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THE EFFECTS OF PHOSPHORUS MANAGEMENT ON YIELD AND YIELD COMPONENTS OF WHEAT VARIETIES

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Abstract

An experiment was performed to evaluate the effect of phosphorus management on yield and yield components of wheat varieties at Agronomy Research Farm, the University of Agriculture Peshawar, during winter season 2015-2016. The treatments were consisted of four wheat varieties (Pirsabak-2013, Siran-2010, Faisalabad-2008 and Atta Habib) and six phosphorus ratios of rock phosphate with diammonium phosphate (Control, 100% P from RP, 75% P from RP + 25% P from DAP, 50% P from RP + 50% P from DAP, 25% P from RP + 75% P from DAP, 100% P from DAP). Experiment was carried out in randomized complete block design (RCBD) with three replication and 3 m x 2.4 m plot size was used which included 8 rows, where 30 cm space was maintained within rows. Results indicated that phosphorus ratios significantly affected growth and yield components of wheat varieties except days to emergence and emergence m^{-2}. Among different phosphorus ratios, 100% DAP decreased days to physiological maturity (158) and enhanced tiller m^{-2} (295), leaf area tiller^{-1} (119.8 cm^2), leaf area index (3.54), plant height (106.73 cm) and biological yield (9803 kg ha^{-1}). Earlier heading (114 days) and taller plants were resulted from 25% P from RP + 75% P from DAP. Among different wheat varieties Pirsabak-2013 produced more tiller m^{-2} (281), leaf area tiller^{-1} (113.8 cm^{-2}), leaf area index (3.21), plant height (102.17 cm) and biological yield (9361 kg ha^{-1}), while early days to heading (117) and maturity (157) and taller plants (102.17 cm) were observed in Siran-2010. It is concluded that Pirsabak-2013 with application of 100% P from DAP can improve wheat productivity in the study area.

Key words: *Wheat; Phosphorus management in ratios; Rock Phosphate and Diamminum Phosphate*

INTRODUCTION

Wheat (*Triticum aestivum* L.) is most important among cereal crops. It can be grown in a wide range of climatic conditions, however dry to mild climate is ideal for sustainable production. Wheat leads over other cereal crops in terms of area and production. It is a staple food of Pakistan as well as many other countries of the world, because it fulfills daily dietary requirements. Wheat grain is a rich source of fiber, carbohydrates, protein and vitamins. wheat straw is used as animals feed, manure and also as raw material for some of the industries. Wheat was grown in Pakistan on about 9170 thousand hectares area. National annual production was 26346 thousand tons with 2873 kg ha^{-1}, while in Khyber Pukhtunkhawa province it was cultivated on area of 746 thousand hectares which produced 1760 thousand tons per year and their average yield was 2359 kg ha^{-1} (MNFSR, 2014). Wheat yield is still low in comparison with developed countries of world, which might be due to lack of optimum fertilization at critical stages, it may play important role in sustainable agriculture system (Ahmed and Rashid, 2004).

Among essential nutrients nitrogen and phosphorus are the primary constituents of plants and responsible for metabolic processes, physiology and phenology of crops (Wu et al., 2005; Muhammad et al., 2013). Photosynthesis, respiration, energy storage and cell division of crop are affected by inadequate P fertilization (Singh and Sale, 2000). Plants need phosphorus for inflorescence, grain formation and ripening (Ibrahim and Kandil, 2007).

Pakistani soils have major deficiency of phosphorus and it was estimated that about 80% of soils are deficient in phosphorus nutrient (Mahmood et al., 2016). Calcium in calcareous soil is present in abundance amount which reacts with phosphorus and form calcium carbonate ($CaCO_3$), thus reducing the phosphorus availability for plant growth and development (Sharif et al., 2000; Hinsinger, 2001; Pereira and Castro, 2014). P deficiencies in soil are compensated by supplemented phosphorus to meet nutrient requirements of the crop. The rock phosphate is a good alternative to be utilized as phosphorus source to meet the adequate requirement of crop. The integrated use of rock phosphate can be a best method to improve its agronomic use efficiency that includes partial acidification, with manure or compacting along inorganic fertilizer and bioavailability by phosphorus solubilizing bacteria (PSB) which increase the mineralization of rock phosphate and P availability in soil (Adediran and Sobulo 1997; Sharif et al., 2014; Yousaf et al., 2014). Soil characteristics that accelerate process of dissolution of rock phosphate are high cation exchange capacity, high organic matter, less Ca and P content in soil solution and low pH (Zoysa et al., 2001). Direct application of rock phosphate in alkaline soil favours the early application, however near or at sowing in very acidic soil (Khan and Sharif, 2012).

The present study focuses on the significant role of phosphorus and varietal variation in improving crop productivity. This experiment was arranged to assess the potential and economical use of rock phosphate with diammonium phosphate in different proportion on wheat varieties.

MATERIALS AND METHODS

An experiment was performed to study “the effect of phosphorus management on yield and yield components of wheat varieties” during winter season 2015-16 at Agronomy Research Farm, the University of Agriculture, Peshawar. The experiment was laid out in randomized complete lock design (RCBD) replicated three times. Plot size was 3m x 2.4m, contained 8 rows each 30cm apart. Nitrogen was applied at the rate of 130 kg ha^{-1} as basal dose. Phosphorus at the rate of 90 kg ha^{-1} was maintained from rock phosphate that contained 28-30 % P_2O_5 and diammonium phosphate in various ratios. All other agronomic practices were uniformly maintained for all plots. The two factors were wheat varieties (Atta Habib, Pirsabak-2013, Faisalabad-2008, Siran-2010) and ratios of RP (rock phosphate) vs DAP (diammonium phosphate). Treatments were Control, 100% P from RP, 75% P from RP + 25% P from DAP, 50% P form RP + 50% P from DAP, 25% P from RP + 75% P from DAP, 100% P from DAP. Data were recorded on days to emergence, emergence m^{-2}, number of tiller m^{-2}, day to heading, leaf area $tiller^{-1}$ (cm^2), leaf area index, plant height (cm), day to heading and biological yield (kg ha^{-1}). Data on days to emergence were recorded by counting the actual number of days from sowing up to 80% emergence in each experimental unit. Seedlings were counted in a meter long row at three random places in each plot and were converted according to the formula. Tillers were counted in each plot at three random places in one meter long row and were converted accordingly. Days were counted from sowing till 80% plants produced heads in each plot for recording days to heading. The leaf area was recorded by measuring leaf length and width of five randomly selected leaves in each plot and were calculated using the formula.

Leaf area $tiller^{-1}$ = Leaf length x leaf width x C.F x No. of leaves $tiller^{-1}$

LAI was calculated at heading stage by the formula.

Leaf Area Index = [(Leaf area $tiller^{-1}$) x (Number of tillers m^{-2})]/10000

Plant height was calculated by measuring 10 randomly selected plants in each plot from the base to the top with the help of measuring rod and average was worked out. Days to maturity were observed by counting number of days from sowing till 80% plants physiologically matured in each unit. Four central rows in each plot were harvested, sun dried, weighed and then converted into biological yield (kg ha^{-1}). The recommended analysis method for randomized complete block design (RCBD) was applied on data collected during experiment, while for means the least significant difference test was used at 5% significance level for those having significant difference (Jan et al., 2009).

RESULTS AND DISCUSSION

Days to emergence and Emergence m^{-2}: Table 1 shows data regarding days to emergence and emergence m^{-2} of wheat as affected by varieties and phosphorus ratios. The analysis of data illustrated that wheat varieties were non-significantly affected by phosphorus ratios, while their interaction was also not significant. However Atta Habib took fewer days (10) to emergence than other varieties. In phosphorus ratios 75% RP + 25% DAP and 50 % RP + 50 % DAP treated plots emerged earlier than the rest of plots. The probable reason might be that seed utilized their own reserves and didn’t depend on external applied fertilizer during the phase of germination. These results are similar with findings of Shrivastava et al. (1992), Khan et al. (2014) and Tigre et al. (2014) who suggested that fertilizers have no significant effect in crop emergence and emergence m^{-2}.

Number of tiller m^2: Among varieties higher number of tiller m^{-2} (281) were recorded by Pirsabak-2013, while less number of tillers m^{-2} (270) were observed in Faisalabad-2008 followed by Siran-2010 (Table 1). Varietal variation in tillers m^{-2} might be due to the variations in their genetic makeup. Alam et al. (2009) and Mumtaz et al. (2014) reported that productive tillers were considerably varied among varieties and also significant responses were noted to phosphorus treatment. Higher number of tiller m^{-2} (295) was counted in 100% DAP plots while minimum tillers m^{-2} (254) were noted in control plot. Maximum phosphorus was available immediately from inorganic source (DAP) as compared to rock phosphate. These findings are supported by Al-Mamun et al. (2012) and Wahid et al. (2015) who found that synthetic fertilizer provides more nutrients to crop as compared to direct application of rock phosphate.

Days to heading: A significant variation in days to heading was observed by varieties and phosphorus ratios (Table 1). Among varieties, Siran-2010 resulted early heading (115 days), while late heading (117 days) was observed in Faisalabad-2008. Variation among days to heading might be attributed to diverse genetic make-up of different cultivars (Munsif and Arif, 2011). Mean values of the data indicated that minimum days to heading (114) were taken by the application of phosphors 25% RP + 75% DAP in comparison with control plot, which took more days to heading (118). Fertilization of phosphorus significantly affected days to heading it might be due to easily available phosphorus nutrient from synthetic fertilizers which ultimately produced early heading. Wahid et al. (2015) suggested similar results that crops have non significance response to raw phosphorus regarding days to heading.

Leaf area tiller^{-1} (cm^2): Pirsabak-2013 produced higher leaf area tiller^{-1} (113.8 cm^{-2}), while lower leaf area tiller^{-1} (106.7 cm^2) was observed in Faisalabad-2008 which was statistically at par with Atta-Habib. Data presented in Table 1. Leaf area tiller^{-1} was significantly affected among different wheat varieties, higher leaf area tiller^{-1} was recorded in Pirsabak-2013. These results are in conformity with the findings of Alias et al. (2003) who observed significant difference in leaf area among maize genotypes. Higher leaf area tiller^{-1} (119.8 cm^2) was maintained by the application of 100% P from DAP, whereas lower leaf area tiller^{-1} (99.3 cm^2) was measured in control plot. In case of V x R Faisalabad-2008 produced maximum leaf area tiller^{-1} (123.67 cm^{-2}) in plot treated with 100 % phosphorus from DAP. Phosphorus ratios significantly affected leaf area tiller^{-1} of wheat. Leaf area tiller^{-1} was increased with P fertilization from DAP only, that might be due to readily availability of nutrients from synthetic fertilizer and thus increasing nutrient uptake, which resulted in vigorous growth and more assimilates are accumulated in the leaves. Wahid et al. (2015) found that rock phosphate may be effective when applied with manure or treated with acid solution, however application with inorganic fertilizer has no pronounced effect on crop growth.

Leaf area index (%): Persibak-2013 has prominent leaf area index (3.21), whereas minimum leaf area index (2.94) was measured in Faisalabad-2008 followed by variety Atta Habib (Table 1). Various environmental factors and different genetic nature of varieties resulted in the variation in plant growth and leaf area index (Laghari et al., 2010). Regarding phosphorus ratios maximum leaf area index (3.54) was recorded by sole application of DAP (100% P from DAP), whereas minimum leaf area index (2.51) was observed in control plot. Phosphorus from rock phosphate and DAP affected leaf area index of wheat crop and higher leaf area index was measured in plots treated with DAP alone. DAP has pronounced effect on leaf area index. Commercial fertilizers immediately responded as compared with other organic fertilizers which may results in higher growth (Laghari et al., 2010).

Plant height (cm): Varieties siran-2010 has tallest plant height followed by Atta Habib and Pirsabak-2013, whereas dwarf plants (97 cm) were observed in Faisalabad-2008 shown in Table 1. A significant difference in plant height among wheat varieties were reported by many scientists (Shahzad et al., 2002; Munsif and Arif, 2011). Mean values indicated that plant height of wheat increased significantly with increasing DAP proportion in phosphorus ratios up to ratio 25:75 and taller plants (106.73 cm) were noticed in ratio 25% RP +75% DAP. In R x V, variety Siran-2010 produced taller plants (109.43 cm) when treated with 25% RP +75% DAP. Phosphorus application from both sources has prominent effect on plant height it may be due to the fact that inorganic fertilizers accelerate the mineralization of rock phosphate and maximum phosphorus nutrient was available for plant growth. These results are in line with findings of Jaggi and Luthra (1983) and Begum et al. (2004) who reported that integrated use of rock phosphate and inorganic fertilizer will significantly increase plant height as compared with sole application of both fertilizers.

Days to physiological maturity: It was evident from statistical analysis that varieties and phosphorus ratios significantly affected days to physiological maturity of wheat, while the interaction of P ratios with varieties was found non-significant (Table 1). Regarding varieties, Siran-2010 variety took less days (157) to physiological maturity followed by Pirsabak-2013. Whereas delayed physiological maturity was recorded in Faisalabad-2008 which took 163 days to physiological maturity. Varietal variation attributed to the different genetic potential to utilize natural resources efficiently for its growth and development. Our results are in agreement with Munsif and Arif, (2011) who stated that variation in maturity could be attributed to diversity among genetic property of cultivars. Mean values of phosphorus ratios revealed that less days (158) to physiological maturity were counted in the plots fertilized with 100% DAP, while more days to maturity (163) were taken by control plot which is statistical at par with the plots treated with 100% P form rock phosphate. Physiological maturity of wheat varied considerably by phosphate fertilizers. This may be due to the fact that the integration rock phosphate and synthetic fertilizer increase the phosphorus utilization efficiently. The phosphorus has potential to cause early maturity of crop. Similar findings were reported by Jaggi and Luthra (1983).

Biological yield (kg ha^{-1}): Maximum biological yield (9361 kg ha^{-1}) was measured in plots sown with variety Pirsabak-2013, while minimum biological yield (8503 kgha^{-1}) was produced by Faisalabad-2008. Biological yield of wheat varieties was significantly affected by P ratios. The difference might be due to genetic variability and adoptability according to its favorable environmental conditions. Bisht et al., (2008) and Al-Doss et al. (2010) reported considerable difference in biological yield of wheat varieties. Biological yield of wheat was significantly increased with phosphorus ratios and maximum biological yield (9803 kg ha^{-1}) was produced by plots which received 100% phosphorus from DAP, however minimum biological yield (8290 kg ha^{-1}) was recorded in control plots. Biological yield was enhanced by phosphorus, which may be due to the fact that inorganic fertilizer released more phosphorus in soil, which has major role in photosynthesis which led to higher dry matter production and increased the biological yield. Triple super phosphate produced more biological yield (Begum et al. 2004; Al-Mamun et al., 2012).

Table 1. Days to emergence, Emergence m^{-2}, Tiller m^{-2}, Days to heading, Leaf area tiller^{-1}, Leaf area index, Plant height (cm), Days to physiological maturity, Biological yield of wheat varieties as affected by different phosphorus ratios.

RP : DAP	**Days to emergence**	**Emergence m^{-2}**	**Tiller m^{-2}**	**Days to Heading**	**Leaf Area Tiller^{-1}**	**Leaf area index**	**Plant Height (cm)**	**Days to Physiological Maturity**	**Biological yield**
0:0	11	90	255 f	118 a	98.63 f	2.51 f	87.60 f	163 a	8290.02 e
100:0	11	97	263 e	117 b	101.74 e	2.68 e	97.98 e	163 a	8656.04 d
75:25	10	92	272 d	117 b	108.22 d	2.95 d	101.78 d	161 b	8710.03 cd
50:50	10	99	279 c	116 c	114.00 c	3.18 c	102.84 bc	160 c	8991.50 bc
25:75	11	97	286 b	114 e	116.75 b	3.34 b	106.73 a	156 d	9007.92 b
0:100	11	97	295 a	115 d	119.83 a	3.54 a	103.94 b	158 e	9802.50 a
LSD (0.05%)	ns	ns	5.99	0.94	2.57	0.09	1.90	2	507.67
Varieties									
Atta-Habib	10	96	275 b	116 b	107.06 c	2.96 c	101.04 ab	161 b	8846.09 b
Pirsabake-2013	11	96	281 a	116 b	113.89 a	3.21 a	99.53 bc	160 b	9361.08 a
Faisalabad-2008	11	93	270 c	117 a	106.79 c	2.90 c	97.84 d	163 a	8502.03 c
Siran-2010	11	96	273 bc	115 c	111.71 b	3.06 b	102.17 a	157 b	8929.02 b

Continued table 1									
LSD (0.05%)	ns	ns	4.89	0.77	2.1	0.07	1.55	1	414.51
Interaction									
RP:DAP x V	ns	ns	ns	Ns	5.13	ns	3.81	Ns	Ns

RP= Rock phosphate, DAP= Diammonium phosphate, ns = non significant

CONCLUSION

It is concluded from the results of the experiment that Pirsabak-2013 with application of 100% P from DAP improved wheat productivity in the study area and therefore recommended for local farmers.

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