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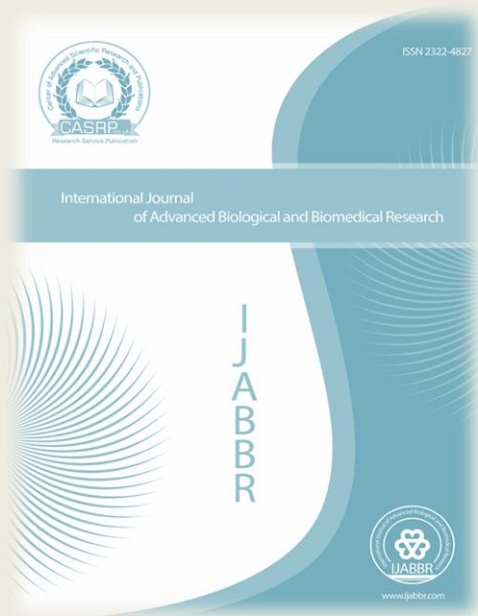

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Seed Yield of Groundnut (*Arachis Hypogaea* L.) as Influenced by Phosphorus and Manure Application at Babile, Eastern Ethiopia

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ABSTRACT

Objective: A field experiment was conducted in order to study the effect of phosphorus and manure application on agronomic performance and seed yield of groundnut. **Methods:** Factorial combination of two groundnut varieties ('Werer 962' and 'Oldhale'), Three rates of phosphorus (0, 90 and 180 kg P_2O_5 ha^{-1}) and three rates of manure (0, 5 and 10 ton ha^{-1}) were laid out in randomized complete block design with three replication. **Results:** The combined application of 180 kg P_2O_5 ha^{-1} and 10 ton manure ha^{-1} resulted in the highest number of pods per plant and seed yield. The increase in number of pods per plant and seed yield at the highest combined application rates of the two fertilizers were 40 and 60%, compared to the control of the two fertilizers. Generally, the present study has shown that the integrated use of manure (10 ton ha^{-1}) and inorganic phosphorus (180 kg P_2O_5 ha^{-1}) fertilizer resulted in highest seed yield of groundnut compared to the application of either fertilizer alone.

Introduction

Groundnut (*Arachis hypogaea L*) is an important annual legume in the world mainly grown for oil seed, food and animal feed (Pande *et al*., 2003; Upadhyaya *et al*., 2006). The world's average groundnut production is 1.49 tonnes (FAOSTAT, 2010). In Ethiopia, groundnut covers about 41,761.12 ha and primarily grown in eastern part of Ethiopia. The average national yield of groundnut is about 1.1 ton ha^{-1} (CSA, 2015), which is significantly lower than the World's average of about 1.49 t ha^{-1} (FAOSTAT, 2010). Groundnut is planted both during the "Belg" season (March) and also during the main season (June), in some parts of western Ethiopia. Groundnut requires nutrients for growth and development. From among these nutrients, phosphate is essential for root and kernel development, increased number, density and efficiency of nodules, and can also significantly increase the uptake of other nutrients. In most of the cropping systems all over the world P is one of the least available mineral nutrients (Shenoy and Kalagudi, 2005). There are many constraints for low yield of groundnut in Ethiopia. There is no recommended rate of fertilizer application on groundnut. Lack of fertilizer use and Low soil fertility (very low organic carbon and very low available phosphorus) are important limiting factors to achieve desirable yield of the crop. Groundnut rust, leaf spots, leaf blight, aflatoxins, bacterial wilts, and soil inhabiting insects (termites) are also important factors reducing groundnut production in Ethiopia (Daniel, 2009). There is no extensive study on the rates of phosphorus fertilizer required to obtain optimum seed yield of groundnut. The use of inorganic P fertilizers and manure may be considered as important factor for increasing groundnut yield in Ethiopia. Thus, the present study was under taken to assess the effect of phosphorus and manure application on seed yield of groundnut.

Materials and Methods

Field experiment was conducted at Babile research station of Haramaya University, Ethiopia to determine the effect of phosphorus and manure application on seed yield of groundnut. Babile is located at 90 13' 13.5'' N latitude and 420 19' 20.9'' E longitudes and at an altitude of 1647 meters above sea level. It is located in Eastern Hararge zone, which is representative for groundnut production in the region. The area has an annual average rainfall of 569 mm and soil texture of sandy loam.

A randomized complete block design was used in a factorial arrangement and replicated three times. The treatments used were; three levels of manure (0, 5 and 10 tons ha^{-1}), three levels of phosphorus (0, 90 and 180 kg P_2O_5 ha^{-1}) and two groundnut varieties ('Werer 962' and 'Oldhale') the former one is an improved variety released by Werer agricultural research centre Ethiopia and the second one is a local variety and both are adaptable to the experimental area. The results of chemical analysis indicated that the soil has very low organic carbon content of 0.74%, total nitrogen content of 0.07% and , available phosphorus content of 4.8 ppm; marginal exchangeable potassium content of 0.4 cmol/ kg/soil; and pH of 6.0. The soil has a composition of 63, 21, and 16 percent of sand, clay and silt contents, respectively. It is considered as sandy soil, according to Ryan *et al*. (2001) and ICARDA Soil Manual (2008).

The total number of plots was 18 × 3 = 54.The plot size was 2.5 × 2.8 (7 m^2) with spacing of 25 cm between plants and 35 cm between rows (Daniel, 2009). The spaces between plots and blocks were 0.5 m and 1.5 m, respectively. The number of rows per plot was eight with ten plants per row bringing the total number to 80 plants per plot. The central six rows were harvested (excluding end of the rows) to determine the response of the plants to phosphate and manure application, to avoid border effects. Thus, the central 48 plants were considered for data collection.

All phosphorus fertilizer was applied at the time of planting and manure fertilizer were applied 30 days before sowing to ensure decomposition. Weeds were controlled by regular hoeing.

The rate of fertilizer is not done before for groundnut in Ethiopia so; the application of the fertilizer is selected based on literature that the area has similar soil character with the experimental area. Data were collected on the days to emergence, days to flowering, days to maturity, plant height, number of leaves per plant, shoot biomass (fresh and dry), total number of pods per plant, number of seeds per pod, shelling percentage, 100 seed weight, seed yield and harvest index.

Harvest index was calculated by using; Harvest Index=

$$\frac{\text{Economic yield}}{\textit{Total Biological Yield}} X100 \text{ formula.}$$

The data recorded were subjected to statistical analysis. The analysis of variance was carried out using SAS software (SAS, 2000). Significance differences between treatment means were delineated by Least Significance Difference (LSD) test at 5% level of significance.

Results

Days to 50% maturity

Results showed that groundnut varieties were significantly ($P<0.01$) different in their days to maturity (Table 1). 'Oldhale' variety matured later than 'Werer 962' variety by about 8 days. These variations could be attributed to genotypic differences. Similarly days to maturity was significantly affected by P rates whereas, manure did not show any effects on days to maturity.

The data showed that increasing the rate of phosphorus shortened maturity days, but the significant difference is only between 180 kg ha^{-1} and the other two rates. At both 0 kg ha^{-1} and 90 kg ha^{-1} Phosphorus application rates, the varieties matured after136 days whereas at the rate of 180 kg ha^{-1} the varieties matured at the 135 days.

Plant Height

Plant height was significantly influenced by the main effect of manure but not by that of phosphorus or variety. Plant height significantly ($P< 0.05$) increased when manure level was increased from 0 to 5 and 10 tons ha^{-1} (Table 1). Thus, compared to plant grown at 0 levels of manure, plant grown at 5 and 10 tons ha^{-1} manure were taller by about 2 and 9 % respectively. The plant heights grown at 5 and 10 tons ha^{-1} was in statistical parity.

Tale 1. The main effects of phosphorus and manure application on agronomic performance of groundnut varieties

Treatment	Days to emergence	Days to flowering	Days to maturity	Plant height (cm)
P_2O_5 (kg/ha)				
0	17.2	36.4	136.2	18.5
90	16.7	36.2	136.1	19.4
180	16.7	36.2	135.7	19.2
LSD(0.05)	ns	ns	0.3	ns
M (ton/ha)				

0	16.5	36.3	136	18.4
5	17.3	36.3	136	18.8
10	16.5	36.2	136	20
LSD(0.05)	ns	ns	ns	1.24
Variety				
Werer 962	16.5	36.14	131.7	18.8
Oldhale	17	36.4	140.3	19.3
LSD(0.05)	ns	ns	0.25	ns
CV (%)	7.75	1.23	0.33	9.62

Where; ns = non significant at 5% probability level; M = manure, LSD= least significance difference and CV= coefficient of variation.

Number of leaves per plant

Increasing rate of phosphorus from 0 to 180 kg ha^{-1} increased the number of leaves but the number of leaves of the plant grown at 90 and 180 kg ha^{-1} phosphorus were in statistical parity (Table 2). Maximum number of leaves per plot of (737) was recorded at the highest level of phosphorus application.

Increasing the rate of manure from 0 to 10 tons ha^{-1} also significantly ($p<0.05$) increased the number of leaves. The maximum number of leaves of 733 was recorded at the rate of 10 ton ha^{-1} manure, and the number of leaves per plant at 5 and 10 ton ha^{-1} manure were in statistical parity.

Number of Pods per plant and Seeds per Pod

The interaction effect of manure and phosphorus was significant on the number of pods produced per plant. ‘Werer 962’ had the higher number of pod per plant than ‘Oldhale ‘(Table 2).

Increasing the level of phosphorus supply while keeping the level of manure at zero significantly decreased the number of pods produced per plant (Table 3). However, increasing the level of phosphorus supply with increase in the supply of manure significantly increased the number of pods produced per plant. Therefore, the highest number of pods per plant was produced at the combined levels of the highest levels of both manure and Phosphorus (10 ton manure ha^{-1} and 180 kg P ha^{-1}). This was closely followed by the number of pods produced at the next highest levels of combined fertilizers (5 ton manure ha^{-1} and 90 kg P ha^{-1}).

Hundred seed weight and shelling percentage

Hundred seed weight of ‘Werer 962’ was significantly ($P < 0.05$) higher than that of ‘Oldhale’ by about 5% (Table 2).Shelling percentage, which is of prime importance to pod yield was not significantly influenced by phosphorus and manure application and varieties not show any difference and their interactions

Table 2. The main effects of phosphorus, manure on yield and yield components of groundnut varieties

Treatment	Number of leaves per plant	Number of pods per plant	Number of seeds per pod	Shelling %	Hundred seed weight (g)
P_2O_5 (kg/ha)					
0	640.6	33.5	2.1	70.2	55.5
90	651.5	35.8	2.1	71.1	54.6
180	736.7	34.4	2.1	70.3	55.6
LSD(0.05)	52.34	ns	ns	ns	ns
M (ton/ha)					
0	655.3b	27.7c	2.1	70.7	54.7
5	640.9b	35.1b	2	70.4	56.3
10	732.6a	40.1a	2.1	70.3	55
LSD(0.05)	52.34	2.29	ns	ns	ns
Variety					
Werer 962	696.4	37.7	2	70.8	56.7
Oldhale	656.1	31.4	2.1	70.2	53.8
LSD(0.05)	ns	1.87	ns	ns	2.20

CV (%)	11.42	9.81	10.77	7.3	7.2

Where; = ns = non significant at 5% probability level, LSD = least significance difference, M= manure and CV = coefficient of variation.

Table 3. Interaction effect of phosphorus and manure on number of pods per plant

P_2O_5 (kg/ha)	Manure (tons/ha)			Means
	0	5	10	
0	29	38	33.7	33.5
90	27.7	37.2	42.7	35.8
180	26.7	30	46.5	34.4
Means	27.8	35.1	40.9	

LSD (0.05) P_2O_5×M = 3.98; CV = 9.81%

Harvest index and Shoot biomass

Groundnut variety 'Werer 962' had a superior harvest index to the 'Oldhale' by about 21% (Table 4). This could be attributed to the production of more vegetative dry matter by the latter. The data also revealed that increasing the rate of manure from 0 ton ha^{-1} to 10 ton ha^{-1} increased harvest index of the plants by 31%. The harvest indices of plants grown at 0 and 5 ton manure ha^{-1} were, however, in statistical parity (Table 4). Analysis of variance further revealed that shoot biomass was not significantly influenced by phosphorus, manure and variety and/or by their interaction.

Table 4. The main effects of phosphorus and manure on harvest index, shoot biomass and seed yield on groundnut varieties

Treatment	Harvest index (%)	Shoot biomass	Seed yield (kg/ha)
P_2O_5 (kg/ha)			
0	36.7	39.9	1523
90	34.6	39.9	1608.6
180	38.1	39.3	1622
LSD(0.05)	ns	ns	ns
M (ton/ha)			
0	33.5	39.5	1473.1
5	32.2	40.2	1574.6
10	43.7	39.5	1705.8
LSD(0.05)	6.93	ns	102.37
Variety			
Werer 962	40	40.3	1666.8
Oldhale	33	39.2	1502.2
LSD(0.05)	5.66	ns	83.58
CV (%)	27.56	8.64	9.53

Where; ns = non significant at 5% probability level, M=manure, LSD= least significant difference and CV= coefficient of variation.

Seed Yield

Consistent with its effect on pod number per plant, the interaction effect of manure and phosphorus was also significant on seed yield. Seed yield was most significantly increased at 10 ton ha^{-1} manure and 180 kg P_2O_5 $ha^{-1}$and the increase in seed yield was about 40% compared to no phosphorus and manure application. Similarly, the seed yield at this level exceeded the yield obtained at 10 ton manure ha^{-1} and 90 kg P_2O_5 ha^{-1} by about 16% (Table 5).

Table 5. Interaction effect of phosphorus and manure on seed yield

P_2O_5 (kg/ha)	Manure (ton/ha)			Means
	0	5	10	
0	1344	1608	1617	1523
90	1623	1580	1622	1608
180	1453	1535	1878	1622
Means	1473.3	1574.3	1705.6	

LSD (0.05) $P_2O_5 \times M$ =177.3; CV = 9.53%

Discussion

The variations of the varieties by days to maturity could be attributed to genotypic differences. The shortening of days to maturity by the application of phosphorus as it promotes rapid cell division is also reported by Brady and Weil (2002).

Manure application significantly increased plant height of soya bean Odunze and chiezey (2009). As the rate of phosphorus increases the number of branches of soybean increased, Sharma *et al*., (2002). Zeidan (2007) reported that both the rate of manure and phosphorus increased the number of branches of lentil, thus resulting in more leaves per plant.

Given the available phosphorus in the experimental soil (4.8 mg P kg soil^{-1}), which is low Ryan *et al.* 2001 and Roy *et al.* 2006), lack of response of pod number to the increasing level of phosphorus supply may be obscure. However, it may give some hint that the soil condition is not conducive for phosphorus availability without other amendments such as improving the carbon pool of the soil which is very low (0.07%).

Karkannavar *et al,* (1991) reported that seed weight traits were genetically heritable and different among varieties. The profound interaction effect of manure in enhancing pod numbers and seed yield in combination with inorganic phosphorus may be attributed to its effect on raising the organic carbon content of the soil, which was very low (0.7%). This suggestion is corroborated by that of Sanchez *et al*. (1998) that cattle manures contain all essential nutrients including carbon, the source of energy for soil biota. In conclusion, the present study has indicated that the combined application of inorganic phosphorus and manure significantly increased seed yield of groundnut in the study area. Application of high amounts of phosphorus was evidently important to attain high seed yield of the crop because the availability of the nutrient is very low in the soil. However, the results clearly revealed that application of inorganic phosphorus fertilizers such as DAP and TSP alone would not lead to increased seed yield of groundnut. Thus, the inorganic fertilizers should be applied in combination with manure or other organic fertilizers to enhance seed yield of the crop. Therefore, integrated use of manure and inorganic P fertilizers is recommended to attain high seed yield in groundnut. It was also observed that groundnut varieties differed in response to fertilizers in terms of seed yield. Thus, some varieties may give higher seed yield than others when fertilizers are used in the study area.

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