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Effect of incremental dose of phosphorous and sulphur upon yield and protein content of wheat

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Abstract

In the current era of bombing population of the world staple food is the requirement; however, in the advanced countries yield is though a prime objective but quality is also a dire need. Studying the effect of different levels of Phosphorous and Sulphur on grain yield and protein content of wheat, a randomized complete block design with split plot arrangements were conducted at New Developmental Farm (NDF) of Khyber Pakhtunkhwa Agricultural University, Peshawar, Pakistan, during Rabi 2010-11 following four replications. Phosphorus (0, 30, 60 and 90 kg ha^{-1}) was used as main plot and Sulphur (0, 10, 20 and 30 kg ha^{-1}) as subplot factor. A subplot size of 1.8×4 m having six rows, 30 cm apart and 4 m long was used. Wheat cultivated variety Saleem-2000 was sown at the rate of 120 kg ha^{-1}. Half of the N fertilizer was applied as basal dose in the form of urea and the remaining half was applied with first irrigation after three weeks of sowing. Ammonium Sulphate was used as source of Sulphur (S) and single super phosphate (SSP) as a source of Phosphorous (P). Data were recorded on various quantitative and quality parameters of which yield was of prime importance. Spikes m^{-2} increased with increase in Phosphorous application rate. Grains $spike^{-1}$ increased to 48 with increased Phosphorous level (90 kg ha^{-1}). Thousand grain weight, grain and biological yield of wheat increased significantly with increase in both "P" and "S" levels, however, the interaction of P×S showed no significant effect on them. Higher 1000-grains weight (46.2 g), grain yield (4263 kg ha^{-1}) and biological yield (8334 kg ha^{-1}) were obtained at "P" treatment of 90 kg ha^{-1} as compared to 42.6 g, 3329 kg ha^{-1} and 7303 kg ha^{-1}, respectively, in plots where "P" was not applied. Similarly higher 1000-grain weight (44.78 g), grain yield (4070 kg ha^{-1}) and biological yield (8075 kg ha^{-1}) were recorded at 30 kg ha^{-1} "S" as compared with 43.98 g, 3624 kg ha^{-1} and 7544 kg ha^{-1}, respectively, in plots where "S" was not applied. Similarly, protein content increased to 9.9% by increasing the level of "S" to 30 kg ha^{-1} as compared with 9.2% in plots where "S" was not applied. It was concluded that "P" and "S" affected grain and biological yield significantly and thus "P" and "S" at the rates of 90 and 30 kg ha^{-1}, respectively, are recommended for higher yield in wheat. This study revealed that the current findings might be applicable to wheat crop around the world for enhancing yield and protein quality.

Key words: Wheat, *Triticum aestivum*, Phosphorus, Sulphur, Protein.

1. Introduction

Wheat (*Triticum aestivum* L.) is the basic component of human diet around the world especially in advanced and under developed countries such as Indo-Pakistan. It plays an important role in the national economy. Decrease in wheat production severely affects the economy of Pakistan and adds into the miseries of people, as the agricultural set-up of this particular country is not yet stabilized. Average yield of wheat in Pakistan has never crossed 30-35% of its yield potential; produced under experimental conditions under diversified climatic conditions (Iqbal *et al.,* 2005). According to statistical data of Pakistan, wheat is being cultivated on 37% cropped area of the country in which the contribution of Punjab is 77%, Sindh 11%, Khyber Pakhtunkhwa (KP) 9% and Baluchistan is 4% (MINFAL, 2010). The prosperity of Pakistan depends directly or indirectly on the proper wheat husbandry as more than 60% people are involved with this major crop. During 2009-10, wheat was cultivated on an area of 9.09 mha with production of 24.03 mtons having an average yield of 2657 kg ha^{-1} in irrigated areas and 1565 kg ha^{-1} in rainfed areas (MINFAL, 2010).

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Wheat being the staple food occupies about 37% of the cropped area and consumes 45% of the total fertilizer used in the country. However, the yield remained stagnant for the last many years (Twyford, 1994). Land used for crop production in Pakistan is approximately 22 mha that is mostly calcareous in nature. About 90% soils are deficient in Nitrogen (N) and Phosphorus (P), and 40% in Potassium (K) (Ahmad & Rashid, 2004). Among the factors that influence wheat yield, fertilizers play an important role. Application of phosphatic fertilizer in balanced proportion at proper time and method of application had a great impact on crop yield (Alam *et al.*, 2002; Nisar *et al.,* 1992). However, plant species and even varieties within species vary in their behavior to acquire and utilize "P" for grain production. This property of wheat cultivars grown in Pakistan has not been fully explored. In a solution culture study, some wheat varieties were found to be differ in "P" acquisition (Gill *et al.*, 1994). Similarly in another field study, differences in "P" utilization efficiency among wheat varieties were reported (Covacevich *et al.,* 2007). Comparison of wheat varieties to fertigation applied "P" sources showed some variation among varieties for yield and "P" efficiency (Alam *et al.,* 2002). The soils of Pakistan having calcareous alkaline nature are generally deficient in "P", although Ullah *et al*., (2011a) reported that importance should be given to complete soil analyses prior carrying out any experiment in Pakistani soils.

Crop species and varieties vary in their "S" requirements. "S" content in plant tissues normally varies from 0.2–0.5%. A Sulphur level of 0.15% and a N:S ratio of 15 in mature wheat tissues are considered critical. However, the "S" requirements of leguminous crops are greater, with critical value of 0.16–0.20% "S", and a N:S ratio of 17 in whole plants at the early bloom stage (Westermann, 1975).

Keeping in view the significant role of "P" and "S" in crop production systems, this research study was designed to find out the effect of different levels of "P" and "S" on wheat productivity in Pakistan and to address these findings to world wheat researchers.

2. Materials and methods

To study the effect of various Phosphorous and Sulphur levels on yield and quality of wheat, an experiment was conducted at New Developmental Farm of KP Agricultural University Peshawar, Pakistan, during winter 2010-11. The experiment was conducted in a randomized fashion with split plot arrangement having four replications. Phosphorus was applied to the main plot and Sulphur to the subplot. A subplot size of 1.8×4 m having six rows, 30 cm apart and 4 m long was used. Cultivated wheat variety of Saleem-2000 was sown at a uniform seed rate of 120 kg ha^{-1} in the experiment as recommended for most of the Pakistani soils. Before sowing the experiment, germination test was carried in laboratory in petri dish to check the proper viability of the seed. The seed was found to have 98% germination. Four treatments of Phosphorus (i.e. 0, 30, 60 and 90 kg ha^{-1}) in main plots and four treatments of Sulphur (i.e. 0, 10, 20 and 30 kg ha^{-1}) in subplots were used. Half of the "N" fertilizer was applied as basal dose at the rate of 120 kg ha^{-1}, in the form of urea and the remaining half was applied with first irrigation after three weeks of sowing. Ammonium sulphate was used as a source of "S" and SSP was used as a source of "P". All agronomic practices were applied uniformly required for the healthy wheat crop.

Data collection procedure

Number of spikes in one meter row at three randomly selected patches in each subplot were counted at physiological maturity and converted the same into spikes m^{-2}. The number of grains $spike^{-1}$ was recorded by randomly selecting five spikes in each subplot. The spikes were threshed; number of grains in each spike was then counted and the average was worked out. A random sample of thousand grains was taken and weighed by sensitive electronic balance to record 1000-grain weight. Grain yield was recorded by harvesting four central rows in each subplot, threshed, cleaned and weighed. The data thus recorded for grain yield in each subplot was converted to kg ha^{-1} by using the following formula:

Grain yield (kg ha^{-1}) = {Grain yield (kg) ÷ Area harvested (1.2×4 m)} ×10,000

For biological yield**,** four central rows of each subplot were harvested at field maturity. The whole materials were sun dried for five consecutive days and then weighed. Yield thus obtained was converted into (kg ha^{-1}) by using following formula:

Biological yield (kg ha^{-1}) = {Biological yield (kg) ÷ Area harvested (1.2×4 m)} ×10,000

Harvest index for each treatment was calculated by using the following formula:

Harvest index (%) = {Grain yield ÷ Biological yield}×100

Protein content was determined by using Kjeldahl distillation method. This method involves the process of digestion, distillation and titration.

The data recorded were analyzed statistically using M Stat-C according to the procedure relevant to randomized complete block design with split plot arrangement. Least significant difference was used for mean comparison in case of significant differences (Steel *et al*., 1997).

3. Results and discussion

Spikes m^{-2}

Data regarding spikes m^{-2} of wheat as affected by various "P" and "S" levels are given in Table I. The data showed that "P" significantly affected the number of spikes m^{-2}. Maximum and at par number of 270.3, 263.5 and 262.0 spikes m^{-2} were recorded in plots that received "P" @ of 90, 60 and 30 kg ha^{-1} while the smallest number of spikes m^{-2} (252) were recorded in plots where "P" was not applied. Nazim *et al.* (2008) reported increase in number of spikes m^{-2} in wheat due to increase in "P" level. Azimzadeh and Koocheki (1999) were of the view that higher rates of "P" influentially raised total tillers as well as spikes m^{-2} in wheat. Various "S" levels showed no effect on spikes m^{-2} of wheat. However, plots which received the highest amount of "S" (30 kg ha^{-1}) produced the maximum number of 267.3 spikes as against the lowest number of 257.8 spikes m^{-2} in plots which received zero level of "S". Siaudinis and Lazauskas (2005) reported non-significant increase in spikes m^{-2} due to increase in "S" level in wheat. However, the interaction of P×S had no effect on number of spikes m^{-2} of wheat.

Grains spike^{-1}

Data regarding number of grains spike^{-1} of wheat as affected by various Phosphorus and Sulphur treatments are shown in Table I. Having look to the data in the table that "P" affected the number of grains spike^{-1} significantly. Maximum and significantly higher number of grains spike^{-1} (48) was recorded in plots that received "P" at the highest rate of 90 kg ha^{-1}. Number of grains spike^{-1} decreased gradually and significantly with gradual decrease in "P" level recorded the smallest number of 41.5 grains spike^{-1} in plots where "P" was not applied. Pervez *et al.* (2008) documented increase in number of grains spike^{-1} due to increase in "P" dosage. As stated earlier for spikes m^{-2} the various levels of "S" showed no effect on number of grains spike^{-1} of wheat. However, plots which received the highest amount of 30 kg ha^{-1} "S" produced the highest number of 45 grains spike^{-1} as against 24.5 grains spike^{-1} produced in plots which received no or low "S" (10 kg ha^{-1}). The interaction effect of P×S had no relevancy with the number of grains spike^{-1} of wheat.

Thousand-grain weight

Data regarding 1000-grain weight of wheat as affected by various levels of "P" and "S" are shown in Table I. Statistical analyses of the data showed that various "P" levels affected 1000-grain weight significantly. Maximum 1000-grain weight of 46.22g was produced in plots had "P" level of 90kg ha^{-1}. The 1000-grain weight decreased gradually and significantly to 22.6 g with gradual decrease in "P" level that was produced in plots with no "P" application. Pervez *et al.* (2008) and Shahzada *et al.* (2007) documented increase in 1000-grain weight of wheat with increase in "P" levels. These findings are also in agreement with Azimzadeh and Koocheki (1999) where they reported the increase in biological and straw yield plus grain yield with increased levels of Phosphorus. Meanwhile, they also noted that increasing the "P" rate from 0 to 160 kg ha^{-1} reduced thousand kernel weights. Regardless of the above statement the various levels of "S" also affected 1000-grain weight significantly. Maximum and significantly higher 1000-grain weight of 44.7g was produced in plots which received the highest level of "S" (30kg ha^{-1}). The plots which received "S" at the rate of 0, 10 and 20 kg ha^{-1}, produced least and statistically at par 1000-grain weight of 43.98, 43.99 and 44.14g, respectively. The interaction of P×S had no significant effect on 1000-grain weight of wheat. However, Ullah *et al.* (2011a) reported a significant interaction of G×E for 1000-grain weight in legumes.

Grain yield

Data regarding grain yield (kg ha^{-1}) of wheat as affected by various "P" and "S" levels are shown in Table II. Statistical analysis of the data showed that various "P" levels affected grain yield significantly. Maximum grain yield of 4263kg ha^{-1} was obtained in plots which received "P" at the rate of 90kg ha^{-1}. Grain yield decreased gradually with decrease in "P" level to the lowest scale of 3328.5kg ha^{-1} produced in plots which were not treated with "P" dosage. Moreover, environmental influence had greatly affected the yield (Ullah *et al.*, 2011c). Pervez *et al.* (2008) and Shahzada *et al.* (2007) reported increase in grain yield of wheat due to increase in "P" level. Azimzadeh and Koocheki (1999) also reported an increase in grain yield with increasing phosphorus application rate. Alam *et al.* (2002) however, reported increase in grain yield of wheat varieties due to increase in "P" application. Similarly various "S" levels also affected grain yield significantly. Maximum and significantly higher grain yield of 4070.3kg ha^{-1} was produced in plots which received the highest level of 30kg ha^{-1}. The plots which received "S" at the rate of 0, 10 and 20 kg ha^{-1}, recorded smaller and statistically at par grain yield of 3623.8, 3790.3 and 3842.5kg ha^{-1}, respectively. Podlesna and Cacak-Pietrzak (2006), and Hussain and Leitch (2005) reported increase in grain yield of wheat due to increase in "S" level. Dealing with oil crops Qahar *et al.* (2010) reported significant increase while increasing the dose of nitrogenous fertilizer. The interaction of P×S was almost of least importance for the grain yield of wheat. However, McGrath & Zhao (1996) reported a positive interaction for the primary nutrient's uptake for seed yield in oil crops in limited environments. The application of Nitrogen, Phosphorous, Sulphur and Potassium can increase the seed yield and helping the winter wheat against leaf disease in boot stage (Sweeney *et al.*, 2000).

Biological yield

Data regarding biological yield (kg ha^{-1}) of wheat as affected by various phosphorus and Sulphur levels are shown in Table II. Statistical analysis of the data showed that various "P" levels affected biological yield significantly. Maximum biological yield of 8333.5kg ha^{-1} was produced in plots which received "P" at the rate of 90 kg ha^{-1}. Biological yield decreased gradually and significantly with gradual decrease in "P" level to the minimum amount of 7302.8kg ha^{-1} produced in plots, which were even not treated with "P". Biologocal yield of wheat had a direct relationship with the increasing levels of "P" (Pervez *et al.,* 2008; Shahzada *et al.,* 2007; Azimzadeh and Koocheki, 1999). Similarly various "S" levels also affected biological yield significantly. Best way to judge the performance of yield of a crop is to analyze the soil prior experimentation (Ullah *et al*., 2011ac). Maximum and significantly higher biological yield of 8075.0kg ha^{-1} was produced in plots which received the highest level of "S" (30kg ha^{-1}). The plots which received "S" at the rate of 10 and 20kg ha^{-1} recorded lesser and statistically at par biological yield of 7767.8 and 7821.0kg ha^{-1}, respectively, while the plots which received no "S" recorded the smallest amount of 7544 kg ha^{-1} biological yield. The interaction of P×S showed no significant effect on biological yield of wheat.

Protein content (%)

Data regarding protein content (%) of wheat as affected by various "P" and "S" levels are shown in Table II. Statistical analysis of the data showed that various "P" levels did not affect protein content significantly. On the other hand, various "S" levels showed significant effect on protein content of wheat. Maximum protein content of 9.9 and 9.8% were recorded in plots which received "S" at the rate of 30 and 20 $kgha^{-1}$, respectively, while the nominal protein content of 9.2% was recorded in plots which were not fertigated with Sulphur. Jarvan *et al.* (2008) reported increase in protein content of wheat due to maximum supply of "S". The interaction of P×S showed no significant effect on protein content of wheat.

4. Conclusions and recommendation

It was concluded that spikes m^{-2} increased with increase in "P" application rate. Thousand-grain weight, grain and biological yield of wheat increased significantly with increase in "P" and "S" levels, however, the interaction of P×S showed no significant effect on them. Protein content increased with increase level of "S". Therefore, "P" and "S" at the rates of 90 and 30kg ha^{-1}, respectively, are recommended for higher grain and biological yield as well as grain protein content in wheat especially for the low income countries of the sub-continent and world. It was also concluded that the P×S interaction was non significant for the current cultivar will still have the open area of research to be judged for the other cultivars of Pakistan or around the world.

Table I. Spikes m^{-2}, grains $spike^{-1}$ and thousand grains weight (g) of wheat cultivars as affected by various Phosphorus and Sulphur levels

Treatment		Spikes m^{-2}	Grains $spike^{-1}$	1000 grain weight (g)
Phosphorus (P)	0	252.0 b	41.5 d	42.60 d
(kg ha^{-1})	30	262.0 ab	44.0 c	43.58 c
	60	263.5 ab	45.3 b	44.50 b
	90	270.3 a	48.0 a	46.22 a
LSD (0.05)		12.81	1.054	0.3943
Sulphur (S)	0	257.8	44.5	43.98 b
(kg ha^{-1})	10	260.0	44.5	43.99 b
	20	262.8	44.8	44.14 b
	30	267.3	45.0	44.78 a
LSD (0.05)		Ns	Ns	0.3663
Interactions	P × S	Ns	Ns	Ns

(Ns: Non-significant)

Mean values of the same category followed by different letters are significantly different from each other at 5% significance level.

Table II. Grain yield (kg ha^{-1}), biological yield (kg ha^{-1}) and protein content (%) of wheat cultivars as affected by various Phosphorus and Sulphur levels

Treatment		Grain yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Protein content (%)
Phosphorus (P) (kg ha^{-1})	0	3329 c	7303 d	9.6
	30	3799 b	7694 c	9.6
	60	3937 b	7878 b	9.7
	90	4263 a	8334 a	9.4
LSD (0.05)		212.6	170.2	Ns
Sulphur (S) (kg ha^{-1})	0	3624 b	7544 c	9.2 c
	10	3790 b	7768 b	9.5 b
	20	3843 b	7821 b	9.8 a
	30	4070 a	8075 a	9.9 a
LSD (0.05)		220.5	203.6	0.24
Interactions	P × S	Ns	Ns	Ns

(Ns: Non-significant)

Mean values of the same category followed by different letters are significantly different from each other at 5% significance level.

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