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Yield Optimization of Drought Stressed Wheat through Exogenous Application of Natural Plant Growth Regulators

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The study was conducted at the Arid Zone Research Center (AZRC) Dera Ismail Khan during the 2018-19 crop years on the exogenous application of plant extracts on wheat seed. The trial was laid down in randomized complete block design with three replications. The seven treatments comprised of T_1 (Control), T_2 (*Conocarpus lancifolius* Engl.), T_3 (*Acacia nilotica* L.), T_4 (*Moringa oleifera* Lam.), T_5 (*Dalbergia sissoo* Roxb.), T_6 (*Eucalyptus camaldulensis* Dehnh.), and T_7 (*Pongamia pinnata* L.) plant extracts applied for seed priming of wheat seed variety AZRIC- Dera Ismail Khan. All the physiological agronomic parameters depicted significant variation among the treatment means. The treatment T_4 (*Moringa oleifera* Lam.) and T_5 (*Delbergia sissoo* Roxb.) produced 7% and 3.56% higher yield than control (T_1) while these treatments gave (15.1%) higher yield than T_6 (*Eucalyptus camaldulensis* Dehnh.). Hence T_4 (*Moringa oleifera* Lam.) and T_5 (*Dalbergia sissoo* Roxb.) may be used as seed priming substances to enhance germination and attain higher yield. Therefore planting of T_4 (*Moringa oleifera* Lam.) and T_5 (*Dalbergia sissoo* Roxb.) should be encouraged for having stimulatory effect on wheat grain yield while planting of T_2 (*Conocarpus lancifolius* Engl.) and T_6 (*Eucalyptus camaldulensis* Dehnh.) should be avoid near the wheat growing field due to inhibitory effect on wheat growth and grain yield.

Keywords: Drought, Plant Growth Regulators, Wheat

INTRODUCTION

Wheat is the main food and feed source in the world; therefore, it has a great importance among other crops. Pakistan obtained 24.12 million tonnes of wheat from an area of 8.83 million hectares during rabi season 2018-19. The share of wheat crop in (GDP) of Pakistan is 1.7% and 1.7% to other agricultural commodities like hay and bakery products (Pakistan Economic Survey, 2017).

The record of wheat is as aged as the history of human being. Muslims believe that Adam (AS) was misguided by devil to eat this crop (wheat) in paradise. Though in Christianity they have believe that the plant was a tree of apple. Archaeologists say that in ancient time's human being were not so civilized and they collect food from surroundings. Some people believe that wheat is being cultivated since ten thousand BC years ago. They were of the view that it was cultivated in Indian sub-continent long ago, (Turkey, Iraq besides Egypt). Crossing of two genotypes of wheat (*Triticum spelta* L. and *Triticum dicoccum* sehubl.) resulted into the creation of today's cultivated wheat.

Wheat is Pakistani people's main food item. Several external factors can affect the germination, growth and grain production of wheat. One hindering of them is allelochemical released by some plants like (*Conocarpus lancifolius* Engl.), *(Eucalyptus camaldulensis* Dehnh.), (*Pongamia pinnata* L.) etc. Some trees grown along cropped areas release these (allelo) chemicals and reduce germination of the crops (Khan et al. 2012). Mortality of seedling and late germination results in lower yield and it is mainly due to these phyto-chemicals which negatively affect crops (Herro and Callaway, 2003).

Pakistan is going to plant 10 billion trees through Tsunami Project in KPK (Khan et al. 2019). Selection of trees that improve the germination and growth of wheat crop is necessary. Improving the productivity of wheat plant under various stresses through different plants leaves extracts will improve the germination, growth, development and finally the grain yield. The improved growth and development in early stages will result in higher yield of wheat. This will solve the problem of early and uniform germination and hence establishment of proper plant population per acre is very necessary for obtaining highest grain yield.

Moringa Leaf Extract (MLE) applied to wheat crops increased wheat leaf area and thus improved photosynthesis and yield and also reduced salinity effects (Yasmeen et al. 2013b). The negative effect of reacting oxygen can be neutralized by MLE. (Zhang and Ervin, 2004). This effect may be due to the presence of growth promoting substances like zeatin, purine, adenine and cytokinin (Makkar et al. 2007). Moring leaf extract application enhanced sorghum germination (Phiri, 2010) and its priming substantially improved sunflower (Basra et al. 2009) and maize (Iftikhar, 2009) germination and seedling growth. Therefore, the current research is proposed to evaluate the positive and negative response of wheat seed phyto-priming.

The aqueous extracts of eucalyptus have had a significant effect on wheat germination, seedling growth and economic production (Khan et al. 2009). *Dalbergia sissoo* Roxb. in fields may affect the germination and growth of agricultural crops through release of allelochemicals. (Akhtar et al.2010). Different concentrations of aqueous leaf extracts of eucalyptus, guava, and lichi were applied on the seeds of maize and wheat crop. All plant leaf extracts have been found to negatively affect seed germination, shooting and root development of corn and wheat (Khan et al. 2014). Two eucalyptus species (*Camal dulensis* and *globulus*) their fresh leaves water extracts was prepared and applied to the seed of four crops (haricot-bean, faba-bean, wheat and maize). All the four crop in the experiment were badly affected by the aqueous extract of two eucalyptus species (Wasihun Regu, 2018).

1. To estimate the influence of phyto-priming (seed priming on germination, growth and yield of wheat crop.

To select the best phyto-extract as priming source for commercial use.

MATERIALS AND METHODS

2.1 Place of work and facilities available

An exogenous application of different plants leaf extract was trailed to check the growth of wheat “Shahid 2017” variety at Arid Zone and Research Centre (PARC) D. I. Khan, KP Pakistan, in the Rabi season 2018-2019.

2.2 Plan of work and methodology adopted

Having three replications in the Randomized Complete Block Design (RCBD) the research was trialed. Each repeat was alienated into 7 sub-plots consisting of a net plot size 1.8 m × 5 m (9 m^2). Seed rate was 125 kg seed $ha^{-1}$and was sown by hand drill. All other management practices like fertilization, irrigation, insect pests control measures and other cultural practices were uniform. The leaves of all six trees were collected, extracted and then used for making aqueous solution. Extract of plant leaves was extracted through extractor Machine. The juice extractor is available at PARC-AZRC laboratory. These leaves extracts were used @ 5% solution (ratio between water and leaf extracts was 95 ml water and 5 ml leaf extracts and then seeds were primed for 36 hours). The seed and solution ratio had been limited to 1:5.

2.3. Treatments studied

G_1 Control / Tape water
G_2 *Conocarpus lancifolius*
G_3 *Acacia nilotica* (Kikar)
G_4 *Moringa oleifera* (Sohanjna)
G_5 *Dalbergia sissoo* (Shisham)
G_6 *Eucalyptus camaldulensis* (Sufaida)
G_7 *Pongamia pinnata* (Sukh chain)

2.4 Methods of data collection

Time start to emergence

Data concerning time to begin the seedling emergence from the soil surface were taken by counting the first seedling emergence from the sowing date.

Time consumed till 50% emergence

When 50% seedlings emerged out the soil in each plot, this time was worked out from time of sowing.

Mean emergence time

MET = Σ (nd)/n

Here nd is the total number of sprouted seeds in days and ∑n stands for number of total emerged (Ellis and Roberts, 1981).

Root length cm

Root measurement lengthwise of five chosen plants were measured after removing the soil through washing roots in water with great care to avoid any loss to roots**.**

Leaf area index LAI

The leaf area index was recorded as per formula at 30 and 60 days after sowing;

$$\text{Leaf area index (LAI)} = \frac{\text{Total leaf area}}{\text{Unit land area}}$$

Leaf area duration LAD

The (LAD) was noted by the method "multiplication of leaf area index (LAI) with total the number of weeks.

Crop growth rate g m^{-2} day^{-1}

It was estimated through dividing difference of final weight and initial weight by time interval as follows:

CGR = $\frac{W2-W1}{T2-T1} \times \frac{1}{GA}$

Here, GA = ground area, W1 = dry oven weight of plants (m^{-2}) noted at time t1, W2 = dry oven weight of plants (m^{-2}) noted at time t2, whereas t_1 and t_2 were the time intervals correspondingly and it is specified in units g m^{-2} day^{-1} (Rajput et al. 2017).

Plant height cm

The height of indiscriminately chosen 5 wheat plants was calculated in every sub-plot at the harvesting time.

Total numbers of tillers m^{-2}

One meter quadratic was used at two places selected randomly for counting total figure of tillers in each plot at the time period of harvest.

Grains $spike^{-1}$

To count the grains ($spike^{-1}$), five randomly selected spikes were used.

1000-seed weight g

Two samples were collected from each plot concerning 1000 grains to determine the weight of thousands of grains and the mean was deliberated on.

Grain yield kg ha^{-1}

Economic output was recorded from every sub plot by the following formula:

$$\left(\frac{seed\ yield\ (kg)}{plot\ size\ (m2)} \times 10000\right)$$

2.5 Sampling technique and procedure

Standard sampling technique were used for data collection. The procedure for data collection is described with each factor.

2.6 Research model /framework used

The (RCBD) was used as research model.

2.7 Statistical test used

The data was evaluated with the help of "Analysis of Variance Techniques" (Steel et al. 1997) and treatments were tested for likeness or differences among each other by $LSD_{0.05}$. Analysis was done through computer windows based software "Statistic version 8.1".

RESULTS AND DISCUSSION

Seedling establishment

Early speedy germination may be the result of plant growth hormones that accelerated the germination process. The data in (Table 1) showed that T_4 and T_5 taken minimum days to emergence while the T_6 and T_2 taken maximum days to emergence which may be due to inhibiting materials that prolonged the germination process. The findings given by Ashraf et al. (2008) are in agreement to our collection who stated that seed priming with moringa extracts accelerated the seed germination of wheat.

The information in (Table 1) with regard to times taken to 50% emergence showed significant variation among the means. The maximum days taken to 50% emergence (15.23, and 14.66) were observed in T_2 and T_6 followed by T_1, T_3, T_5, and T_7 by providing 13.04, 13.03, 12.50 and 13.04 days respectively. While the minimal time taken to 50% outgrowth (11.68 days) was noted in T_4. The minimum days taken by T_4 in 50% emergence may be due to some germination enhancing substances in the extracts of moringa. These collection are backed by the results obtained by Rehman et al. (2014) who concluded that moringa have taken minimum time to 50% emergence.

Mean outgrowth time is the sign of early and speedy germination either due to large seed reserves or stimulating substances present in the seed. The (Table 1) displayed the momentous variation among the primed seed treatments regarding mean germination time.

Table 1: Individual comparison of means of treatment for germination attributes

Plant growth promoters	Germination attributes		
	Time taking to initiate emergence in days	Time required to fifty percent emergence in days	Mean germination time(MET) in days
Control	10.00 ab	13.04 b	13.02 c
***Conocarpus lancifolius* Engl.**	10.66 a	15.23 a	15.42 a
***Acacia nilotica* L.**	9.33 bc	11.68 c	12.64 c
***Moringa oleifera* L.**	7.66 d	12.50 bc	11.93 c
***Dalbergia sissoo* Roxb.**	8.33 cd	14.66 a	12.62 c
Eucalyptus camaldulensis	10.66 ab	13.03 b	14.45 ab
***Pongamia pinnata* L.**	9.66 ab	13.04 b	13.07 bc
LSD value	**1.24**	**1.33**	**1.43**

The longest duration for emergence (15.42 and 14.45 days) noted in T_2 (15.42) and T_6 (14.45), followed by T_7 (13.07) which have taken 13.07 days. While all other treatments including control (T_1) took minimum (11.93 days) and at par days for emergence. The maximum days taken by T_2 and T_6 might be due to some inhibiting substances that slow down the development process. These outcomes are in statement with the finding of Iftikhar, (2009) who reason out that moringa leaf extract (MLE) improve the mean beginning time of wheat crop.

3.2 Growth contributing parameters

Plant tallness is the result of higher asexual development either by nutrients or hormones. The results of the primed seeds with plant extracts indicated significant difference among the treatment means (Table 2). The tallest wheat plant were observed in T_4 (110.29 cm) followed by T_5 (106.57 cm) and T_3 (104.19 cm) and T_1 (103.66 cm) which produced plants with heights of 106.57, 104.19, and 103.66 cm respectively. The smallest plants were (96.18 and 97.33 cm) were found in T_2 (96.18 cm) and T_6 (97.33 cm). The highest plants in T_4 (110.29 cm) might be due to the strong growth enhancing substances and some amount of macro and micro nutrients that boosted its vegetative growth. The findings of Culver et al. (2012) are in text with our results who also recorded taller plants when moringa solution was used.

The root length of primed seeds with various extract produced important variation among the treatment. The roots with peak length (22.33 and 21.66cm) were noted in T_4 (22.33cm) and T_5 (21.66cm) respectively, followed by T_3 (20.66cm) which produced the root length of 20.66 cm. The lowest root lengths of 19.0, 19.33 and 19.66 cm were measured in T_2, T_6 and T_7 respectively. The control treatment T_1 produced more root length (20.33cm) as compared to T_2, T_6 and T_7 indicating the negative effect of these treatments on the performance of roots length. Khan et al. (1999) too produced analogous results to our findings and stated that eucalyptus produced inhibiting effect on the growth of root length.

Greater the leaf area index is indication of higher vegetative growth and hence better photosynthesis process. The data presented in (Table 2) proved significant distance among the maximum leaf area index of 0.78, 0.75 and 0.73 was measured in T_4, T_5, and T_3 followed by T_1 (Control) that gave LAI of 0.70 while all other treatments produced higher LAI then control might be due to some growth promoting allele-chemical that accelerated the leaf growth resulting in lengthy and larger leaves with better light acceptance. The findings of Fuglie, (2000) confirm our results,who found large (LAI) when treated with (MLE) extract.

Leaf area duration show the active green leaves to prepare photosynthate for longer period (time) to produce more dry matter. The primed treatments presented in (Table 2) depicted significant variation among the treatment regarding LAD. The maximum LAD (8.65,8.28 and 8.10) found in treatments T_4, T_5 and T_3 (8.10) followed by control T_1 (7.70) which gave LAD of 7.70 while the lowest and at par LAD was noted in T_2 (4.03), T_6 (4.14) and T_7 (4.18) by producing LAD of 4.03, 4.14 and 4.18 respectively. The lower leaf area in treatments T_2, T_6 and T_7 than control indication the suppressing effect of these plant extract on LAD. Fuglie, (2000) also found similar results to our findings who declared that moringa leaf extract enhanced the LAD.

Higher crop growth rate (CGR) is clear proof of accelerated crop growth in a specified time. The data concerning to CGR given in (Table 2) displayed significant deviation among the treatment means. The maximal CGR (2.77 gm^{-2} day^{-1} was obtained in T_4 2.77 gm^{-2} day^{-1} followed by T_5 2.70 gm^{-2} day^{-1} which produced CGR of 2.70 gm^{-2} day^{-1}. The control treatment T_1 2.62 gm^{-2} day^{-1} and T_3 2.62 gm^{-2} day^{-1} produced CGR of 2.63 and 2.62 gm^{-2} day^{-1} while the maximum CGR of 2.03 and 2.07 gm^{-2} day^{-1} was recorded in T_2 2.03 gm^{-2} day^{-1} and T_6 2.07 gm^{-2} day^{-1}. The higher CGR as compared to control T_1 2.62 gm^{-2} day^{-1} might be the consequence of growth hormones present in the extract of these plants which have accelerated the vegetative growth of wheat in active growing period. Fuglie (2000) also found similar results that moringa leaf extracts increased the crop growth rate.

Table 2: Individual comparison of means of treatment for growth attributes

Plant growth promoters	Growth attributes				
	Plant height (cm)	Root length (cm)	Leaf area index (LAI)	Leaf area duration (LAD)	Crop growth rate (g m^{-2} day^{-1})
Control	103.66 bc	20.33 cd	0.70 b	7.70 b	2.62 c
***Conocarpus lancifolis* Engl.**	96.18 d	19.00 e	0.36 c	4.03 c	2.03 f
***Acacia nilotica* L.**	104.19 bc	20.66 bc	0.73 ab	8.10 ab	2.62 c
***Moringa oleifera* L.**	110.29 a	22.33 a	0.78 a	8.65 a	2.77 a
***Dalbergia sissoo* Roxb.**	106.57 b	21.66 ab	0.75 ab	8.28 ab	2.70 b
Eucalyptus Camaldulensis	97.33 d	19.33 de	0.37 c	4.14 c	2.07 e
***Pongamia pinnata* L.**	101.59 c	19.66 cde	0.38 c	4.18 c	2.12 d
LSD value	3.09	1.06	0.57	0.63	0.03

3.3. Yield and yield components

Data regarding number of tillers (m^{-2}) demonstrated important divergence among the treatments means (Table 3). The data means depicted that the highest number of tillers (321.33 m^{-2}) were counted in treatment T_4 followed by T_5 which produced 283 tillers (m^{-2}). The remaining all treatments include control (T_1) resulted the lowest and statistically at par tillers (m^{-2}). The higher tillers in T_4 (321.33 m^{-2}) might be due to abundant nutrients micro and macro along with growth promoting substances (zeatin and cytokinin) which have enhanced the amount of tillers (m^{-2}) in wheat crops. These outcomes are verified by the results obtained by Yang and Zhang, (2010). They concluded that (MLE) enhanced the total number of tillers.

Numbers of Grains spike^{-1} is an essential parameter for increasing grain yield. Data in Table 3 clearly showed significant deviation regarding number of grains per spike. The maximum grains spike^{-1} (49.33) were recorded in T_4 preceded by T_5, and T_3 which produced 47 and 45.67 grain spike^{-1} respectively. Next to their T_1 (44 spike^{-1}) and T_7 (43.33 spike^{-1}) produced 44 and 43.33 Grain spike^{-1}, while the least number of grains spike^{-1} 38.66 and 39.66 were counted in T_2 (38.66 spike^{-1}) and T_6 (39.66 spike^{-1}). The move number of grains spike^{-1} then control T_1 (44 spike^{-1}) may be the result of growth hormones and some nutrients that increased the numbers of grains spike^{-1}. These outcomes are endorsed by the finding of Taiz and Zeiger, (2006) who also found higher numbers of grains spike^{-1} when treated with moringa.

The heavier grain is the net result of photosynthetic efficiency along with more availability of growth nutrients. The data regarding 1000-seed weight presented in (Table 3), indicated significant difference regarding treatment means. The maximum 1000-seed weight (48.63 and 47.11 g) was noted in T_4 (48.63 g), T_5 (47.11 g) followed by control T_1 (44.55 g) which gave 1000- seed weight of (44.56 g). The lowest 1000 grain weight of 38.44 and 39.63 g was produced by T_2 (38.43 g) and T_6 (39.63 g). The heavier 1000-seed weight than control T_1 (44.55 g) might be due to better photosynthetic efficiency of plants treatment with extracts of these plants. These outcomes are backed up by the collection of Taiz and Zeiger, (2006) who also recorded supreme 1000-seed weight when moringa was applied.

The supreme goals of any investigation project are to increase economic or grain production for better financial returns. The grain yield as stricken by seed priming of wheat with different plant extracts showed clear and prominent variation (Table 3) The peak grains yield (4506.0) was found by T_4 followed by T_5 (4348.7) T_2 (3717.3) and T_5 (4348.7) which gave 4348.7, 4224.7 and 4190.0 grain yield kg ha^{-1}. Next of this T_7 (3924.3) produced 3942.3) while the lowest grain yield of 3717.3 was recorded in T_2 (3717.3). The higher grains yield than control might due to growth promoting allelochemical along with macro and micro nutrients which accelerated the movement of photosynthates from leaves and stem to the grain and enhanced the tillers (m^{-2}), spikelets per spike numbers of grains and 1000 grain weight accordingly, while the grains yield lower them control treatment (T_1) depicted some suppressing effect of allelochemical present in their extracts that reduced the growth parameters and finally the grain output. These findings are in correspondence with those of Rehman et al. (2017) who recorded higher grain output when treated with plant extracts of moringa.

Table 3: Individual comparison of means of treatment for yield attributes

Plant growth promoters	Growth attributes			
	Total number of tillers (m^{-2})	**Grains (spike^{-1})**	**1000-seed weight (g)**	**Grain yield (kg ha^{-1})**
Control	227.67 c	44 cd	44.55 c	4194.0 c
***Conocarpus lancifolius* Engl.**	200.67 c	38.66 e	38.43 e	3717.3 f
***Acacia nilotica* L.**	230 c	45.66 bc	45.70 bc	4224.7 c
***Moringa oleifera* L.**	321.33 a	49.33 a	48.63 a	4506.0 a
***Dalbergia sissoo* Roxb.**	283 b	47 b	47.11 ab	4348.7 b
Eucalyptus camaldulensis	210 c	39.66 e	39.63 e	3823.7 e
***Pongamia pinnata* L.**	211 c	43.33 d	41.81 d	3924.3 d
LSD value	**3.48**	**2.16**	**1.53**	

CONCLUSION

In this study it is concluded that Moringa (*Moringa oleifera)* and Shesham (*Dalbergia sissoo*) may be used as seed priming to enhance germination and attain higher yield under drought stressed conditions. These may also use as agro-forestry model. However, planting of Cono (*Conocarpus lancifolius*) and Sufaida (*Eucalyptus camaldulensis* Dehnh.) should be avoid near the wheat growing field due to inhibitory effect on wheat growth and grain yield.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

Sami Ullah and Iqtidar Hussain conducted this research trial. Asma Hanif, Adila Irum and Ayesha Malik wrote this paper. Naila Sarwar, Ayesha Irum and Waqar Elahi analyze the data. Zahida Parveen and Sami Ullah set the references. All authors read and approved the final version.

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