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# Studies on the effects of phosphorus levels on growth and yield of wheat (*Triticum aestivum* L.) in semi-arid region of Kandahar Afghanistan

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**Abstract**
A field experiment was conducted at Students` Instructional Farm at Afghanistan National Agricultural Science and Technology University, Kandahar (ANASTU) Afghanistan during winter season of 2014-15 to study the effect of phosphorus levels on growth and productivity of wheat (*Triticum aestivum* L.) varieties. The treatments consisted of two varieties of wheat *viz.* Shashambagh-08 and PBW-154 and five phosphorus levels *viz.*0, 40, 60, 80 and 100 kg P2O5/ha which were evaluated in factorial randomized block design with 3 replications.

Results revealed that maximum and significantly higher growth and yield attributes *viz.* plant height, dry matter accumulation, leaf area index, number of tillers per square meter, length of spike, number of grain per spike, grain weight per spike, and1000-grain weight were recorded higher with Shashambagh-08, grain yield (3.53 t $ha^{-1}$), straw yield (4.85 t $ha^{-1}$) and biological yield (8.36 t $ha^{-1}$) were also recorded significantly higher with Shashambagh-08 variety, but spikes per square meter and harvest index were registered higher in PBW-154.

Phosphorus levels significantly increased growth parameter up to 100 kg P2O5 but were at par with 60 kg P2O5 and 80 kg P2O5. With successive increase in levels of phosphorus significant increase plan height, dry matter accumulation, leaf area index number of tillers per square meter, length of spike, number of grain per spike, grain weight per spike, 1000-grain weight, grain yield, straw yield and biological was recorded only up to 60 P2O5/ha. However, maximum number of tillers per square meter, length of spike, number of grain per spike, grain weight per spike, 1000-grain weight, grain yield, straw yield and biological was recorded with 60 kg P2O5/ha.

It is conclude from the study that variety Shashambagh-08 is more productive and respond to phosphorus application up to 60 kg P2O5.

**Keywords:** growth behavior of wheat, yield attributes and yield

## 1. Introduction
Wheat [*Triticum aestivum* (L.) emend Fiori and Paol.] is one of the world′s most outstanding crops that exceed all other cereals both in area and production (Costa *et al*., 2013) [13]. It is cultivated worldwide and was one of the first crops to be domesticated some 10000 years ago. Unlike rice and maize, which prefer tropical environment, wheat is extensively grown in temperate regions occupying 17% of all crop acreage worldwide. It is the staple food for 40% of the world's population (Peng *et al*., 2011) [23]. It provides more nourishment for humans than any other food source and its contribution to human diet puts it in the top of crops list that feed the world (Safdar *et al*., 2009) [26]. It provides nearly 55% of the carbohydrate and 20% calories consumed globally (Breiman and Graur, 1995) [7]. Wheat is generally grown in intensive cropping system. Intensive cultivation has resulted depletion of soil nutrient of greater extant, thus the nutrient requirement of crop has increased considerably during the last decades. To meet the challenges of intensive cropping system were adopted which resulted in declining nutrient status of soil and therefore the use of chemical fertilizers are increasing day by day (Balyan and Idnani, 2000) [5]. Adequate phosphorus enhances many aspects of plant physiology like fundamental process of photosynthesis, flowering, seed formation, energy transfer and maturation (Salisbury and Ross, 1992) [27]. Phosphorus is the second most essential element after nitrogen for crop production. It is deficient in most soils around the world and to achieve maximum yields phosphorus fertilization is require (Brady and Weil, 2002) [6].

Plants require adequate P from the very early stages of growth for optimum crop production (Grant *et al.*, 2005) [11]. The performance of wheat genotypes is mainly associated with the soil and climatic conditions, application of inputs and other management conditions (Piepho *et al.*, 2004) [24]. Each variety has a genotype-specific ability to maintain performance over a wide range of environmental conditions (Hancock, 2004) [12]. This ability is usually referred to as the sensitivity or adaptability of a variety. Such ability is an important property, because farmers naturally want to use varieties which perform well in their own fields (Bajaj, 1990) [4]. Cultivars significantly differed in number of fertile tillers per square meter, spike length, 1000-grain weight and straw yield (Mudassir, 2005) [21]. Different varieties respond differently to varied environment and hence differ in their yield. Cultivars differed significantly due to difference in number of tillers per square meter (Jan *et al*., 2003) [14].

## 2. Materials and Methods

The present investigation entitled studies on the effects of phosphorus levels on growth and productivity of wheat (*Triticum aestivum* L.) varieties were conducted during winter season of 2014-15. Geographically, Kandahar is situated in south part of Afghanistan having semi-arid hot climate and falls between latitude ranging from 310 30' north and longitude from 650 50' east and is located on an altitude of about 1010 meters above mean sea level. The annual rainfall is about 190.6 mm received mostly during January. In order to determine the physical and the chemical properties of the experimental field, the soil samples were collected randomly from the whole field from 0-20 cm. The samples of all the places were mixed together to form a composite sample for mechanical and chemical analysis.

The treatments consisted of two varieties of wheat *viz.* Shashambagh-08 and PBW-154 and five phosphorus levels *viz.*0, 40, 60, 80 and 100 kg P2O5/ha which were evaluated in factorial randomized block design with 3 replications. The soil of experiment site was sandy clay loam, slightly alkaline in reaction (pH 7.2), low available N (32.2 kg/ha NH4 and 36.2 kg NO3), medium in available P (23.0 kg/ha P2O5) and high in available K (480 g/ha K2O). Wheat was sown @ 100 kg seed/ha with 20 cm row spacing on 28 December 2014 and recommend dose of N and K (120 N and 30 K2O) was applied through urea equally and potassium sulphate. Full dose of K and half dose of N were given as basal and remaining half of N was top dressed after first irrigation and second irrigation. For weed control sulfosulfuran was applied at @ of 25 gram/ha at 35 DAS.

## 3. Results and Discussion

### 3.1 Growth parameters of wheat

Data regarding growth parameter of wheat under different P levels presented in Table 3.1. Plant height of wheat showed significant difference between the varieties. The effect of variety on plant height was non-significant at 30 and 60 DAS while at 90 DAS and harvest the difference in plant height of varieties was significant. Maximum plant height was recorded with the variety Sheshambagh-08 (59.4 and 70.4 cm) over variety PBW-154 (57.1 and 66.6 cm) at 90 DAS and at harvest. These finding was supported by Karim and Jahan (2013) [16], who revealed significant differences in plant height among the different genotypes of bread wheat. Plant height of wheat improved remarkably due to different phosphorus levels at all the growth stages. Maximum plant height was recorded with 100 kg P2O5 /ha at all growth stages (21.6, 41.5, 61.3 and 72.5 cm at 30 DAS, 60 DAS, 90 DAS and at harvest respectively). Plant height with 100 kg P2O5 at 30 DAS was significantly different over control, 40 kg P2O5, 60 kg P2O5 and 80 kg P2O5/ha. At 60 DAS plant height recorded with 80 kg P2O5/ha was at par with 100 kg P2O5 but it was significant over control, 40 kg P2O5/ha and 60 kg P2O5/ha. At 90 DAS and harvest plant height recorded with 100 kg P2O5/ha were at par with 60 kg P2O5 and 80 kg P2O5/ha and was significantly superior over control and 40 kg P2O5/ha. The uniformity with the results was reported by Alam *et al.* (2003) [2]. Interaction effect of varieties and levels of phosphorus on plant height of wheat was found non-significant.

Significant difference were observed in the dry matter accumulation between the varieties at the all growth stages, variety of Sheshambagh-08 recorded higher dry matter accumulation (2.34, 3.35, 5.32 and 8.76 ) over the PBW-154 variety (2.16,3.13, 4.63 and 8.22) at 30, 60, 90 DAS and harvesting similar results was reported by Musa *et al*. (2012) [22]. Phosphorus application significantly increased dry matter accumulation over control at all growth stages. Maximum dry matter accumulation was observed with the 100 kg P2O5/ha at all growth stages (2.51, 3.69, 5.55 and 9.21 t $ha^{-1}$ at 30 DAS, 60 DAS, 90 DAS and at harvest respectively). Treatment with 100 kg P2O5/ha at 30 and at harvest were significantly different over control and 40 kg P2O5, while it was statistically similar with 60 and 80 kg P2O5. Plant height with 100 kg P2O5/ha at 60 DAS and 90 DAS were significant over control, 40 P2O5 and 60 kg P2O5 but it was statistically at par with 80 kg P2O5. With successive increase in Phosphorus levels dry matter accumulation increased significantly up to 60 kg P2O5/ha. Similar finding reported by Chaturvedi (2006) [8]. Interaction of varieties and levels of phosphorus on dry matter accumulation of wheat was not observed significant.

Effect of varieties on leaf area index was significant at different growth stages except at 30 DAS. At all growth stages higher leaf area index was recorded with variety of Shashambagh-08 (2.78, 3.28) over variety of PBW-154 (2.66, 3.15). These finding was supported by the result of Musa *et al*. (2012) [22].

Effect of phosphorus levels on leaf area index was significantly at all the growth stages. The highest leaf area index was observed with the 100 kg P2O5/ha at all growth stages (1.68, 2.87 and 3.37 at 30 DAS, 60 DAS and 90 DAS respectively).Leaf area index with 100 kg P2O5 at 30 DAS was significantly superior over control, 40 kg P2O5 and 60 kg P2O5/ha. At 60 and 90 DAS statistically similar leaf area index was recorded due to 60, 80 and 100 kg P2O5/ha. Leaf area index recorded with control and 40 kg P2O5 was also at par but further increase to 60 kg P2O5 caused marked improvement over control. Across the stages leaf area showed improvement up to 90 DAS. These results are in line with the findings of Jiang *et al.* (2006) [15], who reported that application of 108 kg/ha P2O5 gave the highest leaf area index. Leaf area index didn't show perfectible variation due to interaction of varieties and levels of phosphorous.

### 3.2 Effect of different P levels on yield attributes and yields of wheat

Effect of P levels on yield attributes of wheat is presented in Table 3.2 and their results are presented as bellow:

Number of tillers per square meter did not show significant variations between the varieties. However Sheshambagh-08 recorded higher number of tillers per square meter (340.3) over PBW-154 (337.8). This confirms the finding Khodadadia *et al.* (2009) [17] who reported that wheat cultivars did not have significant differences regarding total number of tillers. With successive increase in phosphorus levels significant differences were found in number of tillers per square meter. Number of tillers per square meter increased significantly up to 60 kg P2O5/ha. Numerically, the highest number of tillers per square meter (345.0) was observed with100 kg P2O5 /ha which were at par with 60 and 80 kg P2O5/ha. Similar finding was supported by Damene (2003) [10]. Interaction of varieties and levels of phosphorus on number of tillers per square meter was not noted.

The data pertaining to number of spikes per square meter was not significantly influenced due to varieties. Numerical value of spikes per square meter was higher that of PBW-154 variety (274.2) over Shashambagh-08 variety (272.4). Result was inconformity of finding of Suleiman *et al.* (2014) [30]. With successive increase in phosphorus levels number of spikes per square meter showed marked increase up to 60 kg P2O5/ha. Maximum spikes per square meter was recorded with 80 kg P2O5/ha (278.8) treated plot which were at par with 40, 60 and 100 kg P2O5/ha but significantly superior to control. Similar finding reported by Zahedifar *et al.* (2011) [31]. Interaction of varieties and levels of phosphorus on spikes per square meter of wheat not observed.

Length of spike of wheat showed significant difference due to varieties. Higher length of spike was recorded with variety Sheshambagh-08(8.73 cm) over variety PBW-154 (8.33 cm). This finding supported by Rahim *et al.* (2010) [25]. Length of spike showed significant difference due to application of phosphorus levels. Maximum length of spike was recorded with application of 100 kg P2O5/ha (9.0 cm). Treatment with 100 kg P2O5/ha being at par with 80, 60 and 40 kg P2O5/ha while it was significantly superior over control. Similar results also reported by Rahim *et al*. (2010) [25]. Interaction of varieties and levels of phosphorus on length of spike of wheat was not found significant.

The result showed that number of grains per spike was not significant different between the varieties. However maximum grains per spike were recorded with variety Shashambagh-08 (36.5) over PBW-154. This result was inconformity of finding of Musa *et al*. (2012) [22]. The data regarding number of grains per spike of wheat showed significant variation due to different levels of phosphorus. With application of 40 kg P2O5/ha marked improvement was recorded in grains per spike. Enhancement of dose further failed to induce significant changes in grains per spike. With 40, 60 and 80 kg P2O5/ha statistically similar grains per spike were recorded. Similar result was also reported by Sharma *et al*. (2009) [29]. Interaction of varieties and levels of phosphorus on number of grains per spike of wheat was not found significant.

It was observed that weight of grain per spike due to varieties showed significant difference. The highest grain weight per spike was recorded with Sheshambagh-08 variety (1.31) over PBW-154 (1.20). This result was in agreement with Adhikary *et al*. (2009) [1]. Weight of grains per spike showed significant difference due to phosphorus application. Maximum grain weight per spike was recorded with 100 kg P2O5/ha (1.38), which was at par with 60 and 80 kg P2O5 but significantly superior to 40 kg P2O5 and control. Effect of 40 kg P2O5/ha on grains weight per spike over control was not significant. With further increase up to 60 kg P2O5 induced significant increase over control. Similar findings were supported by Arif *et al.* (1993) [3]. Interaction of varieties and levels of phosphorus on grain weight per spike of wheat didn't show significant.

1000-grain weight of wheat showed significant difference due to the varieties. The highest 1000-grain weight was recorded with the variety of Shashambagh-08 (35.75) over PBW-154 (34.41). Similar result also reported by Khokhar *et al.* (1985) [18]. Successive increase in levels of phosphorus caused significant in 1000-grain weight of wheat up to 60 kg P2O5/ha. Maximum 1000-grain weight was observed with 100 kg P2O5 treated plot which was at par with 60, and 80 kg P2O5/ha. All were markedly higher over 40 kg P2O5 and control. Similar results were also reported by Mehdi *et al.* (2007) [20]. Data regarding interaction of varieties and levels of phosphorus on 1000-grain weight didn't show significant variation.

The result showed that grain yield difference between varieties was significant. Maximum grain yield was recorded with the variety Shashambagh-08 (3.53 t $ha^{-1}$) over variety of PBW-154 (3.36 t $ha^{-1}$). In term of percent, grain yield of Shashambagh-08 was 5.05 % higher over PBW-154.The results were supported by Laghari *et al.* (2010) [19]. Significant variation in grain yield was recorded due to phosphorus levels. With successive increase in phosphorus levels significant increase in grain yield was recorded up to 60 kg P2O5. Further increase in P levels failed to induce perceptible increase up to 100 kg P2O5. Treatment with 100 kg P2O5/ha was significant over control and 40 kg P2O5 while it was statistically at par with 60 kg P2O5 and 80 kg P2O5/ha. With application of 40, 60, 80 and 100 kg P2O5, 31.03, 42.14, 42. 91 and 43.67 % increase in grain yield was recorded over control. Such a findings were also supported by Chaturvedi (2006) [8]. Interaction of varieties and phosphorus levels was not observed on grain yield.

Data pertaining to straw yield showed significant difference between varieties. Significantly higher straw yield was recorded in Sheshambagh-08 variety (5.21 t $ha^{-1}$) which was 7.42 % higher over PBW-154. Similar finding was reported by Suleiman *et al.* (2014) [30]. Straw yield increased significantly due to phosphorus application. Maximum straw yield was recorded with 100 kg P2O5 (5.37 t $ha^{-1}$) which was at par with 80 and 60 kg P2O5 but significantly higher over control and 40 kg P2O5/ha. Significant effect of successive increase in phosphorus levels on straw yield was up to 60 kg P2O5/ha. Application of 40, 60, 80 and 100 kg P2O5 12.24, 17.68, 18.36 and 21.76 % increase in straw yield noted. This result is similar with the findings of Sharma *et al*. (2011) [28]. Interaction of treatment on straw yield was not significant.

Effect of varieties on biological yield was significant. Maximum biological yield was observed with Shashambagh-08 variety (8.74 t $ha^{-1}$) over PBW-154 (8.20 t $ha^{-1}$). Increase in biological yield of Shashambagh-08 over PBW-154 was 6.58 percent. Similar finding also supported by Hussain (2007) [13]. Different levels of phosphorus application showed significant differences on biological yield of wheat. Maximum biological yield was recorded with treatment 100 kg P2O5 (9.12 t $ha^{-1}$). Treatment with 100 P2O5 kg was significant over control and 40 kg P2O5

but it was statistically similar with treatment 60 kg P2O5 and 80 kg P2O5. Significant effect of successive increase in phosphorus levels on biological yield was up to 60 kg P2O5/ha only. Application of 40, 60, 80 and 100 kg P2O5 18.91, 26.74, 27.13 and 29.72 % increase in biological yield was observed. This result is similar with the findings of Arif *et al.* (1993) [3]. Interaction of varieties and different levels of phosphorus on biological yield didn't show significant variation.

Data regarding harvest index didn't show significant difference between varieties. However higher harvest index was found with PBW-154 (40.75) over Shashambagh-08 (40.30). This result was inconformity of finding of Khodadadia *et al.* (2009) [17]. Effect of phosphorus levels on harvest index of wheat was significant. The highest harvest index was recorded with treatment of 60 kg P2O5 (41.74) and the lowest was recorded with control(37.19).Treatment with 60 kg P2O5 was significant over control but it was statistically at par with treatment of 40, 80 and 100 kg P2O5/ha. These results coincide with the finding of Arif *et al.* (1993) [3], they reported that harvest index of two studied cultivars can be improved by bio-fertilization plus phosphorus application. Interaction of varieties and levels of phosphorus on harvest index of wheat was not significant.

**Table 3.1.** Effect of varieties and levels of phosphorus on plant growth indices of wheat at different days after sowing DAS.

| | Plant height (cm) | | | | Dry matter accumulation t ha$^{-1}$ | | | | Leaf area index | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Treatment** | **30 DAS** | **60 DAS** | **90 DAS** | **Harvest** | **30 DAS** | **60 DAS** | **90 DAS** | **Harvest** | **30 DAS** | **60 DAS** | **90 DAS** |
| **Varieties** | | | | | | | | | | | |
| PBW-154 | 19.7 | 38.6 | 57.0 | 66.6 | 2.16 | 3.13 | 4.63 | 8.22 | 1.46 | 2.66 | 3.15 |
| Sheshambagh-08 | 19.8 | 39.0 | 59.4 | 70.4 | 2.34 | 3.35 | 5.32 | 8.76 | 1.44 | 2.78 | 3.28 |
| SEm± | 0.29 | 0.50 | 0.78 | 0.91 | 0.04 | 0.04 | 0.05 | 0.08 | 0.03 | 0.03 | 0.03 |
| CD(P=0.05) | N.S | N.S | 2.31 | 2.69 | 0.12 | 0.12 | 0.16 | 0.26 | N.S | 0.10 | 0.10 |
| **Phosphorus levels (Kg P2O5/ha)** | | | | | | | | | | | |
| Control | 17.9 | 35.5 | 53.5 | 62.2 | 1.54 | 2.43 | 3.88 | 7.03 | 1.23 | 2.56 | 2.96 |
| 40 | 19.1 | 37.5 | 56.8 | 66.8 | 2.26 | 3.12 | 4.88 | 8.36 | 1.34 | 2.62 | 3.10 |
| 60 | 19.9 | 38.7 | 59.0 | 70.0 | 2.45 | 3.40 | 5.20 | 8.85 | 1.43 | 2.73 | 3.32 |
| 80 | 20.2 | 40.8 | 60.5 | 71.7 | 2.48 | 3.56 | 5.37 | 9.03 | 1.58 | 2.81 | 3.34 |
| 100 | 21.6 | 41.5 | 61.3 | 72.5 | 2.51 | 3.69 | 5.55 | 9.21 | 1.68 | 2.87 | 3.37 |
| SEm± | 0.45 | 0.80 | 1.23 | 1.43 | 0.06 | 0.06 | 0.08 | 0.13 | 0.05 | 0.05 | 0.05 |
| CD(P=0.05) | 1.35 | 2.36 | 3.65 | 4.25 | 0.19 | 0.20 | 0.25 | 0.41 | 0.15 | 0.17 | 0.15 |

DAS*=Days after sowing
NS**=Non-significant

**Table 3.2:** Effect of varieties and levels of phosphorus on yield attributes and productivity of wheat.

| **Treatment** | **Yield attributes** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Tiller /m$^2$** | **Spikes /m$^2$** | **Spike length (cm)** | **Number of grains per spike** | **Grain weight per spike** | **1000-grain weight (g)** | **Grain yield (t ha$^{-1}$)** | **Straw yield (t ha$^{-1}$)** | **Biological yield (t ha$^{-1}$)** | **Harvest index %** |
| **Varieties** | | | | | | | | | | |
| PBW-154 | 337.8 | 274.2 | 8.33 | 35.2 | 1.20 | 34.41 | 3.36 | 4.85 | 8.20 | 40.75 |
| Sheshambagh-08 | 340.3 | 272.4 | 8.73 | 36.5 | 1.31 | 35.75 | 3.53 | 5.21 | 8.74 | 40.30 |
| SEm± | 2.6 | 1.9 | 0.11 | 0.5 | 0.03 | 0.41 | 0.04 | 0.07 | 0.08 | 0.57 |
| CD(P=0.05) | N.S | N.S | 0.35 | N.S | 0.10 | 1.22 | 0.14 | 0.23 | 0.26 | N.S |
| **Phosphorus levels (Kg P2O5/ha)** | | | | | | | | | | |
| Control | 325.5 | 261.0 | 7.63 | 32.6 | 1.10 | 30.0 | 2.61 | 4.41 | 7.03 | 37.19 |
| 40 | 338.0 | 271.5 | 8.50 | 35.8 | 1.21 | 34.5 | 3.42 | 4.95 | 8.36 | 40.87 |
| 60 | 343.0 | 278.0 | 8.70 | 36.5 | 1.27 | 36.7 | 3.71 | 5.19 | 8.91 | 41.74 |
| 80 | 344.0 | 278.8 | 8.85 | 37.0 | 1.31 | 37.0 | 3.73 | 5.22 | 8.95 | 41.67 |
| 100 | 345.0 | 277.5 | 9.00 | 37.5 | 1.38 | 37.2 | 3.75 | 5.37 | 9.12 | 41.16 |
| SEm± | 4.2 | 3.0 | 0.18 | 0.5 | 0.05 | 0.65 | 0.07 | 0.12 | 0.13 | 0.91 |
| CD(P=0.05) | 12.5 | 9.1 | 0.55 | 2.3 | 0.16 | 1.93 | 0.23 | 0.37 | 0.41 | 2.70 |

## 4. Conclusions

The following conclusions have been drawn from the present investigation:

- Among the levels of phosphorus, significant increase in grain was recorded up to 60 kg P2O5/ha.
- Between the varieties, Shashambagh-08 was found more productive than PBW-154.
- Economic optimum dose of phosphorus for PBW-154 variety was observed 88 kg P2O5/ha while for Shashambagh-08 it was 86 kg P2O5/ha.
- Interaction effect between the varieties and levels of phosphorus was not found significant.

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