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Response of Maize to Compost and A-mycorrhizal under Condition of Water Stress

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ABSTRACT

Two field experiments were conducted at the experimental farm of the faculty of Agriculture- Saba Basha, Alexandria Governorate, Egypt, during 2014 and 2015 summer growing seasons to study the impact of compost and A- mycorrhizal on yield and its component, protein content (%), leaf water potential and leaf proline content of maize under water stress condition. The experimental design a split plot design with four replications. The main plots included the three water stress (10, 15 and 20 days intervals), while Control, A-Mycorrhizal, compost, mixture (compost + mycorrhizal) were arranged in the subplots. The main results could be summarized as follows; the irrigation intervals had significant effect on yield and its components and protein (%), where irrigation every 15 day recorded higher mean value for most of studied yield characters i.e. plant height at harvest, ear diameter, ear length (cm), number of rows/ear, number of kernels/row, number of kernels/ear, 100- grain weight, ear weight (g), grain, stover, and biological yields (tons/fed.) as well as harvest index and protein content (%) as compared with irrigation every 20 days. Increasing irrigation intervals, significantly, decreased grain yield/fed., and its components. On the other hand, irrigation every 20 days increased leaf water potential and grain proline content. Also, application of mixture of compost + A-mycorrhizal, significantly increased analysis, grain yield and its components and proline content (%) than control treatment, whereas application of mixture of compost + A- mycorrhizal especially A- mycorrhizal was a most times greater of leaf water potential than control treatment.

Key words: maize; mycorrhizal; compost; yield; grain; water potential; proline

Introduction

Maize (*Zea mays*, L.) is an important cereal which ranks the third after wheat and rice. In Egypt, cultivated area from maize about 1.00 million hectar=2.40 feddan, in 2012 season. Produced 7.20 million tons grains with an average production of 7.20 tons/ha., this production, however does not meet consumption where about 5 million tons are improved (FAO, 2012). Moreover, the strategy bused in mixing grain partly with wheat to reduce wheat importing and increase self sufficiency from bread, wheat is partly based on making use of maize or reduce maize export using maize in forage and silage crop.

This is turn necessitates more extension in the maize cultivated area and as well as optimizing the needs of irrigation water. Optimal water irrigation strategies thus become an important factor due to limitations in the supply of irrigation water caused by uncontrolled increase in rice cultivated area which receives a great part of irrigation water in the summer season.

Several studies had been carried out to explore the effect irrigation interval on maize yield attributes and its components. In this respect, Samuel *et al*. (2005) and Mohsen *et al*. (2012) detected that 100- kernel weight (g), grain weight/ear and grain yield decreased due to extreme drought. Water deficit stress had significant effects on grain yield. Water deficit stress at vegetative phase had significant effect on leaf solution proteins and reduced it in stress treatments when compared with control. At the end of each phase of stress, water deficiency induced significant increase of Proline in leaves. Water deficit stress led to significant decrement of chlorophyll content in examined cultivars. Water deficiency had significant effect on free amino acid content of leaf at the end of reproductive stress (Soltani *et al*., 2013). Also, El-Sobky *et al*. (2014) reported that irrigation every 14 days recorded higher averages of yield and its components of maize crop as compared with irrigation every 18 days. And Gomaa *et al.* (2014) detected that water stress affected, significantly, the most of yield and its components attributes; whereas, irrigation every 15 days led to the highest mean values of most yield and its components parameters namely; ear length, number of row/ear, number of kernels/row, number of kernels/ear, 100- kernel weight (g), grain, straw and biological yields tons/ha., harvest index % in both season, respectively. Meanwhile, irrigation of maize plants every 20 days recorded the lowest ear length, number of kernels/row, number of kernels/ear, 100- kernel weight (g), grain yield tons/ha., straw yield tons/ha., and biological yield tons/ha., but protein content increased with irrigation every 20 days during both seasons (11.09 and 10.38 %).These results reveal that increasing irrigation interval from every 10 to 20 days resulted in

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a significant decrease in maize plants all parameters except protein %. However, Abbas *et al*. (2015) concluded that maize crop was sensitive to severe water stress (21 days interval) during the first stage from 20–60 DAS and also during the third stage from 82–106 DAS.

The coincident application of organic manure and biofertilizer is frequently recommended firstly for improving biological physical and chemical properties of soil and secondly to get clean agricultural products free of undesirable high doses of heavy metals and other pollutants. Organic manures contain higher level of relatively easily available nutrient elements which are essentially required for plant growth. Moreover, it plays an important role to improve soil physical properties (Abdel-Ghany *et al*., 2005). Many researchers investigated the nutrient value of organic manure and bio-fertilizers of maize production (Soliman *et al*., 2001 ; El-Mekser, 2004).however, Abdel- Ghany *et al*. (2005) evaluated the performance and increase maize production maximize the use of organic farming manure on the agronomic a aspects of adding organic application on plant height, ear length, ear diameter, number of rows/ear, straw, grain and biological yields/fed., harvest index % and protein yield/fed., of maize crop, where the application of organic fertilizer + biofertilizer results in highest increases.

Therefore, the objective of the present investigation was carried out in order to study the impact of compost and A-mycorrhizal application on the productivity and quality characters of maize under water stress condition.

Materials and Methods

Two field experiments were conducted at the Experiment Farm, Faculty of Agriculture (Saba Basha) Alexandria University, Egypt during the summer growing seasons of 2014 and 2015 to study the response of maize plants to A-Mycorrhizal and compost under water stress conditions on the productivity and quality of maize hybrid (S.C.130).

The experiment was carried out in four replicates in a split plot design where the three water stress (irrigated every 10, 15 and 20 days intervals) were arranged in main plots. Control, A-Mycorrhizal, compost, mixture of compost and mycorrhizal were done in sub plot.

Representative soil samples were taken from experimental soil before starting experimental work. The soil samples were at dried, passed through a 2 mm save, and then analyzed according to the method described by Chapman and Partt (1978). The soil type of experimental site was clay loam. The mechanical and chemical analyses of the experimental site in presented in Table (1).

Table 1: Some Physical and chemical properties of the experimental soil in 2014 and 2015 seasons

Soil properties	Season	
	2014	2015
A) Mechanical analysis :		
Clay %	38	37
Sand %	32	33
Silt %	30	30
Soil texture	Clay loam soil	
B) Chemical properties		
PH (1 : 1)	8.34	8.35
E.C. (ds/m)	3.91	3.88
1) Soluble cations (1:2) (cmol/kg soil)		
K+	1.52	1.54
Ca++	9.42	8.77
Mg++	18.3	18.5
Na++	14.30	13.90
2) Soluble anions (1 : 2) (cmol/kg soil)		
CO3-- + HCO3-	2.90	2.85
Cl-	20.4	20.80
SO4-	13.50	12.90
Calcium carbonate (%)	6.50	7.00
Total nitrogen %	1.00	0.91
Available phosphate (mg/kg)	3.70	3.55
Organic matter (%)	1.44	1.45

Organic manure (compost) at the one rate was added (10 m^3/feddan=fed.=0.42 hectar) at the soil preparation before planting in both seasons analysis of organic manure in Table (2).

Inoculation with A-mycorrhizal fungi *Glomusm acrocorpuim* strain from Plant production Department (Saba Basha), Alexandria University, at a note of 250 ml infected roots and was mixed with the soil, and decanting technique as described by Radwan (1998) the proceeding crops were wheat (*Triticum aestivum*, L.). In the just season and Egyptian clover (*Trifoluim alexandrineem*, L.) in the second season, respectively. Each subplot consist ridges, 3.5 m length and 70 cm in the width, plot area was 14.7 m^2 (3.5m length x 4.20 m. width). The sowing dates were 22 and 20 May was for 2014 and 2015 season, respectively.

Table 2: Composition of organic manures (compost)

Determination	Compost
Moisture (%)	10.70
Organic matter (%)	45.30
Total N (%)	1.90
Total P (%)	1.70
Total K (%)	1.10
PH	6.53
EC	1.40
Fe (ppm)	2660
Zn (ppm)	55.00
Mn (ppm)	280.00
Cu (ppm)	12.50

The soil of experimental was ploughed twice, then it was fertilizer by 200 kg calcium super phosphate (15.5% P_2O_5) and 50 kg potassium sulfate (48% K_2O).The experimental plot were irrigated immediately after sowing nitrogen fertilizer recommended (120 kg/fed) in the form of urea (46.50 % N) were applied in two equal doses before that first and the second irrigation .The three irrigation intervals were every10, 15 and 20 days during the growing period which began after the first main irrigation i.e. sowing irrigation (Al-Mohayat) later than 21 days after sowing and the next irrigation after 21 days were randomized within each main plots all recommended agricultural practices for growing maize were done .

Yield and yield components which were recorded are plant height at harvest, ear length (cm), number of kernels/row, number of rows/ear, number of kernels/ear, 100 kernel weight (g), straw yield (tons/fed.), grain yield (tons/fed..), biological yield (tons/fed..), harvest index (HI), protein percentage, leaf water potential as well as grain proline content.

Data were statistically analyzed as split- plot design according to Gomez and Gomez (1984), using the split- split model obtained by CoStat 6.311 (1998-2005) as statistical program. Treatment means were compared according to (Duncan's, 1955) test at 0.05 level of probability to estimate the significant differences among treatments.

Results and Discussion

A. Yield and Yield components:

Data as shown in Tables (3 and 4) revealed that the water stress and bio-organic fertilizer affected significantly, the most of yield and its components attributes whereas irrigation every 15 days led to the highest mean values of most yield and its components namely, plant height (cm) at harvest, ear diameter, ear length (cm), number of rows/ear, ear weight, 100- kernel weight (g), grain, stover and biological yield (tons/fed.) as well as harvest index %, whereas, without significant between irrigation every 10 and 20 days for ear diameter, number of kernels/row, 100 kernel weight and harvest index in both seasons and plant height in the first season, respectively, but protein content increased with irrigation every 20 days during both seasons (12.55 and 12.57 %).

The results reveal that increasing irrigation intervals from every 10 to 20 days resulted in a significant decrease in maize plants all parameter except grain protein (%). These findings indicate that high water stress enhanced the growth plants of maize thereby its yield attributes. In this connection Abddel-Aziz and El-Bialy (2004) and Ibrahim and Kandil (2007) in they reported a significant decrease in maize grain yield due to prolonging the irrigation intervals to 18 days.

The effect of fertilizer types on yield and yield components are presented in Tables (3, and 4). Application of mixture of compost and A- mycorrhizal gave significant difference were plant height at harvest, ear diameter, ear length, number of rows/ear, number of kernels/row, number of kernels/ear, ear weight, 100- kernel weight, grain, stover and biological yields (tons/fed.), harvest index and grain protein (%). The statistical analysis indicated that there were highly significant differences among the fertilizer treatments on grain yield, where the application of organic (compost) + biofertilizer (A-mycorrhizal) resulted in highest increases (12.55 and 12.57 %) during 2014 and 2015 seasons, respectively. On the other hand, no significant response to all types of used fertilizer was observed for ear diameter, stover yield/fed., harvest index and protein % in cropping seasons, number of rows/ear, number of kernels/row, 100- kernel weight, grain yield/fed., and biological yield in the second season. It could be concluded that the role of available nitrogen from organic and/or biofertilizer as essential element in building maize ears due to the positive effect of nitrogen an increasing the vegetative growth, photosynthetic accumulation and net assimilation rate in maize as C4 crop. As well as, the increasing in grain yield/fed., (as the end product) may be due to role of microorganisms resulted from organic (compost) manure and biofertilizer (A-mycorrhizal) application in breaking down the organic matter and releasing useful compounds for plant which leads to increase of chlorophyll formation then photosynthetic accumulation and so on. Therefore the increase in protein content in grains takes place simultaneously with the chlorophyll increasing. Moreover, organic matter plays an important role to improve soil physical properties. Similar results were reported by (Soliman *et al*. (2001); Ahmed *et al*. (2003); Nofal and Salem (2003); Abdel-Gany *et al*. (2005).

Table 3: Means of yield and its components of maize as influenced by water stress and bio- organic fertilizer (Compost and Mycorrhizal) during both seasons of 2014 and 2015.

Treatments	Plant height (cm)		Ear diameter (cm)		Ear length (cm)		Number of row ear-1		No. of kernels/row		No. of kernels/ear		Ear weight (g)	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Water stress														
Irrigation every 10 days	228.60	225.24	2.74	2.69	17.90	17.92	14.84	14.74	36.50	36.14	541.61	532.47	196.08	194.69
Irrigation every 15 days	230.96	242.43	2.76	2.78	18.84	18.89	16.14	16.14	35.72	36.39	576.67	587.40	210.33	219.00
Irrigation every 20 days	184.78	190.93	2.60	2.62	15.25	14.82	14.45	15.03	32.15	31.15	465.02	470.39	159.94	158.12
LSD 0.05	7.109	6.849	0.072	0.126	0.620	0.454	0.712	0.940	1.053	1.029	24.16	35.24	9.79	14.60
Compost and Mycorrhizal														
Control	206.67	210.42	2.58	2.61	17.15	16.64	14.20	14.33	34.12	33.71	487.33	485.47	168.45	170.09
Mycorrhizal	214.23	215.68	2.72	2.72	17.21	16.74	15.10	15.33	34.47	34.69	519.62	531.74	183.34	186.92
compost	216.25	223.60	2.71	2.72	17.13	17.64	15.43	15.45	34.52	34.22	533.56	530.07	187.69	186.07
Mixture	221.96	228.43	2.78	2.74	17.82	17.81	15.83	16.08	36.05	35.61	570.54	573.06	215.65	219.33
LSD 0.05	4.545	6.270	0.079	0.116	0.551	0.495	0.688	0.845	1.322	1.371	30.72	32.65	12.25	14.29
Interactions														
Water stress x Compost and Mycorrhizal	*	*	*	*	*	*	*	*	*	*	*	*	*	*

**: Significant at 0.05 level of probability.*

Table 4: Means of yield, its components and grain protein % of maize as influenced by water stress and bio- organic fertilizer (Compost and Mycorrhizal) during both seasons of 2014 and 2015.

Treatments	100- kernel weight (g)		Grain yield (tons/fed.)		Stover yield (tons/fed.)		Biological yield (tons/fed.)		Harvest index (HI) %		Grain protein (%)	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Water stress												
Irrigation every 10 days	36.16	36.52	2.68	2.75	4.26	4.42	6.94	7.16	38.54	38.30	11.20	11.70
Irrigation every 15 days	36.39	37.13	3.02	3.11	4.22	4.32	7.24	7.43	41.66	41.82	11.64	11.84
Irrigation every 20 days	34.31	33.71	2.10	2.06	3.24	3.11	5.34	5.17	39.23	39.96	12.55	12.57
LSD0.05	0.877	1.134	0.183	0.224	0.093	0.140	0.189	0.238	1.958	1.555	0.207	0.415
Compost and Mycorrhizal												
Control	34.43	34.89	2.36	2.47	3.60	3.64	5.97	6.11	39.64	40.71	10.95	10.98
Mycorrhizal	35.24	35.09	2.54	2.69	3.94	4.07	6.48	6.77	38.92	39.76	12.08	12.28
compost	35.15	35.11	2.61	2.62	3.99	3.98	6.60	6.59	39.39	39.50	12.16	12.38
Mixture	37.65	38.06	2.89	2.77	4.09	4.11	6.98	6.88	41.27	40.14	12.01	12.52
LSD0.05	0.933	1.180	0.185	0.174	0.168	0.184	0.280	0.294	1.846	1.848	0.496	0.508
Water stress x Compost and Mycorrhizal	*	*	*	*	*	*	*	*	*	*	*	*

Furthermore, results of both Tables, also, showed significant the interaction between water stress and bio- organic fertilizer on yield and its component and protein % in both seasons.

Figures 1 and 2 show the interaction effect between water stress (irrigation intervals) and bio- organic fertilizer treatments (compost, Mycorrhizal, and mixture) on grain yield of maize, whereas irrigation maize crop every 15 days with application of mixture of compost and A- mycorrhizal recorded the highest mean value of grain yield of maize during the two growing seasons.

B- Leaf water potential (LWP)

Results in Table (5) indicated significant differences in leaf water potential (LWP) due to drought stress treatment where LWP was measured 60, 75 and 90 DAS from planting in both seasons. LWP was significantly, higher the irrigation every 20 days treatment than other treatments at all growth stages in both seasons. Leaf water potential is important because of its relation to cell turgor pressure and osmotic potential. The turgor component is important in cell expansion and cell division while the osmotic component influence cell metabolism and enzyme activity (Mohsen *et al.,* 2012).

The results showed that during unwaterd period and after rewatering leaf water potential of mixture of compost + A-mycorrhizal especially Mycorrhizal plants was a most time greater than in control treatment plants, particularly in plant infected by *Glomus macrocarpum*. Mycorrhizal plants were able to postpone the onset of drought plant. Similar results were reported by Amerian and Stewart (2001).

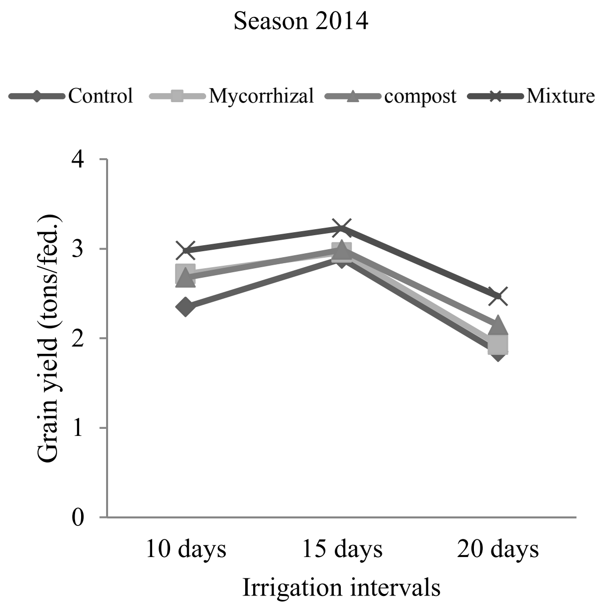

Fig. 1: Interaction effect of water stress and bio- organic fertilizer on grain yield (tons/fed.) of maize during season of 2014.

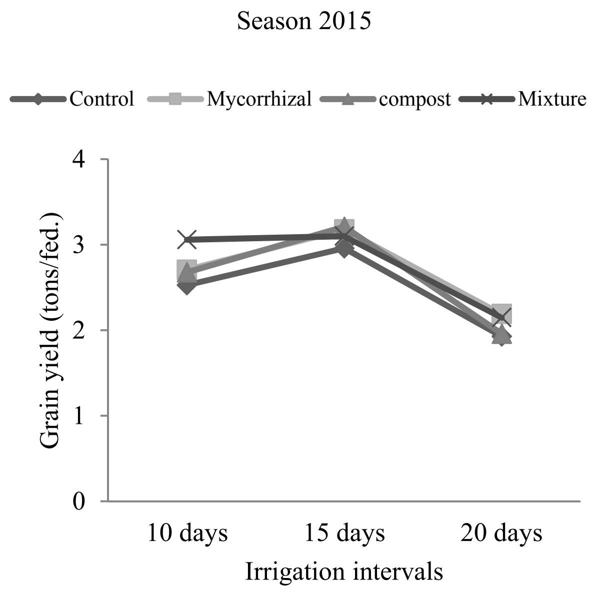

Fig. 2: Interaction effect of water stress and bio- organic fertilizer on grain yield (tons/fed.) of maize during season of 2015.

Table 5: Means of leaf water potential (LWP) (-bar) at three times (50, 65 and 80 DAS) and leaf proline content (LPC) at two times (75 and 90 DAS) of maize as influenced by water stress and bio- organic fertilizer (Compost and Mycorrhizal) during both seasons of 2014 and 2015.

Treatments	Leaf water potential (LWP) (-bar)						Leaf proline content (LPC)			
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
	50 DAS		65 DAS		80 DAS		50 DAS		65 DAS	
Water stress (W)										
Irrigation every 10 days	7.40	7.70	13.96	15.40	16.90	15.62	20.96	25.92	14.42	14.57
Irrigation every 15 days	10.54	9.43	14.66	17.45	18.06	17.31	22.60	28.41	15.24	16.31
Irrigation every 20 days	10.54	10.69	16.31	19.12	19.18	19.60	26.57	40.64	18.82	21.19
$LSD_{0.05}$	0.284	0.208	0.346	0.836	0.567	0.339	0.502	1.192	0.671	0.975
Compost and Mycorrhizal (CM)										
Control	9.14	9.04	14.28	16.82	17.61	17.12	25.89	32.80	17.02	18.01
Mycorrhizal	9.42	9.55	15.01	17.35	18.09	17.45	22.56	32.37	15.96	17.07
compost	9.53	9.04	15.02	17.50	18.13	17.64	22.84	32.21	16.22	17.39
Mixture	9.88	9.67	15.59	17.62	18.55	17.83	22.23	29.25	15.44	16.95
$LSD_{0.05}$	0.362	0.519	0.430	0.624	0.752	0.509	1.23	0.925	0.873	1.257
Water stress x Compost and Mycorrhizal (CM)	*	*	*	*	*	*	*	*	*	*

**: Significant at 0.05 level of probability.*

C. Leaf proline content (LPC)

Leaf proline content as an indicator of drought stress at 75 and 90 DAS were increased significantly, by irrigation every 20 days as compared to other treatments. Leaf proline content reached its maximum values (26.57 – 18.82 mg/g) and (40.64 – 21.19 mg/g) at 75 and 90 DAS in both seasons (Table 5). Proline is considered to be involved in adaptation mechanisms in drought stress. Similar results were reported by Darwesh (2006).

Accumulation of proline increased considerably in shoots drought stress also induced the accumulation of proline. However, in such plants tissue AM- plants accumulated 13 % less proline than control treatment.

The interaction between irrigation intervals and bio- organic fertilizer was significant effect on leaf water potential (figures 3 to 8) and leaf proline content at different growth stages in both seasons.

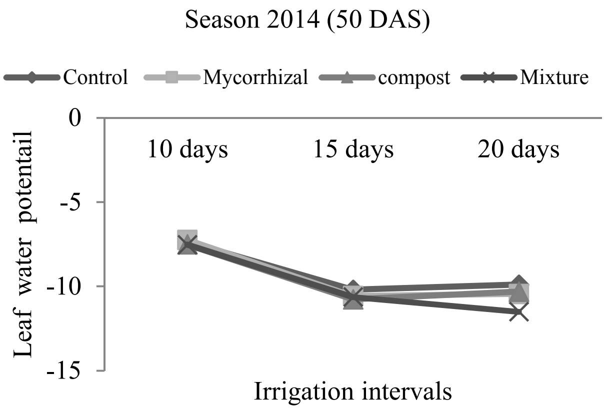

Fig. 3. Interaction effect of water stress and bio- organic fertilizer on leaf water potential (LWP) at 60 DAS of maize during season of 2014.

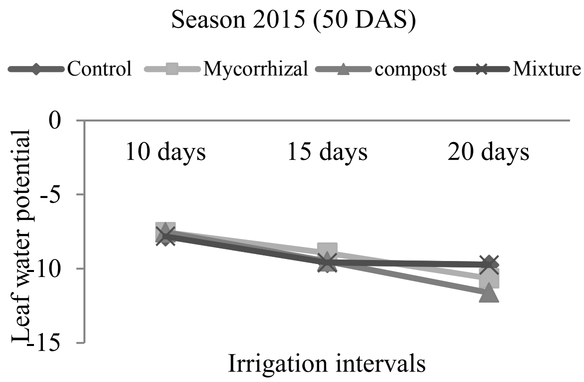

Fig. 4: Interaction effect of water stress and bio- organic fertilizer on leaf water potential (LWP) at 60 DAS of maize during season of 2015.

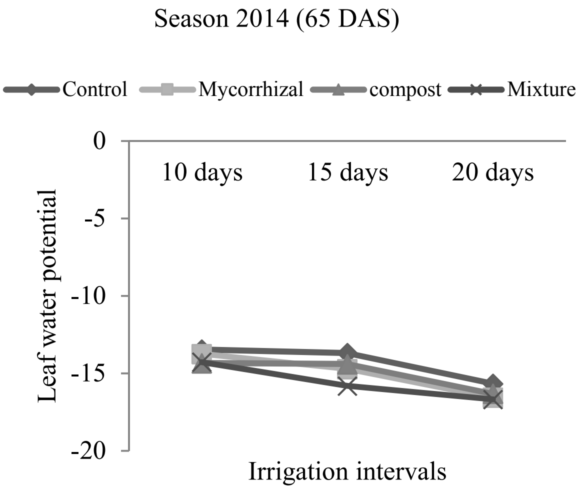

Fig. 5: Interaction effect of water stress and bio- organic fertilizer on leaf water potential (LWP) at 75 DAS of maize during season of 2014.

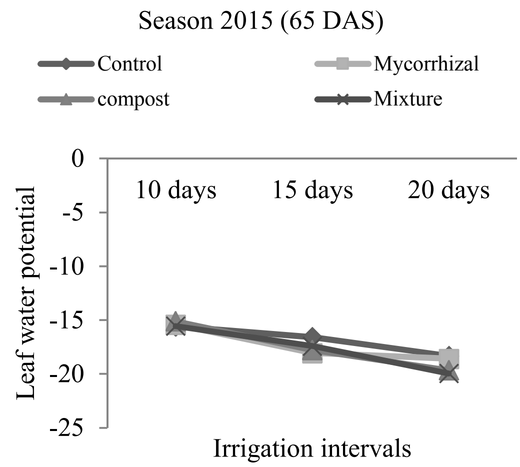

Fig. 6: Interaction effect of water stress and bio- organic fertilizer on leaf water potential (LWP) at 75 DAS of maize during season of 2015.

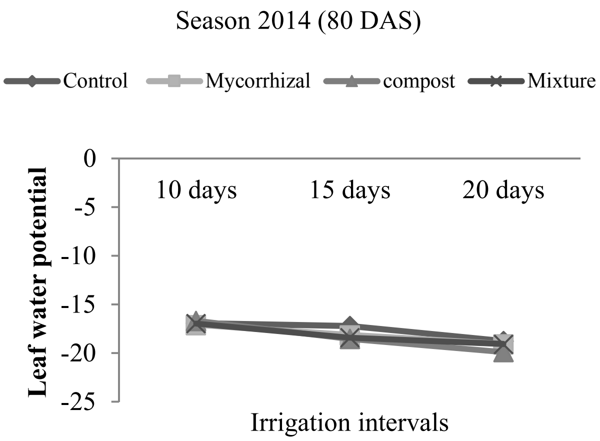

Fig. 7: Interaction effect of water stress and bio- organic fertilizer on leaf water potential (LWP) at 90 DAS of maize during season of 2014.

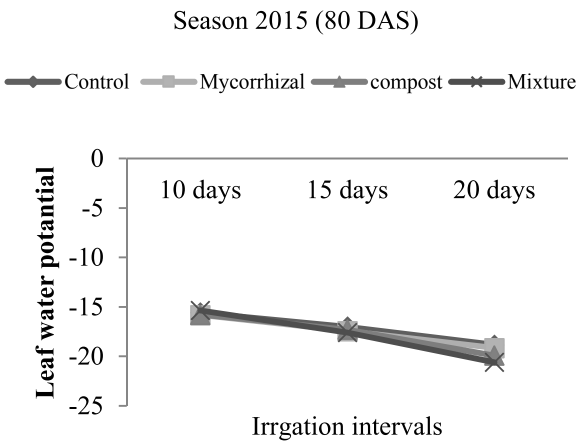

Fig. 8: Interaction effect of water stress and bio- organic fertilizer on leaf water potential (LWP) at 90 DAS of maize during season of 2015.

Conclusion:

In conclusion using irrigation every 15 days and bio- organic treatments produced highest value of most yield and its components and protein content %.

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