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Research Article

Effect of Salicylic Acid on Yield and Yield Components of Wheat under Drought Stress

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ABSTRACT

Worldwide, wheat (*Triticum aestivum* L.) is one the most important agricultural crops both economically and strategically. Because of its relatively good adaptation to different regions of the world with tropical climate and low water irrigation, it is usually considered as more resistant to abiotic stresses than the hexaploid wheat plants. Salicylic acid (SA) is an endogenous growth regulator of phenolic nature and also an important signaling molecule regulates physiological processes in plants such as growth, photosynthesis and some other metabolic processes. Several studies support a major role of SA in modulating the plant response to various abiotic stresses. In addition, it has been found that plants treated with SA generally exhibited better resistance to drought stress. The field experiment was laid out split plot with randomized complete block design with three replications. Treatments included drought stress (I_0: control, I1: Irrigation cut in pod stage, I2: Irrigation cut in flowering) as main plot and sub plot consisted of foliar application of salicylic acid (S1: control, S2: 4%Mm, S3: 7%Mm and S4: 1 Mm). Analysis of variance showed that the effect of drought stress and salicylic acid on all characteristics was significant.

Key words: Biological yield, Grain yield, 1000seed weight

INTRODUCTION

Worldwide, wheat (*Triticum aestivum* L.) is one the most important agricultural crops both economically and strategically. Because of its relatively good adaptation to different regions of the world with tropical climate and low water irrigation, it is usually considered as more resistant to abiotic stresses than the hexaploid wheat plants (Tas and Tas, 2007). About one-third of the world climates have been classified as arid and semi-arid in which wheat is the major food source for their inhabitants. Consequently, finding the biochemical and physiological responses of some of the cultivated wheat plants to drought stress is helpful in selecting cultivars most adaptable to these climates. Water is one of the most important ecological factors determining wheat growth and development; any water deficit will cause serious damage to crop yield (Sankar, 2007). Drought stress occurs when the available water in the soil is reduced and atmospheric conditions cause continuous loss of water through transpiration or evaporation (Jaleel *et al.,* 2008). Water deficit (commonly known as drought) can be defined as the absence of sufficient moisture for the plant to grow normally and complete its life cycle (Jaleel *et al*., 2008). Wheat yields are reduced by 50-90% of their irrigated potential in drought conditions in at least 60 million hectares in the developing world (Skovmand *et al*., 2001). Plants have to cope with drought stress at least at some point in their life cycle (Cruz de Carvalho, 2008). They have however evolved mechanisms that allow them to adapt and survive in the periods of water deficit (Noctor and Foyer, 1998). Plants are said to escape, avoid or tolerate drought stress according to the type of strategy adopted (Levitt, 1972). The plant's response to drought depends not only on the species' inherent "strategy" but also on the duration and severity of the drought period(Cruz de Carvalho, 2008). If prolonged over a certain extent, drought stress will inevitably result in oxidation (Smirnoff, 1993). Effect of drought is among the environmental constraints that affect crop growth and crop production Worldwide (Ashraf and Harris, 2004; Farooq *et al*., 2009). It has been estimated that up to 45% of the world agricultural lands are subjected to drought (Bot *et al*., 2000). Moisture stress on wheat depends on different developmental stage and it could significantly affect yield and other physiological traits (Euarrje &

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Jones, 1979). In arid and semiarid regions climate, wheat crops usually encounter drought during the grain filling period, which reduces grain yield, dramatically (Sanjari *et al*., 2008). Yield is reduced mostly when drought stress occurs during the heading or flowering and soft dough stages (Gholamin *et al*, 2010). However, there are some reports that moisture stress before pollination could decrease number of spikes in unit of area. Sanjari *et al*., 2008 reported that grain yield and duration of grain filling I influenced by drought and when the numbers of grains were constant in pollination stage weight is most important factor in wheat total yield (Gholamin *et al*, 2010). In contrast to the breeding approach which is difficult and costly, seed treatment with plant PGRs is an easy, low cost and low risk technique and an alternative approach to overcome agricultural problems. Salicylic acid (SA) is an endogenous growth regulator of phenolic nature and also an important signaling molecule which regulates physiological processes in plants such as growth, photosynthesis and some other metabolic processes (Khan *et al.* 2012). Several studies support a major role of SA in modulating the plant response to various abiotic stresses. In addition, it has been found that plants treated with SA generally exhibited better resistance to drought stress (Kadioglu *et al,*. 2011). It is a well-found fact that SA potentially generates a wide array of metabolic responses in plants and also affects plant water relations (Hayat *et al.* 2010). Treatment of drought stressed plants with exogenous SA was found to be effective in modulating both enzymatic and non-enzymatic components of antioxidant defense system (Kadioglu *et al.* 2011). Many molecules such as Jasmonic acid, SA and polyamines have been suggested as signal transducers and messengers who may have profound effects on plant growth and development (Krantev *et al*., 2008; Watson and Malmberg, 1998). Salicylic acid (SA), as a natural signal molecule has been shown to play important roles in regulating a number of physiological processes in plants. Its exogenous application has promoted plant performance under biotic and abiotic stresses. SA is a common plant-produced phenolic compound known as an important signal molecule for modulating plant responses to environmental stresses (Senaratna *et al*., 2000). It is now clear that SA provides protection against a number of abiotic stresses such as heat stress in mustard seedlings (Dat *et al.,* 1998b), chilling damage in different plants (Kang and Salveit, 2002; Tasgin *et al*., 2003), heavy metal stress in barley seedlings (Metwally *et al.,* 2003) and drought stress in wheat plants (Singh and Usha, 2003). Salicylic acid (SA) is recognized as an endogenous regulator of plant metabolism, mainly involved in biotic and abiotic stress (Lian et al.2000;Aydin and Nalbantoglu 2011). There are some reports that SA could increase salt tolerance in wheat seedling (Kang *et al*., 2002) and drought stress (Janda, 1999). Stiven G and Sanaratna, 2006 reported that treated plants with SA survive more and exhibited higher relative growth rate (RGR) and more vegetative growth. Water deficit reduced plant height, in particular by irrigation at anthesis (18%) while AA (6%) and SA(14%) significantly increased plant height (Azimi *et al*., 2013). Reduction by drought stress could be due to adverse effects of drought on dry matter production causing reduced availability of assimilates for stem growth (Bartels, and Sunkar, 2005). According Azimi *et al* (2013) results, was founded that drought stress decreased number of tillers per m2. Maximum tiller production was observed at full irrigation and decreased by irrigation at anthesis+ grain filling and Irrigation at anthesis 14 and 28% respectively. Singh et al 1996 reported that drought stress decrease in number of grain in spikes (Saini & Aspinall, 1981). Maximum grains number mean (49.3) was obtained at full irrigation and decreased by irrigation at anthesis+ grain filling and irrigation at anthesis 8 and 19% respectively. AA and SA increased grains number, in other words these treatments decreased negative effects of drought stress (Azimi *et al*., 2013). Water stress near florescence, significantly interfere grain formation and fertilization and resulted in lower number of grain with higher grain weight in spike (Azimi *et al*., 2013). The reason of this phenomenon is decrease in competition for obtaining photosynthetic products while stress at grain filling, significantly lower translocation of photosynthetic products and resulted in wrinkle of grains and 1000 seed weight (Machado *et al*., 1993). According to results of Azimi *et al*., 2013, it was founded that water deficit decreased 1000 seed weight and maximum 1000seed weight (39.32 gr) produced by full irrigation.1000 seed weight is one of the most important parts of final wheat yield and it is determined by rate and duration of grain filling (Azimi *et al*., 2013). Rate of grain filling is highly depends on genotype but duration of grain filing in depends on environment (Quarrie& Jones, 1979). SA application increased 1000 seed weight and highest value was observed at 1.5 mM.SA can increase 1000 seed weight by some ways; one of them is change in photosynthesis, Zhou et al. (1999) reported that photosynthetic pigments were increased in corn with SA application. Moreover, Khan et al. (2003) showed that SA increased photosynthetic rate in corn and soybean. Treatments had significant effects on Yield so water deficit reduced yield but AA and SA improved yield of wheat seed (Azimi *et al*., 2013). Maximum yield (5369 kg/ha) was observed at full irrigation treatment and yield was reduced by up to 30 and 51% in the irrigation at anthesis+ grain filling and Irrigation at anthesis compared with unstressed plants (Azimi *et al*., 2013). AA application had positive effects in reduction of drought negative effects. The influence of the SA treatment was dependent on the concentration which was used. The results obtained were presented in, maximum yield was obtained at 1.5mM.SA application may result instomatal closure, increased WUE, increased chlorophyll content, increased respiratory-pathways and intercellular CO_2 concentration, and stimulatory changes inother physiological and biochemical attributes (Ashraf *et al.*, 2010). Harvest index were very significantly reduced with water deficit. AA and SA treatments improved harvest index in wheat under drought stress (Azimi *et al*., 2013). It was shown that 1.5mM treatments of SA had maximum harvest index as compared with control and 0.75mM (Azimi *et al*., 2013). Harvest index obtain with seed yield/ biological yield formula so drought stress decreased yield and indirectly decreased this index (Azimi *et al*., 2013). According to results, we suggested that amino acid and salicylic acid application reduced negative effects of water deficit on wheat; however the recovery was not complete (Azimi *et al*., 2013).

MATERIALS AND METHODS

Location of experiment

The experiment was conducted at the zahedan which is situated between 29° North latitude and 60° East longitude.

Composite soil sampling

Composite soil sampling was made in the experimental area before the imposition of treatments and was analyzed for physical and chemical characteristics.

Field experiment

The field experiment was laid out split plot with randomized complete block design with three replications.

Treatments

Treatments included drought stress (I_0: control, I1: Irrigation cut in pod stage, I2: Irrigation cut in flowering) as main plot and sub plot consisted of foliar application of salicylic acid (S1: control, S2: 4%Mm, S3: 7%Mm and S4: 1 Mm).

Data collect

Data collected were subjected to statistical analysis by using a computer program SAS. Least Significant Difference test (LSD) at 5 % probability level was applied to compare the differences among treatments` means.

RESULTS AND DISCUSSION

Biological yield

Analysis of variance showed that the effect of water stress on biological yield was significant (Table 1). The maximum of biological yield of treatments control was obtained (Table 2). The minimum of biological yield of treatments Podding stage was obtained (Table 2). Analysis of variance showed that the effect of foliar application of salicylic acid on biological yield was significant (Table 1). The maximum of biological yield of treatments 0.7 was obtained (Table 2). The minimum of biological yield of treatments control was obtained (Table 2). Reduction by drought stress could be due to adverse effects of drought on dry matter production causing reduced availability of assimilates for stem growth (Bartels, and Sunkar, 2005).

Grain yield

Analysis of variance showed that the effect of water stress on grain yield was significant (Table 1). The maximum of grain yield of treatments control was obtained (Table 2). The minimum of grain yield of treatments podding stage was obtained (Table 2). Analysis of variance showed that the effect of foliar application of salicylic acid on grain yield was significant (Table 1). The maximum of grain yield of treatments 0.7 was obtained (Table 2). The minimum of grain yield of treatments 0.4 was obtained (Table 2). Treatments had significant effects on Yield so water deficit reduced yield but AA and SA improved yield of wheat seed (Azimi *et al*., 2013). . Maximum yield (5369 kg/ha) was observed at full irrigation treatment and yield was reduced by up to 30 and 51% in the irrigation at anthesis+ grain filling and Irrigation at anthesis compared with unstressed plants (Azimi *et al*., 2013). AA application had positive effects in reduction of drought negative effects. The influence of the SA treatment was dependent on the concentration which was used. The results obtained were presented in, maximum yield was obtained at 1.5mM.SA application may result instomatal closure, increased WUE, increased chlorophyll content, increased respiratory-pathways and intercellular CO_2 concentration, and stimulatory changes in other physiological and biochemical attributes (Ashraf *et al*., 2010).

1000 seed weight

Analysis of variance showed that the effect of water stress on 1000 seed weight was significant (Table 1). The maximum of 1000 seed weight of treatments control was obtained (Table 2). The minimum of 1000 seed weight of treatments flowering stage was obtained (Table 2).

Table 1: Anova analysis of the wheat affected by salicylic acid and drought stress

S.O.V	Biological yield	Grain yield	1000 seed weight
R	74444.44	90711.11	2.52
Drought stress (a)	35021944.44**	602302.77**	90.02**
Error a	260694.44	44594.44	1.11
salicylic acid (b)	7225555.56**	812525.92**	42.54**
A*B	1357500.00*	118506.48ns	4.21ns
Error b	417129.6	49262.96	4.76
CV (%)	5.59	5.68	6.30

*, **, ns: significant at p<0.05 and p<0.01 and non-significant, respectively.

Table 2: Comparison interaction of different traits affected by salicylic acid and drought stress

Treatments	Biological yield (kg/ha)	Grain yield (kg/ha)	1000seed weight (gr)
Drought stress			
control	13241.7a	4118.33a	37.66a
Podding stage	9825.0c	3670.83b	33.91b
flowering	11550.0b	3914.17a	32.33c
salicylic acid			
control	10488.9c	3726.7b	32.88b
0.4	11544.4b	3572.2b	33.55b
0.7	12677.8a	4205.6a	37.77a
1	11444.4b	4100.0a	34.33b

Analysis of variance showed that the effect of foliar application of salicylic acid on 1000 seed weight was significant (Table 1). The maximum of 1000 seed weight of treatments 0.7 was obtained (Table 2). The minimum of 1000 seed weight of treatments control was obtained (Table 2). According to results of Azimi *et al*., 2013, it was founded that water deficit decreased 1000seed weight and maximum 1000seed weight (39.32 gr) produced by full irrigation.1000 seed weight is one of the most important parts of final wheat yield and it is determined by rate and duration of grain filling (Azimi *et al*., 2013). Rate of grain filling is highly depends on genotype but duration of grain filing in depends on environment (Quarrie& Jones, 1979). SA application increased 1000 seed weight and highest value was observed at 1.5 mM.SA can increase 1000 seed weight by some ways; one of them is change in photosynthesis, Zhou et al. (1999) reported that photosynthetic pigments were increased in corn with SA application. Moreover, Khan et al. (2003) showed that SA increased photosynthetic rate in corn and soybean.

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