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Effect of Phosphorus Rates on Growth, Phosphorus (P) Uptake and Yield of Cowpea (*Vigna unguiculata* L.) Varieties at Dabo Hana District, South West Ethiopia

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Abstract: Cowpea (*Vigna unguiculata* L.) is an edible legume crop grown with multiple uses. Phosphorus (P) deficiency is particularly important in acid soils of South west Ethiopia affecting growth and yield of grain legumes particularly cowpea. Therefore, a field experiment was conducted to determine the response of cowpea varieties to P application on the soils of Dabo Hana District. The experiment consisted of Sewunet, Bole and Bekur cowpea cultivars and five P fertilizer rates (0, 23, 46, 69, and 92 kg P_2O_5 ha^{-1}). The experiment was laid out in a randomized complete block design in a factorial arrangement with three replicates. Data on growth and yield; P uptake parameters were collected and statistically analyzed using SAS version (9.3) software. The interaction effects of varieties and P rates significantly ($p < 0.01$) influenced different parameters. The highest grain yield (2582.89kg ha^{-1}) and straw yield (12,164 kg ha^{-1}) were obtained from the treatment combination of variety Sewunet and 69 kg P_2O_5 ha^{-1}. In conclusion, the study pointed out that cowpea varieties responded differently to the various P rates suggesting the possibility of exploiting varietal differences to combat P requirement of cultivars under acidic conditions. However, the present result based on one season and location may not lead us to make definite conclusion. As a result, it is recommended that the study should be repeated in more than one season and locations.

Keywords: Cowpea, Phosphorus Uptake, Seed Yield

1. Introduction

Cowpea (*Vigna unguiculata* (L). *Walp*.) belongs to the family *Fabaceae* and subfamily Faboideae [1]. Cowpea seeds provide a rich source of proteins and calories, as well as minerals and vitamins. The starch found in cowpea is digested more slowly than the starch from cereals, which is more beneficial to human health [2]. It is often called "meat for poor people" since its protein is the cheapest. In other case, the crop has been described as a "hungry-season crop" that is an important component in hunger fighting strategy, especially in the Sub-Saharan Africa where the peasant farmers can experience food shortage a few months before the maturity of the new crops [3]. It is reported that the plant can fixes atmospheric nitrogen up to 240 kg ha^{-1} and leaves about 60-70 kg nitrogen for successive crops, thereby reducing N fertilizer demand and cost for growing the crop [4].

Cowpea is cultivated around the world particularly in the semi-arid tropics primarily as a pulse, but also as a vegetable (for both grains and the green peas) as well as a cover and fodder crop [6]. However, according to FAOSTAT [5] world cowpea production is estimated at 4.5 million tones, dominated by West African countries such as Nigeria, Niger and Burkina Faso. Mean yield in Africa is between 450 to 500 kg grain ha^{-1} [5]. In Ethiopia the higher average mean grain yield was 691kg ha^{-1} [7]. As to Ethiopia, at the farm level, productivity of cowpea appears to be severely constrained through limited or no use of chemical fertilizers (e.g. phosphates); very limited availability of improved varieties (mostly grown from unimproved cultivars with low genetic potential); lack of appropriate technology and biotic and a biotic stresses are the major production constraints of the crop in the country. The deficiency of phosphorus nutrient is the most limiting soil fertility factor for cowpea production [8]. Phosphorus is critical to cowpea yield because it is reported to stimulate growth, initiate nodule formation as well as influence the efficiency of the rhizobium-legume symbiosis [9].

The P use efficiency (PUE) of crops differs; and it is categorized into P acquisition efficiency (PAE) and P utilization efficiency (PUE). PAE refers to mobilization of P from poorly soluble sources or to take up the soluble P available in the soil solution while PUE is the ability to produce biomass or yield efficiently using the limited acquired phosphorus. Numerous studies have revealed that increase in PAE is associated with root morphology and root architecture while PUE is associated with the efficient use of P in the plant [10].

Stamford *et al*. [11], stated phosphorus application significantly enhances number of nodules; nodules dry weight and phosphorus uptake of the cowpea. [8] reported, that application of 60 kg P_2O_5 ha^{-1} significantly improved grain and biomass yield of cowpea. Application of phosphorus is, therefore, recommended for cowpea production on soils low in P not only to enhance their growth and yield but also nitrogen fixation [4]. So that one of the options of reducing low yields due to soil phosphorus content is to determine the best rate of phosphorus fertilizer, to increase yield and returns from cowpea. At Dabo Hana cowpea production becoming important and many farmers expanding its production due to its various advantage. However, there is no more varieties in used in the area and farmers are also using blanket application of P to increase the yield of the crop on only Lojo local variety. So that, to make site-specific recommendation of P fertilizer for cowpea production, nutrient rate experiment and superior variety of cowpea is needed. Therefore, the study was conducted with the general objective of examining the effect of P fertilizer rates on growth, P uptake and yield of cowpea Varieties in Loko Kebele, Dabo Hana District.

Specific objectives

1) To determine the interaction effect of phosphorus and cowpea varieties on growth and yield of the crop under Dabo Hana District, Southwest Ethiopia.
2) To evaluate the phosphorus use efficiency of cowpea varieties under Dabo Hana district, southwest Ethiopia.

2. Materials and Methods

2.1. Description of the Study Area

The study was conducted in Loko kebele at Dabo Hana District during the 2016 cropping season (July- December). Dabo Hana is located at 8° 40′41″ N latitude and 36° 19′ 05 ″ E longitudes in Buno Bedele Zone, Oromiya Regional State (Figure 1), at 519 km Southwest of Finfine and 36 km far from Bedele town. The altitude of the experimental site is 1658 m a. s. l. The area receives an average annual rain fall ranges from 500 to 1500 mm. The rainy season extends from April to October and the maximum rain is received in the months of May-September with the mean monthly rainfall exceeding 302.5 mm. The annual average, mean minimum and mean maximum temperatures are 19.8, 11 and 28°C, respectively.

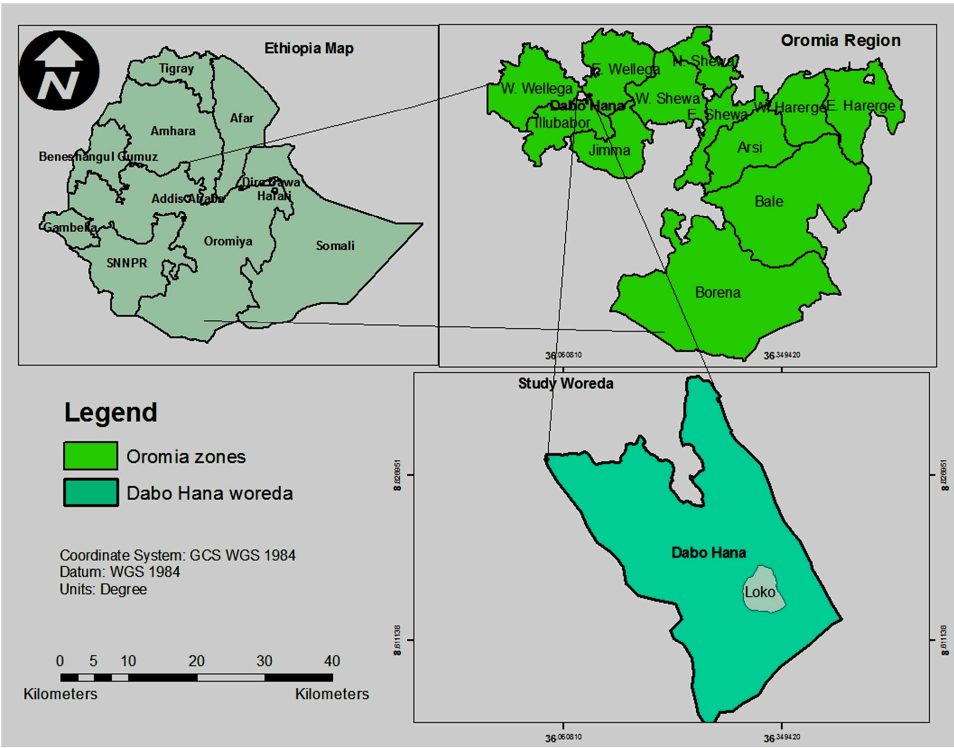

Figure 1. *Map of the study area.*

The area is covered by variety of crops and species of natural vegetation. The dominant crops in the area are maize, teff, sorghum, finger millet, faba bean, common bean and Cowpea. The major land use types are cultivated land/crop land, forest land and grazing land. Farmers use crop rotation practice cereal with legumes to maintain soil fertility of the land and have been applying chemical fertilizers such as DAP/NPS and Urea at the rates of blanket recommendation of 100 kg respectively. The trial was conducted on farmer's training centers (FTC).

2.2. Treatments and Experimental Design

The treatments consisted of a factorial combination of three varieties of cowpea: Sewunet (IT 93 KD 596), Bole (85 D-3517-2) and Bekur (838 689 4) and five rates of phosphorus: 0kg ha^{-1}, 23 kg ha^{-1}, 46 kg ha^{-1}, 69 kg ha^{-1}and 92 kg ha^{-1}. The treatments was laid out as randomized complete block design in a 5x3 factorial arrangement and replicated three times. The experimental plot size was 2m x 2.8m (5.6m^2). The spacing between blocks and plots was 1.5 m and 0.5 m, respectively.

2.3. Experimental Procedures

The experimental field was ploughed by oxen, disked and harrowed before sowing. Sowing was done on August 20, 2016. Cowpea crop were sown in inter-row spacing of 40cm and intra row spacing of 20 cm. Nitrogen was applied at the rate of 20 kg N ha^{-1} in the form of Urea (46% N) to be used as a starter fertilizer at sowing time [12]. Weeding and other crop management practices like pest control were done for all experimental plots as required. The outer most two rows on each side of a plot were left as a boarder row. The middle three rows were used for data collection and yield measurements.

2.4. Soil and Plant Tissue Sampling Analysis

2.4.1. Soil Sampling and Analysis

A soil sample was randomly collected from the selected field in a zigzag pattern at the depth of 20 cm using an auger and composited and it was analyzed for organic carbon, total N, soil pH, available P, cation exchange capacity (CEC) and texture by using standard laboratory procedures at JUCAVM soil laboratory.

2.4.2. Plant Tissue Sampling and Analysis

At physiological maturity, five randomly selected plants were harvested from three central rows and partitioned into grain and straw. Total P uptake was calculated as the summation of grain and straw. P uptake was calculated according to the formulae described by Godwin and Blair [13] as follows;

$$\text{Total P uptake} = \text{grain P uptake} + \text{Straw P uptake}$$

2.5. Data Collection and Measurements

Growth and Yield Parameters like Plant height (cm), Number of primary branches per plant and Number of nodules per plant were taken. *Yield and yield component parameters*: Number of pods per plant, Number of seeds per pod, Hundred seed weight (g), Grain yield (kg/ha, Straw yield per plot and Harvest index (%). *Phosphorus use efficiency*: Based on the laboratory results of plant tissue analysis, phosphorus up take was calculated.

2.6. Statistical Data Analysis

The data was subjected to Analysis of Variance using SAS software [14]. When ANOVA showed significant difference, mean separations were carried out using, LSD test at 5% probability level. Pearson's correlation analysis was done to observe the relationship between related parameters.

3. Results and Discussion

3.1. The Initial Physico-Chemical Properties of a Soil

The result of soil analysis showed that the experimental soil had a pH $_{(H2O)}$ of 5.44 (moderately acidic). [15] reported that the preferable pH ranges for most seed crops are in between 4 and 8. Thus, the pH of the experimental soil was within this range and suitable for the crop under study Texture of the soil have compositions of 35% clay, 36% silt and 29% sand, which is in the textural class of clay loam in which it is also suitable for experimental crop as well as for other agricultural crops [16]. Total nitrogen and organic carbon content of the experimental site soil was 0.16% and 4.15%, respectively (Table 1) that are in the range of medium. Available P of the soils was 5.57 ppm and according to Hazelton and Murphy [17], the experimental soil is found to be very low and deficient in P. As the area receives heavy rainfall, P is probably fixed by high concentrations of aluminium and iron because of leaching of the basic cat-ions. In general, the experimental soil was found to be conducive for cowpea cultivation with external P application.

Table 1. *Initial physico-chemical properties of the soil.*

Parameter	Value	Rating	Reference
Texture class	**Clay loam**		
pH	5.44	Moderately acid	Landon (1991)
OC (%)	4.15	Medium	Hazelton and Murphy (2007)
TN (%)	0.16	Medium	Bruce and Rayment (1982)
Av.p (ppm)	5.57	low	Hazelton and Murphy (2007)
CEC (Cmol)	19	Medium	Landon (1991)
Sand (%)	29		
Clay (%)	35		
Silt (%)	36		

Where, Cmol= Cent mole; pH=hydrogen power; %OC=percent of organic carbon; %TN=Percent of Total nitrogen; Av.p.ppm=available P in parts per million; CEC=Cation exchange capacity; %=percent

3.2. Growth and Nodulation Parameters of Cowpea

3.2.1. Plant Height (cm)

Plant height was significantly affected *(p<0.01)* by the interaction effects of varieties and P rates. The highest value for plant height (94.93 cm) was recorded on Sewunet variety at application of 92 kg P_2O_5 ha^{-1}, whereas the lowest value of plant height (49 cm) was recorded on Bekur at zero application (Table 2). This indicates that the cowpea varieties utilized the phosphorus fertilizer applied judiciously in growth and development processes. The interaction effect might be attributed to the fact that plant height is generally governed by genetic constitute of varieties and phosphorus treatments. Similarly, significant effect of varieties and phosphorus rate on plant height of cowpea was reported by Nkaa *et al*. [4].

3.2.2. Number of Primary Branches Plant^{-1}

The interaction effects of varieties and P rates showed highly significant *(p<0.01)* effect on number of primary branch at maturity. The highest number of primary branch (11.5) was recorded from Sewunet variety at the highest rate of P application (92 kg P_2O_5 ha^{-1}) while the lowest number of primary branch (3.96) was recorded from Bole variety in the control plot (Table 2). Prasad, [18] also reported that enhancing the phosphorus level from 0 to 30 or 60 kg P_2O_5 ha^{-1}, increased the number of branches per plant, with different varieties of cowpea.

Table 2. *Mean plant height (PH), number of primary branch (NPB) and number of nodule (NND) of cowpea as influenced by interaction effect of varieties and P application at Dabo Hana, 2016.*

P rates P_2O_5 kg ha^{-1}	PH (cm)			NPB			NND		
	Variety								
	Sewunet	Bole	Bekur	Sewunet	Bole	Bekur	Sewunet	Bole	Bekur
0	58.333^{i}	56.667^{i}	49^{j}	4.1^{hi}	3.96^{i}	4.53^{ghi}	19.4^{j}	20.3^{j}	12.6^{j}
23	71.13^{g}	67.8^{h}	59^{i}	6^{efg}	7.2^{def}	5.63^{fgh}	59.3^{h}	63.6^{gh}	41.2^{i}
46	81.53^{de}	78.96^{ef}	67.6^{h}	7.53^{cde}	6.3^{ef}	6.1^{efg}	122.5^{d}	168.9^{b}	71.7^{g}
69	88^{bc}	83.6^{d}	77.26^{f}	8.96^{bc}	7.3^{cde}	7.4^{cde}	151.6^{c}	168^{b}	86.3^{f}
92	94.93^{a}	90^{b}	86.8^{c}	11.5^{a}	9.73^{b}	8.76^{bcd}	193.9^{a}	163.4^{b}	102.1^{e}
CV (%)		2.22			13.73			5.05	
$LSD_{(0.05)}$		2.6873			1.6336			8.12	

CV=coefficient of variation, LSD=least significance difference

3.2.3. Number of Nodules Per Plant

The result revealed that, number of nodule was significantly *(p<0.01)* influenced by the interaction effect of varieties and different rates of P applications. The highest number of nodules $plant^{-1}$ (193.9) was recorded from 92 kg P_2O_5 $ha^{-1}$for Sewunet variety, whereas the lowest number of nodules $plant^{-1}$ (12.6) was obtained from 0 kg P_2O_5 ha^{-1} of Bekur variety (Table 2). The application of higher rate of phosphorus favored for increased number of nodules to P efficient genotype crop. In agreement with the current result, significant increase in nodulation following P application rate was also observed by Olaleye *et al*. [19].

3.3. Yield Parameters

3.3.1. Number of Pods Per Plant

The analysis of variance showed significant *(p<0.01)* variation among the varieties of cowpea in number of pods $plant^{-1}$, P rates and their interaction. However, Sewunet variety had the highest number of pods $plant^{-1}$ (42.83) at a rate of 69 kg P_2O_5 ha^{-1}, while Bekur variety produced the lowest number of pods $plant^{-1}$ (20.1) (Table 3) in unfertilized treatments. The variation on the number of pods $plant^{-1}$ might be primarily related to the genotypic variation of the cowpea varieties. Singh *et al*. [8] reported that pod $plant^{-1}$; yield and grain yield of cowpea significantly increase with the application of 60 kg ha^{-1} over 0, 20 and 40 kg $ha.^{-1}$of P_2O_5.

3.3.2. Pod Length (cm)

The result showed that, the interaction effect of variety and P fertilizer rate had highly significant *(p<0.01)* effect pod length. Likewise Sewunet variety produced the longest pod length (14cm) at the application of 92 kg P_2O_5 ha^{-1}, whereas the smallest pod length was recorded from Bekur variety at zero application and non-significant difference at 23kg P_2O_5 ha^{-1} on the same variety (Table 3). The longer period for pod formation due to application of P might be attributed to improvement in growth attributes owing to improved availability of P that could play an important role in cell division [20]. This result is inconformity with the findings of several scholars who stated phosphorus greatly increased the length of pod per plant [4, 26].

Table 3. *Mean Number of pods per plant (NPPP), pod length (PL) and number of seeds per pod (NSPP) of cowpea varieties as influenced by interaction effect of varieties and P application at Dabo Hana, 2016.*

P rates P_2O_5 kg ha^{-1}	NPPP			PL(cm)			NSPP		
	Variety								
	Sewunet	Bole	Bekur	Sewunet	Bole	Bekur	Sewunet	Bole	Bekur
0	25.3^{gh}	22.86^{i}	20.1^{j}	9.3^{f}	8.13^{h}	4^{k}	8^{e}	6.56^{fg}	2.86^{i}
23	28.66^{f}	26.46^{g}	23.66^{hi}	10.23^{e}	8.66^{g}	4.23^{k}	8.9^{d}	7.96^{e}	3^{i}
46	33.3^{ed}	30.33^{f}	28.8^{f}	10.46^{de}	10.8^{d}	5.43^{j}	9.53^{d}	10.63^{c}	5^{h}

P rates P_2O_5 kg ha^{-1}	NPPP			PL(cm)			NSPP		
	Variety								
	Sewunet	Bole	Bekur	Sewunet	Bole	Bekur	Sewunet	Bole	Bekur
69	42.83^{a}	39.06^{b}	35.6^{c}	12.86^{b}	12^{c}	6.3^{i}	11.86^{b}	11.5^{b}	6^{g}
92	38.16^{b}	32.53^{e}	35^{cd}	14^{a}	13.23^{b}	7.9^{h}	13^{a}	12^{b}	6.96^{f}
CV(%)		3.4			2.58			4.99	
LSD$_{(0.05)}$		1.75			0.38			0.67	

CV=coefficient of variation, LSD=least significance difference

3.3.3. Number of Seeds Per Pod

The number of seeds pod^{-1} was highly significantly *(p< 0.01)* affected by varieties of cowpea and different rates of P application. Moreover, the interaction effect of varieties and P application rates had significant effect on the number of seeds pod^{-1}. The highest number of seeds pod^{-1} (13) was recorded at 92 kg P_2O_5 ha^{-1} on Sewunet variety whereas the lowest number of seeds pod^{-1} (2.86) was obtained at 0 kg P_2O_5 ha^{-1} on Bekur cultivars (Table3) which are statistically similar with Bole variety at application of 23kg P_2O_5 ha^{-1}. Number of seeds pod^{-1} was perceived as a significant constituent that directly imparts in exploiting potential yield recovery in leguminous crops [21].

3.3.4. Hundred Seed Weight (HSW) (g)

Hundred seed weights was found to be affected significantly *(p<0.01)* by cowpea varieties and P application rates and by the interaction effect. Hundred seed weight is an important yield component which reflects the magnitude of seed development which ultimately reflects on the final yield of crops [22]. The highest hundred seed weight (13.87 g) was recorded on Sewunet variety to the applied 69 kg P_2O_5 ha^{-1} while the lowest hundred seed weight (4.8g) was recorded on Bekur variety at no fertilizer application. An increased of P application might be attributed to important roles that P played in growth potential of the crop [20].

Table 4. *Mean hundred seed weight of cowpea varieties as influenced by interaction effect of varieties and P application at Dabo Hana, 2016.*

P rates kg P_2O_5 ha^{-1}	HSW		
	Variety		
	Sawunet	Bole	Bekur
0	7.35^{f}	6.01^{g}	4.8^{h}
23	8.93^{d}	8.9^{de}	6.27^{g}
46	11.66^{b}	10.01^{c}	7.93^{ef}
69	13.87 ^{a}	10.48^{c}	10.16^{c}
92	12.62^{b}	11.72^{b}	10.16^{c}
CV (%)		6.2	
LSD$_{(0.05)}$		0.98	

CV=coefficient of variation, LSD=least significance difference

3.3.5. Grain Yield (kg ha^{-1})

The results of analysis of variance revealed that grain yield was significantly *(p<0.01)* affected by the interaction of varieties and P rates. The highest grain yield (2582.89 kg ha^{-1}) was recorded from Sewunet variety at 69 kg P_2O_5 ha^{-1}, whereas the lowest grain yield (563kg ha^{-1}) was recorded from Bekur variety at a plot of no applied Phosphorus (Table 5). These results showed that Sewunet responds best to the applied phosphorus for the production of grain yield, and variation in variety is only genetic characteristics to produce yield, which may arise from variation in P acquisition and translocation and use of absorbed P for seed formation [23].

3.3.6. Straw Yield (kg ha^{-1})

Interaction effect of Varieties and P was highly and significantly affected *(p<0.01)* the straw yield. The maximum straw yield was produced by Sewunet variety (12164 kg ha^{-1}) from plots that received 69 kg P_2O_5 ha^{-1} that was statistically not different on plot that received 92 kg P_2O_5 ha^{-1} with Sewunet and Bole variety, while the minimum straw yield (4846 kg ha^{-1}) was produced by Bole with unfertilized plot. The variation in straw yield of the varieties across P levels might be attributed to enhanced availability of P for root growth and number of nodules by which increases nutrient absorption that contribute for full development of above ground parts of the plants. [24] reported that with increase in P_2O_5 ha^{-1} level from 0 to 60 kg ha^{-1} resulted in maximum dry matter yield of cowpea.

3.3.7. Harvest Index (%)

Main effects of P, variety and their interaction had significant *(p<0.01)* effect on harvest index. The mean comparison showed that highest harvest index (23.23) was recorded from application of 69 kg P_2O_5 ha^{-1} on Sewunet variety. Whereas the lowest value of harvest index (7.56) was observed from no P application of Bekur variety. The highest mean of harvest index also implies higher partitioning of dry matter into seed. The low harvest index at low level of P_2O_5 ha^{-1} might be due to poor development of plant to different growth stages.

Table 5. *Mean grain yield (GY) and Straw yield (SY) harvest index (HI) of cowpea varieties as influenced by interaction effect of varieties and P application at Dabo Hana, 2016.*

P rates P_2O_5 kg ha^{-1}	GY (kg ha^{-1})			SY (kg ha^{-1})			HI (%)		
	variety								
	Sewunet	Bole	Bekur	Sewunet	Bole	Bekur	Sewunet	Bole	Bekur
0	877.25^{gh}	765.27^{hi}	563^{j}	4981.7^{f}	4846^{f}	6478.3^{cdef}	12.8^{bcdef}	12.69^{cdef}	7.56^{f}
23	1183.67^{f}	1083^{ef}	686.08^{ij}	5676^{f}	5963^{ef}	7661.7bcde	15.02bcdef	13.67bcdef	9.6^{ef}
46	1859.67^{d}	1778.5^{d}	823.33^{ghi}	6425.3def	6612.7^{cdef}	8166.7^{bcd}	17.11^{abcde}	18.2^{abcd}	9.84^{ef}

P rates P_2O_5 kg ha^{-1}	GY (kg ha^{-1})			SY (kg ha^{-1})			HI (%)		
	variety								
	Sewunet	Bole	Bekur	Sewunet	Bole	Bekur	Sewunet	Bole	Bekur
69	2582.89^{a}	2206.67^{c}	956.67^{fg}	12164^{a}	9571.8^{b}	8397.1^{bc}	23.23^{a}	19.78^{abc}	13.1^{bcdef}
92	2389.89^{b}	2257.67^{bc}	1036.67^{f}	12078.7^{a}	11838.7^{a}	8960.3^{b}	20.85^{ab}	19.7^{abc}	11.2^{def}
CV (%)		5.29			13.88			21.91	
LSD $_{(0.05)}$		143.8			1951.1			8.01	

CV=coefficient of variation, LSD=least significance difference

3.4. Phosphorus Uptake

Grain, Straw and Total P Uptake

The uptake of phosphorus by cowpea grain (GUP), straw (PUSt) and total uptake (grain + straw) were showed significant ($p < 0.01$) variation due to phosphorus and varieties interaction. The maximum P uptake by grain, straw and total P uptake was recorded from Sewunet variety with the rate of 69kg P_2O_5 ha^{-1}application, whereas the lowest P uptake were recorded in Bekur variety at control plot in grain, straw and total P uptake, respectively (Table 6). The seed P uptake accounted for 56.18% of the maximum total P uptake, whereas straw P accounted for 43.81%. Therefore, the variation in seed, straw and total P uptake might be due to plant root architecture regulates the capacity of soil explored by roots, thereby playing a central role in P acquisition. Thus, the differences in these root traits explain the differences among cowpea genotypes in P acquisition efficiency. Given the fact that P is immobile in the soil, a well-developed rooting system is necessary for effective P uptake. In contrast to this result Havlin *et al*. [25] indicated that large quantities of P are found in seed and P is considered to be essential for seed formation.

Table 6. *Mean P uptake by grain (PUG), straw (PUSt) and total P uptake (TPU) of cowpea as influenced by interaction effect of cultivars and P rate at Dabo Hana, 2016.*

P rate P_2O_5 kg ha^{-1}	PUG (kg ha^{-1})			PUSt (kg ha^{-1})			TPU (kg ha^{-1})		
	Cultivars								
	Sewunet	Bole	Bekur	Sewunet	Bole	Bekur	Sewunet	Bole	Bekur
0	9.42^{g}	8.97^{h}	8.43^{i}	6.51^{g}	6.09^{g}	5.21^{h}	15.93^{j}	15.06^{k}	13.64^{l}
23	10.64^{f}	10.45^{f}	10.33^{f}	8.42^{e}	8.20^{ef}	7.90^{f}	19.07^{h}	18.65^{hi}	18.23^{i}
46	11.61^{e}	11.45^{e}	11.35^{e}	9.46^{d}	8.47^{e}	8.50^{e}	21.07^{ef}	19.92^{g}	19.85^{g}
69	13.67^{a}	13.01^{b}	12.24^{cd}	10.66^{a}	10.31^{ab}	9.77^{cd}	24.33^{a}	23.32^{b}	22.55^{cd}
92	12.50^{c}	12.15^{d}	11.96^{d}	10.06^{bc}	9.47^{d}	8.61^{e}	22.56^{c}	21.62^{de}	20.57^{f}
CV (%)		1.78			2.7			2.16	
LSD$_{(0.05)}$		0.33			0.427			0.627	

CV=coefficient of variation, LSD=least significance difference

4. Summary and Conclusion

The present study was conducted to evaluate the effect of Phosphorus rates on growth, P uptake and yield of cowpea varieties in Loko kebele at Dabo Hana District of Oromia regional state. Analysis of variance was showed that interaction of variety with P rates on growth parameters was significant. Likewise, yield and yield related parameters were significantly affected by the interaction effect of p rates and variety. Nodulation parameters like number of nodules per plant were significantly improved by the interaction of applied phosphorus fertilizer and variety. The highest yield was recorded from the application rate of 69kg P_2O_5ha^{-1} using variety Sewunet. Specifically, the study indicated that cowpea varieties responded differently to the various P application rates suggesting the possibility of exploiting varietal differences to reduce P deficiency under acidic conditions.

Accordingly, Sewunet variety as noticed from its performance on various growths and phenological characters, grain and straw yield including its response to P rates was the best variety under the agro-ecology of the study area, which was superior to Bole and Bekur variety. Hence, application of 69kg P_2O_5 ha^{-1} and Sewunet variety is recommended for the study area and similar agro-ecology. Actually, cowpea is grown mainly for its edible beans, but almost all parts of the plant can be used as food. It is a good food security item since it mixes well with other recipe since the crop can be grown as a vegetable that can be used to make delicious and nutritious vegetable dishes. However, this study did not consider the leaf yield of this crop and need further investigation. Therefore, more research should be conducted under multi-locations related to optimizing the leaf yield of cowpea with out compromising seed yield too much to evaluate different cowpea genotypes for better leaf yield production.

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Conflicts of Interest

The authors declare no conflict of interest.

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