Range Mgmt. & Agroforestry 35 (1) : 66-72, 2014
ISSN 0971-2070

Productivity and profitability of fodder sorghum + cowpea – chickpea cropping system as influenced by organic manure, phosphorus and sulphur application in central India

A. K. Dixit, Sunil Kumar, A. K. Rai[1] and D. R. Palsaniya

Indian Grassland and Fodder Research Institute, Jhansi-284003, India
[1]Present address: Central Soil Salinity Research Institute, Karnal, India
Corresponding author e-mail: dixitak21@yahoo.com
Received: 27th March, 2014 Accepted: 29th May, 2014

Abstract

A field experiment was carried to find out the effect of phosphorus, sulphur and FYM on productivity and profitability of fodder sorghum + cowpea ï chickpea cropping system during 2010-11 and 2011-12 at Jhansi. Experiment was laid out in factorial randomized block design with three replications, comprising of two FYM levels, three P_2O_5 levels and two sulphur levels. Use of 60 kg P_2O_5 ha^{-1} gave significantly higher dry fodder yield (11.0 x 10^3 kg ha^{-1}) of sorghum + cowpea than 30 kg P_2O_5 ha^{-1}. Application of FYM (5 t ha^{-1}) and sulphur (20 kg ha^{-1}) gave significantly higher green fodder yield (41.7 x 10^3 and 41.3 x 10^3 kg ha^{-1}, respectively) than their respective controls. Chickpea responded to FYM application and recorded 14.2, 20.3 and 14.7 % increase in grains/pod, grain and stover yield, respectively. Application of 30 kg P_2O_5 ha^{-1} produced 7.2, 13.4, 19.1 and 31.9 % higher plant m^{-2}, pods $plant^{-1}$, straw and grain yield, respectively over the control, however 60 kg P_2O_5 ha^{-1} did not have significant difference from 30 kg P_2O_5 ha^{-1}. Sulphur application (20 kg S ha^{-1}) to chickpea recorded increased branching and higher grain (9.0 %) and straw (11.4 %) yield over control. Significantly higher system productivity in term of chickpea equivalent yield was obtained with the application of 5 t FYM ha^{-1}, 30 kg P_2O_5 ha^{-1} and 20 kg S ha^{-1}. The agronomic use efficiency (AUE) of P was 1.5 to 1.7 times higher at 30 kg P_2O_5 ha^{-1} as compared to 60 kg P_2O_5 ha^{-1}. System profitability, net return and B: C ratio were also higher with the application of 5 t FYM ha^{-1}, 60 kg P_2O_5 ha^{-1} and 20 kg S ha^{-1} in fodder ï food cropping system.

Keywords: Agronomic use efficiency, Fodder ï food cropping system, Productivity, Profitability

Abbreviations: AUE: Agronomic use efficience; **B:C**: Benefit cost ratio; **FYM**: Farm yard manure; **OC**: Organic carbon; **RBD**: Randomized block design

Introduction

Fodder sorghum + cowpea - chickpea is one of the prominent fodder - food cropping system in central Indiahaving considerable share in food, feed and fodder basket of the country. However, the production and productivity of system has stagnated and reached to a plateau due to imbalanced and inadequate use of nutrients. Nutrient management is one of the important agronomic practices which greatly affect productivity and profitability of the cropping system, but in recent past due to increased cropping intensity, imbalance in nutrient application and increased reliance on inorganic fertilizers alone, the productivity of soils has gone down (Prasad, 2006). Role of the organics in improving soil fertility and sustainability of the cropping system is well documented. It ensure regulated supply of nutrients by releasing them slowly resulting in increased crop yield and nutrient use efficiency (Sharma, 2002), long term sustainability of soil fertility by improving level of soil organic carbon, availability of nutrients and soil microbial properties (Melero *et al*., 2007). Phosphorus (P) and sulphur (S) are major nutrient elements for cereal - legume cropping system (Jiang *et al*., 2006; Palsaniya and Ahlawat, 2009). Cowpea and chickpea have higher P requirement because the process of symbiotic nitrogen (N) fixation consumes a lot of energy (Schulze *et al*., 2006). Sulphur is another nutrient which limit the performance of the legume based cropping systems. Sulphur is an integral component of ferredoxin, which have a significant role in nitrogen dioxide and sulphate reduction and assimilation of N by root nodule and free living N-fixing soil bacteria (Scherer, 2008; Scherer *et al*., 2008). In many soil types of central India, P and S are the most limiting nutrients for the production of crops (Tripathi and Hazra, 2000; Tripathi *et al*. 2003). Considering this fact, study was conducted to find out optimum dose of phosphorus and sulphur in conjunction with FYM for obtaining higher yield and economic return from fodder sorghum + cowpea ï chickpea cropping system.

Materials and Methods

Field experiment was conducted at Central Research Farm, Indian Grassland and Fodder Research Institute Jhansi (25°27ôN latitude and 78°35ôE longitude at an elevation of 271 m above mean sea level) for two consecutive years from *Kharif* 2010-11 to *Rabi* 2011-12. The soil at study site had pH (1:2 soil: water) 6.9, electrical conductivity (1:2 soil: water) 0.13 dS m^{-1}, bulk density 1.25 Mg m^{-3} and clay loam texture. The organic carbon (OC) content was 0.72 %. Before the start of the experiment the available nitrogen, phosphorus, potassium and sulphur were 227.5, 23.9, 159.7 and 31.7 kg ha^{-1}, respectively. Treatments comprised of two levels of organic manure (no FYM and 5 t FYM ha^{-1}), three levels of phosphorus (0, 30 and 60 kg P_2O_5 ha^{-1}) and two levels of sulphur (0 and 20 kg S ha^{-1}) in factorial randomized block design (RBD) with three replications. Phosphorus and sulphur were applied through DAP and elemental sulphur, respectively. Fodder sorghum (*cv*. PC-6) and cowpea (*cv*. BL-1) were sown in intercropping system with 1:1 ratio during first fortnight of July and chickpea (*cv*. Awarodhi) was sown during fourth week of November to first week of December. Crops of both seasons were sown with row to row spacing of 30 cm. During *Kharif* season no irrigation was applied, however, during *Rabi* two irrigations at critical crop growth stage were applied. Sorghum + cowpea and chickpea were also fertilized with 60 kg N and 20 kg K_2O ha^{-1} and 20 kg N and 20 kg K_2O ha^{-1}, respectively and whole quantity of nitrogen and potassium were applied as basal. Sorghum and cowpea were harvested for green forage at 50% flowering stage. Observations on various biometric parameters, system productivity and quality were recorded. Protein yield was calculated using nitrogen content in stover and grain. The agronomic use efficiency was calculated by using following expression-

$$AUE = \frac{Yt - Yc}{Pa}$$

Where, AUE is agronomic use efficiency in kg dry fodder or grain/kg nutrient applied, Yt is the dry fodder or grain yield (kg ha^{-1}) in nutrient applied plot, Yc is the dry fodder or grain yield (kg ha^{-1}) in control plot and Pa is the nutrient applied (kg ha^{-1}).

AUE of FYM was worked out on the basis of N content that was 5.4 and 3.8 kg N t^{-1}, respectively during the year 2010-11 to 2011-12. The chemical composition of applied FYM during the year 2010-11 and 2011-12 was 0.54 & 0.38 % N, 0.31 & 0.23 % P_2O_5 and 0.49 & 0.57 % K_2O, respectively. For system productivity, chickpea grain equivalent yield was worked out by converting the fodder yield of sorghum + cowpea and chickpea straw yield on the basis of marketable price rate of each component and chickpea grain and expressed in kg ha^{-1}. Similarly system profitability was also computed on the basis of prevailing market price of different components. Data on all observations were subjected to analysis of variance (ANOVA) by using software SAS 9.2. Treatment means were compared by least significant difference ($LSD_{5\%}$) test.

Results and Discussion

Fodder production from sorghum + cowpea: Application of farm yard manure (FYM), phosphorus and sulphur significantly increased the fodder yield of sorghum + cowpea in both the years (Table 1). Pooled data of 2 years study showed that application of 5 t FYM ha^{-1} produced 41.7 x 10^3 kg ha^{-1} green fodder and 10.4 x 10^3 kg ha^{-1} dry fodder yield of sorghum + cowpea system which was 8.8 and 7.3 % higher than green and dry fodder yield obtained from control (without FYM). However, the dry matter content (%) was significantly lower when sorghum + cowpea raised with 5 t FYM ha^{-1}, due to increased succulence. Mean AUE of 5 t FYM ha^{-1} application was 29.3 kg dry fodder kg^{-1} N. Kumar *et al.* (2005) also reported that application of FYM increased the yield of maize crop.

Application of 60 kg P_2O_5 ha^{-1} gave significantly higher green fodder yield (42.9 x 10^3 kg ha^{-1}), dry matter content (25.5 %) and dry fodder yield (11.0 x 10^3 kg ha^{-1}) of sorghum + cowpea than without phosphorus application but it was statistically at par with application of 30 kg P_2O_5 ha^{-1} except dry matter content (Table 1). Application of 30 and 60 kg P_2O_5 ha^{-1} increased the green fodder yield by 15.9 and 20.3 per cent, respectively over no phosphorus. The application of 60 kg P_2O_5 ha^{-1} resulted in 5.7 % increase in dry fodder yield as compared to application of 30 kg P_2O_5 ha^{-1}, respectively. The dry matter content (%) also showed same trend and progressively increased up to 60 kg P_2O_5 ha^{-1} level. The agronomic use efficiency was 54.1 and 36.9 kg dry fodder per kg P_2O_5 at phosphorus levels of 30 and 60 kg ha^{-1}, respectively. Sheoran *et al.* (1994) also reported that application of 60 kg P_2O_5 ha^{-1} improved forage yield and quality of cowpea.

The green and dry fodder yield of sorghum + cowpea also increased with the application of sulphur in both the years (Table 1). Pooled data showed that application of 20 kg S ha^{-1} produced 41.3 x 10^3 kg ha^{-1} green fodder yield, 25.3 % dry matter content and 10.4 x 10^3 kg ha^{-1} dry fodder yields. On the basis of pooled data analysis, increase in green fodder yield due to sulphur fertilization was 6.6 per cent over control. Similar trend was also observed for dry forge yield and it was 8.8 per cent higher over control. The dry matter content also increased with sulphur application. The agronomic use efficiency with the application of sulphur was 42.2 kg dry fodder kg^{-1} S application. Hazra and Tripathi (1998) reported that the response of green fodder kg kg^{-1} S at optimum level of S application was 87 and 85 with sorghum and cowpea, respectively.

Yield attributes and yield of chickpea: Nutrient management significantly influenced yield and various yield attributes of chickpea (Table 2). Among yield attributes of chickpea, grains per pod and yield of grain and straw were affected significantly with FYM application. The pooled data of two years revealed that grains pod^{-1} (1.7), grain yield (1489 kg ha^{-1}) and stover yield (1194 kg ha^{-1}) increased by 14.2, 20.3 and 14.7 per cent, respectively, over no FYM application. However, FYM applied to chickpea did not affect the plants population m^{-2}, branches $plant^{-1}$, 100-seed weight, pods $plant^{-1}$ and harvest index significantly. The agronomic use efficiency for FYM application (5 t ha^{-1}) was 12.2 kg grain yield kg^{-1} N applied through FYM.

Table 1. Green and dry fodder yield and agronomic use efficiency (AUE) of sorghum + cowpea in fodder ï food cropping system as influenced by nutrient management

Nutrient management	Green fodder yield, GFY($x10^3$ kg ha^{-1})			Dry matter content (%)		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
Organic manure						
No FYM	43.0	33.5	38.3	24.9	25.5	25.2
5 t FYM ha^{-1}	48.0	35.4	41.7	24.5	25.2	24.9
SEm$\pm$	1.0	0.4	0.5	0.1	0.1	0.1
$LSD_{5\%}$	3.0	1.2	1.6	0.2	NS	0.2
Phosphorus (P_2O_5) levels						
No P_2O_5	40.7	30.7	35.7	24.2	24.8	24.5
30 kg P_2O_5 ha^{-1}	46.8	36.0	41.4	24.8	25.3	25.1
60 kg P_2O_5 ha^{-1}	49.0	36.8	42.9	25.1	25.9	25.5
SEm$\pm$	1.2	0.5	0.6	0.1	0.2	0.1
$LSD_{5\%}$	3.7	1.5	1.9	0.3	0.4	0.3
Sulphur (S) application						
No S	43.7	33.7	38.7	24.5	25.1	24.8
20 kg S ha^{-1}	47.3	35.3	41.3	24.9	25.6	25.3
SEm$\pm$	1.0	0.4	0.5	0.1	0.1	0.1
$LSD_{5\%}$	3.0	1.2	1.6	0.2	0.4	0.2

Nutrient management	Dry fodder yield, DFY($x10^3$ kg ha^{-1})			AUE, kg DFY kg^{-1} nutrient applied		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
Organic manure						
No FYM	10.7	8.6	9.7	-	-	-
5 t FYM ha^{-1}	11.8	8.9	10.4	38.1	20.5	29.3
SEm$\pm$	0.3	0.1	0.1	-	-	-
$LSD_{5\%}$	0.8	0.3	0.4	-	-	-
Phosphorus (P_2O_5) levels						
No P_2O_5	9.9	7.6	8.7	-	-	-
30 kg P_2O_5 ha^{-1}	11.6	9.1	10.4	58.6	49.9	54.1
60 kg P_2O_5 ha^{-1}	12.3	9.5	11.0	41.2	32.3	36.9
SEm$\pm$	0.3	0.1	0.2	-	-	-
$LSD_{5\%}$	1.0	0.4	0.5	-	-	-
Sulphur (S) application						
No S	10.7	8.5	9.6	-	-	-
20 kg S ha^{-1}	11.8	9.0	10.4	54.1	29.6	42.2
SEm$\pm$	0.3	0.1	0.1	-	-	-
$LSD_{5\%}$	0.8	0.3	0.4	-	-	-

Table 2. Performance of chickpea in fodder - food cropping system as influenced by nutrient management (Pooled data of 2 years)

Nutrient management	Plants m^{-2}	Branches $plant^{-1}$	Grains pod^{-1}	100-seed weight (g)	Pods $plant^{-1}$	Grain yield (kg ha^{-1}) 2010-11	Grain yield (kg ha^{-1}) 2011-12	Grain yield (kg ha^{-1}) Pooled
Organic manure								
No FYM	24.5	4.7	1.55	17.4	32.9	1133	1342	1238
5 t FYM ha^{-1}	25.1	5.1	1.71	17.2	34.6	1256	1721	1489
SEm$\pm$	0.4	0.1	0.04	0.2	1.2	26	84	32
$LSD_{5\%}$	NS	NS	0.11	NS	NS	77	246	95
Phosphorus (P_2O_5) levels								
No P_2O_5	23.5	4.7	1.61	17.5	30.7	1057	1152	1105
30 kg P_2O_5 ha^{-1}	25.2	5.2	1.64	17.1	34.8	1254	1661	1458
60 kg P_2O_5 ha^{-1}	25.7	4.8	1.64	17.3	35.8	1272	1781	1527
SEm$\pm$	0.5	0.2	0.05	0.2	1.4	32	103	40
$LSD_{5\%}$	1.5	NS	NS	NS	4.2	94	301	117
Sulphur (S) application								
No S	23.9	4.7	1.61	17.4	32.5	1144	1465	1305
20 kg S ha^{-1}	25.7	5.2	1.65	17.1	34.0	1245	1598	1422
SEm$\pm$	0.4	0.1	0.04	0.2	1.2	26	84	32
$LSD_{5\%}$	1.3	0.4	NS	NS	NS	77	NS	95

Nutrient management	Stover yield (kg ha^{-1})	Harvest index (%)	AUE, kg grain kg^{-1} nutrient applied 2010-11	AUE 2011-12	AUE Pooled
Organic manure					
No FYM	1041	54.5	-	-	-
5 t FYM ha^{-1}	1194	55.5	4.5	19.9	12.2
SEm$\pm$	36	0.4	-	-	-
$LSD_{5\%}$	106	NS	-	-	-
Phosphorus (P_2O_5) levels					
No P_2O_5	977	53.4	-	-	-
30 kg P_2O_5 ha^{-1}	1164	55.8	6.6	17.0	11.8
60 kg P_2O_5 ha^{-1}	1211	55.8	3.6	10.5	7.0
SEm$\pm$	44	0.5	-	-	-
$LSD_{5\%}$	129	1.5	-	-	-
Sulphur (S) application					
No S	1057	55.4	-	-	-
20 kg S ha^{-1}	1178	54.6	5.0	6.6	5.8
SEm$\pm$	36	0.4	-	-	-
$LSD_{5\%}$	106	NS	-	-	-

Application of phosphorus significantly increased the plants m^{-2}, pods $plant^{-1}$, grain yield, straw yield and harvest index of chickpea. Application of 30 and 60 kg P_2O_5 ha^{-1}, being at par, recorded 7.2 and 9.4 % higher plants m^{-2} over control. Similarly, the respective increase in pods $plant^{-1}$ was 13.4 and 16.6 % over control (Table 2). Similar results were also reported by Siag (1995) and Amanullah *et al*. (2012). In case of grain and straw yield of chickpea, similar trend was also observed where, 30 and 60 kg P_2O_5 ha^{-1} being at par, produced significantly higher grain yield by 31.9 and 38.2 % and stover yield by 19.1 and 24.0 per cent, respectively over control. Harvest index also showed same trend. However, other parameters like branches $plant^{-1}$, grains pod^{-1} and 100-seed weight were not affected significantly due to application of phosphorus. Higher agronomic use efficiency was recorded with the application of 30 kg P_2O_5 ha^{-1} (11.8 kg grain yield kg^{-1} P_2O_5) whereas application of 60 kg P_2O_5 ha^{-1} gave only 7.0 kg grain yield kg^{-1} P_2O_5. The initial supply of phosphorus and FYM that played a vital role in physiological and developmental processes in plant life having P stress and the favourable effect of these important nutrients might have accelerated the growth processes that increased the biomass yield of the crop. But at increased level of P response was reduced as plants were not facing the nutrient stress. Similar results were also obtained by Siag (1995) who reported increase in grain yield with P application up to 60 kg P_2O_5 ha^{-1}.

Application of S to chickpea significantly enhanced plants m^{-2}, branches $plant^{-1}$ and grain and straw yield (Table 2). However, grains pod^{-1}, 100-seed weight, pods $plant^{-1}$ and harvest index remained unaffected by S application to chickpea. Application of 20 kg S ha^{-1} to chickpea produced 7.5 % more plants m^{-2} than no sulphur. Similarly, branches $plant^{-1}$ increased by 10.6 % over control due to S fertilization to chickpea. The grain and stover yield of chickpea increased by 9.0 and 11.4 %, respectively over control due to 20 kg S ha^{-1} application. The increase in yield parameters might be due to involvement of S in synthesis of sulphur containing amino acids, carbohydrates metabolism, protein synthesis, energy transformation and chlorophyll synthesis. Similar findings were also reported by Saraf *et al*. (1997), Palsaniya and Ahlawat (2009) and Srinivasarao *et al*. (2010). The agronomic use efficiency was recorded as 5.8 kg grain yield kg^{-1} S applied.

System productivity: System productivity calculated in terms of chickpea grain equivalent yield was influenced significantly with the application of FYM, phosphorus and sulphur in fodder sorghum + cowpea ï chickpea cropping system in both the years (Table 3). Pooled data of 2 years showed that application of 5 tonne FYM per hectare recorded 3039 kg ha^{-1} chickpea grain equivalent yield from the system which was 14.3 % higher than control (without FYM). Kumar *et al*. (2005) also reported that application of FYM either to *Kharif* crop or *Kharif* and *Rabi* crop both increased the system productivity by 7.7 %. Application of 30 kg P_2O_5 ha^{-1} produced significantly higher chickpea grain equivalent yield (23.3 %) over control. Chickpea supplied with 20 kg S ha^{-1} produced 2979 kg ha^{-1} chickpea grain equivalent yield which was significantly higher than control. This trend of system productivity may be attributed to the effect of treatments on the yield of individual component crops of the system. Similar results were also reported by Palsaniya and Ahlawat (2009) in pigeon pea ï wheat cropping system.

System protein yield: Application of FYM, phosphorus and sulphur significantly enhanced the total protein yield of the sorghum + cowpea - chickpea cropping system as compared to their respective control (Table 3). Pooled data showed that application of FYM (5 t ha^{-1}) in *Kharif* and *Rabi* season gave protein yield of 1293 kg ha^{-1} from fodder sorghum + cowpea, 303 kg ha^{-1} from chickpea and 1596 kg ha^{-1} from whole system and was 12.7, 22.7 and 14.5 % higher over control (1394 kg ha^{-1}), respectively. The increase in protein content was also reported by Srinivasarao *et al*. (2010) with the application of 4 t ha^{-1} FYM. Application of 60 kg P_2O_5 ha^{-1} produced 1669 kg ha^{-1} protein yield which was significantly higher than 30 kg P_2O_5 ha^{-1} (1555 kg ha^{-1}) and control (1260 kg ha^{-1}) by 7.3 and 32.5 % respectively. Application of 20 kg S ha^{-1} also produced 142 kg ha^{-1} more protein yield than no sulphur application. Enhanced protein yield due to S fertilization may be attributed to the role of S in formation of S-containing amino acids namely cystein, cystine and metheonine (Palsaniya and Ahlawat, 2009). The protein yield was more during *Kharif* season than *Rabi* season due to higher biomass production by fodder crops which will lead to nutritional security of ever increasing animal population *vis-à-vis* human beings. Tripathi *et al.* (1992) also reported that the crude protein of fodder sorghum was considerably improved by S application.

System profitability: Application of FYM, phosphorus and sulphur influenced the economics of sorghum + cowpea - chickpea based fodder - food cropping system (Table 3). Application of 5 t FYM ha^{-1} realised net return of Rs. 32527 ha^{-1} which was higher by Rs 5826 ha^{-1} over without FYM application. Phosphorus application at 60 kg P_2O_5 ha^{-1} produced net return of Rs. 35011 ha^{-1} which was higher by Rs 14517 and 1679 ha^{-1} over control and 30 kg P_2O_5 ha^{-1}, respectively. In case of sulphur nutrition, application of 20 kg S ha^{-1} resulted in net return of Rs 31118 ha^{-1} from the system which was higher by Rs 3006 ha^{-1} than without sulphur application. The benefit cost ratio was also higher with the application of 5 t FYM ha^{-1} (0.77), 60 kg P_2O_5 ha^{-1} (0.84) and 28 kg S ha^{-1} (0.75) than their respective control in fodder ï food cropping system. This might be due to higher system productivity and higher economic return with higher level of nutrient application. Similar results were also obtained by Siag (1995) with the application of 60 kg P_2O_5 ha^{-1} and Srinivasarao *et al.* (2010) with the application of 20 kg S and 4 t FYM ha^{-1}.

Conclusion

These results suggested that in fodder sorghum + cowpea ï chickpea cropping system, the optimum productivity cannot be realised in absence of the P and S nutrition due to the deficiency of these nutrients in the region. Application of 5 t FYM, 30 kg P_2O_5 and 20 kg S ha^{-1} in both the seasons (*Kharif* and *Rabi*) was adequate for the higher productivity and profitability of fodder sorghum + cowpea ï chickpea cropping system under semi arid region of Central India.

Table 3. System productivity, protein yield and economics of fodder sorghum + cowpea ï chickpea cropping system as influenced by nutrient management (Pooled data of 2 years)

Nutrient management	Chickpea Equivalent Yield of System (kg ha^{-1})			Protein yield (kg ha^{-1})		
	2010-11	2011-12	Pooled	Kharif	Rabi	Total
Organic manure						
No FYM	2713	2605	2659	1146	247	1394
5 t FYM ha^{-1}	3014	3063	3039	1293	303	1596
SEm$\pm$	51	60	39	18	7	19
$LSD_{5\%}$	149	176	114	53	19	56
Phosphorus (P_2O_5) levels						
No P_2O_5	2551	2308	2430	1041	219	1260
30 kg P_2O_5 ha^{-1}	2970	3019	2995	1262	293	1555
60 kg P_2O_5 ha^{-1}	3070	3174	3122	1355	314	1669
SEm$\pm$	62	73	48	22	8	23
$LSD_{5\%}$	182	216	140	65	24	68
Sulphur (S) application						
No S	2748	2734	2741	1162	262	1424
20 kg S ha^{-1}	2979	2933	2956	1277	289	1566
SEm$\pm$	51	60	39	18	7	19
$LSD_{5\%}$	149	176	114	53	19	56

Nutrient management	Economics of fodder sorghum + cowpea – chickpea system			
	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
Organic manure				
No FYM	38243	64944	26701	0.70
5 t FYM ha^{-1}	41993	74520	32527	0.77
Phosphorus (P_2O_5) levels				
No P_2O_5	38588	59082	20494	0.53
30 kg P_2O_5 ha^{-1}	40118	73450	33332	0.83
60 kg P_2O_5 ha^{-1}	41648	76659	35011	0.84
Sulphur (S) application				
No S	39018	67130	28112	0.72
20 kg S ha^{-1}	41218	72336	31118	0.75

MSP of chickpea Rs. 2100 q^{-1}, local market price of chickpea stover Rs. 100 q^{-1} and green fodder Rs. 75 q^{-1}in the year 2011-12 and MSP of chickpea Rs. 2800 q^{-1}, local market price of chickpea stover Rs. 150 q^{-1} and green fodder Rs. 100 q^{-1} in the year 2012-13.

Acknowledgement

The authors wish to acknowledge the support and facilities received from Coordinating unit of AICRP on chickpea, Kanpur and Director, IGFRI Jhansi to undertake this study.

References

Amanullah Jan, Amanullah Habib Akbar and B. C. Blaser. 2012. Chickpea response to tillage system and phosphorus management under dryland conditions. *J. Plant Nutr.* 35 (1): 64-70.

Hazra, C. R. and S. B. Tripathi. 1998. Effect of secondary and micro nutrients on yield and quality of forages. *Fertilizer News* 43 (12): 77-82.

Jiang, D., H. Hengsdijk, T. B. Dai, W. de Boer, Q. Jing and W. X. Cao. 2006. Long term effect of manure and inorganic fertilizer on yield and soil fertility for a winter wheat- maize system in Jiangsu, China. *Pedosphere* 16: 25-32.

Kumar, Anil, K. S. Thakur and Sanjay Sharma. 2005. Integrated nutrient management in maize (*Zea mays*) ï gobhi sarson (*Brasica napus* ssp oliefera var. annua) cropping system under rainfed condition. *Indian J. Agron.* 50 (4): 274-277.

Melero, S., E. Madejon, G. C. Ruiz and G. F. Herencia. 2007. Chemical and biochemical properties of clay soils under dryland agriculture system as affected by organic fertilization. *Euro. J. Agron.* 26: 327-334.

Palsaniya, D. R. and I. P. S. Ahlawat. 2009. Sulphur management in pigeonpea (*Cajanus cajan*) ï wheat (*Triticum aestivum*) cropping system. *Indian J. Agron.* 54 (3): 272-277.

Prasad, R. 2006. Towards sustainable agriculture in India. *National Academy Science Letters* 9 (1&2): 41-44.

Saraf, C. S., B. G. Shivakumar and R. R. Patil. 1997. Effect of phosphorus, sulphur and seed inoculation on performance of chickpea. *Indian J. Agron.* 42(2): 323-328.

Scherer, H. W. 2008. Impact of Sulphur on N_2 Fixation of Legumes. *In*: Khan, N.A. (ed.), *Sulphur assimilation and abiotic stress in plants*. Kluwer Academic Publications, The Netherlands: 51-53.

Scherer, H. W., S. Pacyna, K. Spoth and M. Schulz. 2008. Low levels of ferredoxin, ATP and leghemoglobin contribute to limited N_2 fixation of peas (*Pisum sativum* L.) and alfalfa (*Medicago sativa* L.) under S deficiency conditions. *Biol. Fert. Soils* 44: 909-916.

Schulze, J., G. Temple, S. J. Temple, H. Beschow and C. P. Vance. 2006. Nitrogen fixation by white lupin under phosphorus deficiency. *Ann. Bot.* 98: 731-740.

Sharma, S. N. 2002. Nitrogen management in relation to wheat (*Triticum aestivum*) residue management in rice (*Oryza sativa*). *Indian J. Agric. Sci*. 72: 449-452.

Sheoran, R. S., S. Ram, U. N. Joshi and J. V. Singh. 1994. Response of forage cowpea varieties to varying levels of phosphorus under irrigated conditions. *Forage res.* 20: 185-189.

Siag, R. K. 1995. Response of *Kabuli* chickpea to genotypes and phosphorus. *Indian J. Agron.* 40(3): 431- 433.

Srinivasarao Ch., Masood Ali, S. Vekateswarlu, T. R. Rupa, K. K. Singh, Sumant Kundu and J. V. N. S. Prasad. 2010. Direct and residual effects of integrated sulphur fertilization in maize (*Zea mays*) ï chickpea (*Cicer arietinum*) cropping system on Typic Ustochrept. *Indian J. Agron.* 55 (4): 259 -263.

Tripathi, S. B. and C. R. Hazra. 2000. *Balance fertilization correcting sulphur deficiency*. Proceeding of TSI/FAI/IFA Workshop on Sulphur in Balanced Fertilization, India Habitat Centre, Lodhi Road, New Delhi, Feb 7-8.

Tripathi, S. B., R. S. Singh and R. K. Tripathi. 1992. Effect of S fertilization on quality constituents of fodder sorghum cv. MP Chari. *Forage Res.* 18 (1) 9-14.

Tripathi, S. B., R. B. Yadav and P. S. Pathak. 2003. Nutrient mining in *Bundelkhand* Agro-climatic zone of Uttar Pradesh. *Fertilizer News* 48 (11): 33-38 & 41-48.