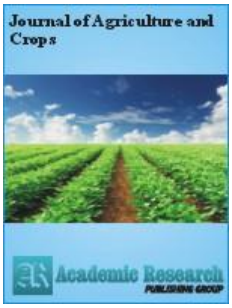

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Nitrogen and Phosporus Fertilizers Rate as Affecting Common Bean Production at Areka, Ethiopia

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Abstract: A field experiments were conducted for two year (2011and 2012) at Areka Agricultural Research Center, in the South Region of Ethiopia to evaluate the response of common bean (Phaseolus vulgaris L.) to N and P fertilizers. Four levels of N (18, 27, 36 and 45 kg N/ ha) and three levels of P (46, 69 and 92 kg P2O5 /ha) with control were arranged in RCBD with three replications. Application of nitrogen increased significantly grain yield of common bean up to 116% than the control. And phosphorus application at a rate of 69 kg P2O5/ha increased significantly grain yield by 113% than control. The highest grain yield was obtained by the application of 45 kg N /ha and 69 kgP2O5/ha, though 45 kg N /ha rate had not cause statistically significant different grain yield than the preceding lower rates (36 and 27 kg N/ha). The economic analysis also supported that the highest net benefit of 23,110 Ethiopian Birr ETB/ha with marginal rate of return of 1270% was obtained by the application of 27 kg N/ha. Net benefit of 21,070 ETB/ha with marginal rate of return of 80% were obtained by the application of 69 kgP2O5/ha. As a result, a combined application of 27 kg N/ha and 69 kgP2O5/ha are optimum and economical for better common bean production at Areka and similar areas.

Keywords: Common bean; Nitrogen; Phosphorus; Fertilizer rate.

1. Introduction

Common bean (*Phaseolus vulgaris)* is an herbaceous annual plant grown throughout the world for its fresh dry and green beans. Common bean ranks third as an export commodity in Ethiopia, contributing about 9.5 % of total export value from agriculture [1]. Common bean is mainly used as sources of food and cash. It serves as a source of protein to supplement the protein deficient main dishes like maize and enset in the southern parts of our country especially in Wolaita and Sidamo areas in south Region of Ethiopia [2].

It is exported to earn foreign exchange and is also one of the cash crops locally used by farmers [3].

Common bean can be grown successfully on most soil types, from light sands to heavy clays, but friable, deep and well-drained soils are best preferred [4].

Despite the importance of the crop to farmers and its importance for national revenue, average yields obtained by farmers are very low. The national average yields of common bean is 823 kg/ha. The low yield may be attributed to combinations of several production constraints among which low soil fertility, periodic low moisture stress, diseases and insect pests, weeds and untimely field operations play a major role [5].

The yields of the pulse crops grown under traditional farming system are low & require research intervention. Increases in fertilizer use and other agronomic practices generate positive impact on productivity of the crop in Ethiopia [6]. And there is a wide gap in productivity of crops between on-farm and research plots [7].

Nitrogen and Phosphorus are considered to be the most limiting nutrients because of their determinant nature of plant growth and development. The addition of inorganic fertilizers such as urea and diammonium phosphate to the soil is one of the easiest and familiar ways to improve soil fertility status by nourishing the soil by macro elements like Nitrogen and Phosphorus. According to [8], the best way of preventing soil from becoming poor is to put back into it what plant has taken out and this can only be achieved by the use of inorganic fertilizers. Phosphorus is the second most essential element of crop production and it is deficient in most soils around the world to achieve maximum yields [9]. Adequate Phosphorus enhances many aspects of plant physiology like fundamental process of photosynthesis, flowering, seed formation and maturation [9].

Therefore, this research was undertaken to find out an optimum level of inorganic NP fertilizer that can maximize growth, dry matter production and grain yield of common bean under the agroclimatic and soil conditions of Areka, South Region of Ethiopia.

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2. Materials and Methods

2.1. Description of the Study Area

A field experiment was conducted at Areka agricultural research center which is located at about 300 km south west of Addis Ababa, Ethiopia, At 7□04'N latitude and 37□41'E longitude and altitude of 1790 meters above sea level. The soil of the Research Center is formed from pyroclastic rocks, and is clayey in texture [10]. The soils at Areka are deep, highly weathered with a pH of 5.2. The climate is tropical, with mean annual rainfall of about 1500 mm. The daily mean maximum and minimum temperature of the area is 25 ^{0}c and 13 ^{0}c, respectively. The main soil type in the area is nitisols.

2.2. Experimental Design

The experiment was conducted on research farm of Areka Agricultural Research Center for two consecutive years in 2011and 2012. Planting was done manually on flat beds in early July, and harvested in October. The improved variety '*Hawassa dume'* was sown using the interrow spacing of 40cm and intrarow spacing of 10 cm .The design was randomized complete block in complete factorial arrangement with three replications, plus a control with no fertilizer. The treatments were the combination of N fertilizer rates (18, 27, 36 and 45 kg N/ha), Pfertilizer with (46, 69 and 92 kg P_2O_5 /ha) and a control without any fertilizer. Diammonium phosphate (DAP) (46% P_2O_5 and 18% N) and urea (46% N) were used as source of P and N in respectively. Cultivation and weeding were carried out them equally and at the same time for the entire experimental units. The whole quantity of N and P fertilizers were applied at sowing. The plots were 4m X 4m.

2.3. Data Collection and Data Analysis

Data were collected on plant height, No of pods/plant, No of seeds/pod, 100 seed weight, biomass weight and grain yield. The data of these variables were subjected to analysis of variance appropriate for analyzing factorial experiment with control in randomized complete block design [11] and significantly different means were separated using least significant difference at $P \leq 0.05$.Agronomic N or P use efficiencies

were calculated using the formula: Agronomic N or P Use Efficiency = (Grain yield of treatment – Grain yield of control) /(N or P added in kg/ha) [12].

For economic analysis, partial budget, dominance analysis and marginal rate of return were used. For the analysis we followed the procedures in the economics training manual by CIMMYT [13]. The two years mean grain yield obtained by the main effects of the two factors were used for economic analysis. Common bean grain was valued at an average local market price of 1200 Ethiopian Birr (ETB)/100kg. The cost of common bean seed was 1500 ETB/100kg. Urea and DAP were purchased at price of 1200 and 1800 ETB /100 kg respectively. The average yields of the trial were adjusted downwards by 10 % to reflect the actual production environment [13].

3. Results and Discussion

Statistical analysis of variance of the two years of the main effects and their interaction effect on common bean grain yield and yield components are presented in Table 1. The main effect of nitrogen fertilizer was significant ($p \leq 5\%$) in affecting the grain yield of common bean. This result is in contrast in the report by Ali, *et al.* [7], that there was no significant yield difference due to nitrogen fertilizer application. But it is in agreement with Mitiku [3] that the application of nitrogen fertilizer resulted in grain yield increase. As the nitrogen fertilizer rate increases the grain yield also increased and the highest grain yield (2238 kg/ha) was obtained by the application of 45 kg/ N/ha though, it was not statistically different than the yield obtained by the application of the preceding lower rates (36 and 27 kg N/ha) (Table 2). The different levels of Phosphorus fertilizer used in the study had not caused significant difference of grain yield, Plant height, No of Pods/plant, number of seeds/pod and 100 seed weight of common bean. Though significant differences were not caused by the applied levels, up to 113% of grain yield, 27% of number of pods/plant and 30% of plant height increases were observed compared to the control by the application of 69 kg /ha P_2O_5 (Table 2). Eden [14] reported similar report that seed yield was increased with increase rate of phosphorus fertilizer up to 30 kg/ha. The interaction of Phosphorus and nitrogen fertilizers used in this study had not caused significant difference of grain yield and yield components of common bean. Non-significant interaction effect of nitrogen and phosphorus fertilizers on common bean yield was also reported earlier [15]. Plant height, Number of Pods/plant and grain yield of common bean significantly increased in fertilized plots compared with control (Table 1). Generally, increment of 27% in Plant height, 38% in number of pods/plant and 107% in grain yield was observed by growing common bean using nitrogen and phosphorus fertilizers compared to the control.

The agronomic use efficiency (AUE) of nitrogen and Phosphorus fertilizers showed an increasing trend for both fertilizers (Figure 1).The highest AUE of nitrogen fertilizer was obtained at a rate of 45 kg N/ha.The highest AUE of P fertilizer was obtained at a rate of 92 kg P_2O_5/ha.The results of N agronomic efficiency are supported by the effects of N fertilization on yields (Table 2 and Figure 1).

Table-1. Analysis of variances for grain yield and yield components as influenced by N and P fertilizer

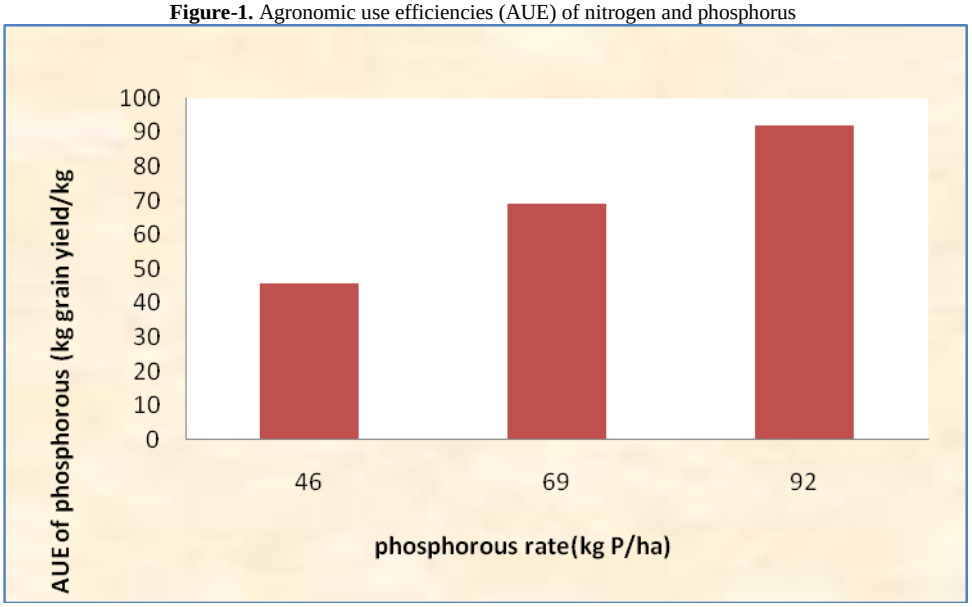
Source		Mean sum of squares				
	Degree of freedom	Plant height	No of Pods/plant	No of seeds/pod	100 seed weight	Grain yield
Control vs. fertilized	1	276.31*	14.19*	0.19 ns	0.32 ns	3354438.63***
Nitrogen (N)	3	151.00ns	1.31 ns	1.31 ns	0.83 ns	635922.080*
Phosphorus (P)	2	44.92ns	0.19 ns	0.32 ns	4.29 ns	140495.33 ns
N X P	6	281.58ns	5.39 ns	0.67 ns	4.81 ns	220142.75 ns
Error	24	849.60	72.99	3.66	15.60	1397828.10

Table-2. Effects of NP on common bean grain yield and yield components (2011-2012)

Treatment	Plant height (cm)	No of Pods/plant	No of seeds/pod	100seed weight (g)	Grain yield (kg/ha)
N(kg/ha)					
18	45.6	11.0	4.9	25.0	1907
27	45.6	10.9	4.7	25.0	2205
36	50.0	11.0	5.1	25.4	2191
45	49.4	11.4	4.9	25.2	2238
LSD (5%)	NS	NS	NS	NS	202*
P_2O_5(kg/ha)					
46	46.3	11.0	4.8	25.6	2051
69	47.6	11.1	5.0	24.7	2201
92	49.1	11.2	4.9	25.1	2153
LSD (5%)	NS	NS	NS	NS	NS
Control vs. fertilized					
Control	37.7	8.8	4.6	24.8	1034
Fertilized	47.7	11.1	4.9	25.1	2135
LSD (5%)	7.3	2.2	NS	NS	298
CV (%)	12.69	15.97	8.05	3.21	11.77

LSD = Least significant differences; CV = coefficient of variations; *,
**= significant at 0.05 and 0.01 probability level respec tively.Control= bean without any fertilizer;

Figure-1. Agronomic use efficiencies (AUE) of nitrogen and phosphorus



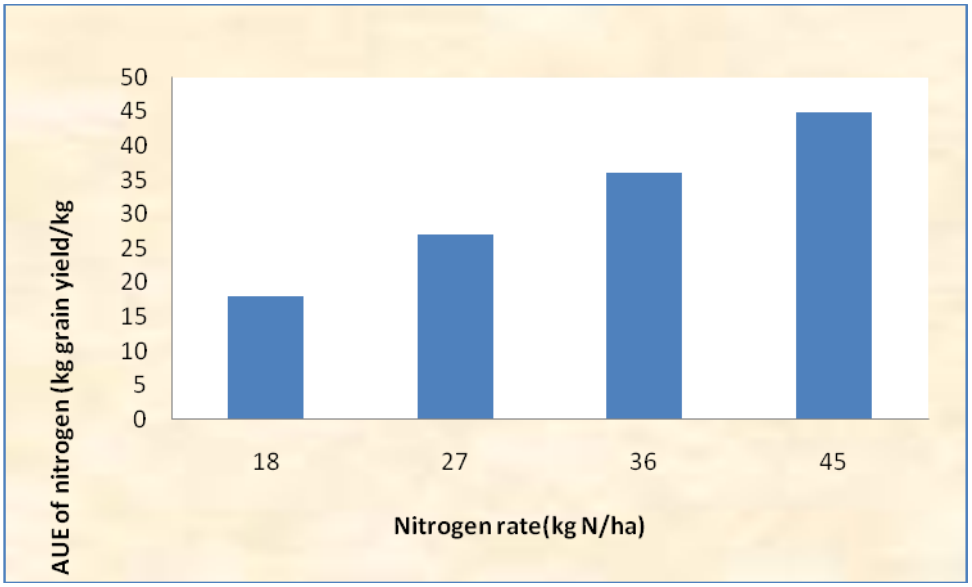


Table-3. Marginal rate of return analysis for NP fertilizer

N(Kg/Ha)	Mean Yield (Kg/Ha)	Adjusted Yield (Kg/Ha)	Gross Benefit (ETB/Ha)	Cost Of Urea (ETB/Ha)	Cost Of Dap (ETB/Ha)	Gross Cost (ETB/Ha)	Net Benefit (ETB/Ha)	MRR
18	1,907	1,716.3	20,595.6	469.57	0	469.57	20,126.03	12.7
27	2,205	1,984.5	23,814	704.35	0	704.35	23,109.65	
36	2,191	1,971.9	23,662.8	939.13	0	939.13	22,723.67[d]	
45	2,238	2,014.2	24,170.4	1,173.9	0	1,173.91	22,996.49 [d]	
P_2O_5(kg/ha)								
46	2,051	1,845.9	22,150.8	0	1,800	1,800	20,350.8	0.80
69	2,201	1,980.9	23,770.8	0	2,700	2,700	21,070.8	
92	2,153	1,937.7	23,252.4	0	3,600	3,600	19,652.4[d]	

MRR=Marginal Rate of Return, field price of common bean grain = 12ETB/kg, price of urea= 12ETB/kg, price of DAP= 18ETB/kg.

Economic analysis also revealed that the highest net benefit of 23,110 ETB/ha with marginal rate of return (MMR) of 1270% and 21,070 ETB/ha with marginal rate of return of 80% were obtained by growing common bean with the application of 27 N and 69 P_2O_5/ha respectively. An increase in output will always raise profit as long as the marginal rate of return is higher than the minimum rate of return i.e. 50 to 100% [13]. Data in Table 3 shows that the marginal rate of return at the nitrogen application rate of 27 kg N/ha was greater than 100% showed an economically feasible application rate at 27 kg N/ha since it has greater than 50% marginal rate of return. The other treatments were dominated by the dominance analysis. The net benefit decreased as the cost increased. Since the marginal rate of return due to phosphorus application is also more than 50 to 100%, application of phosphorus fertilizer is economically profitable up to the rate of 69 kg P_2O_5/ha. Rate of phosphorus fertilizers at 92 kg P_2O_5/ha was dominated. Straw yield was not considered in the partial analysis. It would improve the economic return of nitrogen and phosphorus fertilization.

4. Conclusion

Nitrogen and phosphorus are known as the most yield limiting nutrients constraining pulse crops productivity including common bean in Ethiopia.The results of this study indicated that increase in common bean grain yield, agronomic use efficiencies with mineral nitrogen and phosphorus fertilization. The application of 27 kg N and 69 kg P_2O_5 /ha has significantly improved grain yield of common bean. This also supported by the economic analysis. The marginal rate of return economically feasible since the marginal rate of return of application is more than 50 to 100% indicating that the application of the fertilizers is economical. The economic analysis reveals that further increase in levels of NP fertilizer is not economical. Thus, application of 27 N and 69 P_2O_5 kg/ha is economical and recommended for production of common bean at Areka.

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