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Research Article

Effect of phosphorus, sulphur and different irrigation levels on phenological traits of Triticale

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Abstract

This field experiment was conducted at Agronomy Research Farm, The University of Agriculture Peshawar during rabi season 2013-2014 to study the response of triticale to phosphorus (P), sulphur (S) and different irrigation (I) levels. The experiment was comparised on randomized complete block (RCB) design with split plot arrangement having three replications. A sub plot size of 5.4 m^2 having six rows of 3 m in length was used. Irrigation numbers (I1 (seedling), I_2 (seedling + tillering), I_3 (seedling + tillering + booting)) were applied to the main plot while phosphorus (60, 90 and 120 kg ha^{-1}) and sulphur (10, 20 and 30 kg ha^{-1}) were applied in combination at sub plot while one control having no P and S application. All of the phosphorus and sulphur were applied at sowing time. The result of this study revealed that more days to anthesis (125) were produced by irrigation applied two times (I_2 = seedling + tillering), more days to physiological maturity (167), and harvest index (32 %) were recorded by irrigation applied one time (I_1 = seedling) while higher plant height (114 cm) and leaf area (21 cm^2) were recorded by irrigation applied three times (I_3 = seedling + tillering + booting). Plots that are treated with phosphorus @ 90 kg ha^{-1} produced more days to anthesis (126), plant height (114 cm) and leaf area cm^2 (21) while more days to physiological maturity (167) was formed by 60 kg P ha^{-1}. Sulphur applied to the plots @ 20 kg ha^{-1} produced higher days to anthesis (126) . It can be concluded from this study that better physiological traits were produced from irrigation applied two times (I_2 = seedling + tillering) in grouping with 90 kg P ha^{-1} and 20 kg S ha^{-1}.

Key words: Triticale (*Triticosecale wittmack)*; Phosphorus; Sulphur; Irrigation number; Phenological traits

Introduction

Triticale, botanically known as *Triticosecale wittmack* belongs to family poaceae and tribe Hordeae. It is relatively a new cereal crop which is a product of crosses between the genera Tritico of which wheat is member and secale of which rye is the member, gaining half of its name from each genus. Triticale is the "man-made" cereal crop. Triticale has been evolved by breeders where kernal are comparatively large and they contain higher content of Lysin (18% of N) and protein (14.7%) than wheat, maize, millet and sorghum **[1].** Triticale is a crop of great importance for making not only bread but also other food products, such as pastas, breakfast cereals, etc. **[2].** In Pakistan when semi dwarf, high yielding wheat was introduced, the national average yield was nearly doubled (1563 kg ha^{-1}) though it is still lower than the major wheat growing countries of the world like France and Mexico. In world Poland produce triticale on large area of 1,258,700 ha while Mexico grow it on 723 ha area having lowest area for the cultivation of triticale in the world **[3].**

Irrigation is needed in many areas of the country for good crop growth and proper grain development as rainfall is inadequate and erotic throughout the country. Water, the most essential but costly input, plays a key role in growth and productivity of all plants, if applied judiciously. Some crops need more water than others but every crop has its own water requirement. So it is important to irrigate the crops as per their needs because too much or too little water can limit the plant growth.

The advantages of Triticale were particularly observable in the Mediterranean environment where yield and biomass were recorded almost twice as compared to wheat, associated with similar magnitude differences in Radiation use efficiency **[4].**

Pakistan is very low in yield of various cereals as compared to other developed countries. Many factors are responsible for the decline in yield. One of the important factor limiting yield is plant nutrition. Triticale varieties were more response to phosphorus application with the grain yield in some genotypes were three times higher in 80 kg phosphorus treatments **[5].** As P is an expensive nutrient compared to N, and wheat while grown on alkaline calcareous soils commonly suffers from P deficiency. It is, therefore, very important to manage it properly to achieve higher benefits **[6].** P reduces lodging by strengthening the straw in cereals and also enhances the resistance of crop to various diseases. It plays a vital role in growth of a plant, division of cell and formation of nucleus. P is also accountable for the development of RNA and DNA which transmit heredity materials.

Sulphur (S) is a necessary plant nutrient as it plays a key role in plant metabolism. The deficiency of S has been extensive in agricultural soil of most European countries in the past few years. The major reasons for S deficiency are reductions in SO_2 emission, use of fertilizers containing less sulphur content, the less return of sulphur with FY manure and less use of fungicides that contain sulphur content **[7, 8, 9].**

Although there is less literature available on combined uses of irrigation, phosphorus and sulphur for triticale production, this study was designed to verify the effect of irrigation, phosphorus and sulphur on the phenological traits of triticale in Khyber Pakhtunkhwa.

Materials and methods

An experiment entitled "Effect of phosphorus, sulphur and different irrigation levels on phenological traits of triticale" was conducted at Agronomy Research Farm, The University of Agriculture, Peshawar, Pakistan during rabi season 2013-14. The experiment was laid out in Randomized Complete Block Design with split plot arrangement having three replications. The size of subplot was 3 x 1.8 m^2. Row to row distance was 30 cm having six rows. Irrigation numbers were allotted to main plot (Factor A) while phosphorus and sulphur were applied in combination to subplots (Factor B). Phosphorus in the form of SSP in various levels (60, 90, 120 kg ha^{-1}) was applied which contains 18% P_2O_5 and 12%

sulphur. Sulphur was applied in the form of ammonium sulphate in various levels (10, 20, 30 kg ha^{-1}) at the time of sowing. Sulphur applied from ammonium sulphate was subtracted from the SSP source. pH of the soil was 7.6 - 7.7. Nitrogen was applied at its recommended rate of 120 kg ha^{-1} in the form of urea. All other agronomic practices were remained uniform for all the treatments. Data concerning days taken by triticale from sowing till emergence were taken by counting down the days from sowing till 50% plants emerge in each plot. By counting the total days from date of sowing till the date when 75 % anthesis occurred, days to anthesis was calculated. Days to physiological maturity was recorded by counting the days from date of sowing to the date when 75 % plants become physiologically mature. Entire loss of the green color from the glumes and maximum dry weight accumulation (when no more photosynthates were going to the grain) considered as indication of physiological maturity. By measuring leaf length, width and known correction factor multiplication, the mean leaf area was calculated. Harvest index can be calculated simply by economical yield divided by biological yield and multiplied with 100. Data was statistically analyzed according to the procedure described by Steel et al. (1996) **[10]** for randomized complete block design and means were separated by least significant differences test ($P < 0.05$) upon significant F test. Fig. 1. Presented the data concerning mean monthly rainfall, temperature and humidity recorded during the crop growth period.

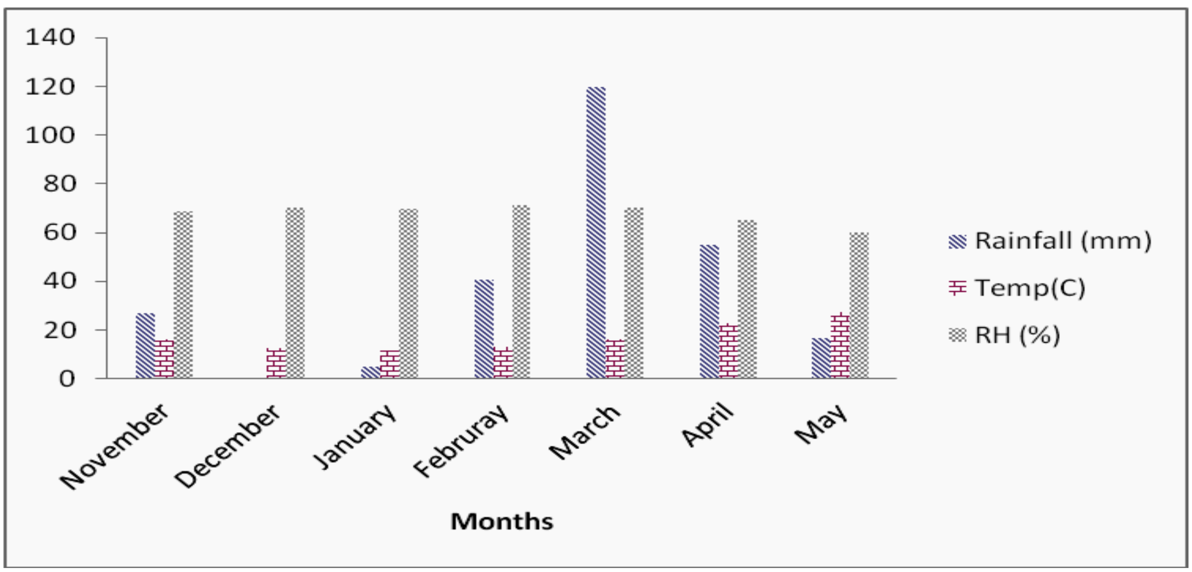

Figure 1. Annual rainfall (mm), temperature (C^0) and relative humidity (%) during rabi 2013-2014

Results and discussion

Days to emergence

Data regarding days to emergence are presenting in Table 1. The data revealed that irrigation number, phosphorus and sulphur levels and their interactions had non-significant effect on days to emergence. Data concerning days to emergence of triticale showed that phosphorus, sulphur and irrigation numbers had non-significant affect. This might be due to the seed which used stored food during germination and did not be depended on external minerals (nutrients/ fertilizers) for germination. There are more other reasons for showing no significant impact that there no effect of fertilizers in the early growth stages where plants ready to emerge. These results are in procession with [11] who stated that there is no effect of fertilizer on emergence.

Days to anthesis

Perusal of the data revealed significant impact of irrigation numbers, phosphorus, sulphur levels and control vs. rest comparison on days to anthesis. Interactions between I x control vs. rest and I x P showed significant influence on days to anthesis (Table 1). Mean comparison of the data showed that two irrigations (I_2 = seedling + tillering stage) took higher (125) days to anthesis which was same with irrigation applied three times (I_3 = seedling + tillering + booting stage) and statistically different from one time irrigation applied (seedling (I_1) stage). Control plots took less (121) days to anthesis. Phosphorus levels showed significant effect on days to anthesis. Phosphorus level of 90 kg ha^{-1} resulted in higher (126) days to anthesis. Different sulphur levels also showed positive response in term of days to anthesis. Sulphur used at the rate of 20 kg ha^{-1} took higher (126) days to anthesis whereas control plots took (121) days to anthesis. In case of interaction between irrigation and phosphorus, days to anthesis appreciably increased at all irrigations levels with rising phosphorus up to 90 kg ha^{-1}. Irrigation, phosphorus, sulphur, control vs. rest comparison, I x control vs. rest and I x P interactions considerably ($P \leq 0.05$) influenced days to anthesis. Irrigation at seedling stage took less days to anthesis as compared to other levels of irrigation which took higher days to anthesis. This might be due to more growth and longer time to produce flower. These results are different from the findings of Ngwako and Mashiqa (2013) [12] who stated that days taken to anthesis were not significantly influenced by irrigation numbers. With increasing P levels days to anthesis were decreased. Phosphorus applied at 90 kg ha^{-1} took higher days to anthesis while untreated plots took less (121) days to anthesis. These results are in line with [13] who reported that optimum amount of phosphorus reduced days taken to anthesis. Sulphur application at 20 kg ha^{-1} took higher days to anthesis. This might be due to the fertilizer application with delayed days to anthesis. These results are different from the results of [14] who reported that there was effect of fertilizer on days to anthesis.

Days to physiological maturity

Statistically analyzed data showed significant impact of irrigation numbers, phosphorus and control vs. rest comparison on days to physiological maturity. Every interaction was non-significant except I x control vs. rest and I x P. Mean comparison of the data showed that irrigation applied one time at (I_1 = seedling stage) took higher (167) days to physiological maturity. Phosphorus levels indicated considerable result on days to physiological maturity. Phosphorus level of 60 kg ha^{-1} resulted in higher (167) days to physiological maturity which is statistically at par with phosphorus level at the rate of 90 kg ha^{-1} and with phosphorus level 120 kg ha^{-1}. Higher (171) days to physiological maturity was counted in control plots as compared to the rest of other plots which took minimum (166) days to physiological maturity. Regarding interactive effect of irrigation and phosphorus, days to physiological maturity, significantly increased at all irrigation numbers with escalating P up to 60 kg ha^{-1}. Irrigation, phosphorus, control vs. rest comparison, I x control vs. rest and I x P interactions considerably ($P \leq 0.05$) inclined days to physiological maturity. Irrigation at seedling stage took higher days to physiological maturity. These results are same with the finding of Ngwako and

Mashiqa (2009) **[12]** who stated that days taken to maturity were significantly influenced by irrigation stages. With increasing P levels days to maturity were decreased. Phosphorus applied at 60 kg ha^{-1} took higher days to maturity. These results are in line with **[13]** who reported that optimum amount of phosphorus minimize days to maturity.

Plant height

Statistically analyzed the data revealed significant impact of irrigation numbers, phosphorus and control vs. rest comparison on plant height. All interactions showed non-significant effect except I x control vs. rest and I x S. Mean comparison of the data showed that three irrigations numbers (I_3 = seedling + tillering + booting stage) produced taller plants (114 cm). Phosphorus levels showed significant impact on plant height. Phosphorus applied at the rate of 90 kg ha^{-1} resulted taller plants (114 cm) whereas control plots resulted lower plant height (96 cm). Interaction between irrigation and sulphur, plant height significantly increased with increasing irrigation up to third irrigation (I_3 = seedling + tillering + booting stage) at all sulphur levels. Irrigation, phosphorus and control vs. rest comparison, I x control vs. rest and I x S interactions considerably ($P \leq 0.05$) influenced plant height. Irrigation at seedling + tillering+ booting stage produced taller plants. This might be due to sufficient availability of nutrients having no moisture stress. These results are also same with **[15]** who reported that irrigation treatments significantly affected plant height. Increasing P levels considerably increased plant height. Phosphorus applied at the rate of 90 kg ha^{-1} produced optimum plant height. These results showed conformity with the findings of **[16]** who reported that rising P rate up to a certain limit increase plant height.

Leaf area

Data concerning leaf area cm^2 as exaggerated by phosphorus, sulphur and different irrigation levels (Table 1). Statistically analyzed data showed significant impact of irrigation number, phosphorus and control vs. rest comparison on leaf area cm^2 while sulphur levels showed non-significant effect on leaf area cm^2. All interactions were also significant impact on leaf area cm^2. Three irrigations (I_3 = seedling + tillering + booting stage) produced higher (21 cm^2) leaf area cm^2 which was higher than control plots (17 cm^2). Phosphorus levels showed significant effect on leaf area cm^2. Level of 90 kg P ha^{-1} produced privileged (21 cm^2) leaf area while control resulted in minimum (17 cm^2) leaf area. In case of interactions between phosphorus and sulphur, leaf area cm^2 significantly increased with increasing P rates up to 60 kg ha^{-1} and sulphur rates up to 30 kg ha^{-1} and then decrease respectively at 90 kg ha^{-1} and 120 kg ha^{-1}. Interaction between irrigation and phosphorus resulted that improved leaf area at all irrigations levels by rising P rates up to 120 kg ha^{-1}. The interaction between irrigation and sulphur revealed that leaf area cm^2 drastically improved with increasing irrigation levels up to three irrigations (seedling + tillering+ booting stage) at 20 kg S ha^{-1} and then decreased at 30 kg S ha^{-1}. Irrigation, phosphorus and control vs. rest comparison, P x S, I x control vs. rest, I x P, I x S and I x P x S interactions considerably ($P \leq 0.05$) influenced leaf area (cm^2). Irrigation at (I_3=seedling + tillering + booting stage) recorded higher leaf area cm^2. These results are same to **[17]** who stated that higher irrigation produced higher leaf area cm^2. Phosphorus application considerably affected leaf area m^2. Phosphorus applied at 90 kg ha^{-1} produced optimum leaf area (cm^2) and minimum leaf area (cm^2) was produced by control plots.

These consequences are in concurrence with [16] who reported that P deficit decrease leaf area which in turn gives us smaller leaves.

Harvest index (%)

Analysis of the data confirmed that irrigation levels and control vs. rest noticeably affected harvest index. All interactions showed significant effect on harvest index. Irrigation applied one time (seedling stage) maintained greater harvest index (32%) while control plots showed minimum (29 %) harvest index. Interaction between phosphorus and sulphur the harvest index improved up to 90 kg P ha^{-1} and 30 kg S ha^{-1} and then tends to decreased at 120 kg P ha^{-1}. The interaction between irrigation and phosphorus, the harvest index increased at seedling stage at all phosphorus levels and then decreases as irrigation level increases. The interaction between irrigation and sulphur the harvest index decreased at 30 kg sulphur ha^{-1} at all irrigation levels. Irrigation, control vs. rest, I x control vs. rest, P x S and I x P, I x S and I x P x S interactions considerably ($P \leq 0.05$) affected harvest index. Irrigation at seedling stage produced higher harvest index % as compared with control plots which gave the lowest harvest index. These results are diverse from the results of [18] who stated that more irrigation applied produced higher harvest index.

Table 1. Days to emergence (DTE), anthesis (DTA), physiological maturity (PM), plant height (cm), leaf area (cm^2) and harvest index (%) of triticale as affected by phosphorus, sulphur and different irrigation levels.

Treatment	DTE	DTA	DTPM	Plant height	Leaf area	Harvest Index%
Irrigation nos						
I_1	11	123b	167a	111b	19c	32
I_2	11	125a	166b	113a	20b	31
I_3	11	125a	165c	114a	21a	29
LSD (0.05)	ns	1	1	2	0.5	1
Phosphorus (kg ha^{-1})						
60	12	125b	167a	113ab	20b	31
90	11	126a	167a	114a	21a	31
120	11	124c	164b	111b	20b	31
LSD (0.05)	ns	0.95	0.78	3	0.7	ns
Sulphur (kg ha^{-1})						
10	11	124b	165	113	20	31
20	11	126a	166	112	20	30
30	12	124a	166	112	20	31
LSD (0.05)	ns	0.95	ns	ns	ns	ns
Control	**12**	**121**	**171**	**96**	**17**	**29**
Interaction						
P x S	ns	ns	ns	ns	*	*
I x P	ns	*	*	ns	*	*
I x S	ns	ns	ns	*	*	*
I x P x S	ns	ns	ns	ns	*	*

Conclusion and recommendation

It was concluded that irrigation applied three times delayed anthesis, physiological maturity, plant height and leaf area. P applied at the rate of 90 kg ha^{-1} delayed anthesis, maturity, plant height and leaf area. Sulphur applied at the rate of 20 kg ha^{-1} dealyed anthesis in triticale. Therefore, it is recommended that irrigations applied two times in combination with phosphorus 90 kg ha^{-1} and Sulphur 20 kg ha^{-1} for better phonological traits of triticale.

Authors' contributions

Conceived and designed the experiments: B Iqbal, B Ahmad & Inamullah, Performed the experiments: B Iqbal, Imran, K Shahzad & S KhanAnalyzed the data: B Iqbal, Inamullah & AA Khan, Contributed reagents/ materials/ analysis tools: AA Khan, S Anwar & A Ali, Wrote the paper: B Iqbal.

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