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Short Communication

Effect of salicylic acid on yield and yield components in triticale under drought stress

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ABSTRACT:

The effect of drought stress and salicylic acid on yield and yield components in triticale were studied. A field experiment using a split plot design based on randomized complete block design with three replications in crop year 2013-2014 was conducted at the research farm of Eslamshahr. In this experiment Irrigation as the main factor in three levels including optimum irrigation, irrigation of the pregnancy (boating stage), disconnecting the water phase pollination (anthesis) and four levels of salicylic acid as sub plot contains not consumed (without salicylic) acid, seed coating of salicylic acid, foliar application of salicylic acid (sprayed), seed coating and foliar application were considered. In this research, traits such as number of grains per spike, number of spikes per square meter, 1000 grain weight, grain yield, biological yield and harvest index were examined. The results showed that the effect of different levels of drought stress on traits such as: number of grains per spike and number of spikes per square meter were significant at 5% and 1000-grain weight, grain yield, biological yield and harvest index were significant at 1%. Also the results showed that the effect of different levels of salicylic acid were significant on all traits at 5%. The results of the average comparison showed that the grain yield under normal irrigation, has increased, so that, the most high grain yield with on average of 2581.88 $kg.ha^{-1}$, (normal irrigation) and the lowest grain yield was with an average of 1691.28 $kg.ha^{-1}$ related to lack of cut irrigation in the stage of gestation (boating stage) treatment, respectively. Also, the most high biological function was on seed coating and foliar application by salicylic acid, (8933.01 $kg.ha^{-1}$) and the lowest yield of 7761.20 $kg.ha^{-1}$ was at control levels (non application).

Keywords:

Drought stress, Salicylic acid, Grain yield, Biological yield and Harvest index.

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INTRODUCTION

Concerning, Iran's location (25 to 39°N), structure, climate and natural component of arid areas to semi-arid areas (Jazaeri Nushabadi and Rezaei, 2007), the water stress is one of the imperative issues in many parts of the nation in the production of crops, particularly in the later phases of plants growth (reproductive stage) even in plants, such as, millet, fox tail and sorghum of nightingales. During photosynthesis of the vegetative phase of growth, grain yield is reduced due to reduced grain filling period and grain weight (Moosavifar *et al*., 2009). Triticale is a plant cross tetraploid of wheat and rye. Studies demonstrate that triticale forage and grain are used as feed for animals and in poultry. In poorer and less inclined soils that are not reasonable for crop production with sandy and sandy-volume production of acid, cereals are best to grow (Iran-Nejad and Shahbazian, 2005). Salicylic acid is one of the phenol compounds present in extensive number of plants and is a vital part for plant growth and development (Kang, 2003). Salicylic acid have an imperative part in providing resistance to ecological anxiety (Rasking, 1992). Salicylic acid showed salt tolerance in wheat seedlings (Shakirova and Bezrukova, 1997). Studies of the impact of salicylic acid on the enhanced performance in specific plants, for example, soybean (Kumar, 1999), nightingales eye beans (Singh, 1980) and peas (Kumar, 1997) were done. Salicylic acid in tomatoes and beans has expanded resistance to low and high temperature (Senaratna *et al*., 2000). Hence, the present study was odne to access the effect of drought stress and salicylic acid application methods on yield and yield components of triticale.

MATERIALS AND METHODS

A field experiment using a split plot design based on randomized complete block design with three replications in crop year 2013-2014 was conducted at the research farm of Eslamshahr. Irrigation as the main factor in three levels including optimum irrigation, irrigation of the pregnancy (boating stage), disconnecting the water phase pollination (anthesis) and four levels of salicylic acid as sub plot contains plants without salicylic acid, seed coating of salicylic acid, foliar application of salicylic acid (sprayed), seed coating and foliar application. All phosphorus fertilizer was used during sowing time. Different nitrogen doses were applied in three split doses *i.e*. 1.3 N at sowing time, 1.3 at tillering stage and 1.3 at the beginning of stem. Adequate plant protection measures were made during the crop growing period. The plot size of 4 x 1.8 m^2 (row x row distance was 30 cm) was maintained. Standard methods were embraced for recording the information on individual parameter of the crop. For computing number of grains $spike^{-1}$, 30 spikes per treatment were haphazardly chosen in each sub plot and afterward their grains were counted and divided by 30 to get the average $grains.spike^{-1}$. Number of spike per m^2 was recorded by counting the quantity of spike in one meter length range of the three central lines in each subplot and their mean was then figured. For 1000 grain weight, two samples of thousand grains were counted from threshed clean lot of every treatment with their weight taken and average calculated. Four central rows were harvested, it was air dried and weighed to record biological yield which was ascertained per hectare basis. Four lines were harvested for grain yield and threshed. Subsequent to threshing, the grains were cleaned, dried and weighted to record the grain yield. Harvest Index (HI) was calculated as

$$HI = (\text{Grain yield}/\text{Biological yield}) \times 100$$

At maturity, the plants from every treatment were collected and yield and yield components were ascertained. For statistical analysis Minitab, SAS, excel were used.

Table 1. Analysis of variance on the effects of drought stress and salicylic acid

S. No	S.O.V	df	Number of grains per spike	The number of spike (m^2)	1000 grain weight (g)	Grain yield ($Kg.ha^{-1}$)	Biological yield ($Kg.ha^{-1}$)	Harvest index (%)
1	Rep.	2	20.11	4356.16	10.91	163358.33	937147.88	2.95
2	Drought stress	2	75.83^{*}	47937.67^{*}	8.14^{**}	5496325^{**}	27267806.05^{**}	80.18^{**}
3	a error	4	15.64	20624.79	5.05	131708.33	942969.67	2.68
4	Salicylic acid	3	9.27^{*}	20118.52^{*}	4.98^{*}	720425^{*}	1815449.91^{*}	21.96^{*}
5	Drought stress Salicylic acid ×	6	15.76^{ns}	1004.02^{ns}	0.59^{ns}	158658.33^{ns}	727438.28^{ns}	9.55^{ns}
6	b Error	18	16.81	5771.64	1.35	115547.22	393196.76	2.67
7	CV (%)		6.55	5.09	4.97	11.88	7.37	6.74

ns, * and **: Not significant, significant at 5% and 1% probability levels, respectively.

RESULTS AND DISCUSSION

The number of grains per spike

Drought stress and salicylic acid on the number of grains per spike was significant at 5% level (Table 1). According to Table 1, the highest of number of grains per spike was with an average of 66.41 to water stress treatment (normal irrigation) and the lowest of number of grains per spike with a average of 60.69 related to cut irrigation in the stage (boating stage) (Table 2). Seed coating and foliar application of salicylic acid with an average of 58.18 was increased the number of grains per spike and lowest of number of grains per spike with an average of 65.48 related to non application salicylic acid (Table 3). Salicylic acid consumption on number of grains per spike showed significant effect. Severe drought due to button step, leading to maximum reduction in number of grains per spike and full irrigation the highest number of grains per spike was obtained, expressed in the drought stress reduced the number of grains per spike in the safflower (Moosavifar *et al*., 2009). It would appear that at the start of the plants growing with water deficiency confronted, its regulatory mechanism in light of a predetermined number of plant seeds in the spike is built, so plants can proceed with growth and capacity in filling the grain number. When plants are confronted with water deficiencies, less number of grains were produced and they deliver food and carbohydrates as grains produced more effort and energy to fill the grain so whatever creates water stress, the final grain weight likewise expanded. Moosavifar *et al*. (2009) stated that between irrigation levels of grain yield, there was significant difference at 1%.

Number of spike in m^2

Analysis of variance showed that the simple effect was significant at 5% level of drought stress and salicylic acid (Table 1). The highest of number of spike per m^2 with an average of 1548.57 to water stress treatment (normal irrigation) and the lowest number of spike per m^2 with an average of 1520.23 related to cut irrigation in the stage of gestation (boating stage) as given in Table 2. Non application of salicylic acid with an average of 1520.23 reduced number of spike per m^2 when compared with seed coating and foliar application of salicylic acid with a mean of 1548.57 (Table 3). Water stress is one of the conceivable causes and seriousness of water stress is more on the overall plant growth, photosynthesis and other plant factors that ultimately influence the effective yield. Salicylic acid compensate the plant moisture evapotranspiration of plants, counteract excessive loss and increase plant yield.

Table 2. Effect of drought stress on parameters studied

S. No	Drought stress	Number of grains per spike	The number of spike (m^2)	1000 grain weight (g)	Grain yield ($Kg.ha^{-1}$)	Biological yield ($Kg.ha^{-1}$)	Harvest index (%)
1	Boating stage	60.69^c	1520.23^b	19.03^c	1691.28^c	7208.21^c	23.46^c
2	Anthesis	63.51^b	1523.15^b	23.40^b	2011.25^b	8260.80^b	24.33^b
3	Normal irrigation	66.41^a	1548.57^a	24.88^a	2581.88^a	9634.11^a	26.77^a

Means followed by the same letter are not significantly different by Duncan's multiple range (P=0.05).

1000 grain weight

Effect of drought stress (1%) and salicylic acid on the 1000 grain weight was significant at 5% level (Table 1). According to Table 1, the highest of 1000 grain weight was with an average of 24.88 g to normal irrigation and the lowest of 1000 grain weight was with an average of 19.03 g related to water stress (cut irrigation from boating) (Table 2). Seed coating of salicylic acid reduced 1000 grain weight (22.06 g) when compared with seed coating and foliar application with salicylic acid (24.35 g) (Table 3). 1000 grain weight has significant effect on grain yield, in reality expressing the density of seeds.

Grain yield

Analysis of variance revealed that the simple effect of water stress at 1% and salicylic acid were significant at the 5% level (Table 1). The results of Table 1 showed that the grain yield increased by increasing the intensity of water stress with an average of 2581.88 $kg.ha^{-1}$ (normal irrigation) and the lowest grain yield was with an average of 1691.28 $kg.ha^{-1}$ related to lack of cut irrigation in the stage of gestation (boating stage) (Table 2). Non application of salicylic acid had reduced grain yield of 1903.37 $kg.ha^{-1}$ when compared with seed coating and foliar application of salicylic acid (2269.17 $kg.ha^{-1}$) as given in Table 3. Drought stress in the vegetative stage leads to reduced leaf area index, leaf area and photosynthesis per unit of leaf area. As a result of reduced yield at this stage, there is reduced number of grains per spike (Rostami *et al.,* 2003). Results of research conducted in connection with the safflower grain yield under drought stress in different areas indicated yield of 1 to 3.3 t ha^{-1} variable (Esendala *et al*., 2008). These results are also recorded in other areas such as Sacramento, California (Cavero *et al*., 1999) and Ariana Tunisia (Hamrouni *et al.*, 2001).

Biological yield

Effect of drought stress on the biological yield was significant at 1% level (Table 1). Regular watering had a biological yield of 9634.11 $kg.ha^{-1}$ and the performance of cut irrigation in the stage of gestation (boating stage) had the lowest rate of 7208.21 $kg.ha^{-1}$ (Table 2). Effects of drought stress at the flowering stage on total dry weight and grain weight was less and the results are in agreement with Verslues *et al*. (2006). Salicylic acid effect on the biological yield was significant at the 5% level (Table 1). Seed coating and foliar application of salicylic acid showed the biological yield of 8933.01 $kg.ha^{-1}$ and the lowest yield of 7761.20 $kg.ha^{-1}$ was noticed in control (non application) as given in Table 3. These results are in concordance with the results of Khan *et al*. (2002) corresponded to the vetch plant. Cabuslay (2002) and Kafi and Rostami (2008) expressed that, the expanded water confinements amid reproductive phase of plant development, is compelling in lessening the grain yield. Lessened grain yield in inundated conditions can be constrained because of absence of irrigation which, quicken maturing and diminish the length of growing period and grain filling related with the plant and additionally leaf and root induction package openings and in the long run decreases net photosynthesis rate (Clavel *et al*., 2005).

Table 3. Effect of salicylic acid on number of grains per spike, number of spikes per square meter, 1000 grain weight, grain yield, biological yield and harvest index

S. No	Salicylic acid	Number of grains per spike	The number of spike (m^2)	1000 grain weight (g)	Grain yield ($Kg.ha^{-1}$)	Biological yield ($Kg.ha^{-1}$)	Harvest index (%)
1	Non application	58.18^c	1432.06^c	22.64^c	1903.37^c	7761.20^c	24.38^c
2	Seed coating	60.65^b	1484.95^b	22.06^c	2053.33^b	8222.50^b	24.81^b
3	Foliar application	63.11^b	1498.57^b	23.69^b	2153.33^b	8554.11^b	24.99^b
4	Seed coating and foliar application	65.48^a	1547.03^a	24.35^a	2269.17^a	8933.01^a	25.23^a

Means followed by the same letter are not significantly different by Duncan's multiple range (P=0.05).

Harvest index

Analysis of variance revealed that the simple effect of water stress at 1% and salicylic acid were significant at the 5% level (Table 1). Highest and lowest harvest index with means of 26.77 and 23.46% was recorded, according to normal irrigation and cut irrigation in the stage of gestation (boating stage) respectively. Salicylic acid intake also had positive effects on harvest index and highest harvest index was with an average of 25.23% when salicylic acid was used for seed coating and foliar application and lower harvest index was noticed from non application of salicylic acid with an average of 24.38% (Table 3). Shortage of water stress had an effect on the harvest index and by increasing the water stress, the harvest index increased too. Maclagan and Good (1993) reported that leaf relative water can be an indicator of the amount of stress. It is reported that the leaf relative water in dry conditions with leaf drought tolerance genotypes is a positive correlation. Certain genotypes under drought conditions have higher leaf relative water and are more drought tolerant (Maclagan and Good, 1993). Additionally it causes diminished grain yield in drought season due to the absence of access to water and lessen the quantity of heads per plant and grain number per head and thousand grain weight and expanded percentage of hollow which happens under noteworthy and positive connection with grain yield (Koutroubas *et al*., 2000).

CONCLUSION

Our results showed that drought stress reduced characteristics such as number of grains per spike, number of spikes per square meter, 1000 grain weight, grain yield, biological yield and harvest index. As expected drought stress an effect on yield and yield components of treated seeds cut irrigation in the stage of gestation (boating stage) and on the other hand the best result was observed from normal irrigation. The application of SA improved all the measured traits and induced drought tolerance in the treated plants. Among salicylic acid concentrations, seed coating and foliar application had better effects on plants as compared to others. Salicylic acid had a positive influence on number of grains per spike, number of spikes per square meter, 1000 grain weight, grain yield, biological yield and harvest index and can be used to improve the performance of plants under drought stress conditions during the end of the growing season.

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