

Original Research Article

<https://doi.org/10.20546/ijcmas.2018.701.302>

Profitable Cropping Systems for Southern Telangana Zone of Telangana State, India

Ch. Pragathi Kumari*, S. Sridevi and M. Goverdhan

AICRP on Integrated Farming Systems, PJTSAU, Rajendranagar, Hyderabad-30,
Telangana, India

*Corresponding author

ABSTRACT

Keywords

Cropping systems,
System productivity,
Profitability, Nutrient
removal, Soil fertility

Article Info

Accepted:
20 December 2017
Available Online:
10 January 2018

A field experiment was conducted during 2016-17 at AICRP on Integrated Farming Systems, PJTSAU to identify bio-intensive complementary cropping systems under LD conditions for light textured soils of Southern Telangana Zone. Amongst the twelve cropping systems tested, cotton + green gram (1:2) – maize for green cobs system recorded highest MEY (11803 kg ha⁻¹) with Rs 78,820 ha⁻¹ of net returns followed by Bt cotton + soybean (1:3) – sesame + groundnut (2:4) system (10155 kg ha⁻¹). Bt Cotton + green gram (1:2) – maize for green cobs system removed significantly higher nitrogen (189.2 kg ha⁻¹) and potassium (158.4 kg ha⁻¹). Removal of phosphorus was significantly more by all maize based cropping systems. The Post harvest soil analysis after *kharif* and also at the end of different crops/cropping systems did not show any remarkable changes in pH, EC, organic carbon, available potassium and phosphorus.

Introduction

Crop diversification has been recognized as an effective strategy for achieving the objectives of food security, nutrition security, income growth, poverty alleviation, employment generation, judicious use of land and water resources, sustainable agricultural development and environmental improvement (Hedge *et al.*, 2003). In the era of shrinking resource base of land, water and energy, resource use efficiency is an important aspect for considering the sustainability of a cropping system (Yadav, 2002). Cotton-maize, maize-sunflower is a widely practiced predominant

cropping systems in the Southern Telangana Zone. Both being exhaustive, non-leguminous in nature the viability and sustainability of system is a matter of concern especially in the context of light textured soils of the region.

Hence identification of bio intensive complimentary cropping systems by inclusion of more hardy cereals and pulse crops in the system which are ecologically sustainable and more viable is very pertinent. The current study mainly aimed at evolving alternative cropping systems with higher productivity and profitability over the widely adopted of maize – sunflower, cotton - maize cropping systems.

Materials and Methods

The study was conducted at research farm of All India Coordinated Research Project on Integrated Farming Systems, Professor Jayashankar Telangana Sate Agricultural University, Rajendranagr during 2016-17. The soil of the experimental field was a red chalka soil. The experiment was laid out with twelve cropping systems as treatments in Randomized Block Design (RBD) with three replications. The twelve combinations of bio-intensive complimentary cropping systems tested during *kharif* and *rabi* seasons were, T₁: Maize – sunflower (check), T₂: Pearl millet + soybean–potato, T₃: Maize-groundnut, T₄: Pearl millet + soybean (3:2) – sunflower + groundnut (2:3), T₅: Maize + soybean (2:3) – potato, T₆: *Bt* cotton + soybean (1:3) – sesame + groundnut, T₇: Maize (Flatbed) + soybean (Raised Bed) – castor (F) + greengram (RB) (2:3), T₈: *Bt* cotton + greengram (1:3) - pearl millet, T₉: Soybean – potato, T₁₀: *Bt* cotton + green gram (1:2) –sesame, T₁₁: Pearl millet – groundnut, T₁₂: *Bt* Cotton + green gram (1:2) –maize for green cobs.

All the *kharif* crops were sown on 2.07.2016 and the following sequence crops during *rabi* were taken up as and when the preceding *kharif* crops were harvested in the respective plots. Economic yield and stover/straw/stalk yield were recorded individually for all the crops in cropping systems.

For comparison of different crop sequences, the yields of all the crops were converted in to maize equivalent yield on price basis. Nutrient removal by different cropping sequences was worked out by estimating the nutrient concentrations (N, P and K) in grain and straw of crops. To understand the impact of various cropping systems on soil fertility, post-harvest soil was analysed for pH, EC, organic carbon and available N, P and K status by following the standard procedures (Jackson, 1973).

Results and Discussion

Productivity and economics of crops and cropping systems

The performance of different crops in terms of maize equivalent yield (MEY) during *kharif*, 2016 indicated that *Bt* cotton intercropped with soybean at 1:3 ratio gave significantly higher maize equivalent yield (7516 kg ha⁻¹) over other crops or cropping systems (Table 1 and 2). However it was found to be at par with *Bt* cotton intercropped with greengram at 1:3 (7474 kg ha⁻¹) or *Bt* cotton intercropped with greengram in 1:2 row ratio (6945 kg ha⁻¹).

The lowest maize equivalent yield was recorded with pearl millet intercropped with soybean in 3:2 row ratio (1742 kg ha⁻¹). Sreerakha *et al.*, (2010) reported that cotton hybrid, Bunny and variety, Narsimha intercropped with soybean recorded 28 and 29 per cent more seed cotton yield, respectively, over corresponding sole crops. Due to higher price of greengram, net returns from *Bt* cotton intercropped with greengram in 1:3 row ratio system were higher (Rs 48676 ha⁻¹) followed by *Bt* Cotton intercropped with soybean at 1:3 row ratio (Rs 46345 ha⁻¹) and *Bt* cotton intercropped with greengram at 1:2 (Rs. 43425 ha⁻¹). Similar maximum net returns (Rs 61604) was observed in cotton + mung intercropping than all other paired row cotton with intercrops (CICR, 2009-10).

During *rabi* 2016, potato crop raised after soybean, recorded significantly highest MEY of 5260 kg ha⁻¹ over other tested crops or cropping systems. It was closely followed by maize grown for green cobs (5173 kg ha⁻¹) and potato (4852 kg ha⁻¹) raised after pearl millet + soybean system. Potato being nontraditional crop provides excellent opportunities in raising the income of the farmers as it has capacity to yield 5-10 times more than cereals, pulses or oilseeds.

Table.1 Performance of crops under bio-intensive complementary cropping systems

Treatments		Kharif (2016)		Rabi (2016-17)		Maize Equivalent Yield (kg ha ⁻¹)				Productivity (MEY -kg ha ⁻¹)		
Kharif-Rabi		Grain yield	Straw/ Stover yield	Grain yield	Straw/Stalk/ Stover yield	Kharif		Rabi				
		(kg ha ⁻¹)	(kg ha ⁻¹)	(kg ha ⁻¹)	(kg ha ⁻¹)	Grain	Straw	Grain	Straw	Kharif	Rabi	System
T1	Maize – Sunflower (Check)	4812	8952	752	976	4812	656	2176	0	5468	2176	7644
T2	Pear millet + Soybean (3:2) - Potato	1037	1287	2649	847	1773	102	4852	0	1875	4852	6727
		389	442									
T3	Maize - Groundnut	5187	8721	882	1081	5187	639	2727	245	5826	2972	8798
T4	Pear millet + Soybean (3:2) – Sunflower + Groundnut (2:3)	887	1153	323	484	1650	92	3111	202	1742	3313	5055
		401	391	704	892							
T5	Maize + Soybean (2:3) – Potato	3562	6982	2573	801	4414	520	4712	0	4934	4712	9646
		435	463									
T6	Bt cotton + Soybean (1:3) – Sesame + Groundnut	2150	3439	185	409	7507	9	2477	162	7516	2639	10155
		487	512	582	714							
T7	Maize (Flat) + Soybean (Raised Bed) – Castor (F)+ Green gram (RB)(2:3)	3721	7234	952	1921	4524	538	3616	80	5062	3696	8758
		410	431	307	527							
T8	Bt cotton + Greengram (1:3) - Pearl millet	2031	4732	1308	2531	7375	100	1274	193	7474	1468	8942
		337	680									
T9	Soybean - Potato	1252	1132	2872	957	2454	21	5260	0	2474	5260	7734
T10	Bt cotton + Green gram (1:2) –Sesame	1987	4710	356	894	6878	66	1304	0	6945	1304	8249
		234	452									
T11	Pearl millet – Groundnut	1302	1532	934	1056	1269	112	2888	239	1381	3127	4508
T12	Bt Cotton+ Green gram (1:2) –Maize for green cobs	1905	3975	14837	11624	6572	58	4322	852	6630	5173	11803
		218	397									
S Em±										270.9	154.8	
CD (0.05)										799.7	456.9	
CV (%)										9.97	7.91	

Kharif: Sale price for Grain (kg⁻¹): Maize = Rs 13.65, Pearl millet = Rs 13.30, Soybean = Rs 27.75, Bt Cotton = Rs 41.60, Greengram = Rs 52.25 Sunflower = Rs 39.50, Groundnut = Rs 42.20, Sesame = Rs 50.00, Castor = Rs. 35.00, Potato = Rs 25.00 Sale price for stover (kg⁻¹) : Maize = Rs 1.00, Pearl millet = Rs 1.00, Soybean = 0.25, Greengram = Rs 2.00, Groundnut Rs 3.00

Rabi: Sale price for grain (kg-1) : Maize (green cobs)= Rs 5/kg, Pearl millet = Rs 13.30, Soybean = Rs 27.75, Bt Cotton = Rs 41.60, Sunflower = Rs 39.50, Groundnut = Rs 42.20, Sesame = Rs 50.00, Castor = Rs 35.00, Potato = Rs 25.00 ; Sale price for stover (kg-1) : Maize = Rs 1.00, Pearl millet = Rs 1.00, Greengram Rs 2.00, Groundnut Rs 3.00

Table.2 Economics of crops under the bio-intensive complementary cropping systems

Treatment		Kharif				Rabi				System	
Kharif-Rabi		Cost of cultivation (Rs. ha ⁻¹)	Gross returns (Rs. ha ⁻¹)	Net returns		Cost of cultivation (Rs. ha ⁻¹)	Gross returns (Rs. ha ⁻¹)	Net returns		Net returns	
				Rs. ha ⁻¹	Rs. Re ⁻¹			Rs. ha ⁻¹	Rs. Re ⁻¹	Rs. ha ⁻¹	Rs. Re ⁻¹
T1	Maize – Sunflower (Check)	43065	74636	31571	0.73	26893	29704	2811	0.10	34382	0.49
T2	Pear millet + Soybean (3:2) - Potato	20460	25595	5135	0.25	58053	66225	8172	0.14	13307	0.17
T3	Maize - Groundnut	43065	79524	36459	0.85	35150	40561	5411	0.15	41870	0.54
T4	Pear millet + Soybean (3:2) – Sunflower + Groundnut (2:3)	20460	23775	3315	0.16	33168	45224	12056	0.36	15371	0.29
T5	Maize + Soybean (2:3) – Potato	47390	67355	19965	0.42	58053	64325	6272	0.11	26237	0.25
T6	Bt cotton + Soybean (1:3) – Sesame + Groundnut	56250	102595	46345	0.82	27886	36017	8131	0.29	54476	0.65
T7	Maize (Flat) + Soybean (RB) – Castor (F)+ Green gram (RB) (2:3)	49390	69101	19711	0.40	27793	50447	22654	0.82	42365	0.55
T8	Bt cotton + Greengram (1:3) - Pearl millet	53350	102206	48676	0.91	17005	20034	3029	0.18	51705	0.73
T9	Soybean - Potato	27560	33774	6214	0.23	58053	71800	13747	0.24	19961	0.23
T10	Bt cotton + Green gram (1:2) –Sesame	51370	94795	43425	0.85	15995	17800	1805	0.11	45230	0.67
T11	Pearl millet – Groundnut	16140	18849	2709	0.17	35150	42678	7528	0.21	10237	0.20
T12	Bt Cotton+ Green gram (1:2) –Maize for green cobs	51370	90506	39136	0.76	30930	70614	39684	1.28	78820	0.96

Table.3 Total Nutrient uptake (Nitrogen, Phosphorus and Potassium) by different cropping systems

Treatment		Kharif uptake			Rabi uptake			System uptake		
		N	P	K	N	P	K	N	P	K
T1	Maize – Sunflower (Check)	99.9	28.2	96.6	29.4	5.0	11.9	129.2	33.2	108.5
T2	Pear millet + Soybean (3:2) - Potato	53.6	7.1	47.0	11.1	1.4	13.7	64.7	8.5	60.7
T3	Maize - Groundnut	106.0	35.1	101.1	39.6	4.2	12.3	145.5	39.3	113.3
T4	Pear millet + Soybean (3:2) – Sunflower + Groundnut (2:3)	49.4	6.3	44.6	46.2	6.0	17.3	95.6	12.3	61.9
T5	Maize + Soybean (2:3) – Potato	99.6	26.7	86.5	11.3	1.5	13.9	110.9	28.2	100.4
T6	Bt cotton + Soybean (1:3) – Sesame + Groundnut	107.3	8.9	63.3	33.1	4.0	11.9	140.4	12.9	75.2
T7	Maize (Flat) + Soybean (Raised Bed) – Castor (F)+ Green gram (RB) (2:3)	108.2	26.4	87.5	66.7	9.0	35.4	174.9	35.4	122.9
T8	Bt cotton + Greengram (1:3) - Pearl millet	136.2	9.7	69.7	37.9	7.7	71.2	174.0	17.4	140.9
T9	Soybean - Potato	77.1	5.8	28.9	8.4	1.8	16.5	85.6	7.6	45.4
T10	Bt cotton + Green gram (1:2) –Sesame	130.3	9.0	69.7	13.3	2.4	7.7	143.6	11.4	77.4
T11	Pearl millet – Groundnut	38.2	8.2	50.2	49.6	4.9	14.5	87.8	13.1	64.6
T12	Bt Cotton+ Green gram (1:2) –Maize for green cobs	113.3	7.6	57.8	76.0	19.5	100.6	189.3	27.1	158.4
	SE(m)±	13.7	1.2	7.2	3.9	0.8	5.1	14.3	1.4	9.3
	CD @ 5%	40.5	3.4	21.2	11.4	2.3	15.1	42.1	4.3	27.3
	CV (%)	25.5	13.3	18.6	19.0	24.1	32.5	19.2	12.2	17.0

Table.4 Soil fertility status at the end of *kharif* and *rabi* under the bio-intensive complementary cropping systems

Trt	Cropping sequence	Kharif						Rabi					
		pH	EC (dS m ⁻¹)	OC (%)	Avail. Nutrients (kg ha ⁻¹)			pH	EC (dS m ⁻¹)	OC (%)	Avail. Nutrients (kg ha ⁻¹)		
					N	P	K				N	P	K
	Initial	8.50	0.38	0.59		30.7	274.8						
T1	Maize – Sunflower (C)	8.06	0.26	0.51	185.4	34.9	247.3	8.51	0.26	0.56	189.3	28.3	242.7
T2	Pear millet + Soybean (3:2) - Potato	8.04	0.24	0.53	215.5	38.0	248.8	8.36	0.28	0.59	209.3	38.1	257.0
T3	Maize - Groundnut	8.05	0.26	0.57	227.9	39.5	255.9	8.53	0.28	0.44	207.7	34.2	261.8
T4	Pear millet + Soybean (3:2) – Sunflower + Groundnut (2:3)	8.20	0.22	0.56	240.6	37.2	232.3	8.34	0.33	0.55	210.8	38.6	258.9
T5	Maize + Soybean (2:3) – Potato	8.05	0.28	0.52	238.3	35.8	223.0	8.45	0.23	0.53	203.1	30.8	257.0
T6	Bt cotton + Soybean (1:3) – Sesame + Groundnut	8.20	0.33	0.61	206.1	27.4	228.6	8.36	0.32	0.58	223.3	33.1	286.3
T7	Maize (Flat) + Soybean (Raised Bed) – Castor (F)+ Gr. gram (RB) (2:3)	8.37	0.25	0.52	231.0	37.1	244.3	8.69	0.35	0.54	221.3	30.5	254.5
T8	Bt cotton + Greengram (1:3) - Pearl millet	7.99	0.32	0.55	211.2	27.5	240.6	8.39	0.34	0.57	194.1	32.4	237.2
T9	Soybean - Potato	8.20	0.22	0.51	230.4	41.8	281.6	8.30	0.35	0.55	196.4	34.5	287.8
T10	Bt cotton + Green gram (1:2) –Sesame	8.03	0.31	0.56	222.9	33.7	232.7	8.64	0.35	0.47	203.9	28.2	270.6
T11	Pearl millet – Groundnut	8.08	0.28	0.59	227.0	37.2	247.7	8.45	0.31	0.50	200.1	29.0	277.2
T12	Bt Cotton+ Green gram (1:2) –Maize for green cobs	8.31	0.32	0.58	191.9	33.0	260.7	8.36	0.24	0.59	191.4	34.9	265.0
	SEm ±	0.16	0.05	0.06	14.8	3.0	17.6	0.10	0.04	0.03	9.2	4.1	13.8
	CD (at 5%)	NS	NS	NS	NS	8.8	NS	NS	NS	NS	NS	NS	NS
	CV%	3.45	3.80	18.57	11.7	14.9	14.1	1.53	12.21	10.91	7.8	22.3	9.1

The high profitability of potato as a cash crop has made it an economically viable enterprise for the small and marginal farmers and has contributed to increasing equity among farmers (Gulati *et al.*, 2007). The lowest MEY was noticed with sesame crop (1304 kg ha⁻¹) grown after Bt cotton intercropped with green gram at 1:2 row ratio. However maize grown for green cobs recorded significantly higher net returns (Rs 39684 ha⁻¹) over other crops.

In terms of system productivity, Bt Cotton + green gram (1:2) – maize for green cobs system recorded highest MEY (11803 kg ha⁻¹) with Rs 78820 ha⁻¹ of net returns, 0.96 BC ratio followed by Bt cotton + Soybean (1:3) – Sesame + Groundnut which registered 10155 kg ha⁻¹ of MEY, net returns of Rs 54476 ha⁻¹ and 0.65 BC ratio. The lowest MEY was recorded with pearl millet – groundnut cropping system (4508 kg ha⁻¹) with net returns of Rs 10237 ha⁻¹. In two year cotton-legume-corn rotation, an yield increase to the tune of 11 per cent was recorded as compared to continuous cotton grown without legumes (Sankaranarayanan *et al.*, 2010). Six Bt cotton based double cropping systems *viz.*, two millets, two pulses and two oilseed crops were evaluated to identify the most profitable, productive and sustainable system. Amongst them, Bt cotton - maize recorded the highest seed cotton equivalent yield (CICR, 2009-10). Banik *et al.*, (2009) also reported that cereal-legume intercropping systems were superior to mono cropping.

Nutrient uptake

Nutrient uptake by various crops and cropping systems varied significantly during kharif 2016 (Table 3). All the systems that have maize or Bt cotton as component crop in the cropping system were found to be on par. Bt cotton + green gram (1:3) cropping system removed significantly higher quantities of

nitrogen (136.2 kg ha⁻¹ and 130.3 kg ha⁻¹) and was closely followed by maize (Flat) + soybean (Raised Bed) system (108.2 kg ha⁻¹) and maize + soybean (2:3) (107.3 kg ha⁻¹) and maize (106.0 kg ha⁻¹) and were on par with nitrogen removal of cotton based systems. Pearl millet removed lowest quantities of nitrogen (38.2 kg ha⁻¹) than all other crops and cropping systems tested. While removal of phosphorus was significantly more by maize (35.1 kg ha⁻¹) and maize + soybean (2:3) system (26.7 kg ha⁻¹) and maize (Flat) + soybean (Raised Bed) system (26.4 kg ha⁻¹) when compared to all other crops and cropping systems (5.8 to 9.0 kg ha⁻¹). Potassium removal was also significantly more by maize (101.1 kg ha⁻¹) and maize + soybean (2:3) system (86.57 kg ha⁻¹) and maize (Flat) + soybean (Raised Bed) system (87.5 kg ha⁻¹) and was lowest by soybean (28.9 kg ha⁻¹). During *rabi* 2016-17, among the crops, maize cultivated for green cobs removed significantly higher nitrogen (76.6 kg ha⁻¹), phosphorus (19.5 kg ha⁻¹) and potassium (100.6 kg ha⁻¹) than all other crops and cropping systems tested and potato crop removed the lowest quantities of nitrogen (8.4 kg ha⁻¹), and phosphorus (1.4 kg ha⁻¹), while potassium removal was lowest by sesame (7.7 kg ha⁻¹). Bt Cotton + green gram (1:2)–maize for green cobs system removed significantly higher nitrogen (189.2 kg ha⁻¹) and was closely followed by and on par with maize (Flat) + soybean (Raised Bed) – castor (F) + green gram (RB) (2:3) system (174.9 kg ha⁻¹) and Bt cotton + green gram (1:3) –pearl millet (174.0 kg ha⁻¹) while pear millet + soybean (3:2) - potato system removed lowest quantities of nitrogen (64.7 kg ha⁻¹) than all other crops and cropping systems tested. Removal of phosphorus was significantly more by maize based cropping systems *viz.*, maize -groundnut (39.3 kg ha⁻¹), maize (Flat) + soybean (Raised Bed) – castor (F) + green gram (RB) (2:3) system (35.4 kg ha⁻¹), maize – sunflower (33.2 kg ha⁻¹), maize + soybean

(2:3) – potato system (28.2 kg ha⁻¹), Bt Cotton + green gram (1:2)–maize for green cobs system (27.1 kg ha⁻¹) and when compared to all other cropping systems and removal was lowest by soybean-potato (7.6 kg ha⁻¹). Potassium removal was significantly different in all the systems, and was more by maize and Bt cotton based systems with significantly highest removal in Bt Cotton+ green gram (1:2) –maize for green cobs system (158.4 kg ha⁻¹) followed by on par removal with Bt Cotton+ green gram (1:2) + pearl millet system (140.9 kg ha⁻¹) while it was lowest by soybean - potato cropping sequence (45.4 kg ha⁻¹).

Soil Fertility

The soil pH, EC, OC and available nutrient status (nitrogen and potassium) values after the sequences did not differ significantly from the initial values (Table 4). However, availability of phosphorus was found to be influenced by various cropping systems. Higher available phosphorus was recorded after soybean crop during *kharif* in soybean-potato cropping system, but at the end of crop sequence no significant changes were recorded in soil fertility. It can be inferred that alternate systems gave better results in terms of productivity in comparison to prevailing maize-sunflower system in Southern Telangana Zone. Cotton + green gram (1:2)–maize for green cobs system recorded highest MEY (11803 kg ha⁻¹) with Rs 78,820 ha⁻¹ net returns followed by *Bt* cotton + soybean (1:3) – sesame + groundnut (T6) system (10155 kg ha⁻¹).

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How to cite this article:

Pragathi Kumari, Ch., S. Sridevi and Goverdhan, M. 2018. Profitable Cropping Systems for Southern Telangana Zone of Telangana State, India. *Int.J.Curr.Microbiol.App.Sci*. 7(01): 2518-2525. doi: <https://doi.org/10.20546/ijcmas.2018.701.302>