Short Communications

Indian Journal of Agricultural Sciences **84** (12): 1555–7, December 2014/Short Communications

Crop diversification through citronella (*Cymbopogon winterianus*) based cropping system

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Received: 20 November 2012; Revised accepted: 30 June 2014

Key words: Citronella, Crop diversification, Cropping system, Economics, Land equivalent ratio, Pulses

Crop diversification is intended to give a wider choice in the production of a variety of crops in a given area, so as to expand production related activities on various crops and also to lessen risk. Crop diversification in India is generally viewed as a shift from traditional grown less remunerative crops to more remunerative crops. It will develop alternative sources of employment in the rural areas, viz. agro industries, supportive infrastructure, etc. Now days, the essential oil bearing plants are playing a major role in commercial production of aromatic oils making India a major partner in the world scenario. Java citronella (*Cymbopogon winterianus*) is a perennial grass and is propagated vegetative by slips. It grows well under varying soil conditions. It yields oil, called oil of citronella which is in great demand in India. Oil of citronella grass is one of the essential oil obtained from different species of aromatic grasses. Citronella oil is a raw material for the production of geranial, citronellal, hydroxyl citronellal and other similar high value perfumery bases. It is also widely used as a starting material for various aromatic chemicals used in scented soaps, sprays, deodorants, detergent, polishes, mosquito repellents etc. However, with the changing scenario of market demands, there is a need to relook and investigate low cost technology for commercial crops in different planting pattern and cropping systems. Therefore, the present investigation entitled "Intercropping of *kharif* (Pigeonpea and maize) and *rabi* (Lentil) crops with citronella (*Cymbopogon winterianus*)" was carried out with the objectives to examine the effect of diversified cropping system on sustaining yield of citronella based cropping systems for realizing maximum yield and profit.

The field experiment was conducted at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (UP) India, during *kharif* and *rabi* season of 2010-11. During the experimental period of 2010-11 mean annual precipitation was about 818 mm. The soil was sandy loam in texture with pH 8.2, organic C 0.4%, EC 0.21 dS/m at 25^0C, available N 255 kg/ha, available P 18 kg/ha and available K 180 kg/ha. The experiment was laid out in randomized block design with thirteen cropping systems (Citronella sole, pigeonpea sole, maize sole, lentil sole, citronella : pigeonpea (1:1), citronella : pigeonpea (2:1), citronella : pigeonpea (2:2), citronella : maize (1:1), citronella : maize (2:1), citronella : maize (2:2), citronella : lentil (1:1), citronella : lentil (2:1) and citronella : lentil (2:2) under four replications. Bio-13, Amar, Azad Uttam and K-75 cultivar of citronella, pigeonpea, maize and lentil, respectively were used for experimental purpose. Crops were grown as per recommended package of practices. Citronella, pigeonpea and maize were sown during the first week of August and lentil in the month of the last week of November 2010. Maize and pigeonpea matured in the first fortnight of November 2010 and May 2011, respectively. While, first cutting of citronella done in the second week of March and 2nd cutting in last week of June 2011. The recommended dose of fertilizer was drilled in bands.

Citronella equivalent oil yield (CEOY), Land equivalent ratio (LER) and crop profitability was computed using the formula;

Citronella equivalent oil yield (CEOY) = (Grain yield of intercrop (t/ha)/ (Market price of main crop (₹/t) × Market price of intercrop (₹/t)

$$LER = \frac{Yab}{Yaa} + \frac{Yba}{Ybb} = La + Lb$$

where, Yaa, yield of component a as sole crop, Ybb, yield of component b as sole crop; Yab, yield of component a as intercrop grown in combination with component b; and the Yba, yield of component b as intercrop grown in combination with a component.

Crop profitability (₹/ha/day) = Net returns (₹/ha) ÷ Number of days field occupied

The highest oil yield was recorded in citronella sole (354.25 q/ha) which was significantly superior over the rest

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Table 1 Effect of cropping systems on yield of sole and intercropped citronella, pigeonpea, maize and lentil

Cropping system	Citronella oil yield (q/ha)	Pigeon-pea (q/ha)	Maize (q/ha)	Lentil (q/ha)
Citronella sole	354.25			
Pigeonpea sole		16.50		
Maize sole			40.65	
Lentil sole				17.14
Citronella : pigeonpea (1:1)	175.61	8.19		
Citronella : pigeonpea (2:1)	263.56	4.47		
Citronella : pigeonpea (2:2)	177.81	8.64		
Citronella : maize (1:1)	175.61		21.11	
Citronella : maize (2:1)	263.36		11.31	
Citronella : maize (2:2)	177.81		21.88	
Citronella : lentil (1:1)	172.58			8.81
Citronella : lentil (2:1)	259.65			4.93
Citronella : lentil (2:2)	174.29			9.15
SEm±	2.95	0.16	0.53	0.35
CD (P=0.05)	8.93	0.53	1.62	1.07

of the cropping systems followed by 2:1 row ratio of citronella + pigeonpea (263.56 q/ha) and citronella + maize (263.36 q/ha). The results of the present investigation are in close conformity with the findings of Singh *et al.* (2008). Sole pigeonpea (16.50 q/ha), sole maize (40.65 q/ha) and sole lentil (17.14 q/ha) were showing higher grain yield over their intercropping with citronella in different ratios (Table1). This might be due to the optimum spacing available for the plants. The higher growth performance in sole crop as compared to intercropping system has also been observed by Patra *et al*. (2005). The intercrop was affected due to the presence of inter and intra-specific competition between main crop and the intercrop (pigeonpea, maize and lentil) for growth resources such as nutrients, moisture and solar radiation due to change in crop geometry as compared to sole crop. The results of the present investigation are in close conformity with the findings of Ghosh *et al*. (2009). The citronella sole cropping system gave significantly the highest CEOY followed by citronella + pigeonpea (2:1) and Citronella + pigeonpea (2:1) intercropping system than other cropping systems. While, citronella + maize (2:1) intercropping system was being statistically at par with citronella + lentil (2:2). It might be due to less effect of competition in citronella sole stand, which reduces inter-specific competition than intercrops. The maximum among intercropping system citronella + pigeonpea (2:1) recorded significantly higher citronella oil equivalent yield as compared to either of the intercropping system.

It was due to similar citronella oil yield under intercropping system as that of its sole stand, and additional yield of pigeonpea as a bonus in intercropping system. The results are in accordance with the findings of Saikia *et al.* (2006). The LER value in intercropping system indicated yield advantage over sole stand due to better land utilization. The higher LER values in citronella: pigeonpea (2:2), citronella: maize (2:2) and citronella: lentil (2:2) intercropping, i.e.1.03, 1.04 and 1.03, respectively clearly indicate 3 to 4% advantage over their sole stand (Table 3). The results are in accordance with the Ghosh *et al*. (2009). Citronella sole recorded the highest crop productivity (837 ₹/ha/days) followed by citronella: pigeonpea (2:2) (770.4 ₹/ha/days). This could be attributed to higher productivity of crops. The results are conformity with (Ghosh *et al*. 2009). Citronella sole system on an average fetched ₹ 272.04×10^3 followed by citronella: pigeonpea (2:2) (₹ 250.4×10^3) net returns (Table 4). The higher B: C ratio was recorded under citronella: pigeonpea (2:2) (12.6) than other cropping systems. The higher CEY coupled with the corresponding stover yield and with minimal increases in cost of cultivation has resulted in higher net returns and B: C ratio in citronella: pigeonpea (2:2) system. The results are in accordance with the findings of Saikia *et al.* (2006).

Table 2 Effect of cropping systems on yield of sole and intercropped citronella, pigeonpea, maize and lentil

Cropping systems	CEOY (q/ha)	LER	Crop profitability (₹/ha/day)	Cost of cultivation ($\times 10^3$ ₹/ha)	Net returns ($\times 10^3$ ₹/ha)	B:C ratio
Citronella Sole	354.26	1.00	837.0	29.08	272.04	9.4
Pigeonpea Sole	75.72	1.00	187.6	10.88	52.92	4.8
Maize sole	59.78	1.00	379.2	11.99	69.03	5.7
Lentil sole	68.59	1.00	371.1	11.37	43.42	3.8
Citronella : pigeonpea (1:1)	213.20	0.99	497.6	19.14	161.74	8.4
Citronella : pigeonpea (2:1)	284.09	1.01	687.9	22.76	223.57	9.8
Citronella : pigeonpea (2:2)	217.49	1.03	770.4	19.80	250.39	12.6
Citronella : maize (1:1)	206.66	1.02	522.5	20.83	169.83	8.1
Citronella : maize (2:1)	280.20	1.02	689.1	24.21	223.96	9.2
Citronella : maize (2:2)	209.99	1.04	532.3	21.49	173	8.0
Citronella : lentil (1:1)	207.82	1.00	472.6	19.39	153.61	7.9
Citronella : lentil (2:1)	279.37	1.02	656.7	22.88	213.43	9.3
Citronella : lentil (2:2)	210.90	1.03	485.9	20.05	157.92	7.8
SEm±	2.25					
CD (P=0.05)	6.84					

Thus results of the present investigation clearly demonstrate that citronella sole cropping system can be practiced to achieve better high yield as well as profitability than other cropping system in sandy loam soils of North and Central India.

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