain in rows 2.03 unit increased. At no fertilizer application, irrigation levels from 50mm to 250mm evaporation from basin reduced this trait by 36.20%, while with fertilizer application, irrigation levels from 50mm to 250mm evaporation from basin resulted in a increase in grain in row by 8.21%. Grain in row had highest correlation with grain in ear (974**), and then with grain yield (943*), harvest index (925*), and biological yield (931*) (Table2). With respect to these results we can suggest that grain in row have direct relation with grain yield, so by raising this trait we can increase grain yield.

Drought stress in preliminary stages of vegetative growth and before male reproductive organs distinction, have not any effect on grain in row, but any stress outbreak in this stage and/or ear growth and also pollination, could affect this trait and reduce that. The bacteria that live in surrounding with produce biologic compounds such as auxin and giberelin increase root growth and cause an increase in nutrient uptake from soil that this could affect the reproductive organs of plants [5].

Row in ear

With respect to figure (2) and irrigation/biofertilizer results, drought stress with no fertilizer application resulted in a significant decrease in row in ear, as delay in irrigation rate per each mm evaporation from basin with no fertilizer application led to 0.81 unit decrease in this trait. Biosuper application in drought stress condition significantly increased this trait, as delay in irrigation rate per each mm evaporation from basin, with fertilizer application resulted in 0.8 unit increase in row in ear. At no fertilizer application, irrigation levels from 50mm to 250mm evaporation from basin cause a reduction by 13.35%, while, with fertilizer application, irrigation levels from

50mm to 250mm evaporation from basin led to increase row in ear by 19.98%. Row in ear affected from genetic factors, but, nevertheless biosuper biofertilizer application can help to increase this trait. There was no correlation between row in ear and other traits.

Grain in Ear

Irrigation/biofertilizer mean square results (Figure 3) illustrated that with no biosuper fertilizer application at irrigation after 250mm level, related to 50mm evaporation from pan led to a decrease in grain in ear rate by 41.65%. Biosuper fertilizer significantly increased this trait (By 25.56%), but raising drought stress to 250mm evaporation from pan only decreased non-significant this traits rate by 6.59%. Thus, delay in irrigation rate per each mm evaporation with no fertilizer application resulted in 79 unit decrease and with fertilizer application resulted in 17.94 unit decrease on this trait. At flowers fertilization times and seed formation stages, biosuper biofertilizer have prevented effects of severe dehydration in this growth stage. Grain in ear had highest correlation with grain in row (974**), and then with harvest index (903*) (Table2). Grain in row have direct relation with grain in ear, that's it with increasing grain in row, also grain in ear will increase.

Zenselmeier *et al* [19], reported that, drought stress in flowering stage delayed tassels emergence. So tassels emerge when the pollination has done and no longer pollen has exists or reduced. Hence, no ovule, have fertilized and consequently no grain forms and this resulted in few grains formation at whole ear.

Ear Weight

With respect to figure (4) and irrigation/biofertilizer mean square results, drought stress both with no fertilizer application and fertilizer application, cause a significant decrease in ear weight, but severity of reduction with biofertilizer application was less than no biofertilizer application, as delay in irrigation rate per each mm in no fertilizer application condition resulted in 27.41 unit decrease and with fertilizer application led to 17.51 unit decrease in this trait. Irrigation after 250mm evaporation from basin led to a decrease in ear weight by 41.54%, but this reduction was only 25.52% in fertilizer application condition. These results indicated that biosuper biofertilizer can reduce effect of drought stress in various physiologic stages. Ear weight had highest correlation with biological yield (973**), and 100 kernel weight (974**), and then with harvest index (913*) (Table 2). With respect to these results we can suggest that 100 kernel weight cause an increase in ear weight and in general, elevated the biological yield. Zahir *et al.* (1998), reported an increase by 18% in ear weight when seed was inoculated by Azotobacter and P. florescence. In the research by Biari *et al.* [2] was found that growth stimulator bacteria such as Azosprillum and Azotobacter have positive effects on corn yield when grown at field conditions. In this study, inoculating corn seeds with bacteria improved some of the growth traits such as stem dry weight, ear dry weight, and grain dry weight. As a result, from economic perspective most suitable biofertilizer levels from 90, 120, and 150 kg per hectare is 90kg per hectare.

100 Kernel Weight

Irrigation levels mean square results (Figure 5), showed that, drought stress cause a significant decrease in 100 kernel weight from 25.76g. to 19.28g. Thus, irrigation after 250mm related to 50mm evaporation from pan, reduced this trait by 32.96%. Biosuper biofertilizer application related to no biofertilizer application resulted in a significant increase in 100 kernel weight by 5.36% (Table 2). Hence, we can suggest that, drought stress raising could led to dehydration stages faced with grain filling and resulted in less transmission of photosynthetic compounds to grains, that it decreased 100 kernel weight, but with Biosuper biofertilizer application we can reduce effects of drought stress-induced decrease in 100 kernel weight. 100 kernel weight had highest correlation with ear weight (974**), grain yield (968**), harvest index (959**), and biological yield (965**) (Table3). So, changes in related traits with grain such as 100 kernel weight could alter this plants biomass. Results of a study by Pendey *et al* [9] indicated that generally, drought stress reduces seed yield, 100 kernel weight, stem diameter and plant height.

Drought stress resulted in a significant decrease in biological yield from 1800 to 1095 g/m^2. Thus, irrigation after 250mm related to 50mm evaporation from pan led to a decrease by 39.16% in this trait. Also, biosuper biologic fertilizer application related to no application of this fertilizer resulted in a increase by 8.32%. Biologic yield had highest correlation with ear weight (965**), 100 kernel weight (973**), grain yield (998**), and then with grain in row (931*), and harvest index (950*) (Table 2). So, the changes in related traits with grain could affect biologic yield. Irrigation levels mean square result, indicated that raising drought stress level from 50mm to 250mm led to a decrease in harvest index by 10.59%. Highest rate of harvest index have obtained from irrigation after 50mm evaporation from pan. Harvest index had greatest correlation with 100 kernel weight (959**), grain yield (967**), and then with biological yield (950*), grain in ear (903*), grain in row (925*), and ear weight (913*) (Table2). Thus, each of the above traits could alter the harvest index outcomes.

Grain Yield

Highest grain yield obtained from irrigation after 50mm evaporation from pan, with a significant difference by 1474 g/m^2. Delay in irrigation with subsequent increase in stress intensity led to a significant decrease in yield. As irrigation after 100, 150, 200, and 250mm evaporation from pan resulted in a decrease in grain yield by 15.4, 24.83, 34.02, and 45.69, respectively. Hence, delay in irrigation rate per each mm evaporation from pan resulted in 162.13 unit decrease in this trait (Figure 6). Irrigation after 50mm evaporation had greatest positive effect on male and female flower production and also on fertility, but because other irrigation regimes, directly affected flowering and fertility, by flowers loss and deficit of grain, row in ear, and grain in row will have less negative effects on grain yield. Biosuper biofertilizer led to a significant increase in grain yield by 80g/m^2 (i.e 800 kg/ha), that shows an increase by 7%. Grain yield had highest correlation with ear weight (970**), and 100 kernel weight (968**), and then with grain in row (943*) (Table 2).

Conclusion

The changes in traits related with grain, could altered grain yield in this plant. Bacteria have positive effect on crop yield and growth, and N content. Those effects are related with biologic N fixation and auxin production [12]. Overall, plants growth improvement through this bacteria is attributed to enhancement of lateral and hairy root growth, water and nutrient uptake and N fixation [7]. Azosprillum, in addition to N fixation ability, improve root growth by produce growth stimulants and subsequent increase in water and nutrient uptake rate, that raising yield [16]. Difference between potential yield and real yield is related with environmental stresses. Biologic fertilizers add to soil increase respond of bacteria to N fixation, that this increase fertility of soil and N fixation cause a increase in growth and yield [4].

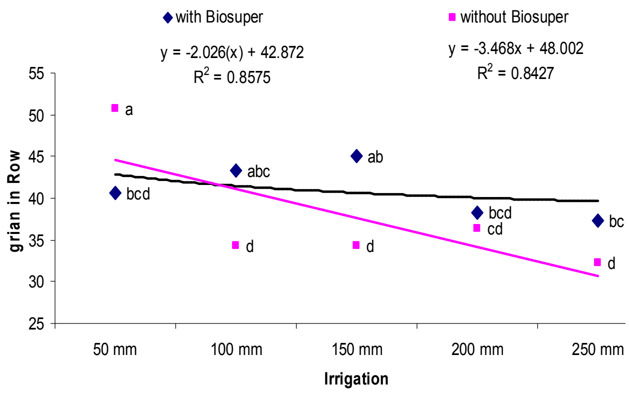

Figure 1: Effect of biosuper application in different irrigation levels on grain in row

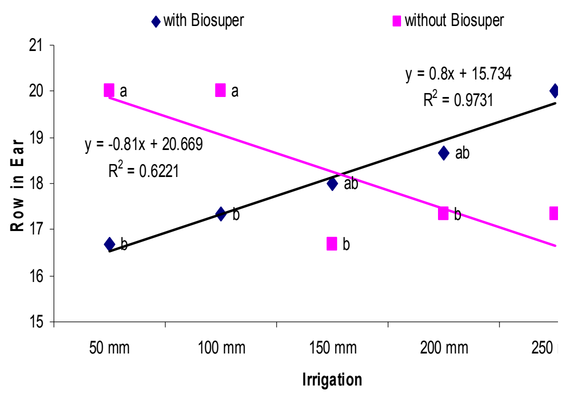

Figure 2: Effect of biosuper application in different irrigation regimes on row in ear

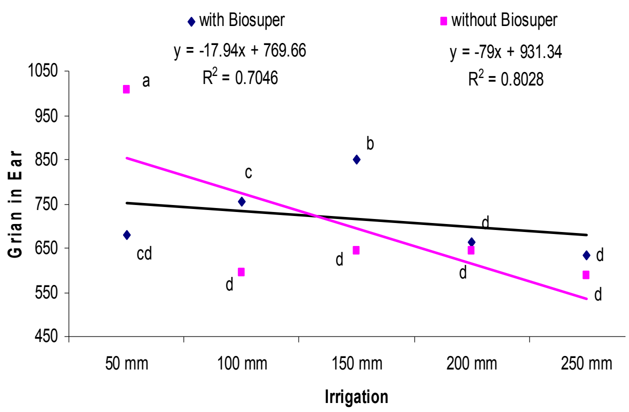

Figure 3: Effect of biosuper application in different irrigation regimes on grain in ear

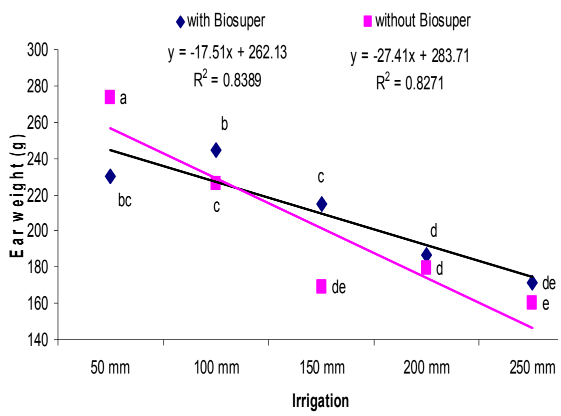

Figure 4: Effect of biosuper application in different irrigation regimes on ear weight

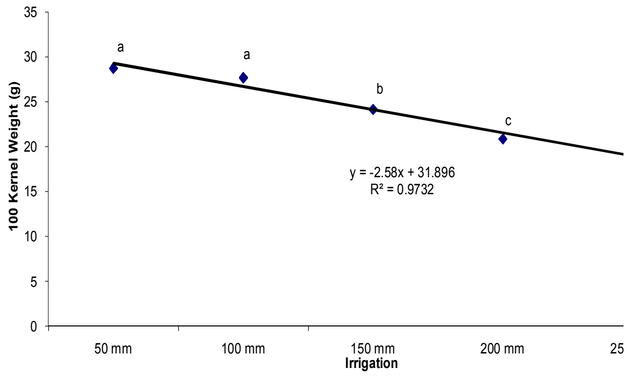

Figure 5. Effect of different irrigation regimes on 100 kernel weight

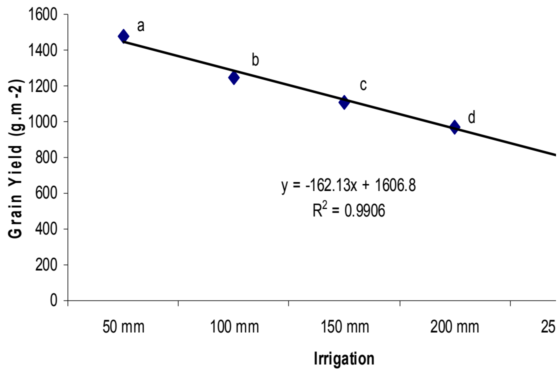

Figure 6 Effect of different irrigation regimes on 504 maize grain yield

Table 1: Analysis of variance for evaluated traits

Source of variation	df	MS							
		Row in Ear	Grain in Row	Grain in Ear	Ear Weight	100 Kernel Weight	Harvest index	Biological yield	Grain yield
Repitition	2	2.800	20.067	9883.3*	0.0001	13.404*	7.890	28880.511*	22364.949**
Irrigation Levels	4	7.200**	388.200**	49870.3**	0.008**	102.642**	78.481**	428391.588**	398246.041**
Biofertilizers levels	1	0.133	83.333	3477.633	0.0002	13.192*	3.696	99679.153**	47338.307**
Irrigation× Biofertilizers	4	5.467*	402.333**	66298.633**	0.002**	0.639	13.048	720.192	2371.827
Error	18	1.467	355.933	2295.374	0.0001	2.760	10.177	6017.014	3687.350
C.V(%)		6.65	11.32	6.79	8.88	6.88	4.13	5.38	5.42

* and ** Significant difference in 5% and 1%, respectively

	100 Kernel Weight	Ear Weight	Row in Ear	Grain in Row	Grain in Ear	Grain Yield	Harvest Index
Ear Weight	0.974**						
Row in Ear	-0.585	-0.467					
Grain in Row	0.841	0.852	-0.381				
Grain in Ear	0.766	0.740	-0.379	0.974**			
Grain Yield	0.968**	0.970**	-0.529	0.943*	0.874		
Harvest Index	0.959**	0.913*	-0.519	0.925*	0.903*	0.967**	
Biologic yield	0.965**	0.973**	-0.556	0.931*	0.852	0.998**	-0.950*

Table 2: Simple correlation between evaluated traits

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