The Effect of Zinc and Humic Acid Applications on Yield and Yield Components of Sunflower in Drought Stress

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***Abstract*—Tests were done to evaluate the effect of zinc and humic acid applications on yield and yield components of sunflower in drought stress condition. An experiment was conducted as a split plot factorial based on RCBD with three replications in 2014 at the Islamic Azad University Bojnourd. Factors under consideration were; Level of Irrigation in three levels (60, 100 and 140mm evaporation from evaporation pan class A) as the main factor; zinc spray application (zero, 2.5 per thousand) and humic acid application (zero, 4 lit/h) as sub-factors. Results showed that sunflower yield decreased under increasing drought stress, but zinc application improved yield by showing increased evaluations for diameter and number of seeds per head. Humic acid application also significantly increased grain yield by increasing grain weight, diameter and number of seeds per head under water stress conditions. It can be stated that the synergistic effect of zinc and humic acid applications improved sunflower yield in drought stress, by increased evaluations of diameter and number of seeds per head and weight of grain.**

***Index Terms*—sunflower, zinc, humic acid, drought stress**

I. Introduction

Sunflower (*Helianthus annuus*) as the fourth annual seed oil crop in the world is expected to have high level performance in a wide range of environmental conditions. The climate conditions in Iran are arid and semi arid area, at latitude of 25 to 38 degrees north where a lack of precipitation causes sharply decreased crop yields. According to the country's demand for such oil and the shortage of water for irrigation, determining proper irrigation application could save water and produce acceptable plant yields. This could be achieved by improving crop plants, including an increase in antioxidant enzymes in plants. The use of some micronutrients such as zinc and some anti-stress elements such as humic acid could be appropriate options for research on drought-resistant crop plants.

Pankovic *et al.*, (1999) states that a lack of moisture during the blooming stage until the end of flowering sunflower hybrids had the most highly negative effect on performance [1]. Ygapan *et al.*, (1982) states that drought stress causes premature aging of leaves, reduced leaf number, diameter, leaf area, seed weight and seed yield of sunflower [2].

According Rahimizadeh *et al.*, (2010) intake of micronutrients such as zinc have a greater impact on sunflower yield in normal conditions. At the same time; there was a positive effect of micronutrients on sunflower yield in drought stress conditions is very promising [3]. One study has shown that foliar application of zinc increased grain weight, number of seeds per head, seed yield and oil content of sunflower under drought stress conditions [4].

Tests have shown that humic acid improved production of sugar, protein and vitamins in plants that had a positive impact on various aspects of photosynthesis and increased yield and quality of the product [5]. One study demonstrated that application of humic acid enhanced evaluations for oil content, seed weight and seed number per head in sunflower [6].

The present study was done to evaluate the effects of zinc and humic acid applications on yield and yield components of sunflower under drought stress.

II. Materials and Methods

The experiment was conducted as a split plot factorial in a randomized complete block design with three replications during 2014 the Research Farm of Islamic Azad University of Bojnourd, Iran. Geographical location of the area was 57 degrees, 21 minutes north and 37 degrees 29 minutes eastern and at 1056 m above sea level. The main factor was drought stress level, tested as follows; without stress, moderate stress and severe stress (irrigation after respectively 60, 100 and 140mm evaporation from evaporation pan class A) and subplot factors were zinc application (at two levels: 0 and 2/5 in thousands) and humic acid application (at two levels: 0 and 4 liters per hectare).

To determine the structure and chemical properties, soil samples were tested in the field before the experiment was done. For this purpose, samples were taken from a depth of 0-30cm at some point after mixing the samples, the samples were combined sent to the laboratory for determinations of soil texture and chemical composition. Soil test results are given in Table I. Bojnourd is generally a mountainous area with a temperate climate of relatively mild summers and cold

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winters and most of its annual precipitation falls in winter and spring (Table II).

The cultivation of sunflower (Progress variety) in 26 May was done manually and drought stress was applied at the four-leaf stage. Zinc fertilizer (Zn % 15) was used for spray application in two steps (steps 4 and 10 foliar) and humic acid [Fulvic acid and humic acid with composition of 12%, 10% urea and 10% potassium (K_2O)] was used as a seed treatment. At the end of the growing season traits for head diameter, grain number, grain weight and grain yield were measured. Finally, all data were analyzed using SAS software and compared using the LSD test.

TABLE I. THE RESULTS OF SOIL TEST

Analyze	Characteristic	unit	sample	Balanced
Soil pH	pH	-	7/7	5/5-7
The electrical conductivity	EC	Ms/Cm	4/22	‹4
Lime	TNV	%	36/5	‹10
Organic carbon	O.c	%	1/65	1/5-2
phosphorus	P	PPM	48	15-20
Nitrogen	N	%	0/1	0/1-0/2
Potassium	K	PPM	295	300-350
Zinc	Zn	PPM	0/9	2
Iron	Fe	PPM	5/81	10

TABLE II. CLIMATE PROPERTIES OF BOJNOURD

Month	May	Jun	Jul	Aug	Sep	Oct
Mean of maximum Temperature (℃)	25/1	30/6	34/1	34/6	31/9	23/2
Mean of Minimum temperature (℃)	11/3	14/9	18/1	17/3	14/9	9/5
Monthly rainfall (mm)	41/3	11/1	2/4	1/2	0/4	17
Monthly evaporation (mm)	186/8	248/5	318/3	295/4	256/9	146/6

III. RESULTS AND DISCUSSION

A. Head Diameter

The results showed a significant effect of drought stress, zinc and humic acid on head diameter (Table III & Table IV). The main effect of drought stress was during vegetative growth that reduced photosynthesis. Continuing drought tension caused many florets and reproductive cell damage and decrease their size and number. In such circumstances, evaluations for diameter of head and number of seeds was reduced significantly. Zinc and humic acid applications can reduce the damage caused by lack of moisture by increasing the diameter of head (Fig. 1). Humic acid increased the nitrogen content in plant and with chelating property lead to increased access to various elements including zinc [7]. In this case, availability of zinc for plants can have an impact on the reproductive organs such as the head.

B. Grain Number per Head

The results showed a significant effect of drought stress, zinc and humic acid applications on evaluations of grain number per head (Table III & Table IV) (Fig. 2). Drought stress will cause dehydration of pollen, stigma and pistil and reduce numbers of fertile florets per head leading to reduced number of seeds per head. In this case, zinc application increased hydrocarbon deposits and induced longevity of pollen. This led to increased fertility and production of more grains per head [4].

In addition, zinc contributes to protein synthesis of pollen tubes and causes storage of protein. This leads to an increased fertility and increased fruit and seed yields [8]. It has been reported that the effect of humic acid on number of seeds per head and seed weight of sunflower was significant [6].

TABLE III. TREATMENTS ANALYSIS OF VARIANCE

Var.source	Deg.of freedom	Head diameter	Seed number/head	seed weight	seed yield
		Mean of squares			
Replication	2	2/75^{ns}	5073/25^{ns}	7/772^{ns}	83793/86^{ns}
Drought stress(D)	2	95/07**	262399**	341/87**	3789934/36**
E_a	4	1/59	861/25	4/37	18560/4
Zinc(Z)	1	2/56*	17733/36*	26/35^{ns}	588800/44**
Humic acid(H)	1	6/93**	52212/25**	110/25**	394384*
D*Z	2	0/21^{ns}	38065/44**	34/55*	467145*
D*H	2	0/58^{ns}	513^{ns}	12/87^{ns}	26340/25^{ns}
Z*H	1	1/96*	6110/03^{ns}	0/69^{ns}	32/11^{ns}
D*Z*H	2	1/63*	21518/77**	18/86^{ns}	414844/36**
E_b	18	0/31	2969/17	7/74	59928/48
CV(%)	-	3/3	5/5	4/9	6/9

^{ns}, ** & * are respectively not significant, significant at α = 1&5%

TABLE IV. TREATMENTS MEANS COMPARISON ON SUNFLOWER TRAITS

Treatment	Head diameter(cm)	Seed No/head	1000 seed weight(g)	Seed yield(kg/ha)
Without stress	20/1 a	1136 a	62/3 a	4135/9 a
Moderate stress	16/6 b	947 b	53/9 b	3334 b
Severe stress	14/6 c	845 c	52/4 b	3052/9 c
No humic acid	16/6 b	98 b	54/4 b	3402/9 b
Humic acid	17/5 a	1014 a	57/9 a	3612 a
No zinc	16/8 b	954 b	55/3 a	3379/7 b
Zinc	17/4 a	998 a	57 a	3635/5 a

Means with similar letters not significant differences based on LSD test (alpha= 5%)

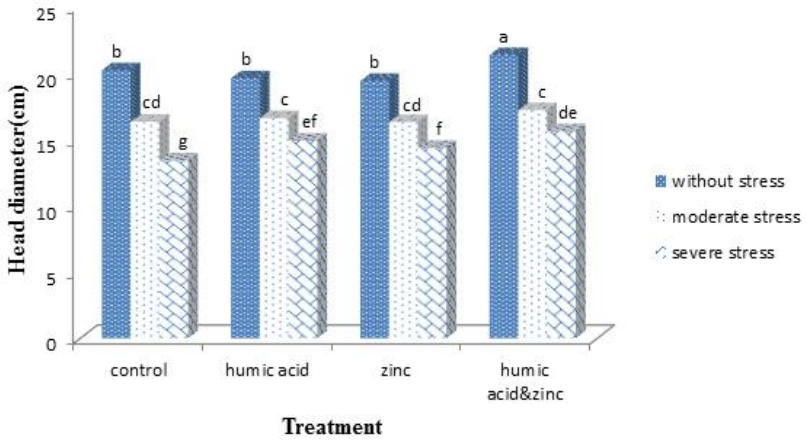

Figure 1. The interaction of treatments on head diameter of sunflower

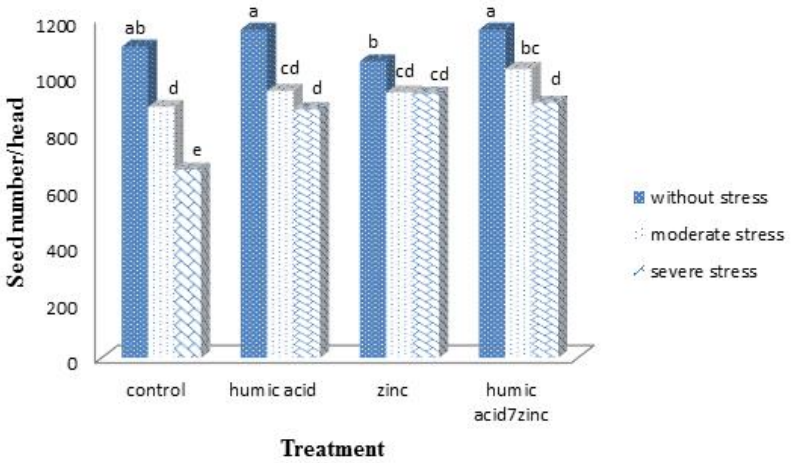

Figure 2. The interaction of treatments on seed number per head of sunflower

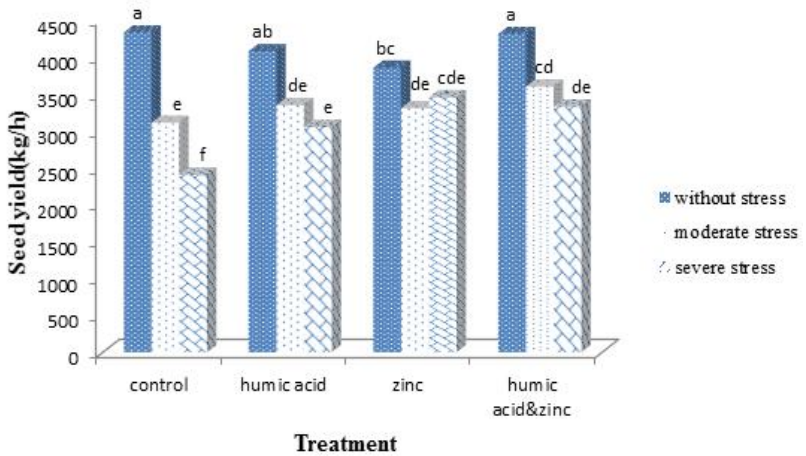

Figure 3. The interaction of treatments on seed yield of sunflower

C. Seed Weight

The results showed a significant effect of drought stress and humic acid on evaluations for Seed weight (Table III & Table IV). The average seed weight was determined primarily by the amount of available assimilators for transfer to the head between stages of flowering and maturity. This is dependent on Leaf Area Duration (LAD) after the flowering stage and sink-source relations [9]. The results showed that increasing irrigation interval caused a decreased seed weight. Determined to shoot as storage for motional non-structural carbohydrates for transfer to the seeds after flowering considered. Drought stress, especially in vegetative growth periods, by reducing leaf area and photosynthesis, reduced the non-structural carbohydrates stored in the stem, as a result, the lack of food stored on secondary sources, caused decreased grain weight [10].

D. Seed Yield

The results showed a significant effect of drought stress, zinc and humic acid on seed yield (Table III & Table IV). Fig. 3 shows that with increasing drought stress, grain yield decreased, but zinc and humic acid applications could significantly reduce the negative effects of drought stress. Zinc application increases auxin and plant water adjustment and improves plant growth and thereby increases photosynthesis and enhances plant performance [11]. The main factors that contribute to increased grain yield are; increased auxin biosynthesis in the presence of zinc, increased chlorophyll concentration, phosphoinol pyruvate carboxylase and riboluse biphosphate carboxylase, reduce sodium accumulation in plant tissues and increased absorption efficiency of nitrogen and phosphorus in the presence of zinc [8].

Humic acid, by increasing the nitrogen content of plant, leads to increasd leaf area duration and eventually improved economic performance. Humic acid can be chelate nutrients such as sodium, potassium, magnesium, zinc, calcium, iron, copper and other elements, in order to overcome the lack of nutrients initiates increased length and weight of roots and lateral roots [7]. Humic acid increases plant yield through its positive physiological effects on cell metabolism and increased concentrations of chlorophyll [12].

IV. Conclusion

The results showed that although sunflower yield decreased with increasing drought stress, application of zinc and humic acid treatments can be used to moderate the decline. In terms of increasing tension, the use of zinc had a positive effect on plant and prevented sharply reduced evaluations of head diameter, seed weight and seed number per head. Humic acid intake has increased grain yield by increasing the diameter, grain number and grain weight. Finally, it can be said that synergistic application of zinc and humic acid could increase yield parameters of diameter, number of seeds and seed weight per head in mild and severe stress, thus adjusting sunflower yield under drought conditions.

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