Optimization of Fertilizer Recommendations for Chickpea at Sayadeberena Wayu District North Shewa, Amhara Region, Ethiopia

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Abstract

Chickpea is one of the most important pulse crops in Ethiopia in general and Sayadeberena Wayu district in particular. However, there is no updated fertilizer sources and rate recommendation sofar for this crop in the above mentioned district. Therefore, an experiment was conducted to select fertilizer utilization options for better yield production of chickpea in the Sayadeberena Wayu district of Amhara Regional State of Ethiopia for the last two consecutive years (2016/17 and 2017/18). The treatments included twelve different types of nutrient sources; control (T1), inoculant-CP11(T2), 10 kg ha^{-1} P (T3), 20 kg ha^{-1} P (T4), 30 kg ha^{-1} P (T5), 0/20 kg ha^{-1} P/K_2O (T6), 10/20 kg ha^{-1} P/K_2O (T7), 20/20 kg ha^{-1} P/K_2O (T8), 30/20 kg ha^{-1} P/K2O (T9), 20/10 kg ha^{-1} P/K_2O (T10), 20/20/5/1/5/0.5 kg ha^{-1} P/K_2O/S/Zn/Mg/B (T11) and 20/30 kg ha^{-1} P/K_2O (T12). The experiment was laid out on a randomized complete block design with farmers as replications. Results showed that seed and straw yield were significantly affected by the application of different inorganic fertilizer sources. The highest chickpea seed yield (2435.6 kg ha^{-1}) and straw yield (1957 kg ha^{-1}) were obtained from the applications of 20 kg P ha^{-1} followed by that obtained from 30 kg P ha^{-1} (2411.3 kg ha^{-1}seed yield and 1981.2 kg ha^{-1}straw yield) even though statistically no significant differences among treatments. The result also showed that the highest net return was obtained from the application of 20 kg P ha^{-1} followed by 10 kg P ha^{-1}, which were economically feasible, high rate of marginal return and can be recommended as alternative P rate for chickpea production in the study area and similar agro-ecologies.

Keywords: Chickpea, inorganic fertilizer, phosphorus, pulse crop, seed yield

Introduction

Chickpea (Cicer arietinum L.) is one of the most important pulse crops in Ethiopia. It is an important legume crop in reducing poverty and hunger, improving human health and nutrition, improving incomes especially to smallholder women farmers, and enhancing ecosystem balance. Chickpea is grown in over 50 countries and is third in production after a dry bean and field pea in the world (FAOSTAT, 2014). Africa accounts for 5% of the world's chickpea production, mostly from Ethiopia, Malawi, Tanzania, and Kenya in Eastern Africa and Morocco in North Africa. Ethiopia is among the top five world producers of chickpea and is the largest producer of chickpea in Africa, accounting for about 60% of the continent's production in 2014. During 2016/17, Ethiopia produced 499,925.55 tons of chickpea from an area of 242,703.3 ha with average productivity of 2.06 ton ha^{-1} (CSA, 2017) which is less than half of the global chickpea production potential (5 ton ha^{-1}). In most chickpea growing areas of the world, the main constraints reported to affect chickpea production are lack of high yielding varieties, limited use of fertilizers, abiotic and biotic stresses (Upadhyaya et al., 2011). From these constraints, lack of high yielding varieties and limited use of fertilizers (especially phosphorus fertilizer) are the major limiting factors of chickpea in the study area.

Although many factors contribute towards the low productivity of chickpea, the major reasons for its low yield are diseases, insect pests, limited use of modern inputs, and inappropriate agronomic practices like inadequate or imbalanced fertilizer application. Nitrogen (N) and phosphorus (P) are the two most yield-limiting nutrients in sub-Saharan Africa, including Ethiopia. Phosphorus is the second most critical plant nutrient overall, but for pulses it assumes primary importance owing to its important role in root proliferation and atmospheric nitrogen fixation. However, information is lacking on the effect of different fertilizer sources and rates on chickpea growth and productivity in Ethiopia. Therefore, the objective of this experiment was to select the optimum fertilizer source and recommendations for chickpea.

Materials and Method

Description of study area

The experiment was conducted at Sayadeberena Wayu district, North Shewa Zone of Amhara Regional State for two consecutive years (2016/17 and 2017/18). Geographically, the experimental site is located at a range of 090 8' to 090 9'N and 380 8' to 380 9'E and a mean altitude of 2644 m.a.s.l at a distance of about 125 km north of Addis Ababa.

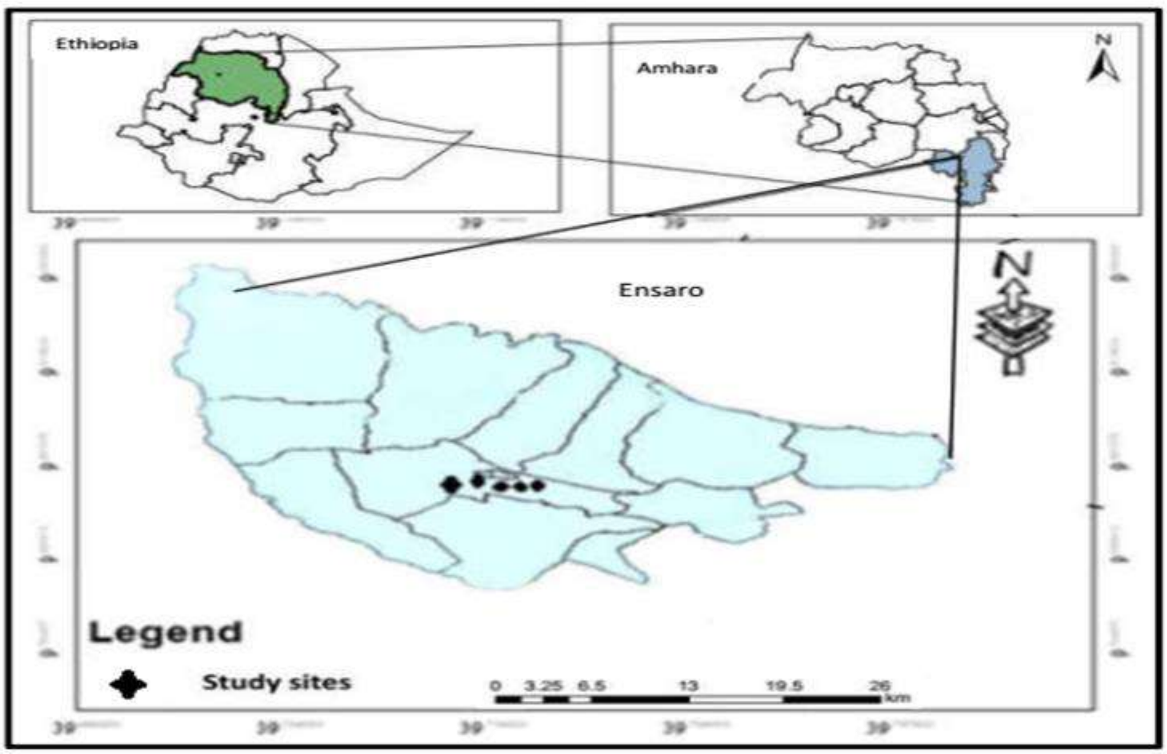

Figure 1. Map of the study area (Ensaro which is Sayadeberan Wayu)

The area is characterized by a unimodal rainfall pattern and receives an average annual rainfall of 926.3 mm, about 85% of which is received from June to September. The annual average minimum and maximum air temperatures are 11.7 and 26.7°C, respectively. Vertisols are the dominant soil type in this district. The crops widely grown in the study area include tef, wheat, lentil chickpea, faba bean and others. Chickpea is mostly grown on residual soil moisture at the end of the rainy season from mid-August to early September. The experiment was laid out in randomized complete block design with farmers as replications and unit plot size was 3.2 m x 3.8m (two BBF 1.2 x 3.8 m size 8 rows per plot) The seed was sown in rows with 30cm spacing between rows and 10cm between plants. Prior to planting, one composite soil sample (0 - 20 cm) was taken from each experimental site for the determination of some selected soil properties. The samples were taken randomly across each experimental field using a soil auger and then air-dried, thoroughly mixed and ground to pass through a 2-mm mesh sieve and packed for laboratory analysis. Soil particle size distribution was analyzed using the Bouyoucos hydrometer method (Bouyoucos, 1962) after destroying organic matter (OM) using hydrogen peroxide (H_2O_2) and dispersed the soils with sodium hexametaphosphate ($NaPO_3$).

The soil samples were analyzed for pH in a 1:2.5 soil-water suspension using a glass electrode as described by van Reeuwijk (1992), organic carbon using wet oxidation methods of Walkley and Black (1934) and total nitrogen by Kjeldahl procedure of Bremner and Mulvaney (1982), available phosphorus by Olsen method (Olsen et al. 1954), exchangeable potassium was determined by extracting potassium with 1 N NH_4OA and determined with a flame photometer. The treatments used in the experiment were control (T1), inoculant-CP11(T2), 10 kg ha^{-1} P (T3), 20 kg ha^{-1} P (T4), 30 kg ha^{-1} P (T5), 0/20 kg ha^{-1} P/K2O (T6), 10/20 kg ha^{-1} P/K2O (T7), 20/20 kg ha^{-1} P/K2O (T8), 30/20 kg ha^{-1} P/K2O (T9), 20/10 kg ha^{-1} P/K2O (T10), 20/20/5/1/5/0.5 kg ha^{-1} P/K2O/S/Zn/Mg/B (T11) and 20/30 kg ha^{-1} P/K2O (T12). The chickpea lignite-based rhizobial inoculant, CP11, obtained from Holeta Agricultural Research Center was used. Triple superphosphate, gypsum and KCl fertilizer sources were applied at planting with respective treatment rates as nutrient sources of phosphorus, sulfur and potassium. The test crop was chickpea variety Mastawal. Plant yield components such as seed and straw yield were collected. Disease and pest control activities were carried out (application of pesticides like deyazenol to control cutworm with recommended rate and time of application).

Statistical analysis

The agronomic data were analyzed using the general linear model (GLM) procedures of the SAS statistical software (2002) to evaluate the effect of different fertilizer treatments. Duncan multiples range test (DMRT) at 5% probability level was used to separate means whenever there were significant differences among different treatments.

Economic analysis

Partial budget analysis was done to examine different fertilizer application effects on the yield of chickpea. Maximum net benefit from the application of different nutrient sources, dominance, and marginal analysis criteria were undertaken to see the economic feasibility of different nutrient sources and rates. To minimize the over estimate of the experimental plot, yield was adjusted to 10 percent that reflected the actual field condition according to the manual of CIMMYT (1988). The two years average farm get price of chickpea seed (19 Birr kg^{-1}) and straw (2 Birr kg^{-1}) and KCl (11.45 ETB kg^{-1}), P (9.364 ETB kg^{-1}), S (12.20 ETB kg^{-1}), B (12.20 ETB kg^{-1}), Mg (12.20 ETB kg^{-1}) and Zn (15.00 ETB kg^{-1}) were used for partial budget analysis.

Result and Discussion

Selected soil physical and chemical properties

The selected soil properties of study sites were presented in Table 1. The textural class of the soil is clay. The average pH value of soils of the study area is 6.76, rated as neutral according to Tekalegn (1991). Generally, the experimental fields are low in soil organic carbon, medium in total nitrogen, very low in available P and high in exchangeable K (Landon, 1991).

Table1. Selected physicochemical properties of the experimental soil at Sayadeberena Wayu District

Year	pH (1:2.5)	OC (%)	TN (%)	Exch.K (cmol (+) kg^{-1})	Av.P (ppm)	Clay (%)	Silt (%)	Sand (%)	Tex. Class
2017	6.66	0.85	0.13	1.66	4.27	58.00	27.00	15.00	Clay
2018	6.86	0.54	0.10	2.25	6.81	70.00	20.0	10.00	Clay
Mean	6.76	0.69	0.12	1.96	5.54	64.00	23.50	12.50	Clay

Effects of different treatment application on chickpea yield

The seed yield of chickpea did not exhibit significant variation because of the application of different treatments (Table 2). Even though there is no significant difference with the control, the highest seed yield (2435 kg ha^{-1}) was obtained with the application of 20 kg ha^{-1} P as compared to control (2231.4 kg ha^{-1}). The application of 20 kg ha^{-1} P increased the grain yield of chickpea by 9.2% as compared to the control treatment, although it is statistically at par. This study did not reveal that applications of inorganic and organic nutrient sources, especially P fertilizer, had a significant effect on seed and straw yield of chickpea.

The analysis of variance of straw yield showed significant differences among the treatment means. The maximum straw yield was recorded in the treatment of 20 kg ha^{-1} P as compared to control (1981.2 kg ha^{-1}) and a minimum amount of yield (1316.7 kg ha^{-1}) was recorded in sole application of potassium at 20 kg ha^{-1} K.

Table 2. Response of chick pea for different fertilizer treatments

Treatments	Seed Yield kg ha^{-1}	Straw Yield kg ha^{-1}
1. Control	2231.4abc	1713.0abc
2. Inoculant (CP11)	1967.1bcd	1535.4bcd
3. 10P	2336.1ab	1961.4a
4. 20P	2435.6a	1957.8a
5. 30P	2411.3a	1981.2d
6. 0P20K	1775.0d	1316.7d
7. 10P20K	1853.0cd	1499.7bdc
8. 20P20K	2247.9abc	1784.3ab
9. 30P20K	2315.4ab	1961.5a
10. 20P10K	2297.7ab	1771.1ab
11. 20P20K 5S 1Zn 5Mg 0.5B	2094.9abcd	1613.6bc
12. 20P30K	1946.0bcd	1460.1cd
CV (%)	13.57	12.04
Sign	**	**

Economic analysis

The highest net return of 44049.0 Ethiopian Birr with MRR value of 250.0 was obtained from the application of 20 kg ha-1 P followed by 10 kg ha^{-1} P with a net return of 42916.0 ETB and MRR 298.3 (Table 3). According to the CIMMYT (1988) manual that showed the minimum rate of return acceptable to farmers would be between 50-100%. Therefore, treatments that have the highest marginal rate of return (MRR %) are optional sources of nutrients for the study area.

Table 3. Partial budget and marginal analyses of different fertilizer application on chickpea

No	Treatments	SY (kg ha-1)	StY (kg ha-1)	GB (ETB ha-1)	TVC (ETB ha-1)	NB (ETB ha-1)	MRR (%)
1	Control	2008	1541.7	41240	0	41240	
2	Inoculant (CP11)	1770	1381.9	36401	440	35961D	-
3	10P	2102	1765.3	43478	562	42916	298.3
4	20P	2192	1762.0	45173	1124	44049	250.0
5	30P	2170	1783.1	44799	1686	43114	111.2
6	0P20K	1598	1185.0	32723	417	32306D	-
7	10P20K	1668	1349.7	34386	979	33407D	-
8	20P20K	2023	1605.9	41651	1541	40110D	-
9	30P20K	2084	1765.4	43124	2103	41022D	-
10	20P10K	2068	1594.0	42479	1332	41146D	-
11	20P20K5S1Zn5Mg0.5B	1885	1452.2	38727	1941	36787D	-
12	20P30K	1751	1310.5	35898	1749	34148D	-

SY= Seed Yield, StY=straw yield,GB=Gross benefit, TVC=Total Variable Cost, NB=Net Benefit

Conclusions and Recommendations

This study explored the potential use of different sources of fertilizer to select economically viable nutrient sources to increase chickpea yield. Results showed that there is no significant difference for seed and straw yield of chickpea among applied treatments as compared to the control. Also, the application of organic sources of fertilizer (inoculants) did not bring outsmart results as compared to the non-fertilizer source treated plots. Based on this finding, application of both sources of fertilizer did not improve the yield components of chickpea. However, as soil maintenance and future sustainable production, application of 10 kg ha-1 of phosphorus had brought comparable seed yield with a high marginal rate of return with a higher net benefit. Further verification and demonstration of this technology at the study and similar agroecology is necessary.

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