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Response of Wheat Lines to Different Levels of Phosphorus Application

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ABSTRACT

Phosphorus fertilization is major input in crop production and is most important nutrient needed by wheat crop. However, genotypes vary for their response to different phosphorus level. The present study was carried out investigate the response of wheat lines *viz.* 9496, ZA-10, Galaxy-2013, ZA-6, 9493 to different phosphorus level with respect to their germination and yield response. This experiment was conducted at Agronomic Research Area, University of Agriculture, Faisalabad during 2016-17 was carried out at Agronomic Research Area, University of Agriculture, Faisalabad during 2016-17 and replicated three times. This experiment was designed in Randomized Complete Block Design in factorial arrangements. The plot size of 1.8 × 6.0 m was maintained. The collected data were analyzed statistically by employing Fisher's analysis of variance techniques. Treatments means were compared by using least significant difference test at (5%) probability level. Observations on yield related and morphological traits were calculated following standard procedures. Data depicted that 100 kg ha^{-1} produced maximum plant height, stem diameter, spike per plant no of tiller, leaf area as compared to control in all genotypes. Further we observed maximum 1000-grain weight and harvest index at 100 kg ha-1 p level as compared to control. Moreover, data shows that genotype Galaxy-2013 performed better as compared to 9496, ZA-10, ZA-6 and 9493 genotypes.

Key words: Wheat, phosphorus application, yield

Wheat (*Triticum aestivum* L.) is an important cereal crop being consumed as staple food by millions across the globe. In Pakistan, wheat crop is ranked first compared with other cereals (Lak *et al.,* 2013). It is being cultivated on 9.05-million-hectare area, with production of approximately 25.4 million tones and consumes almost 50% of phosphorus fertilizer used in the country (Govt. of Pakistan, 2016-17). Soil phosphorus (P) deficiency is a major constraint to increased crop yields in many areas of the world (Vance *et al*., 2003). The total P in soil accounts approximately for 0.04-0.10%, only 1.00-2.50% of which can be absorbed by plants. To reduce P deficiencies and ensure plant productivity, nearly 30 million tons of phosphorus fertilizer are applied worldwide every year, up to 80% of which is lost because it becomes immobile and unavailable uptake by plants due to adsorption, precipitation, or conversion to organic forms (López Bucio *et al.,* 2000).

The available P by plant in soil depends on the P supplying characteristics. More than 71% of total P can be up taken by wheat in the soil of a high P level (Yang *et al*., 2006), and in low-P soil, the absorption proportion increased with P fertilizer increasing. Therefore, improving the use efficiency of P plays a key role to increase P uptake by plant from low-P soil. On the other hand, P availability is correlated with moisture conditions of the soil, because higher water content in soil due to frequent irrigation generally leads to a better mobility and availability of P (Yang *et al*., 2011), which also improves the P conversion in the internal of plant (Smith *et al.,* 2001), by enhancing root-shoot ratio and root elongation releasing of organic acids or protons (Hinsinger *et al*., 2003) and phosphatases (Neumann *et al.,* 2000).

Phosphorus application improves the performance of wheat crop as it promotes tillering and enhances root development (Sainio *et al.,* 2006). Ability of plant to uptake and utilize P in various parts determine its yield (Shen *et al.,*

2011). Plants have evolved diverse array of strategies including morphological, molecular and physiological, to acquire adequate P for their normal growth under deficient soil (Plaxton and Carswell, 1999). These approaches also include release of organic acid in rhizosphere (Watt and Evans, 2003), remobilization and redistribution of internal P, expansion of root surface and root hairs (Plaxton and Carswell, 1999) and enhanced expression of transporters related to P. These adaptive strategies differ among various genotypes and this genetic variability can be exploited to develop genotypes that are more efficient for P uptake. Development of such genotypes helps in improving the nutrient efficiency which will reduce the cost of production (Aziz *et al.,* 2006). Alternate option to improve P use efficiency is the development of crop species or genotypes that have greater ability to uptake P from soil and assimilates in their functional parts (Yaseen *et al.,* 2004).

Extent of variability among crop plants to acquire soil P is influenced by both genetic and environmental factors (Nielsen, 1983). Genetic differences among crop genotypes can be exploited for identification of genotypes more suited to a low-input agricultural system (Yaseen and Malhi, 2009). Phosphorus efficient genotypes can be useful for maintaining high productivity in low input agriculture. From mineral nutrition point of view, a genotype is more efficient than others if it mobilizes and absorbs more P from soils (P acquisition efficiency) and makes better use of the absorbed P to produce biomass (P use efficiency). Grain yield and P uptake of grain were significantly and positively correlated at genotypic and phenotypic levels. The relatively greater value of genotypic than phenotypic correlation indicated the larger contribution of genotypic factors in the development of the association and in the production of grains. Additional breeding of new crop genotypes with improved P efficiency may be a supplementary alternative for reducing the traditional amendments of soils by the applications of fertilizers (Batten, 1992).

The role of P in improving the performance and yield of wheat crop by application of P fertilizers is well known. However, very limited literature is available that describes the response of various wheat lines to different P levels. Therefore, this study was carried out to investigate the response of various wheat lines with respect to germination and yield traits at different P level.

Materials and methods

In this study, response of wheat lines to different phosphorus level was evaluated. This field experiment was conducted at student's farm, Agronomic Research Area, University of Agriculture, Faisalabad during 2016-17. The experiment was laid out in Randomized Complete Block Design (RCBD) with factorial arrangement having three replications. Plot size of 1.8 m × 6.0 m was utilized for present study maintained. Wheat lines were sown in 22.5 cm spaced rows during last week of November by using single row hand drill. Seeds of five wheat lines (9496, ZA-10, Galaxy-2013, ZA-6, 9493) and three phosphorus levels (P1: control, P2: 50 kg $acre^{-1}$, P3: 100 kg $acre^{-1}$) were used in this study. The genetic source for seed was collected from Wheat Research Institute, Ayub Agriculture Research Institute (AARI), Faisalabad. Following observations like Plant height (cm), Leaf area (cm^2), Number of tillers (m^{-2}), Number of productive tillers (m^{-2}), Spike and Panicle length (cm), Spikelet's per spike, Number of grain per spike, 1000-grain weight (g), Biological yield (t ha^{-1}), Grain yield (t ha^{-1}), Harvest index (%) were recorded using standard procedures.

Statistical Analysis

Data collected on all parameters was analyzed statistically by using MSTAT-C software on computer (Crop and Soil Sciences Department of Michigan University of the United States). Least significance difference (LSD) test at 5% probability level was applied to compare the treatments means (Steel *et al*., 1997).

SOV	Df	PH	NL	SL	SD	NT	PT	LA	SS	GS	1000 GW	BY	GY	HI
REP	2													
P	2	0.0119*	0.0001**	0.0001**	0.1266ns	0.6445ns	0.0432*	0.5422ns	0.3540ns	0.1266ns	0.0428	0.0443*	0.1862ns	0.051
Genotypes	4	0.3559ns	0.675 ns	0.675 ns	0.0006*	0.1407ns	0.0498*	0.0000**	0.1103ns	0.0006*	0.0278*	0.6392ns	0.0073*	0.000*
PXV	8	0.0036*	0.018*	0.018*	0.0006*	0.0007*	0.0006*	0.8230ns	0.1372ns	0.0006*	0.5574ns	0.5591ns	0.0019*	0.000*

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E	28													
TOTAL	44													

Results and discussion

This experiment was performed at student's farm, Agronomic Research Area, University of Agriculture, Faisalabad. The results of the experiment are mentioned as follows:

Table 1. Analysis of variance for all recorded parameters

* = Significant ns = Non-significant

Plant height (PH), number of leaves (NL), spike length (SL), Stem diameter (SD), number of tillers (NT), number of productive tillers (PT), leaf area (LA), Spikelet's per spike (SS), grains per spike (GS), 1000 grain weight (1000GW), biological yield (BY), grain yield (GY), harvest Index (HI)

Plant height (cm)

The results regarding effect of various levels of phosphorus on plant height of different wheat lines were processed statistically and results obtained are given in Table 1. This table revealed highly significant differences in plant height with respect to different level of phosphorus. Phosphorus and cultivars interaction were also significantly different. Results exhibited highly significant difference (P >0.0001) among phosphorus and Cultivars interaction.

Results indicated that 100 kg ha^{-1} was significantly dominated over control and height of different lines was significantly greater in 100 kg ha^{-1}. All wheat lines were statistically at par with each other. The data given in table 2 show that 100 kg ha^{-1}. Phosphorus level gained maximum plant height (83.63cm) while lowest plant height in all wheat lines were recorded in control.

Results indicate that enhanced level pf P increased plant height of wheat lines. Our results are in line with finding of McLaughlin *et al*. (2011) who reported that plant height of wheat and rice increased when increase in soil P in systems with more P added than removed. Long-term application of P fertilizers is shown to increase available P and decrease P sorption in soils. Over an extended period of time, applied P fertilizers is found to be distributed in all P fractions (Vu *et al*., 2009) but predominantly in inorganic forms (McLaughlin *et al*., 2011).

Effect of phosphorus application on plant height of different wheat lines.

Table 2: Comparison of Treatment means

Treatment	9496	ZA-10	Galaxy	ZA-6	9493	Means
Control	79.29	80.66	75.90	79.56	78.42	80.16 B
50 kg ha^{-1}	85.85	81.69	84.96	82.36	83.11	83.59 A
100 kg ha^{-1}	80.00	82.83	87.47	86.66	81.20	83.63 A
Means	81.71	81.06	82.78	82.86	80.91	

Any two means not shearing a letter differ significantly at 5% level of probability

Number of leaves

The results regarding effect of various levels of phosphorus on number of leaves of different wheat lines were processed statistically and results obtained are given in Table 1. This table revealed highly significant differences in Number of leaves with respect to different level of phosphorus. Phosphorus and Cultivars interaction were also significantly differed. Results exhibited highly significant difference (P >0.0001) among Phosphorus and Cultivars interaction.

Results indicated that 100 kg ha^{-1} was significantly dominated over control and number of leaves of different lines was significantly greater in 100 kg ha^{-1}. All wheat lines were statistically at par with each other. The data given in table 3 show that 100 kg ha^{-1} P level gained maximum spike length (9.78cm) while lowest spike length in all wheat lines were recorded in control.

Our results are in line with the results of Xin *et al.* (2017) who reported that the increased in p level spike length of wheat lines increased. Similar with the results of Maa *et al*. (2011) who studied that organic compost (OM), half compost in combination with half mineral fertilizer NPK (1/2 OM), mineral fertilizer NPK (NPK), mineral fertilizer NK (NK), and an unfertilized control (CK).

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Effect of phosphorus application on number of leaves of different wheat lines.

Table 3: Comparison of Treatment means

treatment	9496	ZA-10	Galaxy	ZA-6	9493	Means
Control	4.9	5.4	5.3	6.1	5.1	5.2 B
50 kg ha^{-1}	5.8	7.8	6.6	6.3	7.8	7.5 A
100 kg ha^{-1}	7.9	5.6	7.5	7.3	8.3	7.7 A
Means	6.24 C	6.9 B	7.2 B	7.38 B	7.9 A	

Any two means not shearing a letter differ significantly at 5% level of probability

Spike length (cm)

The results regarding effect of various levels of phosphorus on spike length of different wheat lines were processed statistically and results obtained are given in Table 1. This table revealed highly significant differences in spike length with respect to different level of phosphorus. Phosphorus and Cultivars interaction were also significantly different. Results exhibited highly significant difference (P >0.0001) among Phosphorus and Cultivars interaction.

Results indicated that 100 kg ha^{-1} was significantly dominated over control and spike length of different lines was significantly greater in 100 kg ha^{-1}. All wheat lines were statistically at par with each other. The data given in table 4 show that 100 kg ha^{-1} Phosphorus level gained maximum spike length (9.78cm) while lowest spike length in all wheat lines were recorded in control.

Our results are in line with the results of Xin *et al.* (2017) who reported that the increased in p level spike length of wheat lines increased. Similar with the results of Maa *et al*. (2011) who studied that organic compost (OM), half compost in combination with half mineral fertilizer NPK (1/2 OM), mineral fertilizer NPK (NPK), mineral fertilizer NK (NK), and an unfertilized control (CK).

Table 4 Effect of phosphorus application on spike length (cm) of different wheat lines.

Comparison of Treatment means

treatment	9496	ZA-10	Galaxy	ZA-6	9493	Means
Control	8.93 bc	9.13 abc	8.6 c	8.69 c	9.2 abc	8.92 B
50 kg ha^{-1}	9.87	9.87 abc	9.61 abc	9.20 abc	9.7 abc	9.59 A
100 kg ha^{-1}	9.9 abc	9.63abc	10.5 a	10.2ab	9.30 abc	9.7 8 A
Means	9.24	9.47	9.6	9.38	9.46	

Any two means not shearing a letter differ significantly at 5% level of probability

Stem diameter (mm)

The results regarding effect of various levels of phosphorus on stem diameter of different wheat lines were processed statistically and results obtained are given in Table 1. This table revealed highly significant differences in stem diameter with respect to different level of phosphorus. Phosphorus and Cultivars interaction were also significantly differed. Results exhibited highly significant difference (P >0.0001) among Phosphorus and Cultivars interaction.

Results indicated that 100 kg ha^{-1} was significantly dominated over control and stem diameter of different lines was significantly greater in 100 kg ha^{-1}. All wheat lines were statistically at par with each other. The data given in Table 5 show that 100 kg ha^{-1} P level gained maximum spike length (9.78cm) while lowest stem diameter in all wheat lines were recorded in control.

Our results are in line with the results of Xin *et al.* (2017) who reported that the increased in p level stem diameter of wheat lines increased. Similar with the results of Maa *et al*. (2011) who studied that organic compost (OM), half compost in combination with half mineral fertilizer NPK (1/2 OM), mineral fertilizer NPK (NPK), mineral fertilizer NK (NK), and an unfertilized control (CK).

Table 5 Effect of phosphorus application on stem diameter (mm) of different wheat lines.

Comparison of Treatment means

Treatment	9496	ZA-10	Galaxy	ZA-6	9493	Means

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Control	2.35	2.44	2.51	2.41	2.51	2.41 C
50 kg ha^{-1}	3.13	3.22	3.41	3.01	3.12	3.00 B
100 kg ha^{-1}	3.9	4.1	3.91	4.3	4.1	4.1 A
Means	3.3 C	3.6 B	3.5 B	4.1 A	3.91 AB	

Any two means not shearing a letter differ significantly at 5% level of probability

No of tiller (m^2)

The results regarding effect of various levels of phosphorus on no of tiller of different wheat lines were processed statistically and results obtained are given in Table 1. This table revealed highly significant differences in no of tiller with respect to different level of phosphorus. Phosphorus and Cultivars interaction were also significantly different. Results exhibited highly significant difference (P >0.0001) among Phosphorus and Cultivars interaction.

Results indicated that 100 kg ha^{-1} was significantly dominated over control and no of tiller of different lines were significantly greater in 100 kg ha^{-1}. All wheat lines were statistically different with each other. The data given in table 6 show that 100 kg ha^{-1} phosphorus level gained maximum no of tiller (307.55 m^2) while lowest no of tiller in all wheat lines were recorded in control.

Results indicate that increased in phosphorus level, number of tillers of wheat lines were also increased. Our results are in line with finding of McLaughlin *et al*. (2011) who reported that no of tiller of wheat were increased when increase in soil P in systems with more P added than removed. Long-term application of P fertilizers is shown to increase available P and decrease P sorption in soils. Over an extended period of time, applied P fertilizers is found to be distributed in all P fractions (Vu *et al*., 2009) but predominantly in inorganic forms (McLaughlin *et al*., 2011).**Table 6. Effect of phosphorus application number of tiller (m^2) of different wheat lines**

Comparison of Treatment means

Any two means not shearing a letter differ significantly at 5% level of probability

treatment	9496	ZA-10	Galaxy	ZA-6	9493	Means
Control	287.73	283.55	285.40	291.44	289.77	290.98
50 kg ha^{-1}	290.44	287.98	290.43	296.77	293.87	294.10
100 kg ha^{-1}	297.67	299.55	315.22	306.44	309.89	307.55
Means	292.61	295.03	302.35	301.22	300.51	

Number of productive tiller (m^2)

The results regarding effect of various levels of phosphorus on no of productive tiller of different wheat lines were processed statistically and results obtained are given in Table 1. This table revealed highly significant differences in no of productive tiller with respect to different level of phosphorus. Phosphorus and Cultivars interaction were also significantly different. Results exhibited highly significant difference (P >0.0001) among Phosphorus and Cultivars interaction.

Results indicated that 100 kg ha^{-1} was significantly dominated over control and no of productive tiller of different lines were significantly greater in 100 kg ha^{-1}. All wheat lines were statistically different with each other. The data given in Table 7 show that 100 kg ha^{-1} phosphorus level gained maximum no of productive tiller (315.55 m^2) while lowest no of productive tiller in all wheat lines were recorded in control.

Our results are in line with finding of McLaughlin *et al*. (2011) who reported that no of tiller of wheat increased when increase in soil P in systems with more P added than removed. However, the dry matter and grain P production efficiency and postponing P application of wheat increased with increasing P application rates (0-180 kg P_2O_5 ha^{-1}) in comparison to the irrigation. The interaction between P and irrigation also affected the P accumulation, grain total P, grain phospholipid P, and P production efficiency (Yu *et al*., 2013).

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Table 7 Effect of phosphorus application on number of productive tiller (m^2) of different wheat lines.

Comparison of Treatment means

treatment	9496	ZA-10	Galaxy	ZA-6	9493	Means
Control	261.73	263.55	271.40	269.44	271.77	298.98
50 kg ha^{-1}	280.44	330.98	289.43	325.77	283.87	303.10
100 kg ha^{-1}	286.67	337.55	340.22	312.44	293.89	315.55
Means	295.61 AB	323.03 A	313.35 AB	311.22 AB	289.51 B	

Any two means not shearing a letter differ significantly at 5% level of probability.

Leaf area (cm^3)

The results regarding effect of various levels of phosphorus on Leaf area of different wheat lines were processed statistically and results obtained are given in Table 1. This table revealed non-significant differences in Leaf area with respect to different level of phosphorus. Phosphorus and Cultivars interaction were also non-significant. Results exhibited highly significant difference (P >0.0001) among wheat lines.

Results indicated that 100 kg ha^{-1} was numerically dominated over control and Leaf area of different lines was numerically greater in 100 kg ha^{-1}. All wheat lines were statistically at par with each other. The data given in Table 8 show that 100 kg ha^{-1} phosphorus level gained maximum Leaf area (4.77 cm^3) while lowest Leaf area in all wheat lines were recorded in control.

Our results in line with finding of Khan *et al.* (2007) conducted a field experiment to study the response of wheat and rice to phosphorus during 2004-05 at D. I. Khan. The basal dose of N at 120 kg and K_2O at 60 kg ha^{-1} was applied with P levels (0, 45 and 90 kg P_2O_5 ha^{-1}) to both wheat and rice crops. The application of P significantly increased the grain yield of wheat from 2920 kg ha^{-1} (control) to 3560 kg ha^{-1} with P (at 90 kg P_2O_5 ha^{-1}) with an increase of 22% over control. The number of tillers, leaf area spikes, spike length and plant height of wheat were also significantly increased by P application. The rice also showed positively response to P application and hence both yield and yield parameters were significantly greater in the P compared with control. Paddy yield was increased to 75% with P application over control.**Table 8 Effect of phosphorus application on leaf area (cm^3) of different wheat lines**

treatment	9496	ZA-10	Galaxy	ZA-6	9493	Means
Control	4.78	5.01	4.02	5.15	3.98	4.61
50 kg ha^{-1}	4.83	5.05	3.83	5.34	4.10	4.63
100 kg ha^{-1}	4.91	5.72	4.02	5.25	3.98	4.77
Means	4.84 A	5.26 A	3.95 B	5.28 A	4.02 B	

Comparison of Treatment means

Any two means not shearing a letter differ significantly at 5% level of probability

Spikelet's per spike

The results regarding effect of various levels of phosphorus on Spikelet's per spike of differ wheat lines were processed statistically and results obtained are given in Table 1. This table revealed significant differences in Spikelet's per spike with respect to different level of phosphorus. Phosphorus and Cultivars interaction were also significantly different. Results exhibited highly significant difference (P >0.0001) among Phosphorus and Cultivars interaction.

Results indicated that 100 kg ha^{-1} was significantly dominated over control and Spikelet's per spike of different lines were significantly greater in 100 kg ha^{-1}. All wheat lines were statistically at par with each other. The data given in Table 9 show that 100 kg ha^{-1} P level gained maximum Spikelet's per spike (0.1372ns) while lowest Spikelet's per spike in all wheat lines were recorded in control.

Our finding is similar with the finding of Coltman *et al*. (1985) who reported that cultivation of high yield cultivars without application of fertilizers and manures depleted the soil nutrient pool and leads to serious reduction in the yield of even higher yielding cultivars. Therefore, at present conditions it is not easy to get the maximum yield potential of crops owing to depletion of nutrients from soil solution.

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Table 9 Effect of phosphorus application on spikelet's per spike of different wheat lines.

Comparison of Treatment means

treatment	9496	ZA-10	Galaxy	ZA-6	9493	Means
Control	17.26	17.00	16.40	15.26	17.56	16.70
50 kg ha^{-1}	18.33	17.86	16.33	16.23	16.60	17.18
100 kg ha^{-1}	17.13	16.86	16.96	17.23	15.83	16.70
Means	17.57	17.06	16.74	16.24	16.66	

Any two means not shearing a letter differ significantly at 5% level of probability

Grains per spike

The results regarding effect of various levels of phosphorus on grains per spike of different wheat lines were processed statistically and results obtained are given in Table 1. This table revealed highly significant differences in grains per spike with respect to different level of phosphorus. Phosphorus and cultivars interaction were also significantly different. Results exhibited highly significant difference (P >0.0001) among Phosphorus and Cultivars interaction.

Results indicated that 100 kg ha^{-1} was significantly dominated over control and grains per spike of different line were significantly greater in 100 kg ha^{-1}. All wheat lines were statistically at par with each other. The data given in Table 10 show that 100 kg ha^{-1} Phosphorus level gained maximum grains per spike (42.46) while lowest grains per spike in all wheat lines were recorded in control.

Khan *et al.* (2007) conducted a field experiment to study the response of wheat and rice to phosphorus. The application of P significantly increased the grain yield of wheat from 2920 kg ha^{-1} (control) to 3560 kg ha^{-1} with P (at 90 kg P_2O_5 ha^{-1}) with an increase of 22% over control. The number of tillers, spikes, spike length and plant height of wheat were also significantly increased by P application. The rice also showed positively response to P application and hence both yield and yield parameters were significantly greater in the P compared with control. Paddy yield was increased to 75% with P application over control.

Table 10. Effect of phosphorus application on grains per spike of different wheat lines

Comparison of Treatment means

treatment	9496	ZA-10	Galaxy	ZA-6	9493	Means
Control	41.66	41.00	42.00	40.00	43.33	41.60
50 kg ha^{-1}	42.00	41.33	43.66	39.66	42.66	41.86
100 kg ha^{-1}	43.33	43.33	44.33	42.00	39.33	42.46
Means	42.33 A	41.88 AB	43.33 A	40.55 B	41.77 AB	

Any two means not shearing a letter differ significantly at 5% level of probability

Grains weight (g)

The results regarding effect of various levels of phosphorus on grains weight of different wheat lines were processed statistically and results obtained are given in Table 1. This table revealed highly significant differences in grains weight with respect to different level of phosphorus. Phosphorus and cultivars interaction were also significantly different. Results exhibited highly significant difference (P >0.0001) among phosphorus and Cultivars interaction.

Results indicated that 100 kg ha^{-1} was significantly dominated over control and grains weight of different lines was significantly greater in 100 kg ha^{-1}. All wheat lines were statistically at par with each other. The data given in Table 11 show that 100 kg ha^{-1} P level gained maximum grains weight (37.64g) while lowest grains weight in all wheat lines were recorded in control.

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Khan *et al.* (2007) conducted a field experiment to study the response of wheat and rice to phosphorus. The application of P significantly increased the grain yield of wheat from 2920 kg ha^{-1} (control) to 3560 kg ha^{-1} with P (at 90 kg P_2O_5 ha^{-1}) with an increase of 22% over control. The number of tillers, spikes, spike length and plant height of wheat were also significantly increased by P application.

Table 11 Effect of phosphorus application on 1000- grains weight (g) of different wheat lines.

Comparison of Treatment means

treatment	9496	ZA-10	Galaxy	ZA-6	9493	Means
Control	36.1	34.33	36.1	33.1	36	36.33 c
50 kg ha^{-1}	38.1	35.33	38.93	34.33	39.66	37.27 b
100 kg ha^{-1}	38.33	37.23	42.1	38.1	40	39.64 a
Means	38.25 AB	35.63 B	40.86 A	36.44 AB	39.22 AB	

Any two means not shearing a letter differ significantly at 5% level of probability

Biological yield (t ha^{-1})

The results regarding effect of various levels of phosphorus on biological yield of different wheat lines were processed statistically and results obtained are given in Table 1. This table revealed highly significant differences in biological yield with respect to different level of phosphorus. Phosphorus and cultivars interaction were also significantly different. Results exhibited highly significant difference (P >0.0001) among Phosphorus and Cultivars interaction.

Results indicated that 100 kg ha^{-1} was significantly dominated over control and biological yield of different line were significantly greater in 100 kg ha^{-1}. All wheat lines were statistically at par with each other. The data given in table 12 show that 100 kg ha^{-1} Phosphorus level gained maximum biological yield (10.34t ha^{-1}) while lowest biological yield in all wheat lines were recorded in control.

Table 12 Effect of phosphorus application on biological yield (t ha^{-1}) of different wheat lines.

treatment	9496	ZA-10	Galaxy	ZA-6	9493	Means
Control	9.36	9.36	9.6	10.03	9.8	9.47 B
50 kg ha^{-1}	10.26	9.76	9.8	10.2	9.9	10.12 AB
100 kg ha^{-1}	10.26	10.53	10.2	10.7	10.53	10.34 A
Means	9.63	9.88	9.97	10.31	10.07	

Comparison of Treatment means

Any two means not shearing a letter differ significantly at 5% level of probability

Grains yield (t ha^{-1})

The results regarding effect of various levels of phosphorus on grain yield of different wheat lines were processed statistically and results obtained are given in Table 1. This table revealed highly significant differences in grain yield with respect to different level of phosphorus. Phosphorus and cultivars interaction were also significantly different. Results exhibited highly significant difference (P >0.0001) among Phosphorus and Cultivars interaction.

Results indicated that 100 kg ha^{-1} was significantly dominated over control and grain yield of different line were significantly greater in 100 kg ha^{-1}. All wheat lines were statistically at par with each other. The data given in Table 13 show that 100 kg ha^{-1} Phosphorus level gained maximum grain yield (3.48t ha^{-1}) while lowest grain yield in all wheat lines were recorded in control.

Khan *et al.* (2007) conducted a field experiment to study the response of wheat and rice to phosphorus. The application of P significantly increased the grain yield of wheat from 2920 kg ha^{-1} (control) to 3560 kg ha^{-1} with P (at 90 kg P_2O_5 ha^{-1}) with an increase of 22% over control. The number of tillers, spikes, spike length and plant height of wheat were also significantly increased by P application.

Table 13 Effect of phosphorus application on grain yield (t ha^{-1}) of different wheat lines.

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Comparison of Treatment means

treatment	9496	ZA-10	Galaxy	ZA-6	9493	Means
Control	3.26	3.1	3.4	3.23	3.16	3.27
50 kg ha^{-1}	3.33	3.3	3.53	3.4	3.2	3.37
100 kg ha^{-1}	3.43	3.4	3.59	3.66	3.63	3.48
Means	3.34 AB	3.43 AB	3.57 A	3.58 A	3.30 B	

Any two means not shearing a letter differ significantly at 5% level of probability

Harvest Index (%)

The results regarding effect of various levels of phosphorus on Harvest Index (%) of different wheat lines were processed statistically and results obtained are given in Table 1. This table revealed highly significant differences in Harvest Index (%) with respect to different level of phosphorus. Phosphorus and cultivars interaction were also significantly different. Results exhibited highly significant difference (P >0.0001) among Phosphorus and Cultivars interaction.

Results indicated that 100 kg ha^{-1} was significantly dominated over control and Harvest Index (%) of different line were significantly greater in 100 kg ha^{-1}. All wheat lines were statistically at par with each other. The data given in table 14 show that 100 kg ha^{-1} P level gained maximum harvest Index (37%) while lowest harvest Index (%) in all wheat lines were recorded in control.

Our results were in line with finding of Ali *et al.* (2014) reported that physiological efficiency of wheat plants to total dry matter into grain yield is measured in to form harvest index. Grain yield was increased by nutri-phite treatments, especially at Morrison. Grain P concentration of plots treated with two applications of Nutri-phite ranged from 13 to 55% more than the nontreated and standard NP received plots at Perkins in 2009/10 and Perry in 2010/11.

Table 14 Effect of phosphorus application on harvest Index of different wheat lines

Comparison of Treatment means

treatment	9496	ZA-10	Galaxy	ZA-6	9493	Means
Control	31.17735	33.45085	35.77083	32.52542	32.56735	32.90 C
50 kg ha^{-1}	32.7807	34.14959	36.38061	33.66667	32.64646	35.86 B
100 kg ha^{-1}	33.76511	35.61159	38.54804	34.54766	34.81766	36.46 A
Means	33.33 B	35.21 AB	37.10 A	33.12 B	33.31 B	

Any two means not shearing a letter differ significantly at 5% level of probability

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