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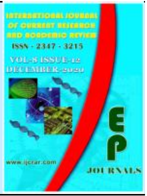

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Effect of Phosphorus Fertilizer Rate on Yield and Yield Components of Soybean Varieties on Nitisols of Jimma, Southwestern Ethiopia

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Abstract

Field experiments were carried out at Kersa district on farmers' fields over three cropping seasons (2017/18,2018/19 and 2019/20).This study aimed to determine optimum rates of phosphorus fertilizers on the growth and yield of three soybean varieties in Kersa district, Jimma Zone, Southwestern Ethiopia. The experiments consisted of five P fertilizer rates (0, 10, 20, 30 and 40 kg P ha^{-1}) and three soybean varieties (Afgat, Clark 63-K and SCS-1) arranged in factorial randomized complete block design and replicated three times. The phosphorus rates and soybean varieties were significantly (P=0.05) influenced most of yield and yield components and growth parameters of soybean. Increase in phosphorus rates also increased plant height, number of pods per plant, hundred seed weight, grain yield, bio-mass yield and harvest index of soybean. The interaction effect of phosphorus rates and soybean variety also significantly (P = 0.05) affected yield and yield components of soybean. Regarding the phosphorus rates, maximum responses were obtained at rate of 69 kg phosphorus ha^{-1} for plant height (65.87cm), number of pods per plant (40.22), hundred seed weight (19.2 g), above ground dry bio-mass (13193.9kg), grain yield (3670.81kg**)** and harvest index (0.31).Considering the interaction between phosphorus rates and varieties, application of 30 kg of phosphorus ha^{-1} on variety Clark-63K led to production of soybean yield and yield components followed by SCS-1 under the agro-ecology of Kersa district from among the five phosphorus rates and three soybean varieties The application of 150 kg ha^{-1} TSP and 100kg of urea ha^{-1} was found to be the most appropriate levels of phosphorus and nitrogen for maximum productivity of soybean. Therefore, applying of fertilizer and liming materials in acidic soil maximize the availability of nutrients especially phosphorus in the soil, which very important for better performance of crops. In general liming is important in the study area; this is because of very strong acidity and low values of some chemical properties of the soil. The application of phosphorus fertilizer increased yields of soybean.

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Grain yield, Parameters, Phosphorus, Soybean

Introduction

Soybean (*Glycine max* L. Merrill), the most important oil seed crop in the world, belongs to the family Fabacae, under sub family Faboideae provides vegetable protein for millions of people and ingredients for hundreds of chemical products. It has been classified more as an oil seed crop than as a pulse (Devi *et al.*, 2012).Soybean is known for its wide adaptability coupled with its higher productivity per unit area compared to other grain legumes (Boyer, 1982). However, it is mostly cultivated in tropical and subtropical areas, where the soils are often deficient in phosphorus (P) and nitrogen due to intensive erosion, weathering, and P fixation by free Fe and Aloxides (Sample *et al.*, 1980; Stevenson, 1986). Therefore, low P availability is often a major constraint to soybean growth and production (Vance *et al.*, 2003). Phosphorus (P) deficiency can limit nodulation by legumes and P fertilizer application canovercome the deficiency (Carsky *et al.*, 2001).

Plants require phosphorus for growth throughout their life cycle, especially during the early stages of growth and development. In soybeans, the demand for P is the greatest during pod and seed development where more than 60% of P ends up in the pods and seeds (Usherwood, 1998). Its uptake and utilization by soybean is essential for ensuring proper nodule formation and improving yield and quality of the crop (Anonymus, 2004). Very high soil phosphate depressed seed protein and oil content, while yield would be low if available phosphorus was less than 30 kg P ha^{-1} (DAFF, 2010). The most important phosphorus sources in arable soils are chemical fertilizers, though 75 to 90 percent of the phosphorus is fixed with iron, calcium and aluminums in soil (Turan *et al.*, 2006). Therefore, the use of phosphate solubilizing bacteria is essential to solve the problem. It has been proven that P increases weight and number of root nodules and also can enhance the pod yield (Jones *et al.*, 1977). Different reports revealed that the increase in soybean yield could not be expected when soil P concentration prevailed above 20 mg kg^{-1} (Webb *et al.*, 1992; Borges and Mallarino, 2003).

Phosphorus availability is of particular concern in the highly weathered soils of the humid tropics and sub tropics, where the crop productivity is severely compromised for lack of available P(Holford, 1997; Sanchez *et al.*, 1997). The crop has great potential for Ethiopia as it has been dully recognized by many researcher and research organizations for its economic importance (IAR, 1982) and its domestic demand for various uses, Indigenous food processing industries using locally produced soybeans are highly expected to satisfy the vast growing interest of soybean based food stuffs. Among all the nutrients for soybean, the most significant are nitrogen and phosphorus. Under research, 46 kg phosphorus and 100 kg urea per ha are used for soybean [*Glycine max* (L) Merrill] around I lubabor and Jimma (Getachew *et al.*, 1987). However, the effect of phosphorus in soybean depends on numerous factors such as soil fertility, precipitation amount, genotypes, seed inoculation etc. Thus, there is a need to develop location specific recommendations of nutrient application. The purpose of the present study was to determine the effect of phosphorus rates on yield and yield components of soybean varieties.

Materials and Methods

Description of the study area

The field experiment was conducted for three consecutive years (2017/18, 2018/19 and 2019/20) in Kersa District at Tikurbalto kebele, which is located in Oromia Regional State, Jimma Zone, southwestern Ethiopia. Geographically, the district is located between 7°35′–8°00′N latitudes, 36°46′–37°14′E longitude and altitude that ranges from 1740 to 2660 m.a.s.l and consists of 10 percent dega, and 90 percent woinadega, agro ecologies. The main rainy season in Kersa area stretches from March to September and the area receives an average annual rainfall of 900-1300 mm. Temperatures are moderate ranking from 20-28^{O}C with variations across specific agro-ecologies. The dominant soil type in the experimental site was Nitisols. Acidity ranges from medium to strong, and pH is generally less than 6 (Feyissa and Mebrate, 1994).

Treatments and experimental design

The treatments consisted of a factorial combination of five rates of phosphorus fertilizer (0, 10, 20, 30 and 40) kg ha^{-1}and three varieties (Clark-63K, Afgat and SCS-1). Three improved soybean varieties named Clark-63k; Afgat and SCS-1 were used as a seeding material. The experiment was laid out as randomized complete block design in factorial arrangement and replicated three times for three consecutive years (2017, 2018 and 2019). Experimental gross plot size was 6 rows of 3m length and 3m width each line of each plot and the experimental net plot size was 4 rows of 3m length and 2.4m width each line of each plot. The gross and net plot was 6x0.6m x 3m (10.8 m^{2}) and 4 x 0.6m x 3m (7.2m^{2}), respectively, consisted of 144 harvestable plants for net plot with different rows and fertilizer rates spaced at 5cm between plants and 60cm between rows. The space between plots and blocks was 1m and 1.5 m respectively.

Experimental procedures

The experimental fields were prepared using a local plow (maresha) according to farmers' conventional farming practices. The fields were ploughed two times to a depth of 15-20 cm and furrows were constructed. A plant spacing of 60cm (inter-row) and 5cm (intra-row) was used. Other appropriate agronomic management practice was followed uniformly across treatments and farmers' fields. At planting the experimental plots having fine seed bed was prepared and according to the design, field layouts were made and each treatment was assigned randomly to the experimental units within a block. Planting was done at early June.

Application of phosphorus as per the treatment was done by banding the granules at the depth of 5cm below the seed at planting. Recommended Urea (46% N) at rate of 50 kg ha^{-1}was applied by drilling at planting and the rest of 50 kg ha^{-1}was done by banding to all the plots except control five weeks after sowing as recommended by Jimma Agricultural Research Centre. The experimental field was weeded by hand three times during the growing period. Harvesting was done when the leaves of the soybean plants senescent and showed yellowing of leaves and pods start to open.

Soil sampling and analysis

An initial soil sample at a depth of 0-20 cm was taken from randomly selected 5 spots diagonally across the experimental field using Auger before sowing and composited. The composited soil samples were analyzed for soil pH, organic carbon, total nitrogen, available phosphorus. Selected soil physical and chemical properties were analyzed at Jimma Agricultural Research Center, Soil and Plant Analysis Laboratory. The pH of soil was measured using potentiometric method in 1:2.5 soil water suspensions (McLean, 1982). Organic carbon content was determined by the wet oxidation method of Walkley and Black (Nelson *et al.*, 1996) and total nitrogen by the semi-micro Kjeldahl method (Okalebo *et al.*, 1993).

Available soil P was determined using Bray-II method as described by Bray and Kurtz, (1945). The particle size distribution was determined by the hydrometer method (Gee and Bauder, 1986). Exchangeable acidity following extraction by 1M potassium chloride and titration of the extract against sodium hydroxide solution procedure described by Okalebo *et al.*, (2002).

Growth parameters

Plant height (cm): Plant height was recorded from 10 randomly selected plants per net plot at physiological maturity from the base of plant to the tip of main stem in cm.

Yield components and seed yield

Number of pods per plant

The total number of pods in ten randomly selected plants from each net plot area was counted at the time of harvest and expressed as the number of pods per plant.

Hundred seed weight (g)

Hundred seeds were counted from the harvested bulk of seeds per net plot and their weight (g) was determined at seed moisture content 10% by using a sensitive balance.

Seed yield (kg ha^{-1})

Grain yield was measured after leaving the harvested plants in an open air for about 14 days to dry so that they attained constant weight. Finally soybean was threshed per net plot area of each treatment and grain yield of each plot was converted to per hectare basis and the average yield was reported in kg ha^{-1}.

Above ground dry-biomass

The total above ground dry biomass of net plot area was determined by harvesting close to the soil surface at physiological maturity and sun-drying to a constant weight. Finally the biomass yield was converted to hectare and expressed in kg ha^{-1}.

Harvest index

The harvest index was calculated as the ratio of grain yield to total above ground dry biomass yield.

Statistical data analysis

All the collected data were subjected to analysis of variance following the procedure described by Gomez and Gomez (1984) using SAS software version 9.0 (SAS Institute, 2001). Least Significance Difference (LSD) test at 5% level of significance was used to separate the treatment means that showed significant differences.

Results and Discussions

Some soil physical and chemical properties

The properties of the soil of the site of the experiment are shown in Table 1. The soils are sandy clay loam in texture. The soil of Kersa district is very strongly acid(4.65). This result clearly indicated that the area is seriously affected by soil acidity, which is not satisfactory for growth of most crops (Havlin *et al.*, 1999). Organic carbon, total N and exchangeable acidity were 1.61%, 0.15% and 0.72 (meq/100g) respectively. Pre-planting soil analysis indicated that the soil of the experimental site was low in soil nutrient status.

The low nutrient status may be due to leaching of basic cations, intense rainfall or perhaps due to the parent material of quarts and sesquioxides which are poor in plant nutrients. This agreed with the findings of Nnaji *et al.*, (2005) who reported large losses of basic cations due to leaching as well as the heavy and prolonged duration of rainfall. Therefore, applying of fertilizer and liming materials in acidic soil maximize the availability of nutrients especially phosphorus in the soil, which very important for better performance of crops. In general liming is important in the study area; this is because of very strong acidity and low values of some chemical properties of the soil. The application of phosphorus fertilizer increased yields of soybean.

Results of soil analysis after harvesting of soybean revealed that the application of different phosphorus rates and soybean varieties affected soil pH, organic carbon and total N. The results of soil analysis revealed that the textural class of the surface soil is clay loam with a pH value ranged 4.54-4.64; organic carbon content of the soil is 0.93-1.35% and total nitrogen content of the soil amounts to 0.1-0.16% (Table 2). Berhanu (1980) classified soils with organic matter >5.20, 2.6-5.2, 0.8-2.6 and <0.8% as high, medium, low and very low, respectively in their organic matter status. Therefore, the organic carbon content 0.93-1.35% of the experimental soil is low.

According to Landon (1991) soils having total N of greater than 1.0% are classified as very high, 0.5-1.0% high, 0.2-0.5% medium, 0.1- 0.2% low and less than 0.1% as very low in total nitrogen content. Therefore, the soil of the experimental site has low total nitrogen content 0.1-0.16%. Bruce and Rayment (1982) classified soils having pH with <4.5, 4.5-5, 5.1-5.5, 5.6-6 and 6.1-6.5 as extremely acid, very strongly acid, strongly acid, moderately acid and slightly acid, respectively in pH value content.

The pH of the soil was analyzed to be 4.54-4.64 showing very strongly acid reach. Soil pH of soybean fields was affected by different soil fertility management treatments.

Table.1 Selected chemical properties of soil before planting on farmer's field

PH(H_2O)	Total N (%)	OC (%)	Ex. Acidity(meq/100g)	Textural class
4.65	0.15	1.61	0.72	Sandy clay loam

Table.2 Effect of P application and soybean cultivar on soil nutrient status in 2019/20 cropping season

Treatments		Results of tested parameters		
Phosphorus rate kg/ha	Variety	**PH(H_2O)**	**TN (%)**	**OC (%)**
0	Clark-63K	4.64	0.10	0.96
10	Clark-63K	4.64	0.13	1.19
20	Clark-63K	4.58	0.13	0.93
30	Clark-63K	4.58	0.10	0.99
40	Clark-63K	4.56	0.15	1.01
0	Afgat	4.63	0.10	1.29
10	Afgat	4.57	0.12	1.19
20	Afgat	4.54	0.11	1.10
30	Afgat	4.54	0.12	1.18
40	Afgat	4.55	0.14	1.05
0	SCS-1	4.54	0.15	1.35
10	SCS-1	4.56	0.12	1.35
20	SCS-1	4.56	0.10	1.11
30	SCS-1	4.56	0.12	1.23
40	SCS-1	4.55	0.16	1.17

Table.3 Main effects of phosphorus rates and varieties on plant height (cm) of soybean

Phosphorus rate (kg/ha)	Variety		
	Clark 63-K	Afgat	SCS-1
0	51.0^{h}	53.67^{fgh}	52.93^{gh}
10	54.47^{efgh}	58.67^{defg}	61.0^{bcde}
20	58.07^{defg}	63.4^{abcd}	66.0^{abc}
30	60.33^{cdef}	67.4^{ab}	65.87^{abc}
40	62.13^{abcd}	66.27^{abc}	68.07^{a}
LSD(0.05)	6.97		
CV (%)	6.90		

Table.4 Main effects of phosphorus rates and varieties on number of pods per plant of soybean

Variety	Number of pods per plant
Afgat	36.67
Clark 63-K	36.67
SCS-1	36.87
LSD(0.05)	3.30
Phosphorus rate (kg/ha)	
0	27.89^{b}
10	37.22^{a}
20	38.89^{a}
30	40.22^{a}
40	39.44^{a}
LSD(0.05)	4.26
CV (%)	12.0

Table.5 Main effects of phosphorus rates and varieties on hundred seed weight (g) of soybean

Phosphorus rate (kg/ha)	Variety		
	Afgat	Clark 63-K	SCS-1
0	15.81^{c}	16.86^{abc}	16.11^{c}
10	16.24^{c}	16.33^{bc}	18.02^{abc}
20	16.59^{bc}	17.12^{abc}	16.50^{bc}
30	17.66^{abc}	19.2^{a}	17.83^{abc}
40	16.91^{abc}	18.14^{abc}	18.67^{ab}
LSD(0.05)	2.39		
CV (%)	8.35		

Table.6 The interaction effect of phosphorus rates and varieties on above ground bio-mass of soybean

Phosphorus rate (kg/ha)	Variety		
	Clark 63-K	**Afgat**	**SCS-1**
0	11231.4^{def}	11782.1^{cde}	10917.1^{f}
10	12476.8^{abc}	11875.0^{cd}	11034.7^{ef}
20	11299.6^{def}	11366.7^{def}	11408.7^{def}
30	12225.8^{bc}	11942.7^{bcd}	11872.0^{cd}
40	13193.9^{a}	12682.2^{ab}	12357.4^{bc}
LSD(0.05)	771.5		
CV (%)	6.98		

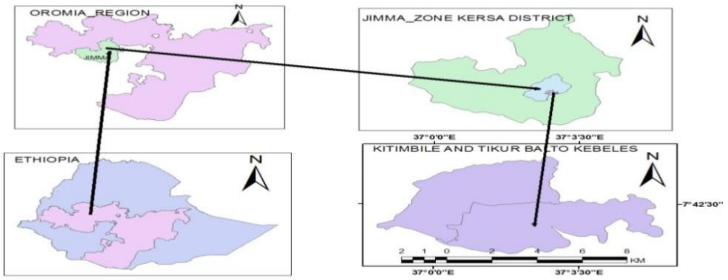
Table.7 Grain yield (kg ha^{-1}) of soybean as affected by the interaction of varieties and phosphorus rates

Phosphorus rate (kg/ha)	Variety		
	Afgat	Clark 63-K	SCS-1
0	2783.94^{g}	2705.81^{g}	2654.02^{g}
10	3224.26^{e}	3250.42^{e}	3053.57^{f}
20	3243.13^{e}	3391.85^{cde}	3250.56^{e}
30	3357.84^{de}	**3670.81^{a}**	3584.56^{ab}
40	3424.65^{bcd}	3599.86^{a}	3538.20^{abc}
LSD(0.05)	168.3		
CV (%)	5.55		

Table.8 Harvest index of soybean as influenced by the interaction of variety and phosphorus rates

Phosphorus rate (kg/ha)	Variety		
	Afgat	Clark 63-K	SCS-1
0	0.2488^{gh}	0.2300^{i}	0.2322^{hi}
10	0.260^{fg}	0.273^{ef}	0.280^{de}
20	0.288^{bcde}	0.30^{abc}	0.297^{abcd}
30	0.277^{ef}	0.31^{a}	0.30^{ab}
40	0.260^{fg}	0.283^{cde}	0.288^{bcde}
LSD(0.05)	0.017		
CV (%)	6.54		

Fig.1 Map of the study area Kersa district-Jimma Zone, Oromia National Regional State



Growth parameters

Plant height (cm)

The analysis of variance showed highly significant ($P<0.05$) differences among the soybean plant height at physiological maturity.Plant height of soybean was affected by phosphorus rates and soybean varieties. The tallest plant height (68.07 cm) was obtained from variety SCS-1 while the shortest plant height (51.0 cm) was obtained from 0kg phosphorus rate with variety Clark-63K (Table 3). However, differences in plant height between varieties Afgat and SCS-1 as well as Clark-63k were not statistically highly significant (Table 3).The increased plant height in variety Afgat may be attributed to its inherent genetic characters and better response to 69 kg/ha phosphorus rate and therefore, more plant growth. Application of 69 kg phosphorus ha^{-1} gave the highest plant height (67.4 cm) whereas the control treatment gave the lowest (51.0 cm) (Table 3). Increasing phosphorus rate from 0 to 30 kg ha^{-1} increased plant height consistently. As the evidence observed from 46 kg and 69 kg phosphorus ha^{-1}, application of P gave higher soybean plant height as compared to control (Table 3).

Yield Components and Yield

Number of pods per plant

The analysis of variance showed non-significant variation among the varieties of soybean in number of pods per plant. Similarly, the effects of phosphorusrates and the interaction were also non-significant except control. However, variety SCS-1 had the highest number of pods per plant (36.87) while variety Clark 63-k and Afgat produced similar number of pods per plant (36.67) (Table 4). With regards to phosphorus rates, the highest number of pods per plant (40.22) was observed at phosphorus rate of 30 kg ha^{-1} while the lowest number of pods per plant (27.89) was recorded in unfertilized treatments. Similar result was also reported in soybean by Subramanian and Radhak (1981); and Jayapaul and Ganesaraja (1990) where the application of 80-120 kg P_2O_5 ha^{-1} of soybean increased the number of pods plant^{-1}.

Hundred seed weight (g)

Different levels of P had significant effect on 100-seed weight of soybean (Table 5). The heaviest 100-seed weight (19.2 g) was obtained with 150 kg ha^{-1}of TSP. Similar trend of results was reported by Devi *et al.*, (2012), who observed a significant variation in 1000-seed weight at different phosphorus levels. The highest 100-grain weight (19.2 g) was recorded from application of 30kg ha^{-1} of phosphorus rate and variety Clark 63-K while the lowest (15.81g) value of 100-seed weight was obtained from control with variety Afgat which was small seeded (Table 5). Chatterjee and Som (1991) reported increase in hundred seed weight due to the application of phosphorus up to 80 kg P_2O_5ha^{-1}. In line with this result, Malik *et al.,* (2006) reported that P fertilizer and seed inoculation having a significant influence on 1000-seed weight of soybean, with the highest value from 90 kg P_2O_5 ha^{-1} with Rhizobium inoculation which was statistically at par with 120 kg P_2O_5 ha^{-1} with inoculation. Zafar *et al.,* (2003) reported that the effect of rates of phosphorus application was highly significant in affecting1000-seed weight. This might be due to the influence of cell division, phosphorus content in the seeds as well as the formation of fat and albumin.

Above ground dry-biomass yield

The main effects of phosphorus rates and varieties were highly significant ($P<0.01$) on the above ground dry biomass yield. The interaction effect of phosphorus rates and varieties were highly significant. The highest biomass yield (13193.9 kg ha^{-1}) was obtained due to 40 kg P ha^{-1} application, while the lowest biomass yield (10917.1 kg ha^{-1}) was obtained from control treatment (Table 6). The effects of Phosphorus rates at control and 10 kg ha^{-1} phosphorus were not significantly different for above ground dry biomass yield. Generally biological yield increased with the increasing doses of P and K fertilizer application along with other recommended applied fertilizer. These results are similar to findings of Munir and McNeilly (1987) who reported that increasing rates of P and K increased the biological yield.

Regarding the variety, the highest above ground dry biomass yield (13193.9 kg ha^{-1}) was obtained from variety Clark-63K while the lowest above ground dry biomass yield (10917.1 kg ha^{-1}) was obtained from variety SCS-1. Phosphorus deficiency generally decreases plant biomass accumulation by limiting interception of photo synthetically active radiation (PAR) rather than reducing efficiency of conversion of PAR into dry matter. The varieties that also take shorter period to their vegetative growth time are more productive under limited resources and the reverses could probably have higher vegetative yield. Similarly, Khamparia (1996) reported that increasing rates of P in inoculated treatment increased biomass yield by 13.1 to 14.7% of soybean. The current investigation was in line with the findings of Yilmaz (2008) who pointed out that increasing phosphorus levels improved above ground biomass at harvest of vetch by as much as 18.5%.

Grain yield (kg ha^{-1})

The main effects of phosphorus rates and varieties had highly significant ($P<0.01$) effects on the grain yield of soybean. Moreover, variety and phosphorus rate interaction was highly significant. Application of 69 kg ha^{-1} of phosphorus treated produced the highest grain yield (3670.81 kg ha^{-1}) with Variety Clark-63k while the lowest grain yield (2654.02 kg ha^{-1}) was obtained from unfertilized treatment (Table 7). Tomar (2001) revealed as that application of phosphorus influenced the seed yield of French bean (Phaseolus vulgaris) significantly up to 60 kg P_2O_5 ha^{-1}. Singh and Singh (2000) and Tewari and Singh (2000) also revealed significantly increased seed yield due to increased phosphorus application from 75 to 100 kg P_2O_5 ha^{-1}.Among the soybean varieties, Clark-63k produced highest grain yield followed by SCS-1 and Afgat variety respectively (Table 7). From these results, Variety Clark-63k and SCS-1 were the better variety due to its feature or attractive of highest yield and early maturity than variety Afgat under the agro-ecology of Jimma, south-western Ethiopia. The result is in agreement with those of Pauline *et al.*, (2010), and Aise *et al.*, (2011) who reported a similar finding on seed yield of soybean under the condition of the proper P application. The decrease in seed yield at the lowest and highest P application was most likely due to the fact that the growth and development of soybean was influenced by nutrient deficiency or nutrition surplus (Xiang *et al.*, 2012). These increased in seed yield was associated with more number of pods plant^{-1} and 100-seed weight.

Harvest index

Harvest index calculated as the ratio of grain yield to the above ground dry biomass weight. Harvest index of soybean varied significantly ($P<0.01$) with different level of phosphorus rates as well as the interaction effect of variety and phosphorus rates (Table 8). The application of phosphorus at 69 kg ha^{-1} resulted in the highest harvest index for variety Clark-63k (0.31) while the lowest harvest index (0.26) was recorded for variety Afgat at 10 kg ha^{-1} of phosphorus rate (Table 8). Among the rates of phosphorus application, the highest harvest index (0.31) was obtained with the application of 30 kg phosphorus ha^{-1} followed by 20 kg phosphorus ha^{-1} while the lowest harvest index (0.23) was obtained from control treatment. The present result is consistent with the findings of Malik *et al.*, (2006) who found that HI varied significantly due to different levels of phosphorus. Zafar *et al.*, (2003) found that values of harvest index showed an increasing trend in the harvest index values with application of Phosphorus. In addition, they also reported minimum harvest index from control plot as compared to fertilized. Among the varieties, Clark-63k gave the highest harvest index (0.31) (Table 8). The higher harvest index of variety Clark-63k might be due to the higher grain yield obtained.

From the results of this experiment it may be concluded that the application of 30P fertilizers influenced growth parameters, yield attributes and seed yield of soybean. Although P played an important role on the yield of soybean, the application of their excess amount however acted negatively. The application of 150 kg ha^{-1} TSP and 100kg of urea ha^{-1}was found to be the most appropriate levels of P and N for maximum productivity of soybean. From this result application of 30kg of phosphorus gave 8.22% yield increment over recommended P (20kg/ha) with variety Clark-63K and 10.28% with variety SCS-1.Therefore, applying of fertilizer and liming materials in acidic soil maximize the availability of nutrients especially phosphorus in the soil, which very important for better performance of crops. In general liming is important in the study area; this is because of very strong acidity and low values of some chemical properties of the soil. The application of phosphorus fertilizer increased yields of soybean; however, the grain yields were low compared with crop potential. So it is recommended that correcting of soil acidity should be done for growth seasons until soil comes to neutral conditions and increased crop production.

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