Karnataka J. Agric. Sci.,25 (1) : (18-24) 2012

Effect of set-furrow method of cultivation in pigeonpea + greengram intercropping system in medium deep black soil under rainfed conditions*

ARJUN SHARMA AND M. B. GULED

Agricultural Research Station, Gulbarga - 585 101, India
Email : arjun2311@yahoo.co.in

(Received: November, 2009 ; Accepted: March, 2012)

Abstract : A field experiment was conducted at Agricultural Research Station, Gulbarga (North Eastern Dry Zone of Karnataka) on medium deep black soil during kharif seasons of 2005 and 2006 to assess the performance of pigeonpea intercropping systems with greengram under different row proportions under set-furrow cultivation. The treatment consists of pigeonpea and greengram in sole stand as well as intercropping systems under set-furrow as well as flat bed method of land configuration. Application of vermicompost in set-furrows significantly increased the soil moisture content at sowing and at all the growth stages of pigeonpea. The intercropping of pigeonpea with greengram under different row proportions as influenced by set-furrow land configurations significantly increased the moisture content when compared to flat bed system. Application of vermicompost in set-furrows significantly increased the water stable aggregates, per cent pore space, maximum water holding capacity and infiltration rate as compared to flat bed system. The pigeonpea + greengram (1:2) intercropping system under set-furrow with vermicompost @ 2.5 t ha^{-1} recorded significantly higher seed yield (16.85 q ha^{-1}) and stalk yield (36.57 q ha^{-1}) as compared to flat bed method (13.58 and 29.60 q ha^{-1}, respectively).Pigeonpea + greengram (1:2) intercropping system under set-furrow with application of vermicompost @ 2.5 t ha^{-1} recorded significantly higher WUE (2.99 kg ha^{-1} mm), pigeonpea equivalent yield (24.60 q ha^{-1}), LER (1.96) and ATER (1.55) over other intercropping systems. The pigeonpea + greengram (1:2) intercropping system under set-furrow recorded significantly higher net returns (₹ 36,916 ha^{-1}) and benefit cost ratio (3.11) over sole crop of pigeonpea (₹ 19,474 ha^{-1} and 2.06, respectively).

Key words: Intercropping, Land equivanlent ratio, Pigeonpea, Set-furrow

Introduction

India has the distinction of being the largest producer of pulses in the world, accounting for 37 per cent of the area and 27 per cent of the world's production. Further, 90 per cent of the total global pigeonpea, 65 per cent of chickpea and 37 per cent of lentil area is in India with production of 93, 68 and 32 per cent of the global production, respectively (Lal *et al.,* 1996).

Though pulses are protein rich crops but they are still being cultivated in more than 78 per cent of the energy starved rainfed condition. Hence, the level of productivity of these crops in India is far below the average productivity of the world. As a result, the per capita availability of pulses in India has declined from 64 g per day (1951-56) to 36 g per day (2002-03), as against FAO/WHO's recommendation of 80 g per day (Asthana and Chaturvedi, 1999). This has lead to the crisis of shortage of Pulses in India, which has aggravated the problem of malnutrition. Thus there is an urgent need to increase the production of pulses to meet the requirement, by manipulating the production technologies appropriately.

Pigeonpea is one of the major grain legume crops of the tropical and subtropical regions. It is grown predominantly under rainfed conditions. Pigeonpea occupies 1.76 per cent of the gross cropped area and 22 per cent of the total pulse production in India. In India, pigeonpea ranks second in both area and production, next only to Chickpea.

The in situ moisture conservation practices such as broad bed and furrow, compartment bunding, tied ridging, contour cultivation, set furrow cultivation, hill method of planting, paired row planting, wider row planting *etc*, mainly aim at conservation of rain water and ensure uniform distribution of moisture in the inter-terraced area. The basic role of in situ moisture conservation is to stretch the infiltration opportunity time for increased rainfall use efficiency and drain out excess rainfall safely out of the crop fields.

In the present investigation, the feasibility of intercropping of pigeonpea with greengram in different row proportions in medium deep black soil under set-furrow method of land configuration was studied.

Material and methods

The field experiment was conducted at Agricultural Research Station, Gulbaraga, University of Agricultural Sciences, Dharwad, during *kharif* seasons of 2005 and 2006 to study the performance of pigeonpea intercropping systems in different row proportions under flat and set-furrow method of land configurations.

There were nine treatment combinations comprising pigeonpea intercropped with greengram and three row proportions (1:1, 1:2 and 2:4) with one each sole crops of pigeonpea and greengram. The experiment was laidout in a Randomized Complete Block Design with three replications. The soil was clay loam with pH 8.0. The available N, P_2O_5 and K_2O contents were 180, 25 and 350 kg ha^{-1}, respectively. The organic carbon content was 0.50 per cent. Available zinc content of soil was low (0.40 ppm). FYM and vermicompost was applied 15 days before sowing of the crop. As per treatments the sowing was undertaken soon after the receipt of normal rainfall. The rainfall during the crop growth period was 579.10mm. The set furrows were made in the month of May. The orientation of set-furrow with respect to soil slope was "V" shape. The

* Part of Ph.D. thesis submitted by the first author to the University of Agricultural Sciences, Dharwad - 580 005, India

recommended spacing was followed for all intercrops. The gross and net plot sizes were 11.70x6.0m and 8.10x5.20m, respectively.

The recommended dose of fertilizers was given for (pigeonpea 25:50:00 and greengram 25:50 N: P: kg ha^{-1}) in the form of urea, and diammonium phosphate were applied as basal dose. In case of intercropping treatments, fertilizers were applied in proportionate to the sole optimum population for main crop and intercrop, separately. Weeding and plant protection measures were undertaken as per their need and the required plant population was maintained.The LER and ATER was worked by using the formulas given by willey, 1979 and Hiebsch, 1980, respectively. The crops were harvested at their physiological maturity. Fischer's method of analysis of variance was used for analysis and interpretation of the data as outlined by Panse and Sukhatme (1967).

Results and discussion

In the pigeonpea + greengram intercropping system under different row proportions as influenced by set-furrow cultivation significantly increased the moisture content when compared to flat bed system during both the years as well as in pooled analysis. The application of vermicompost in set-furrows significantly increased the soil moisture content during both the years as well as in pooled analysis.

In the pigeonpea + greengram (1:2) intercropping system under set-furrow cultivation with application of vermicompost recorded significantly higher soil moisture content at 30 DAS (29.62 cm/m) over flat bed method (25.51 cm/m). Similar trend of soil moisture content was observed at all the growth stages of crop growth in the top one meter soil profile. Higher soil moisture with ridges and furrows is attributed to lesser soil loss and higher infiltration rate due to reduced bulk density and increased porosity (Table 1). Kiran (2004) reported that the soil moisture content was significantly influenced by in-situ moisture conservation practices during crop growth period. At different growth stages higher amount of soil moisture was conserved in in-situ moisture conservation practices compared to flat bed which helped for better performance of crop in Vertisol at Dharwad. The above results were in accordance with the findings of Bairathi *et al.* (1974), Dhruva Narayana (1986), and Mastiholi (1994).

The differences in physical properties *viz*., Water Stable aggregates (%) (>0.25 mm), Porosity (%), Maximum water holding capacity and Infiltration rate (cm hr^{-1}) as influenced by set-furrow cultivation differed significantly as compared to flat bed. However, the differences in Bulk density (Mg m^{-3}) and Particle density (Mg m^{-3}) did not differ significantly (Table 2).

Addition of vermicompost in set-furrows improved the soil physical condition and made it conducive for better plant growth. Application of vermicompost improved the pigeonpea yields which might be due to higher soil moisture retention in different soil depths from sowing to till harvest.

The present study revealed that, the soil reaction did not differ significantly among the treatments, but numerically lower pH values were noticed with application of vermicompost in the set-furrows as compared to flat bed methods. Electrical conductivity was also found to be non significant with any of the treatments. However, higher electrical conductivity value of 0.47 dS/m was noticed with application of vermicompost in set-furrows compared to flat bed (0.43 dS/m). It may be due to addition of vermicompost in set-furrows which was having high EC value of 0.47 dS/m. Organic carbon content was also found to be non significant with any of the treatments. However, higher organic carbon content of 0.48 per cent was noticed in the pigeonpea + greengram (1:2) intercropping system with vermicompost applied in set-furrows as compared to flat bed system (0.43%) (Table 3). These results corroborate with the findings of Badanur *et al.* (1990) and Mastiholi (1994) who reported that application of crop residues and vermicompost to the soil increases the organic carbon in different crops.

In the present study, considerable improvement in the population of soil micro organisms was noticed. Application of vermicompost and respective crop residues in set-furrows with different planting patterns showed significantly higher population of bacteria, fungi, actinomycetes, Azotobacter, PSB and Fluorescent pseudomonas. In the pigeonpea + greengram

Table 1. Soil moisture content (cm) upto 90 cm soil depth as influenced by set-furrow method of cultivation in pigeonpea + greengram intercropping systems in medium deep black soil (pooled)

Tr. No.	Treatment	Soil moisture content (cm)						
		At sowing	30 DAS	60 DAS	90 DAS	120 DAS	150 DAS	At harvest
T_1	Sole Pigeonpea	27.44	26.07	28.01	27.42	26.51	21.49	20.13
T_2	Sole Greengram	27.01	25.95	27.86	27.53	26.32	21.33	20.22
T_3	PP+GG (1:1)-Flat bed	25.82	24.78	26.62	26.15	25.53	20.08	18.77
T_4	PP+ GG (1:2)- Flat bed	26.62	25.51	27.42	26.81	26.85	20.74	20.00
T_5	PP+ GG (2:4)-Flat bed	26.54	25.32	27.31	26.82	26.69	20.64	19.64
T_6	PP+ GG (1:1)-Set furrow	27.31	26.11	28.00	27.51	27.38	21.30	20.32
T_7	PP+ GG (1:2)-Set furrow	29.42	28.13	30.14	29.68	29.55	23.43	22.51
T_8	PP+ GG (2:4)-Set furrow	27.03	25.93	27.84	27.35	26.74	21.16	20.14
T_9	PP+GG (1:2)-Set furrow + Vermicompost @ 2.5 t ha^{-1}	30.62	29.62	31.44	30.95	30.65	24.67	23.62
	S. Em±	0.24	0.27	0.28	0.24	0.26	0.27	0.23
	C. D. at 5%	0.72	0.81	0.84	0.74	0.79	0.81	0.70

PP-Pigeonpea GG- Greengram

Table 2. Soil Physical properties as influenced by set-furrow method of cultivation in pigeonpea + greengram intercropping system in medium deep black soil.

Tr. No.	Treatment	Bulk density (Mg m^{-3})	Particle density (Mg m^{-3})	Water stable aggregates (%) (> 0.25 mm size)	Porosity (%)	Maximum water holding capacity (%)	Infiltration rate (cm hr^{-1})
T_1	Sole pigeonpea	1.24	2.64	46.52	54.00	49.38	0.70
T_2	Sole Greengram	1.23	2.64	46.30	54.00	49.30	0.68
T_3	PP+GG (1:1)-Flat bed	1.24	2.65	45.03	54.00	48.55	0.80
T_4	PP+GG (1:2)-Flat bed	1.23	2.63	45.78	54.00	48.64	0.85
T_5	PP+GG (2:4)-Flat bed (paired row)	1.23	2.65	45.68	54.00	48.54	0.78
T_6	PP+GG (1:1)-Set-furrow	1.19	2.63	46.33	56.00	49.19	1.02
T_7	PP+GG (1:2)-Set-furrow	1.18	2.64	47.39	56.00	50.25	1.10
T_8	PP+GG (2:4)-Set-furrow	1.19	2.63	46.18	56.00	49.04	1.10
T_9	PP+GG (1:2)-Set-furrow + Vermicompost @ 2.5 t ha^{-1}	1.16	2.63	48.60	57.00	51.46	1.18
	S. Em±	0.05	0.08	0.48	0.45	0.39	0.04
	C. D.at 5%	NS	NS	1.44	1.35	1.19	0.12

PP-Pigeonpea GG- Greengram NS- Non Significant

Table 3. Chemical properties of soil after harvest and biological properties of fresh soil at 45 DAS of pigeonpea as influenced by set-furrow method of cultivation in pigeonpea + greeengram intercropping systems in medium deep black soil (pooled)

Tr. No.	Treatment	pH	EC (dS/m)	Organic carbon (%)	Bacteria (CFU/ g soil) (x10^6)	Fungi (CFU/ g soil) (x10^3)	Actinomycetes (CFU/ g soil) (x10^4)	Azotobacter (CFU/ g soil) (x10^4)	PSB (CFU/ g soil) (x10^4)	FP$_S$ (CFU/ g soil) (x10^4)
T_1	Sole pigeonpea	8.19	0.44	0.45	13.04	14.18	10.14	6.18	11.91	6.35
T_2	Sole Greengram	8.18	0.41	0.44	15.55	15.88	12.16	10.07	9.71	7.04
T_3	PP+GG (1:1)-Flat bed	8.18	0.40	0.43	16.51	18.29	13.75	7.60	15.26	8.75
T_4	PP+GG (1:2)-Flat bed	8.17	0.43	0.43	20.78	20.63	14.67	14.43	16.01	9.07
T_5	PP+GG (2:4)-Flat bedx (paired row)	8.18	0.42	0.43	18.80	23.20	16.82	16.41	17.62	13.16
T_6	PP+GG (1:1)-Set-furrow	8.16	0.41	0.46	27.47	24.92	18.27	19.58	19.67	15.30
T_7	PP+GG (1:2)-Set-furrow	8.14	0.45	0.47	34.71	33.80	20.96	25.60	23.69	21.36
T_8	PP+GG (2:4)-Set-furrow	8.12	0.44	0.45	36.77	35.03	22.76	27.74	24.47	20.87
T_9	PP+GG (1:2)-Set-furrow + Vermicompost @ 2.5 t ha^{-1}	8.10	0.47	0.48	38.56	38.16	24.49	30.62	25.40	23.40
	S. Em±	0.09	0.01	0.01	0.70	0.43	0.37	0.51	0.59	0.60
	C. D.at 5%	NS	NS	NS	1.10	1.29	1.11	1.53	1.78	1.82

PP-Pigeonpea GG- Greengram VC- Vermicompost NS- Non Significant.

(1:2) intercropping system under set-furrow with vermicompost application recorded significantly higher microbial population and the increase in population was 85.56, 84.97, 66.93, 112.19, 58.65 and 157.99 per cent, respectively over flat bed method (Table 3). Improvement in the soil organic carbon content by addition of vermicompost and crop residues in set-furrows might have played vital role in enhancing microbial activity. Anger *et al.* (1995) were of the opinion that, dynamics of soil organic matter and microbial biomass were most important and had greater influence on soil fertility enrichment. Incorporation of residues might stimulated the population of nitrogen fixing bacteria *viz.*, Azotobacter and Rhizobium spp. (Mukherjee and Gaur,1980), bacteria, actinomycetes, fungi and ammonifying bacterial population in the soil (Mukherjee *et al.*, 1990).

In the present study, significantly higher pigeonpea seed and stalk yield were obtained in the pigeonpea + greengram (1:2) intercropping system under set-furrow with vermicompost application (16.85 and 36.57 q ha^{-1}, respectively) and it was on par with pigeonpea + greengram (1:2) system under set-furrow (16.45 and 35.73 q ha^{-1}, respectively), and these two treatments were significantly superior to pigeonpea + greengram (1:2) system with flat bed method (13.58 and 29.60 q ha^{-1}, respectively) and sole pigeonpea (14.46 and 31.90 q ha^{-1}, respectively) (Table 5). The seed yield of pigeonpea (16.85 q ha^{-1}) with greengram (1:2) intercropping system under set-furrow cultivation with vermicompost applied @ 2.5 t ha^{-1} was significantly higher by 24 per cent when compared to flat bed system (13.58 q ha^{-1}). Further, significantly higher husk yield and leaf fall yield were obtained in the pigeonpea + greengram (1:2) intercropping system under set-furrow with vermicompost application (8.60 and 13.71 q ha^{-1}, respectively) (Table 5). Grain, stalk, husk and leaf fall yields of pigeonpea were significantly higher in set-furrow treatments compared to flat bed method. Addition of organic sources improve the soil physical properties thereby increase the

Table 4. Growth parameters of pigeonpea at harvest as influenced by set-furrow method of cultivation in pigeonpea + greeengram intercropping systems in medium deep black soil (pooled)

Tr. No.	Treatment	Plant height (cm)	Number of primary branches per plant	Number of secondary branches per plant	Leaf area (dm^2 plant^{-1})	Leaf area index (LAI)	Dry matter accumulation in stem (g plant^{-1})	Dry matter accumulation in leaves (g plant^{-1})	Dry matter accumulation in pods (g plant^{-1})	Total dry matter production (g plant^{-1})
T_1	Sole pigeonpea	204.20	12.10	10.27	9.07	0.50	117.07	8.45	48.72	175.06
T_2	Sole Greengram	-	-	-	-	-	-	-	-	-
T_3	PP+GG (1:1)-Flat bed	196.63	11.18	9.50	7.96	0.44	115.94	7.61	47.23	171.63
T_4	PP+GG (1:2)-Flat bed	200.69	12.32	10.36	9.58	0.53	117.30	8.19	49.59	175.91
T_5	PP+GG (2:4)-Flat bed (paired row)	196.58	10.52	9.11	7.88	0.65	113.05	7.22	45.10	166.16
T_6	PP+GG (1:1)-Set-furrow	207.11	12.39	11.22	10.95	0.60	120.35	8.79	51.37	181.46
T_7	PP+GG (1:2)-Set-furrow	211.77	13.05	11.90	12.59	0.69	126.65	9.28	54.17	191.07
T_8	PP+GG (2:4)-Set-furrow	207.05	11.31	10.65	10.68	0.88	116.66	8.40	48.77	174.77
T_9	PP+GG (1:2)-Set-furrow + Vermicompost @ 2.5 t ha^{-1}	212.73	13.78	12.38	12.79	0.71	127.48	9.56	55.45	193.47
	S. E m.±	2.79	0.52	0.66	0.88	0.04	2.63	0.36	1.62	3.61
	C. D.at 5%	8.46	1.58	2.02	2.68	0.12	7.97	1.12	4.94	10.94

PP-Pigeonpea GG- Greengram VC- Vermicompost

porosity and infiltration rate consequently reduce the runoff and soil loss and conserve the moisture for longer period.

In the present investigation application of vermicompost in the set-furrows recorded higher moisture in the soil profile from sowing to till harvest which might have resulted in higher yields. Application of vermicompost showed higher soil moisture in different soil depths and also in the top 90 cm soil profile from sowing till harvest. Bellakki and Badanur (1994) quoted higher soil moisture content in the profile with subabul and sorghum stubble application compared to fertilizer application in the vertisols of Bijapur. Improvement in soil moisture in set-furrows with vermicompost may be attributed to improved soil physical properties and increased infiltration rate over flat bed method. In the pigeonpea + greengram (1:2) intercropping system with set-furrow along with vermicompost application recorded significantly higher infiltration rate of 1.18 cm hr^{-1} and it was higher by 38.82 per cent over flat bed method (0.85 cm hr^{-1}). Increased infiltration rate with vermicompost application may be attributed to increased porosity and reduced bulk density. Improvement in water stable aggregates and decreased bulk density might have resulted in increased infiltration rate and maximum water holding capacity in set-furrows along with vermicompost application (Venkateshwarlu, 1984).

The variations in yield can also be traced back through the variations in growth and yield attributes. The higher grain yield of pigeonpea in set-furrow with vermicompost application was mainly due to better yield components and growth parameters. Higher grain yield of pigeonpea with vermicompost application in set-furrows might be due to significantly higher plant height (212.73 cm), higher number of primary branches per plant (13.78), more number of secondary branches per plant (12.38) and satisfactory improvement in leaf area (12.79 dm^2 plant^{-1}) and leaf area index (0.71) at harvest (Table 4). The higher total dry matter production (TDMP) in set-furrow cultivation with vermicompost application may be attributed to better plant growth and more number of primary and secondary branches which might resulted in higher dry matter accumulation in stem (127.48 g plant^{-1}), leaves (9.56 g plant^{-1}), pods (55.45 g plant^{-1}) and total dry matter production (193.47 g plant^{-1}) at harvest (Table 4). Significantly higher dry matter production reflected in higher number of pods plant^{-1} (182.26) and 100 seed weight (10.03 g). All these parameters might have influenced the pigeonpea crop to give significantly higher yield under set-furrows with vermicompst application. The increase in values of growth and yield components in set-furrow cultivation may be attributed to higher moisture content in soil profile throughout the crop growth period. These results are in conformity with the findings of pervious workers (Patil *et al.,* 1991; Narendra Kumar and Gautam, 2004).

The observations on total uptake of nitrogen indicated that pigeonpea + greengram (1:2) intercropping system under set-furrow cultivation with vermicompost applied @ 2.5 t ha^{-1} recorded significantly higher total uptake of nitrogen (190.57 kg ha^{-1}), phosphorus (15.58 kg ha^{-1}) and potash (79.27 kg ha^{-1}) as compared to flat bed method of cultivation. Significantly higher grain yield, yield components and total dry matter accumulation per plant at harvest mainly contributed for higher total uptake of N, P and

Table 5. Yield & yield parameters and protein content of pigeonpea as influenced by set-furrow method of cultivation in pigeonpea + greeengram intercropping systems in medium deep black soil (pooled)

Tr. No.	Treatment	Number of Pods plant^{-1}	100 Seed weight (g)	Seed yield (q ha^{-1})	Stalk Yield (q ha^{-1})	Husk yield (q ha^{-1})	Leaf fall yield (q ha^{-1})	Harvest index (%)	Protein content (%)
T_1	Sole pigeonpea	150.73	9.14	14.46	31.90	7.51	11.39	0.21	21.24
T_2	Sole Greengram	-	-	-	-	-	--	-	
T_3	PP+GG (1:1)-Flat bed	147.95	9.08	12.98	28.91	6.85	9.85	0.21	20.94
T_4	PP+GG (1:2)-Flat bed	152.23	9.13	13.58	29.60	7.03	10.47	0.22	21.09
T_5	PP+GG (2:4)-Flat bed (paired row)	141.54	8.96	11.69	25.46	6.12	8.57	0.22	20.89
T_6	PP+GG (1:1)-Set-furrow	158.78	9.42	15.56	33.36	7.85	12.59	0.22	21.14
T_7	PP+GG (1:2)-Set-furrow	177.69	10.00	16.45	35.73	8.49	13.39	0.21	21.24
T_8	PP+GG (2:4)-Set-furrow	158.01	9.36	13.10	28.36	6.63	9.77	0.22	20.94
T_9	PP+GG (1:2)-Set-furrow + Vermicompost @ 2.5 t ha^{-1}	182.26	10.03	16.85	36.57	8.60	13.71	0.22	21.42
	S. Em±	2.60	0.18	0.69	1.17	0.23	0.28	0.07	2.17
	C. D. at 5%	7.89	0.55	2.11	3.56	0.70	0.87	NS	NS

PP-Pigeonpea GG- Greengram VC- Vermicompost NS- Non Significant

K by pigeonpea in pigeonpea + greengram (1:2) intercropping system under set-furrow with vermicompost application (Table 6). Set-furrow cultivation recorded significantly higher uptake of nutrients as compared to flat bed method. This might be due to set-furrow cultivation that would have created a favourable physical environment for the increased mineralization and mobility of nutrients which was noticed in improvement of available N, P and K contents resulting in higher nutrient uptake. Patil (1998) revealed that deep tillage and ridging with subabul loppings @ 5 t ha^{-1} with 50 kg N ha^{-1} recorded significantly higher nutrient availability and uptake of nutrients.

It is the ratio of yield (Y) to that of water applied. Higher the value more efficient is the system/technology evolved. Higher WUE was observed in set-furrow cultivation as compared to flat bed. In the pigeonpea + greengram (1:2) intercropping system under set-furrow with vermicompost application recorded significantly higher WUE (2.99 kg ha^{-1} mm) compared to flat bed method (2.41 kg ha^{-1} mm). In the pigeonpea + greengram (1:2) intercropping system under set-furrow with vermicompost application recorded 24 per cent higher WUE over flat bed method (Table 6). The grain yield in intercropping system is an outcome of interaction between the crop species grown in association. Yield advantage in intercropping occurs when component crop differ in their use of growth resources. Similar observations were made by the previous workers (Bhagwandin and Bhatia, 1989). The grain yield in intercropping system is an outcome of interaction between the crop species grown in association. Yield advantage in intercropping occurs when component crop differ in their use of growth resources. The pigeonpea + greengram (1:2) intercropping system under set-furrow cultivation with vermicompost application recorded significantly higher pigeonpea equivalent yield (24.60 q ha^{-1}) and it was on par with pigeonpea + greengram (1:2) system under set-furrow cultivation (24.10 q ha^{-1}) and these two treatments were significantly superior over pigeonpea + greengram (1:2) system with flat bed method (20.01 q ha^{-1}). The pigeonpea + greengram (1:2) intercropping system under set-furrow cultivation with vermicompost application recorded 23 per cent higher pigeonpea equivalent yield over flat bed method. These results are similar to those reported by Srinivasan and Ahlawat (1984).

Intercropped pigeonpea under different treatments resulted in 56 to 96 per cent yield advantage (LER of 1.56 to 1.96) over sole crop of pigeonpea. The pigeonpea + greengram (1:2) intercropping system under set-furrow with vermicompost application recorded significantly higher LER of 1.96 and it was on par with pigeonpea + greengram (1:2) system under set-furrow (1.93) and these two treatments were significantly superior over flat bed method. The higher LER under intercropping systems may be due to better planting geometry and spatial arrangements which might have avoided the coincidence of the peak period of growth of component crops. This might have helped for efficient use of natural resources by the component crops under intercropping system. Many workers have reported higher land equivalent ratio when pigeonpea was intercropped with greengram (Rajput *et al.* (1995) and Omprakash and Bhushan (2000). The area time equivalent ratio realized from intercropped pigeonpea was significantly higher (1.19 to 1.55) than that obtained from the sole crop of pigeonpea (1.00). Senapati and Mahapatra (1997) recorded a yield advantage of 32 per cent on ATER basis in pigeonpea + rice intercropping system. The pigeonpea + greengram (1:2) intercropping system under set-furrow with vermicompost application recorded significantly higher ATER (1.55) and it was on par with pigeonpea + greengram (1:2) system under set-furrow (1.53) and these two treatments were significantly superior to pigeonpea + greengram (1:2) system with flat bed method (1.24). The ATER values were higher under set-furrow cultivation compared to flat bed method (Table 6).

The intercropping system of pigeonpea + greengram under different row proportions recorded higher net income (₹ 24,441 to ₹ 36,916 ha^{-1}) compared to the net returns obtained from the sole crop of pigeonpea (₹ 19,474 ha^{-1}) and sole crop of greengram (₹ 9,596 ha^{-1}). The higher net returns may be due to maximum pigeonpea equivalent yield obtained under intercropping systems. The pigeonpea + greengram (1:2) intercropping system under set-

Table 6. Total nutrients uptake and water use efficiency (kg ha-1 mm), and other related parameters of pigeonpea as influenced by set-furrow method of cultivation in pigeonpea + greeengram intercropping systems in medium deep black soil (pooled)

Tr. No.	Treatment	Nitrogen uptake (kg ha^{-1})	Phosphorus uptake (kg ha^{-1})	Potash uptake (kg ha^{-1})	Water use efficiency (kg ha^{-1} mm)	Pigeonpea equivalent yield (q ha^{-1})	LER	ATER
T_1	Sole pigeonpea	157.35	12.85	65.57	2.56	14.46	1.00	1.00
T_2	Sole Greengram	-	-	-	1.83	13.34	1.00	1.00
T_3	PP+GG (1:1)-Flat bed	142.16	11.60	59.33	2.30	18.94	1.66	1.19
T_4	PP+GG (1:2)-Flat bed	146.57	11.98	60.90	2.41	20.01	1.75	1.24
T_5	PP+GG (2:4)-Flat bed (paired row)	129.37	10.31	52.44	2.07	17.55	1.56	1.09
T_6	PP+GG (1:1)-Set-furrow	166.12	13.59	68.89	2.76	22.64	1.90	1.40
T_7	PP+GG (1:2)-Set-furrow	177.13	14.48	73.62	2.92	24.10	1.93	1.53
T_8	PP+GG (2:4)-Set-furrow	140.76	11.51	58.48	2.32	19.95	1.80	1.24
T_9	PP+GG (1:2)-Set-furrow + Vermicompost @ 2.5 t ha^{-1}	181.34	14.83	75.36	2.99	24.60	1.96	1.55
	S. E m.±	5.94	0.47	2.36	0.10	0.72	0.22	0.04
	C. D. at 5%	18.04	1.43	7.17	0.31	2.17	0.67	0.12

PP-Pigeonpea GG- Greengram VC- Vermicompost LER: Land equivanlent ratio
ATER: Area time equivanlent ratio

Table 7. Economics as influenced by set-furrow method of cultivation in pigeonpea + greengram intercropping system in medium deep black soil

Tr. No	Treatment	Gross returns (₹ ha^{-1})			Cost of cultivation (₹ ha^{-1})			Net returns (₹ ha^{-1})			Benefit Cost ratio		
		2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled
T_1	Sole pigeonpea	30300	27560	28930	9281	9631	9456	21019	17929	19474	2.26	1.86	2.06
T_2	Sole Greengram	21410	9718	15564	5730	5935	5833	15680	3783	9731	2.73	0.63	1.66
T_3	PP+GG (1:1)-Flat bed	44223	32459	38341	10423	10753	10588	33800	21706	27753	3.23	2.02	2.62
T_4	PP+GG (1:2)-Flat bed	46801	34205	40503	10445	10795	10620	36356	23410	29883	3.47	2.17	2.82
T_5	PP+GG (2:4)-Flat bed (paired row)	41244	29874	35559	10940	11295	11118	30304	18579	24441	2.77	1.64	2.20
T_6	PP+GG (1:1)-Set-furrow	52808	38822	45815	11673	12030	11852	41135	26792	33963	3.52	2.22	2.87
T_7	PP+GG (1:2)-Set-furrow	56304	41259	48782	11690	12040	11865	44612	29219	36916	3.81	2.42	3.11
T_8	PP+GG (2:4)-Set-furrow	46990	33828	40409	12196	12536	12366	34794	21292	28043	2.85	1.70	2.27
T_9	PP+GG (1:2)-Set-furrow + VC @ 2.5 t ha	58841	42136	50489	14190	14535	14363	44651	27601	36126	3.23	1.89	2.56
	S. E m.±	1398	1325	1340	-	-	-	1398	1325	1340	0.14	0.11	0.12
	C. D.at 5%	4190	3972	4016	-	-	-	4190	3972	4016	0.42	0.34	0.37

PP-Pigeonpea GG- Greengram VC- Vermicompost

furrow cultivation recorded the highest net return (₹ 36, 916 ha^{-1}) which was 23.53 per cent higher over flat bed method (₹ 29, 883 ha^{-1}) (Table 7). Similar findings have also been reported by Goyal *et al.* (1991) and Bajpai and Singh (1992) in intercropping of pigeonpea with greengram.

The same trend in B:C ratio was observed under intercropping system (2.20 to 3.11). The pigeonpea + greengram (1:2) intercropping system under set-furrow recorded significantly higher B: C ratio of 3.11 and it was 50 per cent higher over sole pigeonpea (2.06).

References

Andrews, D. J., 1972, Intercropping with Sorghum in Nigeria. *Exp. Agril.,* 8: 139-150.

Anger, D. A., Voroney, R. P. and Dose, D., 1995, Dynamics of soil organic matter and corn residues affected by tillage practices. *Soil Sci. Soc. American J.*, 59: 1311-1315.

Asthana, A. N. and Chaturvedi, S. K., 1999, A little impetus needed. The Hindu, *Survey Indian Agril.*, pp.61-65.

Badanur, V. P., Poleshi, C. M. and Balachandra Naik, K., 1990, Effect of organic matter on crop yield, physical and chemical properties of a Vertisol. *J. Indian Soc. Soil Sci.*, 38:426-429.

Bairathi, R. C., Gupta, M. M. and Seth, S. P., 1974, Effect of different legume crop residues on soil properties, yield and nutrient uptake by succeeding wheat crop. *J. Indian Soc. Soil Sci.,* 22 (4): 304-307.

Bajpai, R. P. and Singh, V. K., 1992, Performance of pigeonpea (*Cajanus cajan*) –based intercropping in rainfed condition. *Indian J. Agron.*, 37 (4): 655-658.

Bellakki, M. A. and Badanur, V. P., 1994, Effect of crop residue incorporation on physical and chemical properties of a vertisol and yield of sorghum. *J. Indian Soc. Soil Sci.*, 42 (4): 533-535.

Bhagwandin, G. and Bhatia, K. S., 1989, Effect of seed bed configuration and mulches on grain yield of rainfed maize. *Indian J. Soil Conserv.,* 17(2): 55-57.

Dhruva Narayana, V. V., 1986, Soil and water conservation Research in *India. Indian J. Soil Conserv.*, 14 (3): 22-31.

Goyal, S. N., Patel, N. L., Patel, N. M. and Ahlawat, I. P. S., 1991, Intercropping studies in pigeonpea under rainfed conditions. *Indian J. Agron*., 36 (1):49-51.

Hiebsch, C. K., 1980, Principles of intercropping: Effect of nitrogen fertilization, plant population and crop duration of equivalency ratios in intercrop versus monoculture comparisons. *Diss. Abstr.* 41: 4337.

Kiran, J. A., 2004, Effect of In-situ moisture conservation practices and nitrogen levels on growth and yield of rabi sorghum in vertisols under rainfed condition. *M. Sc. (Agri.) Thesis,* Univ. Agril. Sci., Dharwad (India).

Lal, S., Brahm Prakash and Sxe of rabi sorghum to biofertilizers and in situ moisture conservation practices in deep black soil. *M. Sc. (Agri.) Thesis,* Univ. Agril. Sci., Dharwad (India).

Mukherjee, D. and Gaur, A. C., 1980, A study on the influence of straw incorporated on soil organic matter maintenance nutrient release and a symbiotic nitrogen. *Zentarablat Bahtiol Abstracts* II, 135: 663-668.

Mukherjee, D., Ghosh, S. L. and Das, A. C., 1990, A study on the chemical and microbiological changes in soil. *Indian Agril.,* 34: 1-10.

Narendra Kumar and Gautum, R. C., 2004, Effect of moisture conservation and nutrient management practices on growth and yield of Pearimillet (*Pennisetum glaucum*) under rainfed conditions. *Indian J. Agron*., 49 (3): 182-185.

Omprakash and Bhushan, L. S., 2000, Productivity and economics of pigeonpea (*Cajanus cajan*) and castor (Ricinus communis) based intercropping systems. *Indian J. Soil Conserv.*, 28 (2): 147-150.

Panse, V. G. and Sukhatme, P. V., 1967, Statistical Methods for Agricultural Workers, ICAR Publication, New Delhi, pp. 167-174.

Patil, N. D., Umrani, N. K., Shende, S. A., Manke, B. S., Kale, S. P. and Shingte, A. K., 1991, Improved crop production technology for drought prone areas of Maharashtra. Technical Bulletin, Mahatma Phule Agricultural University, Solapur, Maharashtra, India.

Patil, S. L., 1998, Response of rabi sorghum (*Sorghum bicolor* L. Moench) to tillage, moisture conservation practices, organics and nitrogen in vertisols of semi-arid tropics. *Ph.D. Thesis,* Univ. Agric. Sci., Dharwad (India).

Rajput, O. P., Aditykumar and Raakeshkumar Sharma, 1995, Intercropping of Pigeonpea (*Cajanus cajan*) with greengram under varying levels of fertility and plant population and residual effect on succeeding wheat. *Indian J. Agron*., 40(4):563-566.

Senapati, P. C. and Mahapatra, P. K., 1997, Response of pigeonpea and rice intercropping system to tillage practices. *Indian J. Soil Conserv.,* 25 (1): 88-89.

Srinivasan, A. and Ahlwat, I.P.S., 1984, Studies on planting pattern and phosphate fertilization of sole and mixed stands of pigeonpea. *Indian J. Agron.*, 29 (2): 249-253.

Venkateswarlu, J., 1984, Residue management. *Adv. in Soil Sci.*, 7: 192-204.

Willey, R.W., 1979, Intercropping, importance and Research needs competition and yield advantages. *Field Crops S Abstr.,*32 (1):1-10.