RESPONSE OF CHICKPEA (C*icer arietinum* L.) TO NITROGEN AND PHOSPHORUS FERTILIZER S IN HALABA AND TABA, SOUTHERN ETHIOPIA

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ABSTRACT

Experiment was conducted to determine optimum N and P fertilizer rates for chickpea production in Halaba and Taba locations of Southern Ethiopia. A factorial experiment consisting of three levels (0, 11.5 and 23 kg ha^{-1}) of N and four levels (0, 10, 20 and 30 kg ha^{-1}) of P fertilizer was laid out in RCB design with three replications. Chickpea variety, Habru was planted as a test crop. Data on nodulation parameters, yield and yield components were collected and subjected to ANOVA. Results revealed that both N and P have significantly affected nodulation capacities, yield and yield components of chickpea in both locations. N applied at 11.5 and 23 kg ha^{-1} increased the grain yield of chickpea by 32 and 36 % over the control respectively in Halaba. The corresponding increases in Taba were 61 and 40 % over the control respectively. Significantly higher grain yield of chickpea was obtained from P applied at 20 and 10 kg ha^{-1} in Halaba and Taba respectively. N by P interaction was significant in Halaba but not in Taba. Significantly higher yield was obtained in Taba than in Halaba irrespective of treatments. This implies that the former location is more favorable for chickpea production than the later. In conclusion, chickpea responds significantly to N and P fertilizers in both locations suggesting low levels of soil N and P. Biological and economic optimum yields of chickpea were obtained from N: P applied at 11.5: 20 and 11.5: 10 kg ha^{-1} in Halaba and Taba respectively.

Key word: Soil fertility, Yield and Yield components, Nitrogen and Phosphorus fertilizer

INTRODUCTION

Chickpea is one of the major food legumes produce in Ethiopia. According to Frehiwot Melesse (2010), it ranked third and fourth in terms of total grain produced and area cultivated under chickpea in 2009/10 cropping season compared with other food legumes. Ethiopia is also the largest chickpea producer in Africa, with a share of about 39 % of total chickpea produced in the continent in 2011 (FAOSTAT, 2012). Chickpea is mainly grown in the central, northern eastern highland and southern region of Ethiopia with altitude ranging 1400-2300 masl, where annual rainfall ranges between 700 and 2000 mm (Yadessa Anbessa and Geletu Bejiga 2002). In the Southern Ethiopia more than 6000 ha of land were planted with chickpea in the year 2008. In the same year, Wolaita Zone stood third in the region as far as chickpea production area is concerned (Minale Kassie et al., 2009).

The grain of chickpea serves as a main source of protein for smallholder farmers supplementing their cereal dominated diet. It also plays a very important role in improving soils fertility due to its N-fixation capacity, its residue is used as animal feed and serves as an important source of cash to farmers (Mishra et al., 1997). It is also one of the main pulse crops which is exported to various countries and serving as a source of foreign currency to the country. Given its ability to grow on residual moisture, chickpea plays an important role in the farming system by fitting in the crop rotation in which it allows farmers to produce extra yield each year.

However, in spite of its potential to produce grain yield up to 3 t ha^{-1}, the average productivity of chickpea is only 1.6 t ha^{-1} (Singh and Khangarot, 1987; Legesse Dadi et al., 2005) which is nearly half of its potential productivity. There are several factors that account for low productivity of chickpea in particular and legumes in general. Such factors include, diseases, insect pests, lack of improved varieties and poor soil fertility (Yadessa Anbessa and Geletu Bejiga, 2002).

P is a major soil factor limiting the production and productivity of crops including chickpea in Ethiopia. It is a very important nutrient needed for effective N_2 fixation because symbiotic N_2 fixation is very high energy demanding process in the form of ATP which has P as its major component. Thus, in soils of low extractable P, Poor nodulation and poor vigor of plants occur (Amijee and Giller, 1998). Acute deficiency of P leads to even no nodule formation indicating how N2 fixation is sensitive to P (Giller and Cadisch, 1995). According to Islam et al. (2012), the yield of chickpea was increased by 65 and 88 % due to the application of P fertilizers in Pakistan and Jordan respectively. However, the optimum P-requirement for adequate production of chickpea varies from soil to soil, by region and agroecology.

On the other hand, Even if legume-Rhizobia association fix N, small amount of N needs to be available in the soil which will be used by the plant in this case chickpea for its establishment and growth until the onset of N-fixation (Giller and Cadisch, 1995).Thus, in soils with N deficiency, there is a need to apply small dose of N fertilizer to legumes to overcome the deficiency and harness their growth and this low dose of N applied externally is called starter dose. In this regard, Thaku et al. (1989) recommend that legume like chickpea requires low rates of N which is between 15-20 kg ha^{-1} in nitrogen deficient soils. This is due to the fact that the crop needs small amount of soil N for its growth until Rhizobia-chickpea association is established and symbiotic N-fixation is commenced. From all these results, it can be inferred that it is essential to apply N and P fertilizer to legumes supposed to be grown in soils which are deficient in these nutrients.

In this regard, most Ethiopian soils are poor in N and P contents indicating that areas growing legumes are also low in N and P (Wassie Haile and Tekalign Mamo, 2013). However, the degree of deficiencies of N and P varies depending soil type, crop variety and environmental variables. This implies that there is a need to test and establish optimum N and P rates for adequate production of chickpeas. Thus, this experiment was conducted in Taba and Halaba location of southern Ethiopia to determine the response of chickpea to N and P Fertilizers and determining the optimum fertilizer rates for improving the production and productivity of chickpea.

MATERIALS AND METHOD

Brief descriptions of the study sites

The experiment was conducted in two districts/locations namely, Halaba and Taba, Southern Ethiopia. Halaba is located between $7^0$20’55.3’’N and 38^0 06’28.7’’ E with an altitude of 1792 masl. It has mean annual rain fall ranges between 505-960 mm and with monthly minimum and maximum temperature of 17 and 26.3^{O}C respectively. Taba is located between 06°83’N and 37° 73’E at an altitude of 1907 masl. Its mean annual rainfall from ranges 1200-1300 mm and its mean monthly temperature varies from 11.5 to 21°C.

According to FAO/UNESCO (1974) classification system the experimental site in Halaba is belongs to Andosol. The soil of Taba on the other hand is belongs to Vertisols. In both locations the experiment was conducted on farmers’ fields where the farmers’ field in Taba has been used as permanent field by Hawassa University CIFSRF project for conducting numerous other experiments.

Composites soil samples from a depth of 0-20 cm were collected from both locations prior to planting and analysed for selected soil physicochemical properties following standard laboratory procedures (Sahlemedhin Sersu and Taye Bekele, 2000). The results of initial soil analytical data on selected chemical properties of the soils revealed that the pH of Halaba soil is near to neutral and that of Taba is in alkaline category (Table 1). The nitrogen content of the soils of Halaba and Taba were in low and very low categories respectively (Brook, 1983). The Mehlich-III extracted P contents of both soils were in low ranges based on Jones (2001).

Table 1. Selected physicochemical characteristics of soils of the experimental sites.

Locations	Texture	pH	TN (%)	SOM (%)	P (mg kg^{-1})	CEC	Ca	K	Mg	Na	BS (%)
						Cmolkg^{-1}					
Halaba	CL	6.9	0.13	3.03	8.1	27	10.5	1.6	2.1	1.4	58.0
Taba	C	7.6	0.08	1.73	18.2	19	8.5	1.4	1.1	0.9	63.0

Treatments and experimental procedures

A factorial experiment consisting of three levels (0, 11.5 and 23 kg ha^{-1}) of nitrogen (N) and four levels (0, 10, 20 and 30 kg ha^{-1}) of phosphorus were laid out in RCB design with three replications. The N levels were coded as N0, N1 and N2 respectively and the P levels were coded as P0, P1, P2 and P3 respectively. Urea and TSP were used a source of N and P respectively. The whole doses of N and P fertilizer were banned applied at planting. The plot size used was 3.2 x 4m to which chickpea variety Habru (Kabuli) was planted with intra and inter row spacing of 10 and 40 cm apart respectively. The experiment was planted by the end of September, 2013. All agronomic practices including weeding, harvesting was done as per the recommendation for the crop.

Data on nodule number per plant (NNP), Nodule dry weight per plant (NDWP), plant height (PHT), Number of branches per plant (NBP), number of pods per plant (NPP), number of seed per pod (NSPP), hundred seed weight (HSW), biomass yield (BMY) and grain yields (GY) were collected.

Statistical analysis

Data on NNP, NDWP, NBP, NPP, NSPP, PHT, HSW, BMY and GY which were collected from the two locations were subjected to using SAS software (SAS, 2000). Those parameters in which their ANOVA results found to be significant, further means separation were done using least significance difference (LSD) at 0.05 probability level.

Economic analysis

Partial budget analysis of selected treatments was done according to CIMMYT (1988). The grain yield data of chickpea produced by each treatment and location was used in the analyses. The grain yield data was obtained from each treatment was adjusted down by 10 % to narrow the yield gap that can occur due to difference in the management of the crop by research and farmers.

The field price of 1kg of grain of chickpea was taken as 16 Ethiopian Birr (ETB). This was the same in both locations based on the information obtained from Bureau of agriculture offices of both sites. The prices (FC) of Urea and TSP were 12.0 and 16.0 ETB kg^{-1} respectively. Gross benefit (GB) was calculated as average adjusted grain yield (kg ha^{-1}) multiplied by field price of the crop (16 ETB kg^{-1}). The labor cost for harvesting (HC) at Halaba and Taba areas were 35 and 50 ETB per man days, whereby 80 and 100 man-days were estimated for harvesting chickpea respectively. For treated plots, the labor requirement was adjusted based on the yield increment over that obtained in the control. The total variable cost (TVC) was calculated as the sum of all cost that was variable or specific to specific treatment against the control. Net benefit (NBT) was calculated by subtracting total variable cost from the gross benefit. Marginal rate of return (MRR) was calculated as the ratio of differences between net benefits of successive treatments to the difference between total variable costs of successive treatments.

RESULTS AND DISCUSSION

Effects on nodulation and yield components and yield of chickpea in Halaba

The main effect result from Halaba location/site showed that N and P fertilizer have significantly affected the NNP, NDWP and yield components of chickpea relative to the control (Table 2). The highest NNP and NDWP were obtained from N1 (11.5 kg N ha^{-1}) followed by N2 (23 kg N ha^{-1}) treatments and the least NNP and NDWP were recorded in the untreated control (N0) treatment. The result implies that both N treatments had stimulating effect on nodulation of chickpea. This is substantiated by several findings that application of starter dose of N fertilizer to legumes enhances nodulation and N-fixation by symbiotic N-fixing bacteria (Thaku *et al*. 1989; Giller and Cadisch, 1995). Similarly, P treatments produced significantly higher NNP and NDP in chickpea compared with the control (P0).

In the case of yield components of chickpea, both N1 and N2 treatments produced significantly higher NBP, NPP, NSPP, PHL and HSW of chick pea relative to the control (N0) treatment. But there were no significant differences between N1 and N2 treatments with respect to these parameters. The P treatments have also significantly increased the NBP, NPP, NSPP, PHT and HSW of chickpea compared with the control (P0) treatment and still there were no significant differences among P treatments in their effect on these parameters.

The N by P interaction effects were non-significant for all parameters shown in Table 2 except NBP. This implies that effects of different levels of N are not affected by the changes in P levels and vice-versa under this study situation.

The biomass and grain yield of chickpea have also been significantly affected by N and P treatments in Halaba (Table 2). Accordingly, both N and P treatments have significantly increased the biomass and grain yields of chickpea relative to the control. N1 and N2 treatments increased the biomass yield of chick pea at by 33 and 36 % over the control (N0) respectively. The corresponding increases in grain yield were 32 and 36 % over the control respectively. However, there was no significant difference between N1 and N2 treatments in their effect on biomass and grain yields of chickpea.

Table 2. Effects of N and P fertilizers on the nodulation and yield components of chickpea in Halaba.

Treatments	NNP[§]	NDP	NBP	NPP	NSPP	PHT (cm)	HSW	BYD (kg ha^{-1})	GY ($kgha^{-1}$)
		N-Fertilizer							
N0	41.2c†	0.18c	2.45b	46.6b	1.4b	47.1b	24.4b	3280b†	1630b
N1	65.2a	0.37a	2.78a	67.2a	1.89a	56.1a	27.7a	4360a	2150a
N2	54.6b	0.28b	2.71ab	63.0a	1.75a	53.7a	26.6a	4460a	2310a
LSD(0.05)	8.9	0.078	0.26	7.06	0.2	3.1	1.32	240	960
		P-Fertilizer							
P0	36.7b	0.17c	2.27b	48.1b	1.27b	48.1a	24.2b	3090c	1560c
P1	54.9a	0.26b	2.62a	62.5a	1.75a	53.2a	27.0ab	4040b	2030b
P2	60.8a	0.36a	2.86a	60.8a	1.86a	55.6a	27.6a	4460a	2360a
P3	59.3a	0.31ab	2.84a	63.0a	1.82a	52.3a	26.0ab	4540a	2300a
LSD(0.05)	10.3	0.09	0.3	7.5	0.3	3.6	1.5	280	220
N XP	ns	ns	**	ns	ns	ns	ns	**	**
CV (%)	19	33	11.7	13	18	7	5.9	7.5	11.4

†Means within column followed with the same letter(s) are not statistically different from each other.
[§]NNP = Number of nodules per plant, NDWP = Nodule dry weight per plant, NBP = Number of branches per plant, NPP = Number of pods per plant, NSPP = Number of seeds per pod, PHT = Plant height (cm), HSW = Hundred seed weight (g)
** Significant at 0.01 probability level, ns = non-significant, †Means within column followed with the same letter(s) are not statistically different from each other.

The increase in biomass and grain yield of chickpea shows that low level soil N in the site. This is in line with Umrai (1995) who reported that in deficient soils, application of nitrogen fertilizer to crops will bring considerable increase in the productivity. The grain yield increase found in this study was similar to that reported by Namvar et al. (2011) who have found only 36 % increase in grain yield of Desi type chickpea grown in silty-loam soil with the application of 46 kg N ha^{-1} in Iran.

In the case of P, the highest biomass and grain yield were obtained from P2 (20 kg P ha^{-1}) and P3 (30 kg P ha^{-1}) treatments and the least from P0 and P1 treatments in that order. P2 and P3 treatments have increased the biomass yield of chickpea by 44.3 and 44% over the control respectively. The corresponding increases in grain yield were 51 and 47 % over the control respectively. However, there was no significant difference between P2 and P3 treatments. The result of the present study with P is in line with Johansen and Sahrawat (1991) who reported that the optimum P rate for chickpea production is in the range of 15- 30 kg ha^{-1} but with optimum rate of 20 kg P ha^{-1}.

The interaction effects of N and P on grain yields of chickpea at Halaba were significant indicating levels of P have significantly increased the yield of chickpea along with increased application of N and vice versa.

Effects on nodulation and yield components and yield of chickpea in Taba

The main effects of N and P fertilizers on NNP, NDWP and yield components of chickpea grown at Taba are presented in Table 3. Both rates of N fertilizer have significantly increased NNP and NWDP of chickpea compared with the control. N fertilizer has also significantly increased NBP, NPP, NSPP, PLH and HSWT relative to the control. But there were no significant differences between N1 and N2 treatments with respects to these parameters on chickpea.

Like N, P fertilizer has also significantly increased the NNP, NDWP and yield components of chickpea compared with the control (P0). However, there were no significant differences among the different P rates in their effect on the nodulation and yield components of chickpea. This suggests that application P beyond 10 kg P ha^{-1} at Taba will bring no addition improvement in the nodulation and yield components of chickpea.

Application of N fertilizer has significantly increased the biomass and grain yields of chickpea compared with the control in Taba (Table 3). N1 and N2 treatments increased the biomass yield of chickpea by 38 and 23 % over the control respectively. The corresponding increases in grain yield were 61 and 40 % over the control respectively.

Table 3. The effect of N and P fertilizers on the nodulation and yield and yield components of chickpea in Taba.

Treatments	NNP	NDP	NBP	NPP	NSPP	PHT (cm)	HSW	BYD (kg ha^{-1})	GY (kg ha^{-1})
			N-Fertilizer						
N0	36.4b†	0.38b	2.3b	75.5c	1.3b	51.3b	24.9b	4000b†	1860c
N1	57.0a	0.40ab	2.8ab	96.0a	1.5a	62.7a	29.4a	5510a	3000a
N2	62.6a	0.44a	3.0a	110.0a	1.6a	64.3a	29.1a	5190a	2610b
LSD(0.05)	5.8	0.05	0.05	10.2a	0.08	2.5	3.5	456	196
			P-Fertilizer						
P0	37.0c	0.32b	2.3b	79.0b	1.3b	56.2b	25.1b	4180b	2180b
P1	49.0b	0.44a	3.0a	102.8a	1.6a	60.1a	28.8a	5160a	2530a
P2	57.6a	0.44a	2.7ab	92.4a	1.5a	59.4a	28.8a	5180a	2660a
P3	63.7a	0.40a	2.8ab	100.0a	1.5a	61.1a	28.3a	5190a	2600a
LSD (0.05)	6.7	0.06	0.56	11.8	0.1	2.9	2.1	530	230
N X P	ns	ns	ns	Ns	ns	ns	**	ns	ns
CV (%)	13	15	21	12	17	15	7.8	11	9.3

†Means within column followed with the same letter(s) are not statistically different from each other.

P fertilizer application has also significantly increased the biomass and grain yield of chickpea at Taba compared with the control. But there were no significant differences among the different P treatments with respect to biomass and grain yields. This is in contrast to what was observed at Halaba where the grain yield of chickpea was significantly increased with increase in P levels from P0 to P2. This suggests that P is more limiting in Halaba soil than in Taba. The results are in line with the available P contents of the experimental soils whereby the initial soil P content of Halaba is much lower than that in Taba. . Additionally, the relatively lower response of chickpea to P at Taba could be explained by repeated previous P fertilizer applications, as the experiment was conducted on the permanent research site of Hawassa University, whereas the same experiment was conducted on farmer's field at Halaba. Similar to the current result, Lester et al. (2008) found significant response of chickpea to lower rate of P (10 kg ha^{-1}) in Vertisols of northwestern Australia. There are several reports indicating that chickpea respond to P application in soils with available P in the range of 2- 5 mg kg^{-1} (Olsen) which very low level soil P for most of crops (Saxena, 1980).

Effects of Fertilizer on chickpea over location differences

The results of data analyzed over two locations revealed that N, P and locations have significantly affected the biomass and grain yields of chickpea (Table 4). N1 and N2 treatments increased the grain yield of chickpea by 48.6 and 42.8% over the control (N0) respectively. But there was no significant difference between the two N treatments. This indicates that application of N beyond 11.5 kg ha^{-1} will not increase the yield of chickpea any further. This is in agreement with Thaku et al. (1989) who reported that chickpea responds well to low rate (10-15 kg ha^{-1}) of nitrogen fertilizers. Similarly, substantial increase in yield chickpea up to 40% was obtained with application of 10-20 kg N ha^{-1}

(Ahlawat, 1990). However, this there are also occasions where by the yield of chickpea can be increased with an application N beyond 20 kg ha^{-1}. For instance, Kumar et al. (1995) found that on calcareous soils, grain yield of chickpea significantly increased with application of 40 kg N ha^{-1}. Similarly, application of 30 kg N ha^{-1} significantly increased grain yield of Desi type chickpea from 1.6 t ha^{-1} in the control to 2.21 t ha^{-1} in Saskatchewan (Walley *et al.*,2005). But, still the N requirement of chickpea is far less than the requirement of most cereals. The fact that chickpea is N fixing crop in symbiotic association with bacterial groups known as Rhizobia, it can be argued that it can satisfy its own need for N and thus there is no need for application of N as fertilizer. However, experimental results revealed that even if chickpea is N fixer and favorable conditions prevails for N-fixation, it is incapable of meeting nitrogen demands by fixation and does not even supply an equivalent quantity of 50 kg ha^{-1} of nitrogen fertilizer (Lopez-Bellido et al. , 2004). Moreover, to stimulate N-fixation process by legumes including chickpea, it is necessary to apply small dose of N fertilizer commonly known as starter dose (15 – 25 kg N ha^{-1}) in soils with low N content such as that revealed in this study (Mishra and Ram, 1971). Starter dose of N has positive effect on the N2 fixation and growth of chickpea during the period between emergence and onset of active N2 fixation (Giller and Cadisch, 1995). However, higher dose of N fertilizer has negative effect on nodulation and subsequent N2 fixation and also stimulate vegetative growth ultimately resulting in grain yield of chickpea.

Similarly, the highest biomass and grain yields of chickpea were obtained from P2 and P3 over the two locations. These treatments increased the grain yield by 34 and 31 % over the control respectively (Table 4). However, P2 and P3 treatments were at par statistically with each other with respect to yield. However, if we examine the effect P fertilizer treatments in individual locations, the highest and optimum yield was obtain from 20 kg P ha^{-1} (Table 2) whereas in Taba the optimum yield was obtained from 10 kg P ha^{-1} treatment (Table 3). From this observation we can infer that we should be very careful and interpreting data analyzed over location.

Compared with the national average yield of chickpea which is 1.6 t ha^{-1} (Minale Kassie *et al*., 2009), N and P fertilizer applied at 11.5 and 20 kg ha^{-1} respectively increased the grain yield by 62.5 and 56.8 % over locations respectively. This suggests that with application of such small doses of N and P fertilizers, appreciable increase in production and productivity of chickpea can be achieved in Ethiopia. However, there are only few occasions where by farmers in Ethiopia apply fertilizers to leguminous crops including chickpea in Ethiopia as opposed to cereals. This is mainly due to the fact that legumes satisfy their nutrient demand and thus they don’t need to be fertilized. Professionals also have done little to verify to farmers that even if legumes can improve soil fertility, they still may require some amount of fertilizers especially P for higher yield and production. Thus, the finding of this study clearly indicates that food legumes including chickpea needs to be fertilized even if not as much as that of cereals.

Table 4. The effects of N and P fertilizer on biomass and grain yield of chickpea over locations.

Treatments	Biomass Yield	Grain Yield
	kg ha^{-1}	
	N-Fertilizer	
N0	3640b†	1750b
N1	4930a	2600a
N2	4830a	2500a
LSD(0.05)	250	130
	P-Fertilizer	
P0	3680b	1870c
P1	4600a	2280b
P2	4820a	2510a
P3	4810a	2450a
LSD(0.05)	290	150
	Location	
Halaba	4000b	2000b
Taba	4900a	2500a
LSD(0.05)	210	110
N X P	ns	ns
N X Location	**	**
P X Location	ns	ns
N X P X Location	ns	ns
CV (%)	9.7	10.4

†Means within column followed with the same letter(s) are not statistically different from each other.

Significantly higher biomass and grain yields of chickpea were obtained at Taba than Halaba irrespective of fertilizer treatments (Table 4). The biomass and grain yields of chickpea obtained in Taba were higher by 22.5 and 25 % than that produced in Halaba respectively. One of the possible reasons that account for the observed difference in the response of chickpea between the two locations could be mainly due to difference in soil types. The soil of Taba is Vertisol and that of Halaba is Andosol and chickpea grows better in Vertisol than Andosol due to its high residual moisture content. It is also possible to predict that the variety of chickpea used in this experiment had better specific adaptation to Taba than Halaba location.

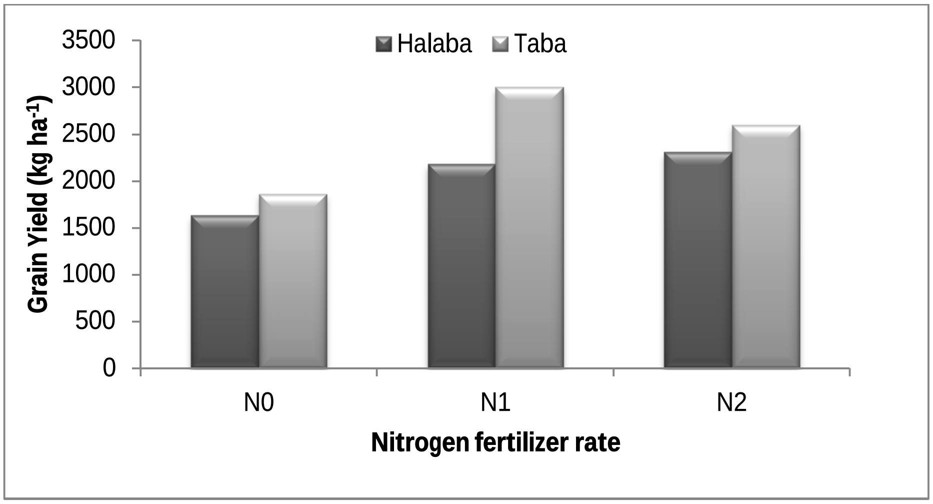

Figure 1. Interaction effect of N fertilizer and location on the grain yield of chickpea

Treatment by location interaction was significant only for N X location (Fig. 1). N1 produced significantly higher grain yield (3.0 t ha^{-1}) of chickpea in Taba than that produced (2.18 t ha^{-1}) in Halaba. It increased the grain yield by over 61 % over the control in Taba whereas the same treatment increased the grain yield of chickpea by only 34 % in Halaba. This suggests that chickpea is more responsive to N in Taba soil than Halaba soil. This finding is supported by the result of initial soils analysis data in which the soil of Halaba had higher total N than that obtained in Taba soils (Table 1). However, with the next higher dose of nitrogen (N2), there was no significant difference between the two locations in the grain yield of chickpea produced. This implies that N1 is the optimum N dose for chickpea production for both locations.

Table 5. Partial budget analysis of data of fertilizer treatments in Halaba.

Treatments	Grain Yield (kg ha^{-1})	Adjusted Yield, (kg ha^{-1})	*GB (ETB ha^{-1})	FC (ETB ha^{-1})	HC (ETB ha^{-1})	TVC (ETB ha^{-1})	NBT (ETB ha^{-1})	MRR (%)
N0 X P0	803	722	11563	0	4000	4000	7563	-
N0 X P1	1689	1520	24321	800	7572	8372	15949	191
N0 X P2	2000	1800	28800	1600	8966	10566	18233	104
N0 X P3	2040	1836	29376	2400	9145	11545	17830	D**
N1 X P0	1833	1649	26395	300	8217	8517	17877	D
N1 X P1	2030	1827	29232	1100	10459	11559	17672	D
N1 X P2	2410	2170	34720	1900	10804	12704	22016	380
N1 X P3	2413	2171	34747	2700	10817	13517	21229	D
N2 X P0	2060	1854	29664	600	9235	9835	19828	D
N2 X P1	2330	2097	33552	1400	10445	11845	21706	93
N2 X P2	2670	2403	38448	2200	11970	14170	24277	110
N2 X P3	2450	2205	35280	3000	10983	13983	21296	D

Economic analysis

The results of partial budget analysis data of treatments for Halaba and Taba locations are presented in Tables 5 and 6 respectively. In Halaba, the highest net benefits were obtained from N2 X P2 followed by N1 X P2 and N2 X P1 treatments in that order

(Table 5). Marginal rate of return (MMR) of treatments ranged between 93 – 380 % and the highest MMR was obtained N1 X P2 treatment.

In Taba location, the net benefit (NBT) obtained ranged between 16384 and 33466 ETB and the highest NTB was obtained from N1 X P treatment, followed by N1 X P2, and N1 X P3 in that order (Table 6). Higher values of NTB were obtained in Taba than Halaba due to higher yield obtained from each treatment in the former than that obtained from the corresponding treatment in the later. The highest value of MMR was obtained from N1 X P1 followed by N2 X P1 and N0 X P1 treatments in that order.

Table 6. Partial budget analysis of data of fertilizer treatments in Taba.

Treatments	Grain Yield (kg ha^{-1})	Adjusted Yield (kg ha^{-1})	*GB (ETB ha^{-1})	FC (ETB ha^{-1})	HC (ETB ha^{-1})	TVC, (ETB ha^{-1})	NBT, (ETB ha^{-1})	MRR (%)
N0 X P0	1485	1337	21384	0	5000	5000	16384	-
N0 X P1	1815	1634	26134	800	6111	6911	19225	148
N0 X P2	2028	1825	29203	1600	6828	8428	20775	D**
N0 X P3	2300	2070	33120	2400	7744	10144	22976	D
N1 X P0	2020	1818	29088	300	6801	7101	21987	D
N1 X P1	3133	2820	45115	1100	10549	11649	33466	252
N1 X P2	3146	2831	45302	1900	10593	12493	32810	102
N1 X P3	3013	2712	43387	2700	10145	12845	30542	D
N2 X P0	2341	2107	33710	600	7882	8482	25228	D
N2 X P1	2676	2408	38534	1400	9010	10410	28124	150
N2 X P2	2620	2358	37728	2200	8822	11022	26706	D
N2 X P3	2830	2547	40752	3000	9529	12529	28223	100

[1]D = Dominant

CONCLUSION

The results of this study revealed that application of N and P fertilizers have significantly increased the yield and yield components of chickpea grown in both Halaba and Taba locations indicating low levels of soil N and P. N applied at 11.5 kg ha^{-1} was found to optimum for chickpea production in both locations whereas P applied at 20 and 10 kg ha^{-1} was found to be optimum for Halaba and Taba locations respectively suggesting that the soil of Halaba is more P limited than that in Taba. N and P fertilizer rates of 11.5:20 and 11.5:10 kg ha^{-1} produced the highest marginal rate of return in Halaba and Taba locations respectively suggesting that fertilizer application for chickpea production is feasible in both areas. Location has significantly affected the yield of chickpea and the higher grain and biomass yield was obtained in Taba than Halaba irrespective of fertilizer treatments. This implies that the former location is more conducive for chickpea production than the later in regards to the chickpea variety used in this study. This may be due to difference between the two locations in their soil types in which the soil of Taba is Vetisol and that of Hababa is Andosol. Vertisol is known to be more suitable for chickpea production than any other soil type. N and P fertilizer rates of 11.5:20 and 11.5:10 kg ha^{-1} are recommended for optimum chickpea production in Halaba and Taba locations respectively. Further, demonstration of these fertilizer rates around the study areas through involvement of as many farmers as possible is recommended.

ACKNOWLDGEMENT

The Canadian International Food Security Research Fund (CIFSRF) is greatly acknowledged for sponsoring this study.

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