

Study the Effects of Super Absorbent Application on Maize (*Zea mays* L.) under Drought Stress Condition

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Abstract – Super absorbent polymers are one of the new methods used mainly in the agricultural systems to decrease the damage effects of drought stress in the field crops. Due to investigation the effects of super absorbent application in dropping the drought stress effects on maize an experiment was conducted in the farm of faculty of agriculture research at university of Zabol. Drought stress was applied as main factor in three levels: irrigation at 90%fc, irrigation at 70%fc and irrigation at 50%fc. Super absorbent was defined as subplot in three levels: check ($0\text{kg}\cdot\text{h}^{-1}$), $50\text{kg}\cdot\text{h}^{-1}$, and $100\text{kg}\cdot\text{h}^{-1}$. Super absorbents were planted at depth 30cm below the culture lines. Results of variance analysis showed significant differences were observed among drought levels and super absorbent levels as well for all traits. Mean comparisons of simple effects indicated that the highest means in all traits belonged to irrigation at 90%Fc. Also the use of $100\text{kg}\cdot\text{h}^{-1}$ super absorbent caused significant increase in yield and yield component. Interaction effects showed in almost all traits there were no significant differences among super absorbent application at 90%Fc. But the use of different amount of super absorbent caused reduction in drought effects on yield and yield components in 70%fc and 50%fc. It seems the highest efficiency of application super absorbent is observed when plants are influenced by moderate stresses and in severe stresses they might not be useful to undergo drought in corn.

Keywords – Drought Stress, Maize, Super Absorbent Yield Components.

I. INTRODUCTION

Drought is one the most important environmental impacts affecting production in the field crops [5]. Drought stress causes considerable physiological effects on growth and particularly development in the field crops[5]. In arid and semi-arid regions, water shortage, high transpiration and low available water in some soils are the most challenges in agriculture. Management and use of advances methods in order to conserve moisture and increase water use efficiency are the applies mechanism to shrink the negative effects during drought conditions. [4][5]. Super absorbents are suggested to be one of the recent methods maintaining moisture and increase water use efficiency in soil. Super absorbent polymers made from hydrocarbons are able to absorb water several times its own weight [1]. These polymers are hydrophilic that have speed and high capacity for water absorption in drought periods and causing drought tolerance in plants [4].

Corn (*Zeamayes*) is known one of the most important cereals that does play impressive role in human and animal nutrition [17][7]. Moreover, corn is classified in C4group with huge requirement to adequate moisture and heat [8]. However, drought affects morphological and physiological

traits and causes a significant reduction in seed and forage yield in maize cultivars [2].Consequences of drought stress differ at growth stages for instance, almost in all domesticated crops flowering and maturing are susceptible phases to drought intensity [21]. Cakir [6] pointed out that yield would be dramatically reduced in the flowering stage in corn during water deficiency periods. Furthermore, water deficiency in the vegetative stages brought out 28-38% decrease in the biomass yield. Larson and Clegg [16] indicated early hybrids are more adaptive than late hybrids in the moisture shortage that would improve their performances in drought conditions. Use of moisture absorbent material is a new mechanism to go up the resistance to water deficiency in corn genotypes. Positive significant results are reported of using super absorbent on growth parameters especially on plant height and biomass yield in forage crops [13][23]. In another research presented by Fazeli et al[9] super absorbent polymers had positive and significant effects on chlorophyll index and leaf area. Kohestani et al[15]reported absorbent polymers promoted yield and yield components in 704S.C under drought environment by climbing the water keeping capacity in soil, reduction in nutrient leaching, better aeration and increase root development. Although numerous researches has been done in the Iran to use absorbent polymers in agriculture, the result of these research are relied on climate, soil and environment contributors and it is unlikely to act in same ways in all various regions of Iran. Thus, it is a good idea to conduct field experiments in different regions of Iran. The main aim of this research was the study of super absorbent application on yield and yield components in maize (*Zeamayes*) under drought conditions in Sistan.

II. MATERIALS AND METHODS

A Split plot experiment was arranged on the complete randomized block with four replications at the Institutes of Agriculture Research in Zabol, Iran. This site is almost located at $30^{\circ}59'N$ latitude, $61^{\circ}40'E$ longitudes and an altitude of 495m above the sea level. This region has a semi-arid climate (354mm rainfall annually) Physical and chemical properties of the soil used in this study are seen in Table 1. Seeds of 704 S.C were provided by the Institute of Agriculture and natural Resources, Zabol, Iran. The investigated factors were drought stress as main factor with three levels containing irrigation at 90%, 70% and 50% field capacity and super absorbent polymers as sub factor in three levels including 0(check), 50, 100 $\text{kg}\cdot\text{h}^{-1}$. The used absorbent polymers in this study was hydrophilic polymer (A200) produced by the Rahab Co. Ltd, Under license of the Iranian Institute of Polymer and

Petrochemical. Some properties of absorbent polymers is specified below:

Water content (%) = 3-5, Density= 1.4-1.5 (g/cm³), PH = 6-7. Water uptake capacity= 220 g.g⁻¹ in distilled water. Polymers were penetrated soil at a depth 15-30 cm in beside planting rows, each plot consisted of 6 cultivation rows with 4 meters length and 75cm row spacing. Normal irrigation was evenly applied to water all plots from the sowing time till complete establishment of plants (appearance of sixth leaves). TDR means (device measures volumetric moisture) was used due to determine soil moisture in the stress treatments and according to soil moisture curve, volumetric moisture, root depth and pots surface, water was given to target plots in three levels of drought stress (90%fc, 70%fc and 50%fc) also in all stages

water amount was measured by counter [10][11]. All agricultural practices and agronomic operations were regularly done according to the recommendation of the Institute of Agriculture Research. At full maturity, plants were randomly harvested by cutting 5 cm above the soil surface and several parameters consisting the number of seeds in the rows of Ear, the number of rows in Ear, Ear length, Ear diameter, 1000 kernel weight, the number of seed in Ear, plant height, grain yield, biomass yield, harvest index were measured. The data were analyzed by variances analysis (ANOVA), using the R, GLM procedure (R Software 2013). Means were compared by Duncan test at 5% probability level. Figures were drawn by Excel (2010) Software.

Table 1: Soil characteristics of the experimental station

Year	pH	EC (dS/m)	N(%)	P(ppm)	K(ppm)	Sand(%)	Silt(%)	Clay(%)
2012	8	7.8	0.053	7.8	190	63	20	17

III. RESULTS AND DISCUSSION

Table 2 accounts for the results of variance analysis. As can be seen, there were significant differences at 1% probability for drought factor in all traits. Mean comparisons at table 3 show the highest means belonged to irrigation at 90%Fc and the lowest trait means observed in the irrigation at 50%fc. There were significant differences between 90%fc and 70%fc for all traits except the number of row in Ear that illustrates moderate stress like 70%fc and severe stress reduced almost whole averages of vegetative and reproductive parameters in maize. Moreover, irrigation at 50% Fc led to virtually 50% loss in grain yield and 40% loss in the biological yield. Setter [20] reported significant decrease in the ear weight through drought stress in corn. It is discussed that reduction in the grain yield was achieved through reduction in the yield components such as 100 kernel weight and the number of seed in ear [10][11]. The results of table 3 illustrates irrigation at 50% fc resulted 20% decrease in 100 kernel weight and 56% decrease in the number of seed in era which led to a 50% decrease in grain yield. These results have been confirmed with the results of other researchers in which due to high correlations between number of seeds in cob and 100 seeds weight with grain yield a decrease in both of them results to yield loss in Maize [21][22]. The variance analysis in Table 2 disclosed that the effect of super absorbent was significant on almost all traits except the number of seed rows in ear and plant height. To illustrate, by increasing the amount of super absorbent of from check to 100 kg.h⁻¹ trait's means underwent a significant rise reaching, 4675 kg from 4474 Kg and for the biomass yield was 1 from 1233.5 to 12595 kg. Ganji [12] stated grain yield goes up with utilizing super Absorbent polymers because yield components are enriched through adequate soil moisture and root aeration in maize. In other traits, increase the amount of polymer from check to 100kg.h⁻¹ caused 20% growth in means. It seems the use of 100kg.h⁻¹ super absorbent took much most effects on trait's means

rather than other levels. Allahdadi et al [3] reported biomass yield in corn is markedly soared with use of greater amount than 100kg.h⁻¹. They explained the application of mounting amount of super absorbent in sand soils is likely to increase available water in root's area and water use efficiency is estimated to grow with rapid water absorption and consequently gradual drainage of water in drought intensity.

Data of Table 2 represent interaction effects of drought in super absorbent showing significant differences at 1% probability for the number of seeds in row, The number of rows in Ear, Ear length, Ear diameter, 100 kernel weight, the number of seed in Ear, plant height, grain yield, biomass yield and harvest index. Mean comparisons at table 4 indicated the highest mean in all traits obtained in treatment of 90%fc in 100kg.h⁻¹. Also, Almost 40% increase in grain yield and 55% increase in biomass yield was created by interaction effect of 90% fc in 100 kg.h⁻¹ polymers rather than 50%fc and check amount of absorbent polymers. For other traits almost 40% increase in means was achieved by this treatment as well as. Whereas, the lowest means in approximately all traits were calculated in treatment of 50%fc in lack of super absorbent. Indeed, polymers improve particularly grain yield not only with nutrient storage but also reduce nutrient leaching in soil in non-drought stress conditions. Positive impacts of absorbent polymers on reducing the adverse effects of drought stress in different crops has been reported by numerous researchers [14][18][19]. Although the use of absorbent materials increased trait's performances in all irrigation levels, there were not the same trends in majority of traits. Additionally, there were no significant differences among the polymers levels in irrigation at 90%fc for all traits exception for height ear, 100 kernel weights and grain yield. Perhaps, there were no significant differences between amount of 100 kg.h⁻¹ and check treatment in applying absorbent polymers in the point of 90% fc. In fact, both of them almost had the same impacts on traits expression. Table 4 indicates the mean of all traits had been gone up with increase amount of super

absorbent from check to 100kg.h⁻¹ in 70%. Furthermore, the highest means devoted to treatment of 100kg.h polymers. Likewise, Evaluation this trend in 50% fc at table 4 revealed in all traits, except the number of seed rows in Ear, with adding polymers from check to 100 kg.h⁻¹ the average of all traits grow noticeably. Figure 1 depicts the effects of polymer application on grain yield in different levels of water deficiency in which climbing amount of polymers affected the grain yield in experimental plots. The most striking trend of this figure is that seed yield took an upward trend in all levels of drought stress. Yet, trend slope is different in experienced drought levels 70%fc>50%fc>90%fc meanwhile sharper slope shows higher efficiency, thus, the greater efficiency is observed in the moderated stress 70%fc. As a same way, figure2 presents the response forage yield to super absorbent polymers under various rates of water deficiency. As is clearly seen, there were a upward trends with increasing the amount of polymers in all points of drought stress. Nevertheless, the lines slope are different in drought levels 70%fc>50%fc>90%fc meaning the most efficiency for polymers application is observed in mild stress 70%fc. These results has been confirmed by prior

researches in various regions of Iran, For instance Talae et al [22] reported the effect of super absorbent polymers is more noticeable at lower moisture.

IV. CONCLUSION

To sum up, this study showed the heights means in all traits were achieved in the treatment of 90%fc in 100kg.h-1 polymers. yet, the highest efficiency was observed in treatment of 70%fc in 100kg.h-1 polymers. It seems in arid and semi-arid regions like Sistan where water shortage and high evaporation are frequently occurred during growth season the application of absorbent polymers is likely to be useful to increase grain and biomass yield in Maize cultivars. However, it can be kept in mind that in stricter stresses like 50%fc the use of super absorbent polymers is not predicted to be completely fit for tolerance to drought stress. Thus, it can be considered as a suggestion to use of alternative methods to reduce negative effects of drought stress on yield and yield component in maize when plants are faced with short - period droughts.

Table 2: Variance analysis of main and interaction effects in different traits of *Zea mays*

S.O.V	D.F	No. Row in Era	No. Seed in Row	Era Length	Era Diameter	100 Kernel weight	No. Seed in Era	Plant Height	Seed Yield	Biological Yield	Harvest Index
Rep	3	10.56	4.56	6.6	2.35	0.32	6.8	125.5	3056.6	12563.3	3.25
Drought Stress	2	63.9**	65.3**	32.3**	198.45**	227.5**	4515.6**	3652.1**	25634.2**	65432.2**	23.2**
Main Error	6	5.3	3.56	3.6	0.132	1.56	23.2	101.2	1232.6	8654.9	5.62
Super Absorb	2	2.3	126.2**	16.65**	16.6**	23.5**	154.2*	6.65	25332.6	32569.6*	8.6**
Drought*Super Absorb	4	4.5*	60.3*	1.56	56.3**	12.6*	36	15.6*	123142.2**	25698.3*	9.26**
Sub Error	18	1.56	12.2	1.23	0.98	5.4	25.5	4.5	5689.3	10203.1	2.56
C.V%		7	11	9	6	12	16	30	29	11	8

*, **: significant at 5 % and 1% level of probability, Respectively.

Table 3: Mean comparisons of drought stress and super absorbent polymers in different traits of *Zea mays*

Factor	No. Row in Era	No. Seed in Row	Era Length	Era Diameter	100 Kernel weight	No. Seed in Era	Plant Height	Seed Yield	Biological Yield	Harvest Index
Drought										
90	15a	44.2a	18.56a	40.1a	26.5a	542.2a	192.2a	5700a	16352a	39.23a
70	17a	40.3b	17.5a	38.5b	23.2b	370.8b	173.5b	4500b	12432b	36.23b
50	12.1b	34.5c	16.5b	34.2c	21.2c	253.2c	152.3c	2950c	9865c	30.21c
Superabsorbent										
0	15.3a	38.5b	16.54c	35.6c	23.2c	432.2b	176.5a	4300b	13521b	35.2b
50	15.4a	40.5a	17.36b	39.2b	25.5b	501.2a	179.5a	4600ab	13560b	36.2a
100	15.7a	42a	18.36a	40.2a	26.2a	523.3a	179.6a	46520a	14125a	36.21a

Means followed by the same letter(s) within a column have not statistically different at the p= 5% level.

Table 4: Mean comparison of Interaction effects in different traits of *Zea mays*

Drought	Super Absorbent	No. Row in Era	No. Seed in Row	Era Length	Era Diameter	100 Kernel weight	No. Seed in Era	Plant Height	Seed Yield	Biological Yield	Harvest Index
90	0	16.2a	33.36ab	18.8bc	39a	27.22b	534.12a	171.4a	5588.6ab	14350a	38.91a
90	50	15.4ab	34.32ab	19.6b	39.5a	27.16b	529.7a	170.5a	5536.2b	14370a	38.051ab
90	100	15.2a	34.6a	20.55a	39.72a	28.88a	532.4a	171.8a	5620a	14360a	39.11a
70	0	14.5b	28d	16.9d	36.15d	23.68d	410.5c	160.11d	4351.1e	12240c	35.54d
70	50	15.6a	30.65c	19c	36.75d	25.23c	478.8b	162.88c	478.2d	12610c	37.71c
70	100	15.11ab	33b	19c	38.8b	26.72b	497.6b	165.77b	5192.5c	13560b	36.6bc
50	0	12.3c	21.72f	14.25f	34.22e	20.83e	263.2e	152.6f	3483.5g	10410e	33.42e
50	50	12.88c	26.4e	15.36e	36.81d	20.97e	336.5d	155.93e	3639.5f	10680e	34.14d
50	100	12.66c	25.6e	16e	37.5c	24.1d	337d	165e	3694.4f	10860d	33.99e

Means followed by the same letter(s) within a column have not statistically different at the p= 5% level.

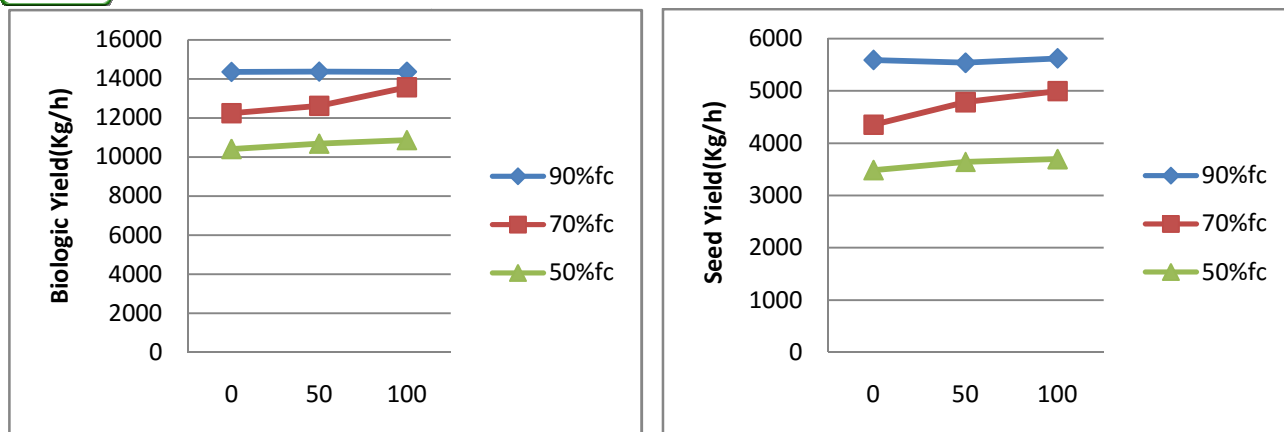


Fig.1. Interaction effects of drought stress and zeolite on Biologic yield Figure2- Interaction effects of drought stress and zeolite on seed yield

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