Journal of Spices and Aromatic Crops
Vol. 13 (2) : 97-101 (2004)

Indian Society for Spices

Intercropping of Indian basil (*Ocimum basilicum* L.) for enhancing resource utilization efficiency of aromatic grasses

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Received 12 March 2003; Revised 17 August 2004; Accepted 08 September 2004

Abstract

Field trials on intercropping of Indian basil (*Ocimum basilicum*) with perennial aromatic grasses such as palmarosa (*Cymbopogon martinii*), lemongrass (*Cymbopogon flexuosus*) and vetiver (*Vetiveria zizanioides*) were conducted at Lucknow (Uttar Pradesh). Indian basil was intercropped with aromatic grasses (spaced at 45 cm) during planting and establishment year of aromatic grasses. Intercropping with Indian basil did not affect the essential oil production of aromatic grasses; however oil yield of Indian basil were reduced by 60% and 24% with palmarosa and lemongrass, respectively, over monocropping. Intercropping however, improved the net economic returns of lemongrass, vetiver and palmarosa by 61%, 140% and 65%, respectively, over their respective monocropping. Intercropping led to considerable improvement in land equivalent ratio (1.36-1.91), area time equivalent ratio (1.04-1.19), land use efficiency (120%-151%) and money equivalent ratio (1.37-3.01).

Key words: aromatic grasses, Indian basil, intercropping, *Ocimum basilicum*.

Introduction

Production of perennial aromatic grasses such as palmarosa (*Cymbopogon martinii* (Roxb.) Wats.), lemongrass (*Cymbopogon flexuosus* Nees ex Steud.) and vetiver (*Vetiveria zizanioides* L.) in India has remained stagnant for several years mainly due to poor financial returns in planting year (Singh *et al.* 1995). Planting of these crops is done at a row spacing of 45-50 cm and they take 20-35 days for establishment and further 30-40 days for development of canopies. Thus, most of the land remains uncovered allowing infestation of weeds which grow at a faster rate and deplete soil moisture and nutrient reserves. Hence, the herb and essential oil yield of aromatic grasses during planting year are low. This situation affords scope for growing of short duration intercrops to improve the productivity of these monocropping systems. Although intercropping systems involving cowpea, blackgram, greengram, clusterbean, pigeonpea and senna with vetiver (Pareek *et al.* 1991) and blackgram, cowpea and soyabean with lemongrass (Singh *et al.* 1995) have been suggested under irrigated conditions, the scope for improving the productivity of these intercropping systems under rainfed conditions is limited. Indian basil (*Ocimum basilicum* L.) is a short duration high value aromatic crop,

in which the oil is obtained through hydrodistillation of entire above ground parts, and hence the risk of crop failure due to uncertain rains is very low. The present study was carried out to explore the possibility of raising Indian basil as intercrop with aromatic grasses for better utilization of available natural resources in initial phase of aromatic grasses and improving the productivity of these monocropping systems during planting year under rainfed conditions of north Indian plains.

Materials and methods

The field experiments were conducted during 1997-99 (July-December) at the Research Farm of Central Institute of Medicinal and Aromatic Plants, Lucknow (Uttar Pradesh) (120 m MSL). The site has a sub-tropical climate with a precipitation of 1014.2, 1112.3 and 920.3 mm during 1997-98, 1998-99 and 1999-2000 (July-June), respectively (Table 1). The soil of the experimental plot was sandy loam in texture with pH 8.4, low in available nitrogen (135 kg ha^{-1}), medium in available phosphorus (11.5 kg ha^{-1}) and low in available potassium (143 kg ha^{-1}).

Three intercropping systems namely, palmarosa + Indian basil, lemongrass + Indian basil and vetiver + Indian basil and sole cropping of palmarosa, lemongrass, vetiver and Indian basil were compared under rainfed conditions. The experiments were laid out in randomised block design with five replications. Thirty five day old nursery raised seedlings of palmarosa (cv. PRC-1) and rooted slips obtained from old plantations of lemongrass (cv. Pragati) and vetiver (cv. KS-1), were planted on 7 July 1997 and 13 July 1998, at a spacing of 45 cm x 30 cm using two seedlings/slips $hill^{-1}$. Simultaneously, 35 day old seedlings of Indian basil were planted between two rows of aromatic grasses at 30 cm plant spacing within rows. Sole cropping as well as all intercropping systems received uniform doses of N, P_2O_5 and K_2O @ 100, 60 and 60 kg ha^{-1}, respectively; no extra dose of plant nutrients was given to the intercrops. The recommended cultural practices were followed for raising the crops till harvesting/digging. Three harvests of palmarosa and lemongrass were made in 1997-98, however, only two harvests were made during 1998-99. The vetiver roots were harvested in December 1998 and December 1999, after 18 months of planting of first and second year experiments, respectively. Indian basil was harvested at flowering stage (80-85 days after planting).

Table 1. Total and effective rainfall during experimental period (1997-2000)

Month	1997-98		1998-99		1999-2000*	
	Total rainfall (mm)	Effective rainfall (mm)	Total rainfall (mm)	Effective rainfall (mm)	Total rainfall (mm)	Effective rainfall (mm)
July	280.5	108.9	443.0	127.5	188.6	173.4
August	177.6	143.2	317.0	71.4	243.4	141.6
September	157.8	81.1	168.2	58.9	211.9	33.2
October	107.6	97.4	19.8	19.8	12.0	12.0
November	36.4	36.4	6.4	6.4	-	-
December	99.6	63.6	-	-	7.0	7.0
January	8.0	8.0	28.8	28.8	2.4	2.4
February	25.4	25.4	8.4	8.4	6.0	6.0
March	16.3	16.3	-	-	-	-
April	10.8	10.8	-	-	33.0	33.0
May	31.0	31.0	4.8	4.8	50.0	50.0
June	63.2	63.2	115.9	89.6	166.0	133.4
Total	1014.2	685.31	1112.3	415.6	920.3	592.0

* Experiment was continued only up to December

The fresh herb yield of palmarosa, lemongrass and Indian basil was recorded immediately after harvest. Roots of vetiver were separated from plants after digging and root yield was recorded (around 55% moisture). Oil content was determined by hydrodistillation method in Clevenger's apparatus (Clevenger, 1928) with a sample of 200 g. The cost of cultivation, gross returns and net returns were calculated by considering prevailing market prices of the inputs and produce. Various resource use efficiencies namely, land equivalent ratio (LER), area time equivalent ratio (ATER), land use efficiency (LUE) and monetary equivalent ratio (MER) were calculated as suggested by Mead & Willey (1980); Hiebsch & McCollum (1987); Kothari *et al.* (1987) and Aditiloye & Adikunali (1989), respectively.

Results and discussion

Herb and essential oil yield of aromatic grasses

There was significant variation in herb and essential oil production of aromatic grasses during both the cropping years (Table 2). The herb and essential oil yield of aromatic grasses was lower during 1998-99 than during 1997-98. This may be attributed to variation in the distribution of rainfall. In the first year of experimentation, rainfall was well distributed over the entire summer season (121.3 mm), but during the second summer season 115.9 mm rainfall out of total rainfall of 120.7 mm was received in the last week of June, when the crop was ready for harvest. Lack of rainfall during the active growth period (March, April and May) of aromatic grasses during the second year of experimentation caused severe moisture stress, and only two harvests were made as against three harvests during the first year of experimentation.

Intercropping Indian basil did not affect herb and oil production of aromatic grasses. Indian basil took 80-85 days to reach maturity. Lemongrass and vetiver required 30-40 days for establishment and further 30-40 days to develop canopies. Hence, in the intercropping systems Indian basil did not create any

Table 2. Yield and net returns of intercropping Indian basil with aromatic grasses

Cropping system	1997-98					1998-99				
	Herb/root yield ($q\ ha^{-1}$)		Oil yield ($l\ ha^{-1}$)		Net returns (000, Rs ha^{-1})	Herb/root yield ($q\ ha^{-1}$)		Oil yield ($l\ ha^{-1}$)		Net returns (000, Rs ha^{-1})
	Aromatic grass	Indian basil	Aromatic grass	Indian basil		Aromatic grass	Indian basil	Aromatic grass	Indian basil	
Palmarosa	116.4	-	80.0	-	17.0	107.0	-	56.0	-	8.6
Lemongrass	120.3	-	90.0	-	18.0	101.3	-	60.0	-	7.6
Vetiver	6.9	-	7.2	-	32.7	05.4	-	5.9	-	23.9
Indian basil	-	126.9	-	85.0	14.9	-	140.0	-	84.0	14.6
Palmarosa + Indian basil	112.0	53.0	76.0	35.0	23.4	103.8	60.0	54.0	36.0	15.9
Lemongrass + Indian basil	120.9	100.0	85.0	65.0	32.5	108.9	106.0	58.7	63.0	22.8
Vetiver + Indian basil	6.4	117.7	7.0	80.0	51.4	5.2	132.8	5.5	81.0	41.4
CD (P=0.05)	-	15.5	-	7.4	3.0	-	17.2	-	7.8	2.2

competition for associated lemongrass and vetiver. Although tillering and canopy development in palmarosa started very early, aggressive growth of palmarosa over Indian basil did not cause considerable reduction in growth and yield of palmarosa oil. However, little loss in essential oil yield of aromatic grasses in intercropping systems over their sole crop yield was observed, which was due to competition for essential plant nutrients since no extra dose of plant nutrients was applied. Singh & Shivraj (1998) also reported that there was no adverse effect of legume intercrop on the essential oil yield of lemongrass.

Herb and essential oil yield of Indian basil

Growth and yield of intercropped Indian basil was almost similar during both the years of experimentation due to almost even distribution of rainfall during cropping period of Indian basil during both the years. The herb and essential oil production of Indian basil under intercropping with vetiver was at par with that of the sole crop; however, significant reduction in herb and essential oil yield was noted when grown in association with lemongrass and palmarosa (Table 2). Comparatively early establishment and quick growth of palmarosa and better plant canopy of lemongrass caused greater shading and hence the reduction in herb and oil yield of Indian basil. Similar observations were recorded by Singh & Shivaraj (1998) in grain yield of blackgram, cowpea and soyabean. Since vetiver took a longer duration for canopy development, there was no competitive effect on the productivity of Indian basil.

Net returns

All cropping systems except sole cropping of Indian basil were found to be more remunerative during the first year of experimentation when compared to the second year, probably due to better distribution of rainfall during winter and summer seasons of first year. Intercropping of Indian basil improved the net economic returns over sole cropping of palmarosa, lemongrass and vetiver by 37.6%, 80.5% and 57.2%, respectively, in 1997-98, 84.9%, 200.0% and 73.2%, respectively, in 1998-99.

Resource use efficiency

Intercropping of Indian basil enhanced LER to the extent of 1.36–1.38, 1.70–1.72 and 1.89–1.91 with palmarosa, lemongrass and vetiver, respectively (Table 3). LERs in the present study over estimated the LUE, since LER does not take into consideration the differences in duration of component crops. In such situation comparison on the basis of ATER has been suggested by Hevsch & McCollum (1987). Data of ATER showed that there was an increase of 4%–12%, 11%–19% and 7%–11% in land use efficiency in intercropping of Indian basil with palmarosa, lemongrass and vetiver, respectively. As per the method quoted by Kothari *et al.* (1987), land use effi-

Table 3. Resource use efficiency of intercropping Indian basil with aromatic grasses

Cropping system	1997-98				1998-99			
	LER	ATER	LUE (%)	MER	LER	ATER	LUE (%)	MER
Palmarosa	1.00	1.00	100.0	1.00	1.00	1.00	100.0	1.00
Lemongrass	1.00	1.00	100.0	1.00	1.00	1.00	100.0	1.00
Vetiver	1.00	1.00	100.0	1.00	1.00	1.00	100.0	1.00
Indian basil	1.00	1.00	100.0	1.00	1.00	1.00	100.0	1.00
Palmarosa + Indian basil	1.36	1.04	120.0	1.37	1.38	1.12	125.0	1.84
Lemongrass + Indian basil	1.70	1.11	140.5	1.80	1.72	1.19	145.0	3.01
Vetiver + Indian basil	1.91	1.11	151.0	1.56	1.89	1.07	148.0	1.73

LER=land equivalent ratio; ATER=area time equivalent ratio; LUE=land use efficiency; MER=monetary equivalent ratio

ciency increased by 20%–25%, 40.5%–45.5% and 48%–51% under intercropping systems with palmarosa, lemongrass and vetiver, respectively.

Monetary equivalent ratio

MER was higher in second year of experimentation in different intercropping systems when compared to the first year (Table 3). However, there was considerable increase (67.2%) in MER of lemongrass + Indian basil in the second year over the first year. The proportionate decrease in net returns of sole cropping of aromatic grasses was much higher as compared to intercropping systems in second year due to lower essential oil yield of grasses and more or less similar yield of Indian basil. Hence, intercropping of Indian basil becomes more advantageous with increase in risk with sole cropping of grasses. Lemongrass + Indian basil cropping system was found to be superior among the other intercropping systems in terms of MER because of highest net returns due to the better compatibility over palmarosa + Indian basil intercropping and nearly 6 month less cropping span over vetiver + Indian basil cropping system.

Acknowledgements

The authors are thankful to the Council of Scientific and Industrial Research, New Delhi, for providing facilities and support.

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