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Research Article

Alleviating the Drought Stress in Wheat (*Triticum aestivum* L.) by Foliar Application of Amino Acid and Yeast

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Abstract | Drought stress is in spotlight as a main limiting factor for crop production across the globe especially in arid to semi-arid regions. Overcome this, various management practices are used one of them is the use of a growth enhancer. In the present study drought ameliorating effects of amino acid and yeast on wheat (*Triticum aestivum* L.), development and yield were observed. A field experiment was performed at Agronomic Research Area, Faculty of Agriculture and Environment, The Islamia University of Bahawalpur in November 2019. Factorial arrangement in Randomized complete block design (RCBD) was used to design the experimentation. The experiment consisted of six treatments viz, Control, a drought at flowering and grain filling stages, Amino acid @ 1.5 ml L^{-1} + drought at flowering and grain filling, Amino acid @ 3 ml L^{-1} + drought at flowering and grain filling, Yeast @ 3g L^{-1} + drought at flowering and grain filling and Yeast @ 6g L^{-1} + drought at flowering and grain filling, respectively. STATISTICS 8.1 programs were used for data analysis. Drought spell significantly reduced the growth development and wheat yield as compared to control treatment. Application of both growth enhancer amino acid and yeast significantly mitigated the adversarial effect of drought on the wheat as compared to the treatments in which drought was imposed without the application of yeast and amino acid. However, yeast more effectively moderated drought effects than amino acids. Maximum spike length (15.73 cm), spike number (18.75), grains per spike number (54.50), 1000 grain weight (44.08g) seed yield (5.445 tons), sugars, proline, total phenols, amino acids, and carbohydrates were recorded in treatment in which yeast was applied @6g L^{-1} + drought at flowering and grain filling. It was concluded that both amino acid and yeast can recompense the unfavorable special effects due to dearth but yeast was proved to be more effective than an amino acid.

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Introduction

Wheat has a place with the Poaceae family that additionally contains a few other significant crops for example rice (*Oryza sativa* L.), barley (*Hordeum vulgare* L.), and maize (*Zea mays* L.) (Sandhu *et al*., 2001). Wheat is a staple food that is utilized for making flour for treats, bread, pasta, and numerous other comparative items. In a normal eating routine, it is the least expensive wellspring of the human protein substance and calories (Lev-Yadun *et al*., 2000). Drought in all over the world has impacted negatively on agricultural crop's absolute production (Abolhasani and Saeidi, 2004). Both high temperature and salinity stresses are the main causal factor of less availability of water to crops plants (Baybordi, 2004; Soriano *et al*., 2004).

Drought stress is mainly linked with lesser contents of leaf water, therefore turgor pressure resulting in low leaf potential. Drought had more pronounce affects than any other environmental factor. The stomatal regulation is greatly affected by fewer contents of water and in extreme cases, the stomata are shut. In that way, the stomatal closure stops the carbon influx and reduces the process of photosynthesis. The plant's metabolism is furthermore destroyed in drought situations and eventually causes the death of plants (Jaleel *et al*., 2008). The cell division processes of plants are not affected much in context to plant cell enlargement during scarce water conditions. All biochemical and physiological processes in plants become slow in reaction to drought stress (Farooq *et al*., 2008).

Grain filling stage in the wheat crop is highly affected for the reason of low starch contents in wheat grain (Yang *et al*., 2007). Amino acids can also be used to increase the absorption and consumption of many essential elements in plants for their growth and development (Taize and Zeiger, 2002). Amino acids are the key structural component of protein; there are more than 20 amino acids that are found to be involved in the making of different types of proteins. These proteins are the main components of cellular organelles and play a pivotal role in most of the physiological processes occurring in plants (Hounsome *et al*., 2008). Drought also degrades and denatures many types of amino acids and ultimately the protein content of plants. Photosynthetic pigments of plants are formed due to amino acid which initiates most of the biochemical and metabolic processes in crop plants i.e. accelerates the digestion system in plants to increase the efficiency of plants for maximum production (Starck, 2007).

Yeasts are the unicellular organisms that belong to the kingdom fungi, can grow quickly on carbohydrates in aerobic or anaerobic pathways (Botha, 2011). They also play an important role in Nitrogen and Sulfur oxidation (Falih and Wainwright, 1995). Yeast has a major role in the stimulation of mycorrhizal-root colonization (Vassileva *et al*., 2000; Mirabal Alonso *et al*., 2008). The stimulating influence of yeast on wheat might be because of biologically active substances formed by bio-fertilizers like gibberellins, cytokinins, auxins, vitamins (Bahr and Gomaa, 2002). Hussain *et al*. (2002) observed that yeast enhances crop development and its yield by creating bioactive substances and rising photosynthesis. The key objective of this study was to evaluate the effectiveness of amino acids and yeast in improving growth, development, and wheat yield during drought stress.

Materials and Methods

Experimental location

The field trial was completed at the Research Area of Agronomy Department during the end seven day of November 2019. The mean annual temperature of the experimental area is 45°C and lies in semi-arid region. All the agronomic practices were arrangements for the typical development of wheat plants. The trial was set out in the randomized complete block design (RCBD) with factorial courses of action with three replicate. Foliar utilization of development enhancers (amino acids and yeast separate) was done under dry spell conditions by skipping the water system at various development stages.

Treatments

The experiment included six treatments viz, Control, Drought at flowering and grain filling, Amino acid @ 1.5 ml L^{-1}under drought, Amino acid @ 3 ml L^{-1}under drought, Yeast @ 3g L^{-1}under drought and Yeast @ 6g L^{-1}under drought. The treatments were applied two times, first at flowering and second at the grain filling stage. All cultural practices were kept constant.

Soil analysis

Soil used in the experiment having following properties; PH 8.7, organic matter 0.77%, Electrical

Conductivity 252 µS/cm, Total Soluble Salts 0.80 %, Available-P 7.11 ppm, Available-K 115 ppm.

Statistical analysis

Least significant difference (LSD) at 5% probability level was used for statistical analysis and mean comparison of computed data with Statistix version 9.2 (Steel et al., 1997).

Results and Discussion

Plant height

The information about plant height has been presented in Table 1 which demonstrates that foliar use of yeast and amino acids didn't altogether influence the height of the wheat plant.

Spike length

The information that appeared in Table 1 shows a critical impact of amino acid and yeast application on the length of the wheat spike. More spike length (17.12 cm) was gotten in charge than a dry spell, while among the dry season stress treatment the most extreme length of the spike (15.73 cm) was noted with the use of yeast @6 g L^{-1} under dry spell followed by treatment in which amino acid @ 3 ml $L^{-1}$was applied under the dry spell (14.65cm) and the base spike length (12.40cm) was recorded under dry season without the use of any development enhancer.

Number of spikelets per spike

Data given in Table 1 demonstrates the significant effect of amino acid and yeast application on the number of spikelets per spike. The highest number of spikelets per spike (22.25) was obtained in control than drought, while amongst the drought-stressed treatments the maximum spikelets per spike (18.75) was recorded with the application of yeast @6 g L^{-1}under drought followed by treatment in which amino acid @ 3 ml $L^{-1}$was applied under drought (17.00) and the minimum spikelets per spike (11.50cm) was recorded under drought without application of any amino acid and yeast.

Number of grains per spike

Information in Table 2 shows a noteworthy impact of amino acid and yeast application on the number of the grains/wheat spike. The most elevated number of grains/spike (63.75) was gotten in control than the dry spell, while among the dry spell focused on treatments the most elevated number of the grains/spike (54.50) was recorded with the use of yeast @6 g L^{-1} under dry season followed by treatment in which amino acid @ 3 ml L^{-1} was applied under the dry spell (50.00) and a minimal number of grains/spike (33.00) was noted in a dry spell.

1000-grain weight (g)

Information introduced shows a critical impact of amino acid and yeast application on the 1000-grain weight of wheat (Table 2). Maximum value for 1000 grain weight Most extreme 1000-grain weight (46.75g) was found in control than the dry spell, while among the dry season focused on treating the most noteworthy 1000-grain weight (44.08g) was recorded with the use of yeast @6 g L^{-1} under dry season followed by treatment in which amino acid @ 3 ml L^{-1} was applied under dry season (42.45g) and the least 1000-grain weight (39.25g) was recorded in a dry spell.

Grain yield (tons)

Data presented in Table 2 shows a significant effect of amino acid and yeast application on the grain yield kg ha^{-1} of wheat. The maximum grain yield (5.875 tons) was obtained in control, then drought, while amongst the drought-stressed treatments the maximum grain yield (5.635tons) was recorded with the application of the yeast @6 g L^{-1} under drought followed by treatment in which amino acid @ 3 ml $L^{-1}$was applied under drought (5.445 tons) and the minimum grain yield weight (4.753 tons) was recorded in drought.

Biological yield (tons)

Data given in Table 2 shows a significant effect of amino acid and yeast application on biological yield kg/ha of the wheat. The maximum biological yield (17.41 tons) was obtained in control than drought, while amongst the drought-stressed treatments the maximum biological yield (16.16 tons) was recorded with the application of the yeast @6 g L^{-1} under drought followed by treatment in which amino acid @ 3 ml L^{-1} was applied under drought (15.50 tons) and the minimum biological yield weight (13.24tons) was recorded in drought.

Harvest index (%)

Data given in Table 2 shows a significant effect of amino acid and yeast application on the harvest index (%) of wheat. Highest harvest index (36.27%) was obtained in amino acid @ 1.5 ml/L under drought which was statistically at par with only drought treatment and treatment in which, the amino acid was applied @ 3 ml L^{-1} under drought and least harvest index (35.88%) was noted in Control. Application of alone yeast treatment yeast @ 6 g L^{-1} under drought showed harvest index (34.84).

Total soluble sugar (mg g^{-1} D.W.)

Data given in Table 3 shows a significant effect of amino acid and yeast application on total soluble sugar of wheat. The maximum total soluble sugar (29.83mg g^{-1} D.W.) was noticed when applied yeast @ 6g L^{-1} under drought condition followed by (27.52 mg g^{-1}D.W.) when applied amino acid applied @ 3g L^{-1} under drought condition. The minimum total soluble sugar (17.00 mg g^{-1}D.W.) was observed in the control treatment.

Total carbohydrates (mg g^{-1} D.W.)

Data are given in Table 3 indicates a significant effect of amino acid and yeast application on total carbohydrates of wheat. The maximum total carbohydrates (255.00 mg g^{-1} D.W.) were recorded when applied yeast @ 6g L^{-1} under drought condition followed by (250.0 mg g^{-1} D.W.). When applied amino acid applied @ 3g L^{-1} under drought condition. The minimum total carbohydrates (199.00 mg g^{-1} D.W.) were observed in control treatments.

Total phenols (mg caticol $^{-1}$100 g D.W.)

Data are given in Table 3 shows a significant effect of amino acid and yeast application on total phenols of wheat. The maximum total phenols (22.00 mg caticol/100 D.W.) were observed when applied yeast @ 6g L^{-1} under drought condition followed by (20.52 mg caticol $^{-1}$100 D.W.) when applied amino acid applied @ 3g L^{-1} under drought condition. The minimum total phenol (15.52 mg caticol-1100 D.W.) was observed in control.

Table 1: *Interactive effect of the foliar application of amino acid and yeast on growth and yield-related parameter of wheat (Triticum aestivum L.) under drought.*

Treatments	Plant height (cm)	Spike length (cm)	Number of spikelets per spike
T_0 = Control	99.25	17.25 A	22.00 A
T_1 = Drought	88.50	12.40F	11.50 F
T_2= Amino acid @ 1.5 ml L^{-1} under drought	95.25	13.23E	13.50 E
T_3= Amino acid @ 3 ml L^{-1} under drought	92.25	14.15D	15.25 D
T_4= Yeast @ 3g L^{-1} under drought	93.50	14.65C	17.00 C
T_5= Yeast @ 6g L^{-1} under drought	94.00	15.73B	18.75 B
LSD	3.234	0.4972	1.677
ANOVA Summary	ns	**	**

*Means sharing different letters differ significantly at p ≤ 0.05. Significant differences are indicated by an asterisk (*); *P ≤ 0.05, **P ≤ 0.01; ns: non-significant.*

Table 2: *Interactive effect of the foliar application of amino acid and yeast on growth and yield-related parameters of wheat (Triticum aestivum L.) under drought.*

Treatments	Number of grains per spike	1000-grain weight (g)	Grain yield (tons)	Biological yield (tons)	Harvest index (%)
T_0 = Control	63.75 A	46.75 A	5.875. A	17.41 A	33.74E
T_1 = Drought	33.00 F	39.28F	4.753F	13.24F	35.89B
T_2= Amino acid @ 1.5 ml L^{-1} under drought	39.50E	40.15E	5.053E	13.92E	36.27 A
T_3= Amino acid @ 3 ml L^{-1} under drought	44.00 D	41.58D	5.335D	14.77D	36.10 A
T_4= Yeast @ 3g L^{-1} under drought	50.00 C	42.45C	5.445C	15.50C	35.13 C
T_5= Yeast @ 6g L^{-1} under drought	54.50 B	44.08B	5.635B	16.16B	34.84 D
L.S.D	4.36	0.75	0.66	0.33	0.69
ANOVA Summary	**	**	**	**	*

*Means sharing different letters differ significantly at p ≤ 0.05. Significant differences are indicated by an asterisk (*); *P ≤ 0.05, **P ≤ 0.01; ns: non-significant.*

Table 3: *Interactive effect of the foliar application of amino acid and yeast on quality parameters of wheat (Triticum aestivum L.) under drought.*

Treatments	Total soluble sugar (mg g^{-1} D.W.)	Total carbohydrates (mg g^{-1}D.W.)	Total phenols (mg caticol $^{-1}$100 g D.W.)	Total free amino acids (mg g^{-1}D.W.)	Proline content (µg g^{-1} D.W.)
T_0 = Control	17.00 F	199.0 F	15.52 F	8.25 F	1.152 F
T_1 = Drought	22.00 E	230.0 E	17.30 E	9.50 E	1.225 E
T_2= Amino acid @ 1.5 ml/L under drought	24.52 D	240.0 D	18.52 D	10.73 D	1.352 D
T_3= Amino acid @ 3 ml/L under drought	26.00 C	245.0 C	19.50 C	12.52 C	1.425 C
T_4= Yeast @ 3g/L under drought	27.52 B	250.0 B	20.52 B	13.65 B	1.572 B
T_5= Yeast @ 6g/L under drought	29.83 A	255.0 A	22.00 A	14.38 A	1.625 A
L.S.D	0.92	0.28	0.90	0.57	0.0115
ANOVA Summary	**	**	**	**	**

*Means sharing different letters differ significantly at p ≤ 0.05. Significant differences are indicated by an asterisk (*); *P ≤ 0.05, **P ≤ 0.01; ns: non-significant.*

Total free amino acids (mg g^{-1} D.W.)

Data are given in Table 3 shows a significant effect of amino acid and yeast application on total free amino acids of wheat. The maximum total amino acids (14.38 mg g^{-1} D.W.) were reported when applied yeast @ 6g L^{-1} under drought condition followed by (13.65 mg g^{-1} D.W.) when applied amino acid applied @ 3g L^{-1} under drought condition. The minimum total amino acids (8.25 mg g^{-1} D.W.) were observed in control.

Proline content (µg g^{-1} D.W.)

Data are given in Table 3, showing a significant effect of amino acid and yeast application on total free amino acids of wheat. The maximum proline content (1.625 µg g^{-1} D.W.) was reported in when applied yeast @ 6g L^{-1} under drought condition followed by (1.572 µg g^{-1} D.W.) when applied amino acid applied @ 3g L^{-1} under drought condition. The minimum proline content (1.152 µg g^{-1} D.W.) was observed in control.

Spike length of wheat adds remarkable contribution towards economical yield as it has a major influence on number of the grains/spike, number of the spikelets, and grain size. Extra spike length means a larger number of spikelets and ultimately more grains. Among the drought stress treatment greatest spike length was noted in T_5 (15.73cm). This promotive effect of amino acid application in wheat was also at par with the outcomes described by (Yongin *et al*., 2003; Al-Khateeb, 2006). The yeast had a positive effect on plant growth due to the creation of biologically active substances such as cytokinins, gibberellins, vitamins, and amino acids (Bahr and Gomaa, 2002).

The potential of wheat production is mostly dependent on number of the spikelets per spike. Number of the spikelets per spike of wheat includes an enormous share in the final economic yield as it has a significant effect on final crop yield. A greater number of the spikelets per spike mean the larger number of the grains and finally maximum yield. Among the drought stress treatments, the application of yeast gave the highest number of spikelets per spike (18.75). More photosynthetic pigments are mainly due to the role of amino acid in metabolical processes. The higher concentration of photosynthetic pigments (chlorophyll) improves the growth (cell division and enlargement) and the development of wheat plant which depicts more number of the spikelets per spike (Starck, 2007).

Amino acid application upgraded the quantity of the spikelets/spike. Wali-Asal (2010) found that foliar utilization of yeast has beneficial outcomes on the number of spikelets/spike and development characters of a wheat plant. Number of the grains/spike is the significant perspective that impacts grain yield. One of the key parts of wheat yield is the quantity of grains/spike which is unfavorably influenced by water shortage conditions. It was noticed that with the foliar utilization of amino acid and yeast under the dry spell, more number of grains/spike can be accomplished. A significant increase in grain/spike with foliar use of amino acid was likewise established on the wheat plant (Al-Khateeb, 2006). Wali-Asal (2010)shows that yeast impacts on development characters of wheat plants. The advancing impact of yeast was due to more addition of the biologically active substance by these bio-fertilizers, like Cytokinins, Gibberellins, Auxins, vitamins, and amino acids which increased the number of the grain/spike (Bahr and Gomaa, 2002).

1000-grain weight has a greater contribution to the final crop yield. 1000-grain weight shows the amount of the development of grain which is mainly an important parameter of grain quality and grain maturity in wheat crop and is concerned with the profitable yield of wheat. Among the drought stress treatments, the maximum of 1000-grain weight was recorded in T_5 (44.08g). The amino acid is a surely understood bio-stimulant that effects on plant development, yield, 1000-grain weight, and curtails the harmful effects brought about by water stress (Kowalczyk and Zielony, 2008). Saeed *et al.* (2005) found that treatments of amino acid mainly enhanced the1000-grain weight of wheat. Wanas (2002) concluded that yeast found to be positive in the formation of chlorophyll.

The grain yield is mainly the manipulating parameter of the wheat which is the ultimate consequence of the other fundamental parameters like spike length, number of the spikelets per spike, number of the grains per spike, and weight of grain. Maximum the yield contributing parameters the greater will be the final yield. It was noted that with the application of amino acid and yeast under water stress, better grain yield could be attained. The positive impact of amino acid includes the production of other natural compounds such as amines, purines, alkaloids pyrimidines, enzymes, vitamins, and terpenoids which enhance the photosynthesis by enhancing the grain yield (Hounsome *et al.*, 2008). Wanas (2002) observed that yeast improved the structure of the chlorophyll and grain yield. Saeed et al. (2005) argued that yeast extracts were found to increase the grain yield of wheat. Mohamed (2006) found that the application of combine, i.e. amino acid and yeast extract was to establish optimistic effects on plant reproductive growth which also affects grain yield.

Biological yield is a genetic character that is also controlled by the applied nutrients. It is also important attribute to calculate the final production. The maximum biological yield (16.16 tons) in the drought stress treatments was noted in T_5. The amino acid is the key chain in the structure of proteins and is involved in the development of plant growth and biological yield (Hounsome *et al.*, 2008). On the other hand, these units of amino acid have a major responsibility in a mixture of other metabolites in plants such as vitamins, enzymes, terpenoids alkaloids, etc. which improve the biological yield (Ibrahim *et al.*, 2010). Physiologically, amino acids have a constructive outcome on the development of plant and diminish the risks of ammonia harmfulness since amino acid is the wellspring of C and vitality (Abdel-Aziz *et al.*, 2010).

Under dry spell stress, it was noticed that the total phenols (TP), total amino acids (TAA) total soluble sugars (TSS), and total carbohydrate (TC) were fundamentally influenced. These all are very influential in drought tolerance of agricultural crops. Under dry spell stress treatment in T5 greatest total soluble sugars (29.83 mg g $^{-1}$ D.W.), total carbohydrate (255.0 mg g $^{-1}$ D.W.) total free amino acids (14.38 mg g $^{-1}$ D.W.) and total phenols (22.00 mg g $^{-1}$ D.W.) were recorded. The given outcomes demonstrated that foliar utilization of the amino acids and yeast increases in TSS, TC, TAA, and TP. Further, Hammad and El-Gamal (2004) found that the total phenols in pepper crops were uniquely expanded under dry season. It was additionally seen that under dry season proline content was likewise expanded when contrast with control treatment. Proline had positive affects in compensating the drought tolerances in crops. The highest proline content was recorded when the use of yeast (1.625 µg/g D.W.) was finished. Proline proceeds as an osmolyte and it additionally included corralling sub-cellular synthesis (for example proteins and membranes), rummaging the free radicals, and buffering cell redox potential submerged stress conditions (Iqbal, 2009).

Conclusions and Recommendations

Amino acids and yeast had positive effects on plant growth and yield as well as to ameliorate drought. Drought stress is a main abiotic stress that severely reduced crop yield. Foliar applied amino acids and yeast essentially improved development and yield of the wheat (*Triticum aestivum* L.) under dry season stress. Use of, amino acids and yeast is beneficial for increasing wheat yield under drought but yeast perform the best.

Novelty Statement

Wheat is a staple crop and cultivated around the globe. There is lot of studies about sole application of either amino acid or yeast on various crops but very rare combine application on wheat crop under drought conditions.

Author's Contribution

IH, MASR and RI: Conceived the idea, overall management of the article, Data collection, initiated, and finalized the paper.
SA, MUA, MI and UR: Provided technical input, supervised the research work, provided technical input at every step.
MS, NA, ZA, MA and SHA: Data entry in SPSS and analysis, technical input, write up of abstract, introduction, references.

Conflict of interest

The authors have declared no conflict of interest.

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