Indian J. Agron. **40** (2) : 181–185 (June 1995)

Effect of spatial arrangement on performance of palmarosa (*Cymbopogon martini* var. motia)—pigeonpea (*Cajanus cajan*) intercropping on a black cotton soil (Vertisol)

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Received: June 1993

ABSTRACT

Higher dry matter of palmarosa [*Cymbopogon martini* (Roxb.) Wats. var. motia Burk.] and pigeonpea [*Cajanus cajan* (L.) Millsp.] and higher yield of the essential oil of palmarosa were obtained during 1989, 1990 and in pooled data. Higher total tonnage was recorded from intercropping of pigeonpea in the intermittent (alternate) rows parallel to palmarosa. This spatial intercropping system always resulted in higher oil-yield equivalent of palmarosa over other systems. This system resulted in higher income-equivalent ratio (IER 1.17), besides higher land-equivalent ratio (LER 1.4) and provided 40% higher biological yields than the monoculture of component crops as well as 20% extra yield compared with the other intercropping systems. Sowing of pigeonpea in alternate rows parallel to palmarosa proved most efficient and economic, as it provided higher economic returns, bonus income and monetary advantage. The oil content and quality in terms of total geraniols of palmarosa were not adversely affected by adoption of intercropping.

Recently palmarosa oil grass [*Cymbopogon martini* (Roxb.) Wats. var. motia Burk.] is successfully cultivated under rainfed as well as irrigated conditions, in black cotton soils in Malwa Plateau of Madhya Pradesh. Palmarosa shows slow growth at initial stage, thereby provides ample space to raise an intercrop. To maximize yield and economic gains/unit area, a medium-duration variety of pigeonpea [*Cajanus cajan* (L.) Millsp.] was introduced with different spatial arrangements in palmarosa plantation.

MATERIALS AND METHODS

An experiment was conducted in randomized block design with 6 replications during the rainy seasons (*kharif*) of 1989 and 1990 under rainfed condition. The experimental soil was shallow black (depth 40–60 cm) belonging to a bench mark of Kamliakheri series Vertic Ustochrepts (Murthy *et al.*, 1982), representing a major area under rainfed crops in the Malwa Plateau of Madhya Pradesh. The soil was non-calcareous ($CaCO_3$ 2%), clayey (clay 52%), non-saline (ECe 0.8 dS/m), non-alkali (pH 8.0) in nature, with available N, P and K content of 247, 26 and 550 kg/ha respectively.

Basal dose of 20 kg N/ha + 40 kg P_2O_5/ha was placed 10 cm deep in rows of 45 cm

width, keeping intra-row spacing of 30 cm in both the crops. Transplanting of palmarosa seedlings and sowing of 'AS 71-37' pigeonpea (duration 150–160 days) was done in the first week of July 1989 and 1990, with a net plot area of 4.32 m^2 under individual treatment. At 45 days after planting, 20 kg N/ha was top-dressed in palmarosa grass. There were 5 treatments, viz. palmarosa alone, pigeonpea alone, pigeonpea sown centrally in palmarosa parallelogram (it was hypothetically resulted by grouping of 4 adjoining palmarosa plants lying in 2 adjacent rows), pigeonpea sown within palmarosa rows and pigeonpea sown in intermittent rows parallel to palmarosa. Palmarosa grass was harvested in October–November at an early seeding stage, 15 cm above the ground; while pigeonpea was harvested during December–January. The biomass is expressed in constant weight on dry-weight basis. Oil content on volume/weight basis was estimated by hydro-distilling the chaffed whole plant material of palmarosa in Clevenger type-all-glass essential oil-determination apparatus. The geraniol content was estimated by gas-liquid chromatograph using flame-ionization detector and 15% carbowax 20 M column on chromosorb W. The temperature of the column was 170°C and the flow rate of carrier-gas N was 40 ml/min. The rainfall from January to December 1989 and 1990 was 1,512 and 1,092 mm (quite low) respectively.

The biological advantage of the treatments was calculated by land-equivalent ratio (LER), income-equivalent ratio (IER) and monetary advantage (MA), showing the absolute value of the genuine yield advantage and it was calculated by equation suggested by Willey (1979). The oil-yield equivalent of palmarosa was calculated from pigeonpea yields besides physico-chemical properties of the essential oil of palmarosa (Table 1). The LER, IER and MA were calculated as:

$$LER = \frac{\text{Yield of main crop in intercropping}}{\text{Yield of main crop in sole cropping}} + \frac{\text{Yield of intercrop in intercropping}}{\text{Yield of intercrop in sole cropping}}$$

$$IER = \frac{\text{Income from both crops in intercropping}}{\text{Income from sole base crop}}$$

$$MA = \text{Value of combined intercrop yield} \times \frac{LER-1}{LER}$$

RESULTS AND DISCUSSION

Higher herbage of palmarosa and grain yield of pigeonpea were recorded by sowing 2 crops alone in 2 seasons and pooled data (Table 1). In intercropping of pigeonpea in palmarosa, the total biological yields of both the crops showed significant decrease under all intercropping systems compared with sole palmarosa. However, sowing pigeonpea in intermittent (alternate) rows parallel to palmarosa gave higher total dry matter compared with the system where pigeonpea was sown within palmarosa rows (intra-row sowing) during 1989. In second year (1990) similar to first year effect of intercropping was seen, except that significantly higher total dry matter was recorded by sowing pigeonpea in alternate rows parallel to palmarosa compared with other intercropping systems. In pooled data a method of intercropping of pigeonpea in the intermittent rows parallel to palmarosa was found the most efficient and competent system.

The essential oil yield of palmarosa was found non-significant under different treatments. However, higher oil yield was recorded by raising sole palmarosa in different

Table 1. Biological efficiency of palmarosa-based pigeonpea intercropping systems, yield equivalent, land-equivalent ratio (LER) and income-equivalent ratio (IER)

Treatment	Palmarosa herb + pigeonpea yield on DWB (kg/ha)			Essential oil yield of palmarosa (kg/ha)			Palmarosa oil-yield equivalent (kg/ha)			Land equi-valent ratio	Income equi-valent ratio	Essential oil (%)			Total geraniol (%)		
	1989	1990	Pooled	1989	1990	Pooled	1989	1990	Pooled	Pooled	Pooled	1989	1990	Pooled	1989	1990	Pooled
Palmarosa sole	5,750	7,560	6,630	63.8	47.5	55.6	63.8	47.5	55.6	1.0	1.00	1.12	0.63	0.87	92.5	90.5	91.5
Pigeonpea sole	2,500	2,450	2,470							1.0	0.51						
Pigeonpea sown centrally in palmarosa parallelogram	4,320 + 1,670	6,170 + 460	5,240 + 1,060	46.0	47.1	46.5	69.5	53.7	61.8	1.2	1.01	1.06	0.76	0.91	91.8	90.6	91.2
Pigeonpea sown within palmarosa rows (intra-rows)	4,010 + 1,540	6,360 + 410	5,180 + 975	43.1	34.7	38.9	65.1	40.6	52.9	1.2	0.73	1.07	0.56	0.81	92.7	91.1	91.9
Pigeonpea sown in intermittent rows parallel to palmarosa	4,780 + 1,980	6,940 + 750	5,860 + 1,360	50.0	47.9	48.9	78.3	58.6	68.5	1.4	1.17	1.08	0.69	0.88	92.8	90.6	91.7
CD (P = 0.05)	1,135	536		NS	NS												

Table 2. Economics of palmarosa–pigeonpea intercropping systems based on essential oil yield and pigeonpea yield

Treatment	Cultivation cost in both years (Rs/ha)	Gross returns (Rs/ha)			Net returns (Rs/ha)			Bonus income (compared to base crop) (Rs/ha)			Monetary advantage (Rs/ha)
		1989	1990	Pooled	1989	1990	Pooled	1989	1990	Pooled	
Palmarosa sole	5,000	22,330	16,625	19,477	17,330	11,625	14,460				
Pigeonpea sole	5,000	12,550	12,250	12,400	7,500	7,250	7,350	− 9,830	− 4,375	− 7,102	
Pigeonpea sown centrally in palmarosa parallelogram	7,000	24,450	18,785	21,617	17,450	11,785	14,575	+ 120	+ 160	(+) 140	960
Pigeonpea sown within palmarosa row (Intra-row)	7,000	22,785	14,195	18,490	17,785	7,195	11,490	− 1,545	− 4 ,430	− 2,987	708
Pigeonpea sown in intermittent row parrallel to palmarosa	7,000	27,400	20,175	23,787	20,400	13,175	16,915	+ 3,070	+1,550	+ 2,310	2,015

Sale price (Rs/kg): Oil of palmarosa, 350; grain of pigeonpea, 5

years and in pooled data due to higher herbage production. The yield of oil was regularly decreased under all intercropping systems. The oil-yield equivalent of palmarosa indicated that the system was highly efficient and advantageous where pigeonpea was sown in alternate rows parallel to palmarosa compared with rest of the systems.

Higher land-equivalent ratio (1.4) and income equivalent ratio (1.17) were recorded when pigeonpea was sown parallel to palmarosa in intermittent rows. The value of LER emphasized that to produce the combined crop yield by growing intercrop with the pure stand would require 40% more area or otherwise this arrangement gave 40% yield increase compared to monoculture of palmarosa or pigeonpea (Table 1). This revealed a greater degree of efficiency and compatibility of the intercrop in palmarosa, particularly with that system which provided maximum advantage.

The pooled essential oil content of palmarosa was higher when pigeonpea was sown centrally in palmarosa parallelogram. However, it did not gave higher oil yield due to less herbage yield of palmarosa compared with palmarosa sole (Table 1). The quality of palmarosa oil did not vary, as the total geraniol content was almost at par under all the treatments.

The cost : benefit ratio showed higher economical values in individual years and pooled seasons. Higher gross and net returns (Rs 23, 786 and 16, 915/ha respectively) were realized on pooled basis by sowing of pigeonpea in intermittent rows parallel to palmarosa. This system in pooled data gave higher bonus income of Rs 2,310 compared with other systems, and as such its superiority was further established by giving higher monetary advantage of Rs 2,015/ha (Table 2).

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