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Identification of Economically Viable Cropping Systems for Vertisols of Northern Telangana Zone

Firdoz Shahana[1*], M. Goverdhan[1], S. Sridevi[1] and B. Joseph[1]

[1]AICRP on Integrated Farming Systems, Sub Centre: Regional Sugarcane and Rice Research Station, Rudrur- 503188, Nizamabad District, Telangana State, India.

Authors' contributions

This work was carried out in collaboration among all authors. Author FS carried out field research study, managed the literature searches, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author MG is the principal investigator and designed the study. Author SS managed the analyses of the study. Author BJ supervised field observations during field level implementation. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during 2016-17 at AICRP on Integrated Farming Systems, Regional Sugarcane and Rice Research Station, Rudrur to diversify existing rice-rice cropping system with less water requiring crops under irrigated dry conditions for vertisols of Northern Telangana Zone. The experiment was laid out with twelve cropping systems as treatments in Randomized Block Design (RBD) with three replications. The twelve combinations of cropping systems tested during *kharif* and *rabi* seasons were rice – rice (check), maize + soybean (2:4) – tomato, maize + soybean (2:4) - rice, maize - sunflower + chickpea (2:4), maize - chickpea, *Bt* cotton + soybean (1:2) on broadbed – sesame + groundnut (2:4), *Bt* cotton - sesame + blackgram (2:4), soybean – wheat, soybean – sunflower + chickpea (2:4), turmeric – sesame, turmeric + soybean (1:2) on flat bed – bajra and turmeric + soybean (1:2) on broadbed – sesame + blackgram (2:4).

On system basis, significantly higher productivity in terms of rice equivalent yield (REY) of 23830 kg ha^{-1} was recorded with turmeric+soybean (1:2) BBF– sesame+blackgram (2:4) turmeric –

**Corresponding author: E-mail: shahanaagro34@gmail.com;*

sesame cropping sequence. However it was on par with turmeric – sesame and turmeric + soybean (1:2) on flat bed – bajra crop sequence with productivity of 23332 kg ha^{-1} and 21389 kg ha^{-1} respectively. Lower productivity was recorded with rice-rice cropping system (10725 kg ha^{-1}). Significantly higher system net returns were recorded with Bt. cotton – sesame + black gram (2:4) on BBF (Rs222838 ha^{-1}) closely followed by Bt Cotton + Soybean (1:2) (BBF) - Sesamum + Groundnut (2:4) (Rs221160 ha^{-1}) and Maize+soybean (2:4)–tomato (Rs212909 ha^{-1}). Lower system net returns were recorded in conventional rice-rice system (Rs88179 ha^{-1}). Bt. cotton – sesame + black gram (2:4) and Bt Cotton + Soybean (1:2) (BBF)- Sesamum + Groundnut ((2:4) and Maize+soybean (2:4)–tomato were economically superior with REE of 152.71%, 150.81% and 141.45%. Rice- Rice cropping adopted by majority of farmers is less productive and economically inferior indicating wider scope of diversifying existing rice- rice cropping system with high productive, economically viable cropping systems in vertisols of Northern Telangana Zone.

Keywords: Cropping systems; system productivity; net returns; production efficiency; economic efficiency.

1. INTRODUCTION

Rice followed by rice is the predominant cropping followed in vertisols of Northern Telangana Zone, Telangana, India Continuous cultivation of rice for longer periods with low system productivity, and often with poor crop management practices, results in loss of soil fertility due to emergence of multiple nutrient deficiency [1,2,3] and deterioration of soil physical properties [4] and decline in factor productivity and crop yields in high productivity areas [5]. During cultivation of rice, soil undergoes drastic changes, i.e. aerobic to anaerobic environment, leading to several physical and electro-chemical transformations. Crop diversification shows lot of promises in alleviating these problems besides, fulfilling basic needs for cereals, pulses, oilseeds and vegetables and, regulating farm income, withstanding weather aberrations, controlling price fluctuation, ensuring balanced food supply, conserving natural resources, reducing the chemical fertilizer and pesticide loads, ensuring environmental safety and creating employment opportunity [6]. Rice, which is high water requiring crop is affected due to less water availability and frequent dry spells during cropping season due to precarious rainfall situation for past few years coupled with depleting ground water resources. Avoiding resource depleting crop and identifying most productive, remunerative crops with less water requirement is necessary. Cropping system is one of the very important tool to augment the agricultural production. The approach involves sequential as well as intercropping and mixed cropping system aimed at efficient utilization of natural and manmade resources of production.

2. MATERIALS AND METHODS

A field experiment was conducted during 2016-17 at AICRP on Integrated Farming Systems, Regional Sugarcane and Rice Research Station, Rudrur to diversify existing rice-rice cropping system with less water requiring crops under irrigated dry conditions for vertisols of Northern Telangana Zone. The experiment was laid out with twelve cropping systems as treatments in Randomized Block Design (RBD) with three replications. The twelve combinations of cropping systems tested during *kharif* and *rabi* seasons were rice – rice (check), maize + soybean (2:4) – tomato, maize + soybean (2:4) - rice, maize - sunflower + chickpea (2:4), maize - chickpea, *Bt* cotton + soybean (1:2) on broadbed – sesame + groundnut (2:4), *Bt* cotton - sesame + blackgram (2:4), soybean – wheat, soybean – sunflower + chickpea (2:4), turmeric – sesame, turmeric + soybean (1:2) on flat bed – bajra and turmeric + soybean (1:2) on broadbed – sesame + blackgram (2:4).Since rice-rice is the predominant cropping system of the region all cropping systems performance was studied in comparision to rice-rice.

All kharif crops were sown during last week of June after receipt of wetting rainfall and 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 rice 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 [7].

3. RESULTS

3.1 Productivity of Crops and Cropping Systems

The performance of different crops in terms of rice equivalent yield (REY) during kharif, 016 indicated that higher productivity in terms of rice equivalent yield (20898 kg ha^{-1}) was recorded with sole turmeric However it was found to be at par with turmeric +soybean (1:2) on flat bed (18999 kg ha^{-1}) and turmeric +soybean (1:2) on broad bed (BBF) (18967 kg ha^{-1}) The lowest productivity was recorded with rice (5489 kg ha^{-1}) (Table 1). During rabi 2, tomato crop raised after maize+ soybean (2:4), recorded significantly highest REY of 11285 kg ha^{-1} over other tested crops or cropping systems. It was closely followed by Sunflower + Chickpea (2:4) raised after sole maize (7467kg ha^{-1}), Sunflower + Chickpea (2:4) raised after sole soybean (7438kg ha^{-1}) and Sesame + Groundnut (2:4) raised after Bt.cotton +soybean (1:2) on BBF (7386 kg ha^{-1}). Tomato 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.

On system basis, significantly higher productivity in terms of rice equivalent yield (REY) of 23830 kg ha^{-1} was recorded with turmeric+soybean (1:2) BBF– sesame+blackgram (2:4). However it was on par with sole turmeric – sesame and turmeric + soybean (1:2) on flat bed – bajra crop sequence with productivity of 23332 kg ha^{-1} and 21389 kg ha^{-1} respectively. Lower productivity was recorded with rice-rice cropping system (10725 kg ha^{-1}).

3.2 Economics of Crops and Cropping Systems

During kharif, profitability in terms of net returns was significantly higher (Rs 187200 ha^{-1}) on par with sole Bt Cotton (Rs 177259 ha^{-1}) closely followed by turmeric +soybean (1:2) on broad bed (Rs160578 ha^{-1}). Due to higher productivity recorded with sole turmeric, net returns were also higher any how lower cost of production with sole Bt cotton compared to sole turmeric has contributed for higher net returns from sole Bt.cotton. During rabi, net returns were significantly higher for tomato raised after maize+ soybean (2:4) (Rs120890 ha^{-1}) followed by Sesame + Groundnut (2:4) raised after Bt.cotton +soybean (1:2) (BBF) (Rs79424 ha^{-1}), Sunflower + Chickpea) (2:4) raised after sole maize (Rs78766 ha^{-1}) and Sunflower + Chickpea) (2:4) raised after soybean (Rs78342 ha^{-1}) over other cropping systems. Bajra raised after turmeric+soybean (1:2) and sesame raised after turmeric were less productive with REY of 2390 kg ha^{-1} and 2434 kg $ha^{-1}$and net returns of Rs13629 ha^{-1} and Rs 12030 ha^{-1}respectively.

System net returns were significantly higher with Bt. cotton – sesame + black gram (2:4) on BBF (Rs222838 ha^{-1}) closely followed by Bt Cotton + Soybean (1:2) (BBF) - Sesamum + Groundnut (2:4) (Rs221160 ha^{-1}) and Maize+soybean (2:4)– tomato (Rs212909 ha^{-1}). Kumar et al. (2008) also reported that inclusion of vegetable crops in rice-based crop sequences improved the netreturns. Growing vegetable crops during summer in areas with assured irrigation facilities is economically remunerative as supply of vegetables from rainfed areas is drastically reduced during summer and vegetable prices soar up. Therefore, excess of vegetables produced can be transported in areas of high demand. Lower system net returns were recorded in conventional rice-rice system (Rs88179 ha^{-1}).

3.3 Nutrient Uptake

Nutrient uptake by various crops and cropping systems varied significantly during kharif and rabi (Table 3).

3.4 Nitrogen Uptake

All the systems that have turmeric or Bt cotton or soybean as component crop in the cropping system removed more nitrogen over other crops. cropping systems Turmeric + Soybean (1:2 on flat bed) (240.70 kg ha^{-1}) and Turmeric + Soybean (1:2 on Broad bed) (216.53 kg ha^{-1}) removed significantly higher nitrogen and were on par with sole Bt.cotton (176.93 kg ha^{-1}) and Bt Cotton + Soybean (1:2 on BBF) (169.70 kg ha^{-1}). During rabi, sunflower+chickpea (2:4) raised after sole maize and sunflower+chickpea (2:4) raised after sole soybean removed significantly higher nitrogen 120.53 kg ha^{-1}, 117.03 kg ha^{-1} respectively followed by sesame+groundnut (2:4) raised after Bt.Cotton+soybean (1:2) on BBF (106.03 kg ha^{-1}) and tomato raised after maize+soybean (1:2) and 104.36 kg ha^{-1}.

Table 1. Productivity of crops under different cropping systems

Treatments		*Kharif*				*Rabi*				Rice Equivalent Yield (kg ha^{-1})				Productivity			Relative productive efficiency RPE (%)
Kharif	Rabi	Grain yield(Kg ha^{-1})		Straw/ Stoveryield (Kg ha^{-1})		Grain yield(Kg ha^{-1})		Straw/Stalk/ Stover yield (kg ha^{-1})		*Kharif*		*Rabi*		(REY -kg ha^{-1})			
		Main crop	Inter crop	Main crop	Inter crop	Main crop	Inter crop	Main crop	Inter crop	Grain	Straw	Grain	Straw	*Kharif*	*Rabi*	*System*	
T1	T1	4297	0	4756	0	4286	-	3979	-	4842	647	4830	406	5489	5236	10725	
T2	T2	5125	0	7639	0	1843	898	2730	3142	4759	1039	7396	71	5798	7467	13265	23.68
T3	T3	5750	650	6458	780	4337	-	3847	-	6566	932	4337	393	7498	4730	12228	14.01
T4	T4	5148	0	9782	0	591	875	845	3088	14569	0	4986	70	14569	5056	19836	82.98
T5	T5	2290	0	2702	0	1814	917	2687	3028	4323	184	7370	69	5507	7438	11967	20.70
T6	T6	2242	1208	4259	1450	584	1758	893	5329	8624	99	7033	353	12822	7386	20215	88.42
T7	T7	2583	0	2832	0	4374	-	1821	-	4876	193	4835	186	9102	5021	14123	31.68
T8	T8	5120	0	4978	0	701	-	1085	-	20898	0	2434	0	20898	2434	23332	117.55
T9	T9	5085	0	8112	0	1924	-	2340	-	4722	1104	5235	159	5825	5395	11220	4.62
T10	T10	3890	1585	3255	1902	2394	-	3289	-	18870	129	2166	224	18999	2390	21389	99.43
T11	T11	5650	715	7778	858	16589	-	2401	-	6596	1117	11285	0	7713	11285	18998	77.14
T12	T12	4010	1320	3886	1584	610	801	1084	2794	18859	108	4799	63	18967	4863	23830	122.19
S Em±		226.63	242.15	270.09	149.81	171.13	31.82	46.27	101.76	342.26	18.21	171.13	31.82	306.91	156.19	336.44	
CD (P=0.05)		668.97	714.80	797.27	442.22	505.15	93.25	137.04	34.46	1010.30	53.75	505.15	93.25	905.95	461.06	993.10	

Kharif Treatments

	Rice
	Maize
T3	*Maize + Soybean*
T4	*Bt Cotton*
T5	*Soybean*
T6	*Bt Cotton + Soybean (BBF)*
T7	*Soybean*
T8	*Turmeric*
T9	*Maize*
T10	*Turmeric + Soybean*
T11	*Maize + Soybean*
T12	*Turmeric + Soybean (BBF)*

Rabi Treatments

T1	*Rice*
T2	*Sunflower + Chickpea*
T3	*Rice*
T4	*Sesamum + Blackgram*
T5	*Sunflower + Chickpea*
T6	*Sesamum + Groundnut (BBF)*
T7	*Wheat*
T8	*Sesamum*
T9	*Chickpea*
T10	*Bajra*
T11	*Tomato*
T12	*Sesamum + Blackgram (BBF)*

Table 2. Economics of different cropping systems

Treatment		*Kharif*				*Rabi*				System Net returns		Relative economy efficiency REE (%)
				Net returns				Net returns				
Kharif	*Rabi*	Cost of cultivation (Rs. ha-$^{-1}$)	Gross returns (Rs. ha^{-1})	Rs. ha^{-1}	Rs. Re^{-1}	Cost of cultivation (Rs. ha-$^{-1}$)	Gross returns (Rs. ha^{-1})	Rs. ha^{-1}	Rs. Re^{-1}	Rs. ha^{-1}	Rs. Re^{-1}	
Rice	Rice	45000	72663	27663	0.54	48000	68973	20973	0.44	88179	0.46	-
Maize	Sunflower + Chickpea(2:4)	30000	85235	55235	1.54	31000	109766	78766	2.54	134001	1.74	51.96
Maize + Soybean(2:4)	Rice	35500	109440	73940	1.54	48000	69818	21818	0.45	95759	0.92	8.60
Bt Cotton	Sesame + Black gram(2:4)	58750	217259	177259	3.27	28750	74329	45579	1.59	222838	2.43	152.71
Soybean	Sunflower + Chickpea	27500	66576	39076	1.05	31000	109342	78342	2.53	117418	1.49	33.16
Bt Cotton + Soybean (BBF)(1:2)	Sesame + Groundnut (2:4)	46750	188486	141736	2.16	29250	108674	79424	2.72	221160	2.13	150.81
Soybean	Wheat	27500	133795	106295	2.93	28550	73809	51259	2.27	157554	1.81	78.68
Turmeric	Sesame	120000	307200	187200	1.25	23750	35780	12030	0.51	199230	1.11	125.94
Maize	Chickpea	30000	85629	55629	1.48	22550	79300	56750	2.52	112379	1.67	27.44
Turmeric + Soybean(1:2)	Bajra	125500	270030	144530	0.95	21500	35129	13629	0.63	158159	0.90	79.36
Maize + Soybean	Tomato	35500	112519	77019	1.60	45000	165890	120890	2.69	212909	2.39	141.45
Turmeric + Soybean (BBF)(1:2)	Sesame + Black gram (2:4)	126800	287378	160578	1.03	28750	71481	42731	1.49	203309	1.06	130.56
S Em±		-	-	4990	0.36	-	-	2675	0.089	5,206	0.28	-
CD (P=0.05)		-	-	14729	1.06	-	-	7895	0.262	15,367	0.83	-

Table 3. Nutrient uptake (Nitrogen, Phosphorus and Potassium (kg ha^{-1}) by different cropping systems

Cropping system		Kharif			Rabi			System		
Kharif	**Rabi**	**Nitrogen**	**Phosphorus**	**Potassium**	**Nitrogen**	**Phosphorus**	**Potassium**	**Nitrogen**	**Phosphorus**	**Potassium**
Rice	Rice	65.59	16.94	74.04	65.67	16.62	64.73	131.25	33.56	138.77
Maize	Sunflower + Chickpea(2:4)	105.59	31.68	102.45	120.53	22.84	50.55	226.12	54.53	153.01
Maize + Soybean(2:4)	Rice	162.42	57.57	163.49	65.00	14.71	66.41	227.42	72.28	229.90
Bt Cotton	Sesame + Black gram(2:4)	176.93	11.00	132.72	65.93	8.03	22.70	242.86	19.03	155.42
Soybean	Sunflower + Chickpea(2:4)	158.05	13.72	63.37	117.03	20.62	50.04	275.08	34.34	113.41
Bt Cotton + Soybean (BBF)(1:2)	Sesame + Groundnut (2:4)	169.70	13.81	108.26	106.03	13.57	26.01	275.73	27.38	134.27
Soybean	Wheat	160.89	13.08	60.24	41.60	6.89	34.10	202.49	19.97	94.34
Turmeric	Sesame	153.90	19.79	128.67	24.10	5.04	10.41	178.00	24.83	139.08
Maize	Chickpea	111.54	31.86	137.60	76.17	13.09	48.50	187.71	44.95	186.10
Turmeric + Soybean(1:2)	Bajra	227.69	24.67	146.16	67.90	14.86	98.72	295.59	39.53	244.88
Maize + Soybean(2:4)	Tomato	140.45	52.35	152.15	104.37	69.41	178.83	244.81	121.75	330.98
Turmeric + Soybean (BBF)(1:2)	Sesame + Black gram (2:4)	216.56	21.61	141.88	63.13	8.00	23.32	279.70	29.60	165.20
S Em±		73.51	13.46	31.05	7.24	2.40	10.87	74.27	14.21	26.80
CD (P=0.05)		24.90	4.56	10.52	2.45	0.81	3.68	25.16	4.81	9.07

Table 4. Soil fertility status in postharvest soils of rabi

Cropping system		pH	E C (dS m^{-1})	OC (%)	Available. N kg ha^{-1}	Available.P_2O_5 kg ha^{-1}	Available.K_2O kg ha^{-1}
Initial		6. 70	0.55	0.46	169.54	39.6	305
Rice	Rice	6.78	0.60	0.52	161.2	36.3	332.1
Maize	Sunflower + Chickpea(2:4)	7.23	0.59	0.55	204.6	37.1	326.5
Maize + Soybean(2:4)	Rice	7.11	0.62	0.58	190.4	39.8	305.4
Bt Cotton	Sesame + Black gram(2:4)	7.18	0.58	0.61	221.5	43.8	386.4
Soybean	Sunflower + Chickpea(2:4)	7.20	0.62	0.58	214.3	34.9	324.7
Bt Cotton + Soybean (BBF)(1:2)	Sesame + Groundnut (2:4)	7.29	0.57	0.64	227.4	45.3	402.4
Soybean	Wheat	7.11	0.63	0.60	186.3	36.5	406.7
Turmeric	Sesame	7.29	0.58	0.57	178.2	38.1	425.1
Maize	Chickpea	7.27	0.62	0.61	180.5	43.1	416.2
Turmeric + Soybean(1:2)	Bajra	7.27	0.60	0.49	200.2	38.8	431.3
Maize + Soybean(2:4)	Tomato	7.20	0.62	0.62	195.89	36.5	422.0
Turmeric + Soybean (BBF)(1:2)	Sesame + Black gram (2:4)	7.27	0.61	0.58	222.4	43.5	405.3
S Em±		0.04	0.01	0.03	5.88	2.79	18.13
CD (P=0.05)		0.12	NS	0.08	17.35	NS	53.52

On system basis, significantly higher nitrogen uptake was recorded with Turmeric + Soybean (1:2 on flat bed)-Bajra cropping system (295.59 kg ha^{-1}). However it was on par with other cropping systems Turmeric + Soybean (BBF) (1:2)- Sesame + Black gram (2:4), Bt Cotton + Soybean (BBF) (1:2)- Sesame + Groundnut (2:4), Soybean- Sunflower + Chickpea (2:4) with uptake of 279.70 kg ha^{-1}, 275.73 kg ha^{-1}, 275.08 kg ha^{-1} respectively.

3.5 Phosphorus Uptake

During kharif, significantly higher phosphorus uptake was observed with maize+soybean (2:4) 57.57 kg $ha^{-1}$and 52.35 kg ha^{-1}, while during rabi, tomato raised after maize+soybean (2:4) removed significantly higher phosphorus 69.41 kg ha^{-1}.

System phosphorus uptake was significantly higher with Maize+Soybean (2:4) –Tomato cropping system (121.75 kg ha^{-1}) followed by Maize+Soybean (2:4)-rice (72.28 kg ha^{-1}).

3.6 Potassium Uptake

During kharif, significantly higher potassium uptake was with maize+soybean (2:4) 163.49 kg ha^{-1} and 152.15 kg ha^{-1} on par with Turmeric + Soybean (1:2 on flat bed) (146.16 kg ha^{-1}) and Turmeric + Soybean (1:2 on Broad bed) (141.88 kg ha^{-1}) respectively. During rabi, potassium uptake was significantly higher with tomato crop raised after maize+soybean (2:4) 178.83 kg ha^{-1} followed by bajra raised after turmeric+soybean (1:2) 98.72 kg ha^{-1}.

Cropping system Maize+Soybean (2:4) –Tomato recorded significantly higher potassium uptake (121.75 kg ha^{-1}) followed by Turmeric + Soybean (1:2) on flat bed-Bajra cropping system 244.88 kg ha^{-1}.

3.7 Soil Fertility

The soil pH, EC, OC and available nutrient status (nitrogen, phosphorus and potassium) values after the sequences differed significantly at the end of crop sequence. No significant changes were observed for EC values, however slight changes were observed between cropping sequences for pH and OC. Rice-rice cropping sequence soil pH was just above the acidic range 6.78 but in other cropping systems it was above 7.1 more favourable for crop growth. Inclusion of legumes in cropping sequence has increased soil organic carbon and soil available nitrogen and phosphorus over rice-rice cropping system. Trend in available soil potassium was not clear but cropping system Turmeric + Soybean (1:2) on flat bed – bajra and Maize + Soybean (2:4)-tomato recorded higher values of 431.3 kg ha^{-1} and 422.0 kg ha^{-1}.

4. DISCUSSION

Among twelve cropping systems studied, except soybean –wheat, maize –chickpea and maize +soybean (2:4) cropping systems relative production efficiency (RPE) of all cropping systems was more than 20 indicating better performance of these cropping systems over existing rice-rice cropping system. Higher RPE values were recorded with cropping system turmeric + soybean (1:2) (BBF)- Sesame + blackgram (2:4) (122.19%) followed by turmeric-sesame (117.55%). Economic evaluation of cropping systems in terms of relative economic efficiency (REE) revealed that cotton based cropping systems were superior which may be attributed to lower cost of production compared to turmeric. This was due to increased proportion of net returns in relation to cost of cultivation. Similar results were also observed by Singh et al. (2011). Bt. cotton – sesame + black gram (2:4) and Bt Cotton+Soybean (1:2) (BBF)- Sesame + Groundnut ((2:4) and Maize+soybean (2:4)– tomato were economically superior with REE of 152.71%, 150.81% and 141.45%.

5. CONCLUSION

From the above study it can be concluded that rice- rice cropping adopted by majority of farmers in Telangana state is resource(water) demanding and less productive and economically inferior indicating wider scope of diversifying existing rice- rice cropping system with high productive, economically viable cropping systems sole Bt. cotton – sesame + black gram (2:4) and Bt Cotton + Soybean (1:2) (BBF)- Sesame + Groundnut (2:4) and Maize+soybean (2:4)– tomato in vertisols of Northern Telangana Zone making agriculture a viable enterprise.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Fujisaka S, Harrington L, Hobbs P. Rice–wheat in South Asia: Systems and long-

term priorities established through diagnostic research. Agric. Syst. 1994;46:169–187.
2. Singh J, Singh JP. Land degradation and economic sustainability. Ecol. Econ. 1995;15:77–86.
3. Dwivedi BS, Shukla AK, Singh VK, Yadav RL. Results of participatory diagnosis of constraints and opportunities (PDCO) based trials from the state of Uttar Pradesh. In: Subba Rao, A., Srivastava, S. (Eds.), Development of Farmers' Resource-Based Integrated Plant Nutrient Supply Systems: Experience of a FAO–ICAR–IFFCO Collaborative Project and AICRP on Soil Test Crop Response Correlation. IISS, Bhopal, India. 2009;50–75.
4. Tripathi RP. Physical properties and tillage of rice soils in rice–wheat system. In: Pandey, R.K., Dwivedi, B.S., Sharma, A.K. (Eds.), Rice–wheat Cropping System. PDCSR, Modipuram, India. 1992;53–67.
5. Yadav RL. Factor productivity trends in a rice–wheat cropping system under long-term use of chemical fertilizers. Exp. Agric. 1998;34:1–18.
6. Gill MS, Ahlawat IPS. Crop diversification - its role towards sustainability and profitability. Indian Journal of Fertilizers. 2006;2(9):125-138,150.
7. Jackson ML. Soil chemical analysis. Prentice Hall of India, Pvt. Ltd. New Delhi. Physiology. 1973;10:400-403.

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