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Response of Bread Wheat (*Triticum Aestivium* L.) Yield and Yield Components to Different Level of Phosphorous in Gozamen District, East Gojjam

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Abstract: The field experiment was done during the cropping season of 2017 at Gozamin district, North western Ethiopia to see the influence of different rates phosphorous fertilizer on the yield and yield components of Bread wheat. The experiment was laid out by Randomized Complete Block Design (RCBD) design with three replications of six phosphorous rates (0, 23, 46, 69, 92 and 115 kg ha^{-1}). Significant differences in plant height (cm), number of effective tillers per plant, number of kernels per spike, spike length (cm), grain yield (Q ha^{-1}) and biological yield (Q ha^{-1}) were observed by the application of different rates of phosphorus fertilizers. However, only Harvesting index (Q ha^{-1}) was not significantly affected by different rates of phosphorus fertilizers. It is concluded that phosphorus application at the rate of 115 kg ha^{-1} is more conducive to achieve the maximum yield (94.47 Q ha^{-1}) for the research area as compared to the other treatments.

Keywords: Bread Wheat, Phosphorous, Yield, Level

1. Introduction

Bread wheat (*Triticum aestivum* L.) is an annual crop plant belonging to the family Poaceae (grass family) and native to the Mediterranean region and southwest Asia [1]. This important cereal crop serves as a stable food for one-third of the world's population [2]. Ethiopia is the second largest producer of wheat in sub-Saharan Africa following South Africa, and about 1.6 million ha of land is cultivated annually for both bread and durum wheat production under rain fed conditions [3].

The high yield potential of modern wheat cultivars required high supplying phosphorus fertilizer [4]. phosphorus plays a vital role in the storage and transfer of energy within the cells, speeds up root development, and higher grain protein content. Phosphorus is an essential nutrient to enhances root growth, flowering, seed formation and seed maturation. Phosphorus is an essential nutrient required by the plant for normal growth in the vertisols of Ethiopia, because most of the agricultural soil in vertisols increases the unavailability of P than the total quantity present in the soil. Phosphorus deficiency is a common soil problem in the area having a calcareous nature. The reaction of phosphate in the soil has an important contribution to crop growth and fertilizer use efficiency [5]. The availability of P to crops for uptake and utilization is a decline in alkaline and calcareous soil due to the decreases of solubility calcium phosphate minerals [6].

Phosphorus availability is controlled by several factors such as soil organic matter levels, soil pH, and soil aluminum and iron contents, making it a challenge to estimate how much P will be supplied to the crop. Moreover, other factors, such as fertilizer placement, can significantly impact P availability during the growing season [5]. Phosphorous availability in most soils is at a maximum in the pH range 6 to 7. As soil pH increases above 7, Ca and magnesium (Mg) react with P, and the availability again declines. Trying to lower the pH of calcareous soils to improve P availability is not practical. Phosphorous deficiency reduced the yield from 10 to 15% [7-26]. Also important are the size of the root system and the extent to which roots grow into the soil, and the efficiency with which roots take up Phosphorous [7].

The main objectives of this study were to determine the effect of phosphorous on wheat yield and yield component at different rates of P.

2. Material and methods

2.1. Description of the Study Area

The research was done at Gozamin District, North-Western Ethiopia during the season of 2017/18 cropping season. The study areas located at a geographical location of 10°1′ 46″ and 10° 35′ 12″ N latitudes and 37° 23′ 45″ and 37° 55′ 52″ E longitudes and the average rainfall for the area is 1380mm per annum [8]. The average temperature also ranges between 14°C and 32°C. for the area the rainfall is bimodal; the short rainy season (*belg)* in March to April followed by more substantial rainfall between June and September *(kremt)* [8].

2.2. Treatments and Experimental Designs

The treatments including T_1 = 0, T_2 =23, T_3 = 46 and T_4= 69, T_5=92, T_6 =115 kg P_2O_5 ha^{-1} were applied to the soil at the time of sowing. The field experiment was laid out in Randomized Complete Block Design (RCBD) with three replications, The size of each plot was 2.4 m x 1.6 m (3.84 m^2) and the distance between the experiment units was 0.5 meter while the distance between blocks was 1 meters. The net central unit areas of each plot net plot size of 2.2m x 1m were used for data collection and measurement. The wheat variety Kekeba was sown on 1st June during winter growing season of 2017 using a seeding rate of 140 kg ha^{-1}. Nitrogen fertilizer was applied in the form of urea (46% N) uniformly for all plots as per the area recommendation of 150 kg N ha^{-1} for the experiment. The nitrogen fertilizer (56.12 kg N) was applied as band application at the time of planting and the remaining 92 kg N was applied as top-dressing at mid tillering stage of the crop (40 days after emergence) after first weeding was completed on each plot. The field was cultivation and management of weed was instigated manually during the cropping season to control weeds and weed-crop competition. Moreover, all the necessary field management practices were carried out as required during the experimental period. Plot wise harvesting was done at harvest maturity of the crop as the crops get matured in each plot.

2.3. Soil Sampling and Analysis

Soil samples were taken from 5 representative spots of the experimental field at 0-30 cm depth before sowing and one composite surface soil sample was made out of it for the purpose of characterization. The composite soil sample was prepared for analysis and was air- dried as well as grinded to pass through a 2mm sieve. The Soil sample was analyzed to determine soil pH, Soil texture, available P, Organic carbon content, cation exchange capacity (CEC) and total N using different methods. Total nitrogen and available phosphorus were analyzed by following the procedure described [9-10]. The percent of organic matter and organic carbon were also determined by using wet oxidation method [11]. Soil texture was analyzed following Bouyoucos hydrometer method [12]. Furthermore, soil pH was measured potentiometrically in the supernatant suspension of a 1:2.5 liquid mixture using pH meter in water (pH-H_2O) [13]. While cation exchange capacity (CEC) was measured using 1M-neutral ammonium acetate [14]. Based on the soil analysis result, the pH and CEC of the experimental soil was 5 and 31.80 meq/100g of soil, respectively. Whereas total nitrogen and available phosphorus were found 0.16% and 7.79 mg/kg, respectively (Table 1). The total nitrogen and available phosphorous of the experimental site is determined with low content of these nutrients [15]. On the other hand, the organic carbon content was found 1.83% which is low [15] (Table 1). The texture of the experimental site was 62% clay, 20% silt and 18% sand; which is classified as clay based on texture triangle classification system and this type of soil conducive for crop production since clay soils absorb and hold more water and exchangeable nutrients or cations than silty or sandy soils.

Table 1. *Physical and chemical properties for the soil of the experimental site.*

Physical soil properties	Value
Soil Texture	%
Sand	18
Silt	20
Clay	62
Textural class	Clay
B. Chemical Properties	
PH	5.00
Organic Carbon (%)	1.83
Total N (%)	0.16
Available P (mg/kg)	7.79
CEC (meq/100gm soil)	31.80

3. Result and Discussion

Wheat Growth and Yield components

Except the harvesting index of the crop all yield components were significantly affected by different rate of Phosphorus fertilizer.

3.1. Plant Height

From this experimental research the plant height was significantly influenced by different rates of phosphorous fertilizer. According to the treatments the highest plant height was recorded on T_6 (107.97 cm) but the result was on par with T_2, T_3, T_4, T_5, however it was significantly different from T_1 (85.55 cm) where it was recorded the list plant height Table 2 (Figure 1).

The result was parallel with the report that increasing the rate of phosphorous fertilizer was significantly increase the plant height, this might be due to better development of root system and nutrient absorption [16-17].

Table 2. *The Effect of different rate of phosphorous fertilizer on Growth and yield Components of wheat.*

Treatments	Plant height (cm)	Spike length (cm)	Number of Effective tillers/plant	Number of kernel/spike
T1 (0)	85.55	6.73	6.00	22.33
T2 (23)	100.02	7.23	6.67	25.67
T3 (46)	103.40	9.70	8.00	33.33
T4 (69)	100.50	9.45	9.00	24.67
T5 (92)	103.68	9.85	9.00	40.67
T6 (115)	107.97	9.75	8.33	48.00
S.EM±	3.99	0.36	0.80	1.17
C.D. at 5%	12.58	1.14	2.53	3.69

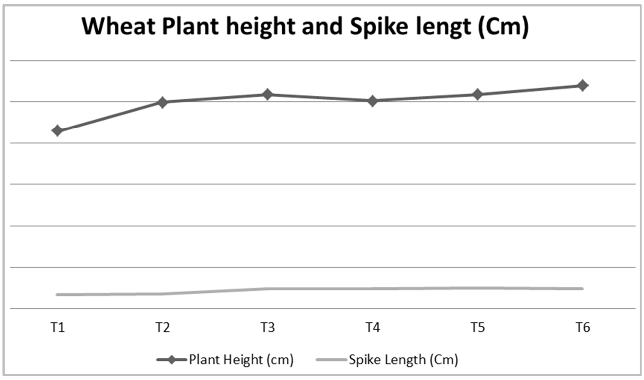

Figure 1. *The Effect of different rate of phosphorus fertilizer on plant height and spike length.*

3.2. Number of Effective Tillers/Plant and Spike Length

The effective tillers/plant and spike length of the crop were showed significantly affected by various application of phosphorous fertilizer. The analyzed data Table 2 (Figure 1) showed that the highest Number of effective tillers and Spike length was recorded on treatment T_5 (9 and 9.85), respectively whereas, the smallest effective tillers number and Spike length (6.00 and 6.75) respectively was recorded on (T_1). The result also identical with those proposed by [18-19]. They revealed that the highest number of tillers and spike length were found under the higher phosphorous rate of application.

3.3. Number of Kernel/Spike

According to the analyzed data (Table 2) the highest number of spike per spike and the smallest number of kernel per spike was recorded T_6 (48) and T_1 (22), respectively but the rest of treatments were recorded a significant different as compared to the highest number of kernel per spike. The numbers of kernel per spike was increase with the highest phosphorous applied to the soil which is parallel result with [20].

3.4. Grain Yield (Q ha^{-1})

Grain yield was significantly affected by different levels of Phosphorous (Table 3). Mean values of the data showed that maximum grain yield (94.47 Q ha^{-1}) was produced by the treatments of T_6 but it was on par with T_5 (84.73 Q ha^{-1}) the rest of treatments were recorded a significant different as compared to T_5 and T_6. The control plots resulted in minimum grain yield (51 Q ha^{-1}).

The progressive increase in grain yield of wheat recorded with increasing the level of phosphorous fertilizer [21]. The research result was supported the grain yield was increased equivalently with phosphorous fertilizer [22]. The increase in grains yields is attributed to the important role of P nutrient in enhancing and improving the naturally existing nutrient transformation activities in the soil profiles.

Table 3. *Effect of different phosphorous rate on wheat yield, Biomass yield and Harvesting index.*

Treatments	yield (Q ha^{-1})	Biological (Q/ha)	HI (%)
T1 (0)	51.00	104.00	49.03
T2 (23)	67.67	145.83	46.40
T3 (46)	74.33	182.50	40.72
T4 (69)	75.00	172.67	43.43
T5 (92)	84.73	181.93	46.57
T6 (115)	94.47	210.80	44.81
S.EM±	5.32	15.25	0.02
C.D. at 5%	16.78	48.05	NS

3.5. Biological Yield (Q ha^{-1})

The statistical analysis result revealed that biological yield was showed a significant different among the different rates of phosphorous fertilizer treatments (Table 3). The maximum biological yield (210.80 Q ha^{-1}) on those plots which received the highest phosphorous fertilizer rates (T_6) but the result was statistically on par with (T_5, T_4 and T_3). The lowest biological yield (104 Q ha^{-1}) was recorded on those plot which was not received any Phosphorous fertilizer (T_1).

The biological yield of wheat was significantly affected by different phosphorus sources and increased with increasing phosphorus levels [23-24].

3.6. Harvesting Index (%)

The statistical analysis of harvesting index was not significantly affected by different phosphorous fertilizer level, however the maximum harvesting index (49.03%) was recorded on T_1 but it was on par with all treatments. The result implies, the physiological efficiency of different crops for converting the total dry matter into final grain yield was not improved by increasing the level of phosphorous. The in-line result was revealed that, phosphorus level did not significantly affect the harvest index value of maize [25]. These results also cope with the findings of the difference between varieties and their interaction with phosphorus levels was found non-significant [22].

4. Conclusion

From the present study it is possible to conclude that different phosphorous fertilizer level was affect the yield and yield components of bread wheat. The results of the data indicated that there were significant different in all agronomic traits except Harvesting index in response to the different level of phosphorous fertilizer. The application of 115 kg P_2O_5 ha^{-1} was increase the grain and Biological yield of wheat as compared to the other treatments 94.47 and 210. 80 Q ha^{-1}, respectively. There is a need for further experimental research in different parts of East Gojjam zone districts to determine the optimum phosphorous fertilizer requirement of the area.

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