ROLE OF GROWTH REGULATORS AND PLANT WATER EXTRACTS ON THE PRODUCTIVITY AND WATER USE EFFICIENCY OF WHEAT GENOTYPES UNDER LIMITED WATER SUPPLY

PAPEL DOS REGULADORES DE CRESCIMENTO E DOS EXTRATOS DE PLANTAS SOBRE A EFICIÊNCIA DA PRODUTIVIDADE E DO USO DA ÁGUA DOS GENÓTIPOS DE TRIGO SOB ABASTECIMENTO DE ÁGUA LIMITADA

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ABSTRACT: Empowerment of wheat genotypes by application of growth regulators, compatible solutes and plant extracts under water restriction is an important strategy for getting sustainable yield. This study aimed to evaluate the effects of drought stress on the growth and yield of wheat genotypes and also monitor and compare the role of ABA, SA as well as moringa and mulbery leaf water extracts in improving drought tolerance of wheat genotypes. The work was performed at the research area of the Faculty of Agricultural Sciences, Ghazi University, Dera Ghazi Khan, Pakistan. Three wheat cultivars Aas-2011, Faisalabad- 2008 and Triple dwarf-1 were subjected to drought stress (skipping the irrigation at grain filling stage). The wheat genotypes were subjected to treatments viz., T_1 i.e. All normal irrigation without application of abscisic acid (ABA), salicylic acid (SA), moringa (MLE) and mulberry leaf water extract (MBLE), T_2 i.e. skipping the irrigation at grain filling stage and application of 2µM ABA, T_3 i.e. skipping the irrigation at grain filling stage and application of 10 m mol SA, T_4 i.e. skipping the irrigation at grain filling stage and application of 15% MLE and T_5 i.e. skipping the irrigation at grain filling stage and application of 10% MBLE. The experiment was laid out in Randomized Complete Block Design with factorial arrangement and repeated three times. From this study it is concluded that Aas-2011 shown best result under drought condition by applying growth regulators and plant water extracts.

KEYWORD: Wheat. Growth regulators. Moringa. Mulberry. Leaf water extracts. Drought stress

INTRODUCTION

Wheat possesses a vital position in Pakistan's financial system to reduce the gap between food productions and consumption, therefore crucial for national food security (ALAM et al., 2008). Rainfed areas are included in the major wheat producing regions of Pakistan. However wheat production in this area is around 50% of the irrigated areas. One of the main targets of Pakistan's national wheat breeding programs is enhancement of drought resistance in wheat cultivars. Although breeders have successfully increased wheat yield at national level, but they have achieved limited success in agro ecological zone where natural conditions are very uncertain and various stresses occur including drought stress (SUZUKI et al., 2014; AHANGER et al., 2016). Genotypic variation in growth and development under drought is an important index of monitoring drought tolerance in wheat genotypes. Pre-anthesis and at anthesis stage deficiency of water can cause reduction in number of spikes and quantity of grains per spike (CHAI et al., 2015). Deficiency of water stress at lateral growth stages has negative impact on number of grains per spike and 1000-grain weight. Wheat growth period from stem elongation to heading and heading to milking reported to be more susceptible to shortage of water stress (GUPTA et al., 2001).

Growth regulators like abscisic acid (ABA) play key role in improving drought tolerance of field crops. Under drought stress condition, ABA is synthesis started in the plant tissues and then it sent as a stress signal to the stomatal cell. ABA application under drought stress improved drought tolerance by conserving plant cell moisture and improving/maintaining plant growth (HUSSAIN et al., 2010; HUSSAIN et al., 2012). Salicylic acid (SA) is phenolic endogenous growth hormone promoted plant photosynthetic rates, production of

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plant biomass and crop leaf area (KHAN et al., 2003). It was reported that SA increase the wheat resistance against osmotic stress caused by water deficit conditions (BHUPINDER; USHA, 2003).

Application of plant water extracts like mulberry and moringa in low concentration under drought stress can also improve the drought tolerance in wheat genotypes. Mulbery and moringa leaf extract has antioxidants, which prevent, stabilize and terminate the reactions of reactive oxygen species by defending oxidative induced cellular damage. Therefore, external supplementation of anti-oxidants is widely recommended to protect cells from the drought (HAQ et al., 2010). Moringa is good plant growth enhancer. Its leaf extract is a rich source of amino acids, nutrients as well as ascorbate and zeatin for plant growth and regulation of enzymes (MAKKAR; BECKER 1996, BASRA et al., 2009). Foliar application of moringa leaf extract to crop plant increased number of roots and plants produce more and larger fruits which ultimately increased 20-35% yield (FUGLIE, 2000).

This study aimed to evaluate the effects of drought stress on the growth and yield of wheat genotypes and also monitor and compare the role of ABA, SA as well as moringa and mulbery leaf water extracts in improving drought tolerance of wheat genotypes.

MATERIAL AND METHODS

The present study was conducted at the Research Area near Airport Campus Ghazi University, Dera Ghazi Khan Pakistan (30°3'22.1"N, 70°38'5.17"E). The climate is arid to semiarid of the study area. Wheat genotypes were sown in line at distance of 22 cm at field capacity after preparing the seedbed with one ploughing and two cultivation and each cultivation followed by planking. Soil texture was clay loam, saturation percentage of experimental soil was 33.7%, soil pH ranges from 6-8.5, and nitrogen was 0.03%. One bag (50 kg) of urea, DAP and SOP per acre were applied at the time of sowing and one bag (50 kg) of urea was also given to crop at the time of first irrigation (25 days after sowing). After the first irrigation 250g logron extra per acre was applied to control the broad leaf weeds. Three wheat cultivars Aas-2011, Faisalabad- 2008 and Triple dwarf-1 were subjected to drought stress (skipping the irrigation at grain filling stage). The wheat genotypes were subjected to treatments viz., T_1 i.e. All normal irrigation without application of abscisic acid (ABA), salicylic acid (SA), moringa (MLE) and mulberry leaf water extract (MBLE), T_2 i.e. skipping the irrigation at grain filling stage and application of 2µM ABA, T_3 i.e. skipping the irrigation at grain filling stage and application of 10 m mol SA, T_4 i.e. skipping the irrigation at grain filling stage and application of 15% MLE and T_5 i.e. skipping the irrigation at grain filling stage and application of 10% MBLE. Randomized complete block design (RCBD) with factorial arrangement was used. The study was repeated three times.

The yield parameters like number of tillers per square meter, spike length (cm), number of spike per square meter , number of spikelets per spike, number of grain per spike, 1000-grain weight (g), grain yield (kg ha^{-1}), biological yield (kg ha^{-1}), harvest index (%) and drought yield index (%) were measured and computed at the time of harvesting. The grain protein contents (mg/g) estimated by Kjeldahl method. Water use efficiency was computed by formula Hussain and Al-Jaloud (1995) as following:

Water use efficiency = Grain yield (kg ha^{1}) / Total water applied (mm)

Leaf relative water content was determined by the formula (KARROU; MARANVILLE, 1995) as following:

Leaf relative water content (%) = Fresh weight–dry weight /turgid weight-dry weight x 100

Statistical analysis

Data regarding studied parameters were statistically analyzed at 5% level of significance through Fischer's analysis of variance technique. Least significant differences test at 5% level of significance was used to compare the means of treatments.

RESULTS

Plant population is a single utmost factor contributing the final crop yield. Statistically significant results were also measured for number of tillers per square meter and maximum number of tillers per square meter (297.81) was noted in T_1 (full irrigations) and minimum number of tillers per m^2 (276.82) was measured in T_5 where 10% mulberry leaf water extract was applied to both wheat genotypes at grain filling stage after skipping the irrigation. Data for varieties showed that the maximum number of tillers per m^2 (292.20) produced from Aas-2011 and minimum number of tillers per m^2 (278.72) was measured from plants of wheat cultivar TD-1 (Table 1)

Treatments and varieties have pronounced affect on number of spikes m^{-2} of wheat cultivars.

Maximum number of spikes m^{-2} 287.72 was noted in T_1 (full irrigations) and minimum number of spikes m^{-2} 273.82 was measured in T_5 (10% mulberry leaf water extract at grain filling stage after skipping the irrigation). Data for varieties showed that the maximum number of spikes m^{-2} 283.62 produced from Aas-2011and minimum number of spikes m^{-2} (277.36) was counted from plants of wheat cultivar TD-1. Treatments impact on wheat genotypes was also well documented for spikelets $spike^{-1}$. Maximum number of spikelets $spike^{-1}$ (20.07) was noted in T_1 and minimum number of spikelet's $spike^{-1}$ (13.68) was counted in T_5 (Table 1).

Maximum grains per spike (57.55) was noted in T_1 (no drought stress) and minimum grains per spike (45.82) was measured in T_5 where 10% mulberry leaf water extract was applied to both wheat genotypes at grain filling stage after skipping the irrigation. Data for varieties highlight the maximum grains $spike^{-1}$ (54.05) were produced by Aas-2011 and minimum grains $spike^{-1}$ i.e., (49.11) were measured from plants of wheat cultivar TD-1. Maximum spike length (13.36 cm) was noted in T_1 and minimum spike length (8.59 cm) was measured in T_5. Maximum 1000-grain weight (43.55 g) was noted in T_1 and minimum 1000-grain weight (37.75 g) was weighed in T_5. Data for varieties showed that the maximum 1000-grain weight (42.54 g) was weighed from Aas-2011 and minimum 1000-grain weight (38.06 g) was produced from wheat cultivar TD-1 (Table 1).

Table 1. Impact drought management strategies on yield components of wheat genotypes

Treatments	Number of tillers per square meter	Number of Spikelets per spike	Number of grains spike	Spike length (cm)	1000-grain weight (g)
a) Drought management strategies	Means of three replication				
T_1= full irrigations, no ABA, SA, MLE and MBLE	297.81 a	20.07 a	57.55 a	13.36 a	43.55 a
T_2 = 2µM ABA (- GF)	287.17 ab	18.56 b	55.21 b	12.38 b	40.95 b
T_3 = 10mM SA (- GF)	278.03 c	14.42 d	48.49 d	9.24 d	38.94 d
T_4 = 15% MLE (- GF)	287.00 ab	17.82 c	51.88 c	11.17 c	40.76 c
T_5 = 10% MBLE (- GF)	276.82 d	13.68 e	45.82 e	8 .59 e	37.75 e
LSD at 5%	0.68	0.41	0.28	0.22	0.31
b) Wheat cultivars	Means of three replication				
Aas-2011	292.20 a	18.89 a	54.05 a	12.12 a	42.54 a
Faisalabad-2008	285.63 ab	16.11 b	52.20 b	11 .35 b	40.56 b
TD-1	278.72 c	14.00 c	49.11 c	9.38 c	38.06 c
LSD at 5%	0.33	0.20	0.14	0.10	0.15

Means sharing the same letter within the column differ non-significantly at the 5% probability level, ABA = abscisic acid, SA = Salicylic acid, MLE = Moringa leaf water extract, MBLE = Mulbery leaf water extract, (- GF) = skipping irrigation at grain filling stage

Divergent treatments and cultivars had shown significant impact on grain yield, biological yield and harvest index. Maximum grain yield (5873.33 kg ha^{-1}) was noted in T_1 and minimum grain yield (5130.34 kg ha-1) was measured in T_5. Data for varieties showed that the maximum grain yield (5711.24 kg ha^{-1}) produced from Aas-2011 and minimum grain yield 5198.55 kg ha^{-1} was noted in wheat cultivar TD-1. Maximum biological yield (16612.61 kg ha^{-1}) was noted in T_1 and minimum biological yield (16059.38 kg ha^{-1}) was measured in T_5. Data for varieties showed that the maximum biological yield (16525.14 kg ha^{-1}) produced from Aas-2011 and minimum biological yield (16177.13 kg ha^{-1}) was measured from plants of wheat cultivar TD-1. Maximum harvest Index 35.35 % was noted in T_1 (no drought stress) and minimum (31.93%) was calculated in T_5 where 10% mulberry leaf water extract was applied to wheat genotypes at grain filling stage after skipping the irrigation. Data for varieties showed that the maximum harvest index (34.55%) was noted from Aas-2011 and minimum harvest index 32.12 % was computed from plants of cultivar TD-1 (Table 2).

Treatments had significant impact on crop WUE of wheat genotypes. Maximum WUE (6.18 kg ha^{-1} mm^{-1}) was noted in T_1 (no drought stress) and minimum crop WUE (3.81 kg ha^{-1} mm^{-1}) was measured in T_5 where 10% mulberry leaf water extract was applied to wheat genotypes at grain filling stage after skipping the irrigation. Similarly maximum drought yield index (100%) was noted in T_1 and minimum drought yield index (87.31%) was measured in T_5. Data pertaining to varieties showed that the maximum drought yield index (93.51 %) produced from Aas-2011 and minimum (92.81%) was measured from plants of wheat cultivar TD-1 (Table 2).

Protein contents, relative leaf water contents and soil moisture contents of wheat genotypes were affected by divergent treatments. Maximum protein contents 19.41 (mg/g) was noted in T_1 and minimum protein contents 13.55 (mg/g) was estimated in T_5. Maximum leaf relative water content 75.14 % was noted in T_1 (no drought stress) and minimum 68.53 % was measured in T_5. Data for varieties showed that the maximum relative leaf water content (LRWC) 73.15% sustained by Aas-2011 and minimum LRWC 70.39 % was measured from plants of wheat cultivar TD-1. Maximum soil moisture contents 16.27 (%) was noted in T_1 (no drought stress) and minimum soil moisture contents 13.04 (%) was measured in T_5 where 10% mulberry leaf water extract was applied to both wheat genotypes at grain filling stage after skipping the irrigation.Aas-2011 produced the maximum soil moisture contents 14.84 (%) and minimum Soil moisture contents 13.45 (%) was measured from plants of wheat cultivar TD-1 (Table 2).

Table 2. Impact drought management strategies on yield and water use efficiency and protein contents of wheat genotypes

Treatments	Grain yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest Index (%)	WUE (kg ha^{-1} mm^{-1})	Drought yield index (%)	Protein contents (mg g^{-1})	Leaf water contents (%)
a) Drought management strategies	Means of three replication						
T_1= full irrigations, no ABA, SA, MLE and MBLE	5873.3 a	16612.6 a	35.3 a	6.18 a	100 a	19.41 a	75.14 a
T_2 = 2μM ABA (- GF)	5708.51 b	16380.9 b	34.85 b	4.78 b	92.21 b	17.37 b	72.65 b
T_3 = 10mM SA (- GF)	5391.59 c	16284.5 d	33.17 c	4.33 c	91.78 c	14.50 c	72.41 c
T_4 = 15% MLE (- GF)	5287.10 d	16188.3 c	32.63 d	4.51 d	89.95 d	14.24 d	69.23 d
T_5 = 10% MBLE (- GF)	5130.34 f	16059.3 e	31.93 e	3.81 e	87.31 e	13.55 e	68.53 e
LSD at 5%	0.41	0.21	0.71	0.65	0.71	0.22	0.78
b) Wheat cultivars	Means of three replication						
Aas-2011	5711.24 a	16525.1 a	34.55 a	5.53 a	93.51 a	16.64 a	73.15 a
Faisalabad-2008	5524.76 b	16213.2 b	34.09 b	4.39 b	93.43 b	15.26 b	72.24 b
TD-1	5198.55 c	16176 c	32.12 c	4.25 c	92.81 c	14.8 c	70 .39 c
LSD at 5%	0.21	0.25	0.54	0.33	0.39	0.10	0.55

Means sharing the same letter within the column differ non-significantly at the 5% probability level, ABA = abscisic acid, SA = Salicylic acid, MLE = Moringa leaf water extract, MBLE = Mulbery leaf water extract, (- GF) = skipping irrigation at grain filling stage, WUE = Water use efficiency.

DISCUSSION

In the present study maximum number of tillers per square meter (297.81) was noted in T_1 (full irrigations) treatment and minimum number of tillers per square meter (276.82) was recorded in T_5 where 10% mulberry leaf water extract was applied to both wheat genotypes at grain filling stage after skipping the irrigation. Akram et al. (2014) conducted a field experiment to find the effect of water stress on wheat crop and concluded that

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drought conditions significantly reduced number of tillers per plant in wheat genotypes.

Number of spikes per square meter is one of the most critical yield attribute and is a direct measure of grain yield in cereals. The yield of wheat genotype is significantly influenced by number of spike per square meter. The wheat genotype Aas-2011 had more number of spikes per square meter as compare to Faisalabad-2008 and TD-1. This variation in number of spikes per square meter can be attributed to genetic potential of wheat cultivars. The Aas-2011 had more potential to produce good amount of spikes as it is less vulnerable to water shortage. This might be due to ability of Aas-2011 plant to conserve more water under limited availability of moisture. Water conservation in plant body under drought is an important point to differentiate between drought sensitive and drought resistant cultivars of field crops (HUSSAIN et al., 2012).

Number of spikelet's per spike contributes positively towards grain yield. More the number of spikelet's per spike, greater will be the grain yield. Therefore, selection of cultivar based on higher number of spikelet's per spike may ultimately lead to the evaluation of better yielding lines. However stresses like drought may significantly reduced the number of spikelets per spike. Significantly positive interaction of grains per spike and spikelet per spike was observed at genotypic level. Grains per spike and total grain weight had positive and significant correlation with grain yield per plant. These results are in the conformity with the results reported by Tosun et al. (1995).

Different yield contributing factors like number of grains per spike, spike length and 1000-grain weight are also important. Drought stress at grain filling stage reduced number of grains per spike, spike length, 1000-grain weight and grain yield and exogenous application of ABA, SA and MLWE counter the impact of water shortage by improving yield and yield contributing parameters (Table1, 2). ABA application partially close the stomata and conserve the plant moisture which ultimately improved the performance of wheat genotypes (HUSSAIN et al., 2012). Application of SA may cause stomatal closure, increased chlorophyll content, increased WUE, increase the intercellular CO_2 concentration and respiratory-pathways in wheat under water deficient conditions. The stimulatory changes in physiological and biochemical attributes (ASHRAF et al., 2010) and drought stress at different stages of wheat crop affect the water use efficiency (AKRAM et al., 2014). Moringa leaf water extracts application to wheat genotypes under drought conditions improved yield and yield components. Moringa leaf extract results in better crop stand wider temperature range of emergence and enhanced both yield and quality of crops, exclusively when exposed to drought and suboptimal environmental conditions (HALMER, 2004). Under drought stress, 30 times diluted moringa leaf extract has been reported to stimulate plant growth and development (ALI et al., 2011). This increase in yield and its components might be due to the fact that moringa leaf extract is enriched with significant concentrations of essential nutrients i.e. potassium and calcium and plant hormones such as cytokinin. It is also rich source of antioxidants, ascorbates, phenols and zeatin (MAKKAR et al., 2007).

CONCLUSION

The Aas-2011 performs better regarding yield and yield contributing attributes as well as attain higher water use efficiency as compared to other two cultivars (Faisalabad-2008 and TD-1) under drought stress condition and application of both growth regulators and plant water extracts.

RESUMO: O fortalecimento de genótipos de trigo pela aplicação de reguladores de crescimento, solutos compatíveis e extratos vegetais sob restrição hídrica é uma importante estratégia para obtenção de produção sustentável. Trilha de campo foi realizada na área de pesquisa da Faculdade de Ciências Agrárias, Universidade de Ghazi, Dera Ghazi Khan, Paquistão. Três cultivares de trigo Aas-2011, Faisalabad-2008 e Triple anão-1 foram submetidas a estresse hídrico (pulando a irrigação no estágio de enchimento de grãos). Os genótipos de trigo foram submetidos a tratamentos, T1, ou seja, irrigação normal sem aplicação de ácido abscísico (ABA), ácido salicílico (SA), moringa (MLE) e extrato de água de amoreira (MBLE), T2¬, pular a irrigação em estágio de enchimento de grãos e aplicação de ABA 2μM, T3 ou seja, ignorando a irrigação no estágio de enchimento de grãos e aplicação de 10 m mol SA, T4 ou seja, ignorando a irrigação no estágio de enchimento de grãos e aplicação de 15% MLE e T5 ou seja, ignorando a irrigação no enchimento de grãos estágio e aplicação de 10% MBLE. O experimento foi exposto no delineamento de blocos completos casualizados com arranjo fatorial e repetido três vezes. A partir deste estudo conclui-se que Aas-2011

apresentou melhor resultado sob condição de seca, aplicando reguladores de crescimento e extratos de água de plantas.

PALAVRAS-CHAVE: Trigo. Reguladores de crescimento. Moringa. Amora. Extratos de água de folha. Estresse hídrico

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