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Impact of row ratio and nutrient management on performance of clusterbean (*Cyamopsis tetragonoloba*) + sesame (*Sesamum indicum*) intercropping system

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ABSTRACT

A field experiment was conducted during rainy (*kharif*) season of 2005 to 2007 at Kukma, Bhuj, (Gujarat) in sandy soil to study the effect of row ratio and nutrient management on sustainability of clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.] + sesame (*Sesamum indicum* L.) intercropping system under arid condition. Treatments comprised of 15 combinations of cropping systems, viz. sole clusterbean, sole sesame, clusterbean + sesame in 1:2, 1:1 and 2:1 row proportions and nutrient management, *viz*. the control, 40 kg N/ha and 20 kg N + 5 t FYM/ha. Intercropping declined the seed yield of clusterbean by 30% compared to sole crop (mean of 3 years 0.71 t/ha). However, clusterbean-equivalent yield (0.92 t/ ha), net returns (Rs 6,251/ ha) and benefit : cost (B : C) ratio (1.67) were higher with clusterbean + sesame (2 : 1) intercropping system over the corresponding values of 0.71, 3,572 and 1.41 in sole clusterbean. Irrespective of the cropping system, application of 20 kg N + 5 t FYM/ha recorded significantly higher clusterbean-equivalent yield (1.036 t/ha), net monetary returns (Rs 7,793/ha) and B: C ratio (1.79) than of 40 kg N/ha alone and the absolute control. Addition of 5 t FYM/ha along with 20 kg N/ha gave 8.5 and 9.8% higher uptake of N than of 40 kg N/ha and the control respectively. The sustainable yield index (SYI) and sustainable value index (SVI) were higher with clusterbean + sesame under 2:1 row ratio (0.74, 0.76), and the highest SYI (0.81) and SVI (0.82) indices were observed under the application of 20 kg N/ha with 5 t FYM/ha. Clusterbean + sesame (2:1) with application of 20 kg N + 5 t FYM/ha was more advantageous and saved 50% recommended dose of N fertilizer.

Key words : Clusterbean, Farmyard manure, Fertility, Intercropping, Sesame

Multiple cropping in the form of intercropping is predominant in the arid and semi-arid tropics. Intercropping is a feasible and viable option for stepping up the production of pulses and oilseeds in our country. Clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.] is a major rainfed crop of arid zone, grown mostly as a mixed crop with pearl millet, mothbean and sesame, but its productivity is low (Faroda *et al*., 2007). Plant population and spatial arrangement in intercropping have important effect on the balance of competition between the component crops and their productivity. Intercropping of oilseed and pulse crops is one of the ways to increase their production because intercropping is more advantageous than sole cropping of either of these crops (Padhi and Panigrahi, 2006). The greatest limitation in increasing the productivity of these crops is inadequate supply of nutrients, because the soils of arid region are poor in native fertility (Singh and Khan, 2003). The continuous application of inorganic fertilizers even in balanced form may not sustain soil fertility and productivity. However, judicious use of chemical fertilizers in combination with organic manures is required to improve the soil health as well as to achieve sustainable crop production (Mankotia, 2007). Farmyard manure is the proven source of nutrition to agricultural crops. Thus balanced fertilization along with sound crop husbandry offers a great scope for increasing, the productivity. A lot of information is available on cereal + legume intercropping, but not on legume + oilseed system. The information on comparative performance, nutrient management, competition relations and sustainability of the system in arid region of Gujarat is lacking. Keeping this in view, an experiment was undertaken to find out the possibility of increasing the production of oilseeds and pulses through intercropping system by adopting appropriate spatial arrangement of crops and nutrient management.

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MATERIALS AND METHODS

A field experiment was laid out at the research farm, Regional Research Station, Central Arid Zone Research Institute, at Kukma, Dist. Bhuj, Kachchh (Gujarat) during rainy season of 2005 to 2007. It is located between 23^{o} 12' and 23^{o} 13' N latitude and 69^{o} 47 to 69^{o} 48 E longitude.

The soil was gravelly sand to loamy sand, with shallow depth (21 cm). The soil was low in organic C (0.25%), available N (55.8 mg/kg soil), available P (1.44 mg/kg soil), and medium in available K (88 mg/kg soil) with pH 8.6. The region is characterized by low and erratic rainfall, high temperature, high wind velocity and high potential evapotranspiration. The total rainfall received during the cropping period (June to October) was 238.2, 689.4 and 701.6 mm in 2005, 2006 and 2007, respectively, compared with the average annual rainfall of 326 mm. In the first year (2005) of experimentation the yield of both the crops were adversely affected due to low and erratic rainfall. Cropping season of 2006 and 2007 was quite normal for the growth of both the crops, and giving higher yields owing to adequate and well distribution of rainfall. However, the yield of both the crops was slightly low in 2007 than in 2006 owing to continuous rainfall during the maturity stage.

Treatments consisted of 15 combinations of cropping systems, viz. sole clusterbean, sole sesame, clusterbean + sesame in 1:2, 1:1 and 2:1 row proportions, and nutrient management, viz. control, 40 kg N/ha and 20 kg N + 5 t FYM/ha. These were tested in randomized block design and replicated thrice. The net plot size of 4.0 x 4.5 m and spacing of 45 x 15 cm were adopted for both the crops which were sown in the last week of June in all these years. A common recommended dose of phosphorus and potassium was applied to the crops at the time of sowing. The cultivars used in the study were: 'RGC 936' clusterbean and 'Guj–1' sesame. The remaining agronomic practices were followed as per recommendations for the region. The economics was calculated on the basis of prevailing market prices of different inputs and outputs. The clusterbean-equivalent yield was calculated by converting the seed yield of sesame into clusterbean yield on the basis of existing market price of the crops. The yields were further used for computation of different competition functions like land-equivalent ratio (LER), relative crowding coefficient (RCC), competitive ratio (CR) and aggressivity, as suggested by Willey (1979). Sustainable yield index (SYI) and sustainable value index (SVI) were calculated as per the procedure described by Singh *et al*. (1990). Chemical analysis for estimation of N was done by micro-Kjeldahl method.

RESULTS AND DISCUSSION

Growth and yield of clusterbean

Sole clusterbean recorded significantly lower plant height and yield-attributing characters than recorded in its intercropping with sesame. Plant height and yield-attributes of clusterbean, i.e. pods/plant, seeds/pod, 1,000-seed weight and harvest index, were significantly higher under intercropping system than under sole cropping (Table 1). Among the intercropping treatments, clusterbean + sesame (2:1) recorded higher plant height, yield attributes and seed yield (Table 2) of clusterbean than under other row ratios of 1:1 and 1:2 in all the three years of experiment, and it could recover maximum (78%, on mean basis) of its sole-crop seed yield owing to higher plant density of the main crop and complementary effect of the intercrop. Ahlawat *et al.* (2005) also observed similar trend of results in chickpea-based intercropping systems. Application of 20 kg N/ha along with FYM 5 t/ha recorded significantly higher plant height, number of pods/plant, seeds/pod, 1,000-seeds weight, harvest index and seed yield (0.644 t/ha) of clusterbean which were 33% more than that of the control (Table 2). This might be due to increased availability of nutrients to the crop plant

Table 1. Effect of row ratio and nutrient management on plant height, yield attributes and harvest index of clusterbean and sesame (mean data of 3 years)

Treatment	Plant height (cm)		Pods or capsules/ plant		Seeds/pod or capsule		1,000-seed weight(g)		Harvest index (%)	
	Clusterbean	Sesame	Clusterbean	Sesame	Clusterbean	Sesame	Clusterbean	Sesame	Clusterbean	Sesame
Cropping system										
Sole cropping	54.4	35.3	31.1	10.7	5.5	31.2	27.4	2.0	24.29	17.38
Clusterbean + sesame (1:2)	60.3	45.9	38.5	17.8	6.0	34.4	29.2	2.1	26.13	19.00
Clusterbean + sesame (1:1)	63.5	43.3	42.1	16.0	6.4	35.5	29.1	2.2	26.67	18.27
Clusterbean + sesame (2:1)	67.3	42.2	47.6	15.2	6.6	35.8	30.7	2.2	27.12	18.03
SEm±	1.2	0.5	1.4	0.5	0.2	1.4	0.4	0.1	0.13	0.21
CD (P= 0.05)	3.5	1.9	4.7	1.3	0.7	4.1	1.2	NS	0.38	0.67
Nutrient management										
Control	52.4	38.3	32.6	12.8	6.2	33.3	28.5	2.0	24.65	17.96
40 kg N/ha	69.3	49.0	55.4	22.8	6.7	39.6	31.3	2.2	28.31	19.48
20 kg N + 5 t FYM/ha	75.5	52.3	64.0	26.3	7.3	45.4	33.4	2.3	28.47	20.14
SEm±	1.5	1.0	2.1	0.8	0.3	1.6	0.6	0.9	0.06	0.18
CD (P= 0.05)	4.6	2.8	6.4	2.7	0.9	4.7	1.9	NS	0.19	0.54

through combined use of organic and inorganic sources (Nambiar, 1994).

Growth and yield of sesame

Plant height and yield-attributing parameters of sesame were better under intercropping system than under sole stand, but the sesame crop gave higher seed yield of 0.22 t/ha (mean basis) in sole stand. The lower seed yield in intercropping systems might be due to lesser number of plants/unit area. Among the intercropping systems, plant height, capsules/plant, seeds/capsule, 1000-seed weight and harvest index (Table 1) as well as the seed yield (Table 2) of sesame were significantly higher in 1:2 row ratio than in other ratios. This could be attributed to the variations in the magnitude of competition among the component crops grown in various proportions. This result confirms the findings of Sarkar *et al*. (2003).The integrated nutrient-supply system of FYM at 5 t along with 20 kg N/ha favourably improved the plant height, yield attributes, harvest index and seed yield of sesame, and gave the highest seed yield, which was 16 and 24% higher than that of 40 kg N/ha and the control respectively. This may be ascribed to the better macro- and micronutrient availability as well as physical condition of the soil. This finding supports the results of Singh (2002) and Imayavaramban *et al*. (2002).

System productivity

All the intercropping systems, irrespective of the row ratio had more system productivity in terms of clusterbean-equivalent yield and production efficiency compared with sole clusterbean (Table 3). Higher clusterbean-equivalent yield under various intercropping patterns was due to additional yield of sesame and better utilization of natural resources, i.e. light, space, nutrients etc., than that under sole stand. Among the different intercropping patterns, 2:1 row ratio gave maximum clusterbean-equivalent yield of 0.92 t/ha, which was 29% more than that of sole cropping. This differential behaviour in clusterbean-equivalent yield was on account of productivity of crops in intercropping systems and their relative market prices (Kumar, 2002). Similarly, production efficiency (10.8 kg/ha/day) was also maximum under 2:1 followed by 1:1 (10.3 kg/ha/day) and 1:2 (10.2 kg/ha/day) row ratios. This revealed a greater degree of efficiency and compatibility of sesame in clusterbean. The fertilizer application (20 kg N + 5 t FYM/ha) to the component crops improved the equivalent yields of system due to proper nourishment and less competition for nutrients.

Competition functions

All the intercropping systems had land-equivalent ratio greater than unity (Table 4). The maximum LER was recorded under 2:1 row ratio, followed by 1:1 and 1:2 ratios. Clusterbean was more competitive under the row ratio 1:2, whereas sesame was in 2:1. The aggressivity of clusterbean was positive in all the intercropping systems, but was negative in sesame. Aggressivity values of intercropping were greater than zero, indicating yield advantage over sole cropping. All the intercropping treatments had higher relative crowding coefficient values, and the product of relative crowding coefficients exceeded unity, indicating their yield advantage compared with their monocultures due to the complementary relationship. The higher RCC value of 5.31 in 2:1 row ratio indicated that the system in this row proportion gave more yield than expected. Application of 20 kg N + 5 t FYM/ha also recorded the highest LER (1.56) and relative crowding coefficient among the nutrient-management practices (Table 4). The lower competition was observed under the plots

Table 2. Effect of row ratio and nutrient management on seed yield of clusterbean and sesame along with economics (mean data of 3 years)

Treatment	Clusterbean seed yield (t/ha)	Sesame-seed yield (t/ha)	Cost of cultivation (Rs/ha)	Net monetary return (Rs/ha)	Benefit : cost ratio
Cropping system					
Clusterbean sole	0.710		8,536	3,527	1.41
Sesame sole		0.216	7,790	2,549	1.33
Clusterbean + sesame (1:2)	0.433	0.156	9,235	5,512	1.60
Clusterbean + sesame (1:1)	0.493	0.126	9,245	5,697	1.62
Clusterbean + sesame (2:1)	0.589	0.102	9,365	6,251	1.67
SEm±	0.024	0.007		143	0.01
CD (P= 0.05)	0.074	0.018		431	0.04
Nutrient management					
Control	0.446	0.124	8,605	4,972	1.58
40 kg N/ha	0.579	0.153	9,782	6,816	1.70
20 kg N + 5 t FYM/ha	0.644	0.173	9,810	7,793	1.79
SEm±	0.020	0.004		315	0.02
CD (P= 0.05)	0.059	0.014		948	0.07

fertilized with 20 kg N + 5 t FYM/ha. Mishra *et al.* (2001) also reported similar results with respect to competitive ratio, aggressivity and relative crowding co-efficient values in linseed + gram intercropping system.

Total N uptake

Sole clusterbean crop removed maximum quantity of N (55.0 kg/ha), which was on a par with that of intercropping in 2:1 ratio (Table 3). Among the intercropping systems, 2:1 ratio removed significantly highest quantity of N than other ratios. Addition of 5 t FYM/ha along with 20 kg N/ha resulted in 8.5 and 9.8% higher uptake of N than that of 40 kg N/ha and the control respectively. This might be due to additional amount of nutrients supplied by FYM as well as the beneficial effects of organic matter addition, which were derived in connection with the physical and chemical properties of the soil (Kumar, 2002).

Economics

All the intercropping systems were more remunerative than sole clusterbean, giving higher net monetary returns and benefit : cost ratio. Among the intercropping cropping systems, planting of clusterbean + sesame (2:1) row proportion gave more net returns of (Rs 2724/ha) over sole cropping of clusterbean (Table 2) with B : C ratio 1.67. The highest net return (Rs 7793/ha) and B: C ratio (1.79) over 40 kg N/ha alone (Rs 6816/ha, 1.70) and absolute control (Rs. 4972/ha, 1.58) respectively were accrued with the application of 20 kg N + 5 t FYM/ha. This result is in close conformity with the findings of Kumar (2002) and Singh (2002) under different intercropping systems with nutrient management. This system was on economically viable intercropping pattern giving higher net returns.

Sustainability

The sustainable yield index (SYI) and sustainable value index (SVI) were higher with clusterbean + sesame under 2:1 (0.74, 0.76) row ratio (Table 3). This was followed by 1:2 (0.73) and 1:1 (0.72) row ratios, indicating that the former was more stable than the others. Bastia *et al.* (2008) also reported higher sustainability of rice-based cropping systems with different oilseeds and pulses. The

Table 3. Effect of row ratio and nutrient management on system productivity, total N uptake and sustainability (mean data of 3 years)

Treatment	Clusterbean equivalent yield (t/ha)	Production efficiency (kg/ha/day)	Total N uptake (kg/ha)			Sustainability	
			Clusterbean	Sesame	Combined	SYI	SVI
Cropping system							
Clusterbean sole	0.710	8.4	55.0		55.0	0.71	0.72
Sesame sole	0.608	7.2		22.2	22.2	0.51	0.52
Clusterbean + sesame (1:2)	0.867	10.2	32.6	14.8	47.0	0.73	0.73
Clusterbean + sesame (1:1)	0.879	10.3	36.0	13.6	49.5	0.72	0.72
Clusterbean + sesame (2:1)	0.919	10.8	39.7	13.0	52.7	0.74	0.76
SEm±	0.012	0.1	1.1	0.4	0.9		
CD (P= 0.05)	0.033	0.4	3.7	1.1	3.0		
Nutrient management							
Control	0.799	9.4	34.0	12.7	46.7	0.75	0.75
40 kg N/ha	0.976	11.5	39.4	13.9	53.3	0.80	0.81
20 kg N + 5 t FYM/ha	1.036	12.2	41.0	14.8	55.7	0.81	0.82
SEm±	0.019	0.2	0.4	0.3	0.7		
CD (P= 0.05)	0.057	0.6	1.4	0.8	2.1		

Table 4. Effect of row ratio and nutrient management on competition functions of clusterbean + sesame system (mean data of 3 years)

Treatment	Land-equivalent ratio	Competitive ratio		Aggressivity		Relative crowding coefficient		
		Clusterbean	Sesame	Clusterbean	Sesame	Clusterbean	Sesame	Product
Cropping system								
Clusterbean + sesame (1:2)	1.32	1.77	0.56	0.27	(-) 0.27	3.22	1.20	3.86
Clusterbean + sesame (1:1)	1.33	1.11	0.90	0.18	(-) 0.18	2.30	1.72	3.96
Clusterbean + sesame (2:1)	1.38	0.65	1.54	0.21	(-) 0.21	1.77	3.00	5.31
Nutrient management								
Control	1.21	1.05	0.95	0.04	(-) 0.04	1.67	1.41	2.35
40 kg N/ha	1.48	1.18	0.85	0.12	(-) 0.12	3.89	2.10	8.17
20 kg N + 5 t FYM/ha	1.56	1.14	0.88	0.09	(-) 0.09	4.86	2.77	13.4

highest SYI (0.81) and SVI (0.82) indices were observed under the application of 20 kg N/ha with 5 t FYM/ha followed by 40 kg N/ha alone (0.80, 0.81) and the absolute control (0.75) respectively.

It was concluded that clusterbean + sesame intercropping system in 2:1 row proportion, receiving with integrated application of 20 kg N + 5 t FYM/ha was most productive, sustainable and remunerative with better resource-use efficiency than in 1:1 or 1:2 ratios in arid tract of Gujarat.

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