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Research Article

MORPHO-PHYSIOLOGICAL RESPONSE OF SWEET CORN (*ZEA MAYS* VAR. MERIT) TO EXOGENOUS SALICYLIC ACID APPLICATION UNDER DIFFERENT REGIMES OF IRRIGATION

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ABSTRACT
In order to investigate the effect of water deficit stress and salicylic acid application on morpho-physiological characteristics of sweet corn (*Zea mays* var. Merit), an experiment was conducted in the split plot form based on Completely Randomized Block Design with three replications during growing seasons of 2013-2014. Treatments were water deficit stress was water deficit stress in three levels: a_1: normal irrigation (100% FC irrigation), a_2: fair stress (75% FC irrigation) and a_3: mild stress (50% FC irrigation). The second factor was the 0/1 mM salicylic acid application of in six levels [b1:control, b2:seed priming, b3: SA application in 3 leaves stage, b4:SA application in pollination stage, b5:seed priming + SA application in pollination stage and b6: SA application in 3 leaves stage + pollination stage. The analysis of variance showed significant effect of interaction between water deficit stress and salicylic acid application on plant height, leaf area index (LAI) and relative water content (RWC). Also, effect of water deficit stress and salicylic acid on stomatal resistance was significant. The results showed that in 75% FC irrigation, SA application at pollination sage indicated 73% more plant height as compared 50% FC irrigation. Besides, the results also proved that in 100% FC irrigation, 0/1 mM SA seed priming and SA application at 3 leaves stage had the highest LAI and RWC (70/90%), respectively. Mid stress as compared to normal irrigation had 27% more stomata resistance. SA application at 3 leaves stage had the highest (46/98) and SA application at 3 leaves + pollination stage had the lowest (24/83) stomata resistance.

Keyword: *Salicylic Acid, Sweet Corn, Water Deficit Stress*

INTRODUCTION
Water deficit is a major environmental factor restricting plant growth, development and productivity, particularly in arid regions more than any other single environmental factor (Huai-Fu *et al.*, 2014).Water stress affects almost every developmental stage of the plant. However, damaging effects of this stress was more noted when it coincided with various growth stages such as germination; seedling shoot length, root length and flowering (Khayatnezhad *et al*., 2010). Plants tend to adapt to drought by accumulation of cyto-compatible organic osmolytes (Rhodes and Hanson, 1993) such as polyols, proline and betaines. Seed treatment or foliar application of chemicals like glycinebetaine, kinetin, salicylic acid (Gunes, 2007; Karlidag, 2009) may increase yield of different crops due to reduction in stress induced inhibition of plant growth (Elwana and El-Hamahmyb, 2009), enhanced photosynthetic rates, leaf area and plant dry matter production (Khan, 2003).
Salicylic acid (SA) is a signalling molecule with ubiquitous distribution in plants, and is accumulated in the plant tissues under the impact of unfavourable abiotic factors, contributing to the increase of plants resistance to salinization (Rao *et al.*, 2012). SA plays an important role in seed germination, seedling establishment, cell growth, respiration, enhancement of enzyme activity, and photosynthesis under adverse environmental conditions (Chen *et al.*, 2014). More recent studies reported that the externally applied SA increased plant tolerance to several abiotic stresses, including salinity (Karlidag *et al.*, 2009), drought (Singh and Usha, 2003), osmotic stress (Mikoajczyk *et al.*, 2000) and temperature stress (Hashempour *et al.*, 2014).
Previous studies have been suggested that SA may enhance the multiple types of stress tolerance in plants by interactive effects on several functional molecules. Thus, the objectives of this study were to

investigate the effects of salicylic acid application on maize performance under different regimes of irrigation.

MATERIALS AND METHODS

The field experiment was carried out in split plot form by Completely Randomized Block Design with three replicates at the Research Station of the Islamic Azad University, Tabriz Branch, north-western Iran, during the 2013 - 2014. The first factor was water deficit stress in three levels: a_1: normal irrigation (100% FC irrigation), a_2: fair stress (75% FC irrigation) and a_3: mild stress (50% FC irrigation). The second factor was the 0/1 mM salicylic acid application of in six levels [b1:control, b2:seed priming, b3: SA application in 3 leaves stage, b4:SA application in pollination stage, b5:seed priming + SA application in pollination stage and b6: SA application in 3 leaves stage + pollination stage. Flooding irrigation was conducted and all of treatments were irrigated completely prior to 8-10 leaves stage. Each plot consists of 4 rows, 75 cm row spacing and 25 cm plant interval. There were 2-5 seeds beside each other and they were thinned at three leaves stage to obtain plant density of 5 plants per m^2. Relative water content of leaf was determined by method developed by Barrs and Weatherley (1962). Second leaf of randomly selected four plants was used for determining relative water content. Fresh weight (FW) immediately recorded, and then leaves were soaked for 4 hours in distilled water at room temperature under a constant light and saturated humidity. Turgid weight (TW) was recorded followed by drying for 24 hours at 80 ºC for dry weights (DW). Relative water content (RWC) was calculated according to the following formula:

$RWC = [(FW - DW) / (TW - DW)] \times 100$

Statistical Analysis

In order to check the normality of data, analysis of variance, and mean comparison MSTAT-C software were used. The means of the treatments were compared using the least significant difference (LSD) test at P<0.05.

RESULTS AND DISCUSSION

The analysis of variance showed significant effect of interaction between water deficit stress and salicylic acid application on plant height, leaf area index (LAI) and relative water content (RWC). Also, effect of water deficit stress and salicylic acid on stomatal resistance was significant (table 1).

Table 1: The analysis of variance of measured traits in experiment

S.O.V	df	Plant Height	LAI	Stomata Resistance	RWC
Rep	2	32/56ns	1686ns	180/28ns	23/25ns
WDS	3	23075**	28091 *	2917**	123/014**
Error	6	130	2465	143	4/35
SA	5	362**	4209ns	563**	15/509ns
SA×WDS	15	158*	67751**	286ns	487/530**
Error	40	66/53	1722	151	9/615
CV		6/41	13/78	33/79	4/27

** and ** significant at 5% &1% respectively, WDS: Water Deficit Stress, SA: Salicylic Acid*

Table 2: Mean comparison of interaction between SA application and deferent regimes of irrigation

WDS	SA	Plant Height (Cm)	LAI	RWC (%)
100% FC	b1	144/8	364/0	62/95
	b2	141/3	396/6	47/27
	b3	153/7	313/7	70/06
	b4	137/0	346/6	60/12
	b5	133/8	344/0	57/85
	b6	158/2	282/9	60/13
75% FC	b1	156/8	289/8	66/85
	b2	145/8	251/3	53/82
	b3	150/6	393/2	47/01
	b4	158/5	295/3	48/93
	b5	143/7	239/9	54/81
	b6	149/8	330/7	50/10
50% FC	b1	101/5	321/5	31/35
	b2	80/83	276/9	57/84
	b3	84/67	255/9	34/86
	b4	73/83	247/4	46/69
	b5	81/13	217/1	46/79
	b6	94/33	255/1	45/26
LSD5%	-	13/60	69/20	5/171

WDS: Water Deficit Stress, SA: Salicylic Acid

Table 3: Mean comparison of deferent regimes of irrigation on stomata resistance

WDS	Stomata Resistance
100% FC	27/10
75% FC	31/28
50% FC	50/95
LSD (5%)	15/66

WDS: Water Deficit Stress

Table 4: Mean comparison of SA application on stomata resistance

SA	Stomata Resistance
Control	46/98
Seed priming	43/17
3 leaves stage	37/20
Pollination stage	33/89
seed priming + SA application in pollination stage	32/60
SA application in 3 leaves stage + pollination stage	24/83
LSD (5%)	8/38

SA: Salicylic application

Plant Height

In fair stress (75% FC irrigation), SA application at pollination sage indicated the highest plant height (158/34 cm) and mild stress (50% FC irrigation) at pollination sage produced the lowest plant height (73/83 cm) (table 2). Sadeghipour and Aghaei (2012) reported that water stress reduced plant height of common bean but seeds soaking in 0/5 mM SA ameliorated this trait in both water stress and control conditions. Under severe water deficiency, cell elongation of higher plants can be inhibited by interruption of water flow from the xylem to the surrounding elongating cells (Nonami, 1998). Role of

SA in amelioration of plant height under water stress may be related to improve mitosis and cell elongation. Umebese *et al.*, (2009) found that water stress reduced tomato and amaranth stem height significantly at the vegetative stages and 3 mM application of SA was effective in keeping plant height similar to the control which was related to the ability of SA to induce antioxidant responses that protect them from damage.

Leaf Area Index

Results showed that in normal irrigation (100% FC irrigation), 0/1 mM SA seed priming as compared to SA seeds soaking + pollination in mild stress had significant effect on LAI (table 2). Development of optimal leaf area is important to photosynthesis and dry matter yield. Water deficit stress mostly reduces leaf growth and in turns the leaf areas in many species of plant (Jaleel *et al.*, 2009). Water deficit reduces the number of leaves per plant and individual leaf size, leaf longevity by decreasing the soil's water potential. Nevertheless, exogenous GB and SA application appreciably improved these attributes under water stress (Sadeghipour and Aghaei, 2012). Increasing of leaf area under treatment with SA has been reported in pearl millet (Mathur and Vyas, 2007), wheat (Hayat *et al.*, 2005) and corn and soybean (Khan *et al.*, 2003).

Relative Water Content

SA application at 3 leaves stage in normal irrigation and no application of SA treatment in mild stress had the highest (70/90%) and the lowest (31/35%) RWC, respectively (table 2). Plant and cell water balance is determined by the difference of water absorbed from the soil and transpirational water loss to the atmosphere.

RWC tend to decline when transpiration exceeds water absorption under drought condition (Tas and Tas, 2007) leading to decrease in cell turgor. Maintenance of high RWC under drought due to relatively more growth of the roots than shoots and/or abscisic acid induced reduction in stomatal opening (Makoto *et al*., 1990) tends to maintain cell turgidity, chlorophyll content (Keyvan, 2010) and photosynthesis.

Stomata Resistance

Results of our experiment showed that, drought conditions increased stomata resistance. Mid stress (50% FC irrigation) as compared to normal irrigation had significant effect on the stomata resistance (table 3). Also SA application at 3 leaves stage had the highest (46/98) and SA application at 3 leaves + pollination stage had the lowest (24/83) stomata resistance (table 4).

Conclusion

In the present study we observed that water stress reduced the morpho- physiological characteristics in sweet corn except stomata resistance but SA application at seed priming, 3 leaves stage and pollination sage had the highest LAI, RWC and plant height respectively.

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