Bangladesh J. Bot. **44**(4): 659-663, 2015 (December)

PHYSIOLOGICAL RESPONSE OF SWEET CORN (*ZEA MAYS* VAR. MERIT) TO FOLIAR APPLICATION OF SALICYLIC ACID UNDER WATER DEFICIT STRESS

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Key words: Physiological response, Salicylic acid, Sweet corn, Foliar application, Water deficit stress

Abstract

The effect of water deficit stress and salicylic acid application on physiological characteristics of sweet corn (*Zea mays* var. Merit), an experiment was conducted. Treatments were 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 in six levels [b_1: control, b_2: seed priming, b_3: SA application in 3 leaves stage, b_4: SA application in pollination stage, b_5: seed priming + SA application in pollination stage and b_6: SA application at 3 leaves stage + pollination stage. The analysis of variance showed significant effect of interaction between water deficit stress and SA application on Chl. a, Chl. b, Chl. a + b, 100-grain weight and ear yield ($p < 0.01$). Results showed that SA application at 3-leaves stage + pollination stage indicated five times more Chl.a as compared with control in 50% FC irrigation. SA application at 3-leaves stage proved 4/2 and 4/4 times more Chl.b and Chl. a + b as compared to control in mild stress. SA application at pollination stage had the highest (36/15 g) and control at mild stress had the lowest (10/56 g) 100-grain weight. Also, SA application at 3-leaves stage + pollination stage had the highest (245/1 g/plant) and control at mild stress had the lowest (74/25 g/plant) ear yield.

Introduction

Salicylic acid (SA) or ortho-hydroxy benzoic acid is an important signalling molecule which is involved in plants response to wide range of environmental stresses (Senaratna *et al.* 2000, Rao *et al,* 2012). SA has been found to play a key role in seed germination, seedling establishment, cell growth, respiration, enhancement of enzyme activity, regulation of plant growth and development, interaction with other organisms and photosynthesis under adverse environmental conditions (Senaratna *et al.* 2000, Chen *et al.* 2012). Studies open a new window for the role to exogenous foliar application of SA in providing tolerance to the plants against various pathogens (Singh *et al.* 2004, Shah 2005). Studies reported that SA increased plant tolerance to several abiotic stresses, including salinity (Karlidag *et al.* 2009), drought (Hayat *et al.* 2008), osmotic stress (Mikoajczyk *et al.* 2000), heavy metal (Zhou *et al.* 2009), uv radiation (Ervin *et al.* 2004) and temperature stress (Hashempour *et al.* 2014). Enhanced germination and seedling growth were recorded in wheat, when the grains were subjected to pre-sowing seed-soaking treatment in salicylic acid (Shakirova 2007). In another study, Khodary (2004) observed a significant increase in growth characteristics, pigment contents and photosynthetic rate in maize, sprayed with SA. The exogenous SA application also enhanced the carbohydrate content in maize. Flowering is another important parameter which is directly related to yield and productivity of plants. SA has been reported to induce flowering in a number of plants (Herrera-Tuz 2004, Larque-Saavedra and

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Martin-Mex 2007). Thus, it may be concluded that SA when applied acts as an regulator that potentially affects the growth and productivity in plants (Martin-Mex *et al.* 2005)

Previous studies 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 SA 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 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 foliar application of salicylic acid in six levels [b_1: control, b_2: seed priming, b_3: SA application in 3 leaves stage, b_4: SA application in pollination stage, b_5: seed priming + SA application in pollination stage and b_6: 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. Water deficit stress was imposed from 8 - 10 leaves stage to physiological maturity. 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.

To determine leaf chlorophyll concentration, one gram of the fresh leaf tissue was cut into small pieces and placed into a specimen bottle containing 10 ml of absolute ethanol and stored in the dark for two weeks. One ml of the filtered extract was then diluted with 6 ml of absolute ethanol and the absorbance of the chlorophyll solution measured using a spectrophotometer at 645 and 663 nm. The chlorophyll a and b content and total chlorophyll a + chlorophyll b were estimated using the formula of Arnon (1949) as:

$$\text{Chlorophyll a (mg/g)} = 0.0127\ A663 - 0.00269\ A645$$

$$\text{Chlorophyll b (mg/g)} = 0.0029\ A663 - 0.00468\ A645$$

$$\text{Total chlorophyll (mg/g)} = 0.0202\ A663 + 0.00802\ A645$$

Ear yield was taken from three middle rows at the centre of each plot. Harvested ears were threshed and 100-grain weight was expressed.

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 $p < 0.05$ (Palaniswamy and Palaniswamy 2005) .

Results and Discussion

Results presented in Table 1 show that in fair stress (75% FC irrigation), SA application at 3-leaves stage + pollination stage indicated the highest Chl.a and SA application at 3-leaves stage proved the highest Chl. b, Chl. a + b, and control in mild stress (50% FC irrigation) produced the lowest Chl. a, Chl.b and Chl. a + b (Table 2). It seems, in general, that chlorophyll concentration would be reduced certainly under severe and extended water stress, but it is possible to increase in fair stress, showing dependency of chlorophyll concentration response to environmental conditions and genotype (Boyer *et al.* 1987). Increased chlorophyll by fair stress may be is a result of increased specific leaf area and reduced leaf area due to reducing new cells size. As a consequence, leaf chlorophyll content increases upon exposure to fair stress because of larger cells per a leaf weight basis (Taiz and Zaiger 2006). The observed reduction of chlorophyll in water stressed plants may be due to a reduction in the lamellar content of the light harvesting chlorophyll a/b protein (Randall *et al.* 1977). These results indicate SA foliar application can increase chlorophyll content. Similar results were obtained when plants of *B. juncea* were sprayed with lower concentrations (10^{-5} M) of SA, where, the chlorophyll content was significantly enhanced, whereas, higher concentrations proved to be inhibitory (Fariduddin *et al.* 2003). Moharekar *et al.* (2003) reported that salicylic acid activated the synthesis of carotenoids and xanthophylls and also enhanced the rate of deepoxidation with a concomitant decrease in chlorophyll pigments and chlorophyll a/b ratio in wheat and moong. Hayat *et al.* (2005) reported that the pigment content was significantly enhanced in wheat seedlings, raised from the grains pre-treated with lower concentration (10^{-5} M) of salicylic acid, whereas, higher concentrations did not prove to be beneficial. Besides seed-soaking treatment, the foliar application of SA also proved to be equally fruitful in increasing the pigment contents in *Brassica napus* (Ghai *et al.* 2002).

Table 1. **Mean comparison of interaction between SA application and different regimes of irrigation**.

WDS	Treatments	Chl.a mg/g	Chl.b mg/g	Chl.a + Chl.b mg/g	100-grain wt. (g)	Ear yield (g/plant)
100% FC	Control	861	303	1164	21/80	189/4
	Seed priming	1079	1130	2209	29/33	228/5
	3-leaves stage	1058	1107	2165	30/98	166/4
	Pollination stage	741	797	1538	36/15	136/3
	Seed priming + pollination stage	1058	713	1771	17/04	121/6
	3-leaves stage + pollination stage	956	1057	2013	28/65	245/1
75% FC	Control	788	740	1528	19/49	93/76
	Seed priming	635	1177	1830	21/38	116/4
	3-leaves stage	1039	1224	2263	24/03	158/4
	Pollination stage	858	1025	1883	28/60	125/9
	Seed priming + pollination stage	557	623	1180	17/87	88/20
	3-leaves stage + pollination stage	1090	948	2038	21/88	129/8
50% FC	Control	215	290	505	10/56	74/25
	Seed priming	644	405	1049	11/94	86/93
	3-leaves stage	628	750	1378	31/29	93/60
	Pollination stage	234	1091	1325	15/58	105/3
	Seed priming + pollination stage	364	1134	1498	12	84/58
	3-leaves stage + pollination stage	771	875	1646	16/73	91/48
LSD5%	-	46/61	54/42	78/69	5/26	30/65

WDS: Water deficit stress, FC: Field capacity.

Results presented in Table 2 showed that in normal irrigation, SA foliar application in pollination stage as compared to control in mild stress had significant effect on 100-grain weight. The application of 0/1 mM SA enhanced the 100-grain weight. In this respect, Arfan *et al.* (2007) studied the effect of exogenous application of SA through the rooting medium of two wheat cultivars differing in salinity tolerance. They found that increase in grain yield along with increase in 100-grain weight, number of grains and number of spikelets per spike with 0.25 mM SA application under saline conditions suggested that improvement in salt-induced reduction in grain yield with SA application was mainly due to increase in grain size and number.

The highest and lowest ear yield were observed in SA foliar application in normal irrigation and control in mild stress, respectively (Table 2). Ear yield of sweet corn is adversely affected by water deficit. Exogenous application of different chemicals may reduce stress induced inhibition of plant such as SA. Foliar application of SA can play an important role in reducing the effects of drought in maize (Rao *et al.* 2012. Under three irrigation treatments, ear yield was significantly enhanced with SA foliar application. Furthermore, the beneficial effect of SA on ear yield may be due to translocation of more photoassimilates to grains during grain filling, thereby increasing grain weight. These results are similar to those of Aldesuquy *et al.* (2012) who reported in SA application produced 9% more maize grain as compared to control treatment.

It may be concluded from the above discussion that salicylic acid acts as a potent regulator that can effectively modulate various plant growth responses. Exogenous application of SA enhanced the chlorophyll a, chlorophyll b, total chlorophyll, 100-grain weight and ear yield under different irrigation regimes.

Acknowledgement

The authors would like to thank Tabriz Branch, Islamic Azad University for the financial support of this research, which is based on a research project contract.

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(Manuscript received on 31 May, 2015; revised on 11 October, 2015)