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Profitability of cropping systems module for different farming systems in Southern Telangana zone of Telangana state

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Abstract
A field experiment was conducted during the year 2017-18 at college farm, AICRP on Integrated Farming Systems unit, PJTSAU, Hyderabad to identify the profitable cropping systems for different farming systems under I.D situation in light textured soils of Southern Telangana Zone (STZ), Telangana. Among the ten cropping systems tested, sweet corn – vegetable system (tomato) was found to be more remunerative with B:C ratio 3.60 followed by okra –marigold - beetroot system with B:C ratio 2.85. Among the ecological cropping systems for improving soil health, Bt cotton + greengram (1:3) - groundnut cropping system was recorded significantly higher rice grain equivalent yield (13,293 kg ha^{-1}) and net returns (1,17,048 Rs ha^{-1}) compared to pigeonpea + greengram (1:7) – sesame cropping system. Out of the two systems tested to meet the household nutritional security, pigeonpea + maize (1:3) – groundnut system recorded higher rice grain equivalent yield (13850 kg ha^{-1}) with higher net returns (123506 Rs ha^{-1}). Within the two fodder crops/cropping systems, fodder maize – lucerne system was resulted in higher B:C ratio (1.61). Rice - maize and Bt cotton which were the pre-dominant cropping systems of the region wherein rice – maize system recorded comparatively higher B:C ratio (1.28) than Bt cotton (1.08).

Keywords: Cropping systems, crop diversification, rice grain equivalent yield (RGEY), system productivity and system profitability

Introduction
Gangwar and Ram (2005) [3] reported that inclusion of legumes in cropping systems under intensification and interruptive approaches, as per resource availability, led to considerable improvement in productivity and profitability on the one hand and soil fertility, on the other hand. At present, cultivars are heavy feeders resulting in an unfavourable effect on the sustainability of soil productivity. There is a pressing need to meet the varied food grain and other nutritional requirements of the growing population and to sustain a higher productivity level. Hence, there is an urgency to diversify present cropping pattern into new areas like vegetables, fodder, oilseeds, pulses and allied fields crops. Crop diversification has been identified as an effective tool for achieving the objectives of food security, nutrition security, income growth, poverty alleviation, employment generation, sustainable agriculture development, environmental improvement and the judicious use of land and water resources (Hedge *et al*., 2003) [4]. Rice, maize and Bt cotton are the predominant crops which are either grown solely or in rotation with other crops in the Sothern Telangana Zone. As all are exhaustive, non–leguminous in nature cropping systems are to be identified to compliment the crops and to improve soil suitability in cropping system module. Several workers (Ravisankar *et al*., 2007, Jayanthi *et al*., 2003 and Rangaswamy *et al*., 1995) [9, 5, 8] in the recent past reported that the productivity and income is far higher when integrated farming systems are practiced than crops alone. In view of this farming system perspective, inclusion of ecological cropping systems, involving pulses / green manures and other crops for improving soil health, cropping system involving cereals / pulses / oilseeds to meet the household nutritional security, cropping system for round the year green / dry fodder production and cropping systems involving vegetables and other high value crops are to be studied for their productivity and sustainability.

Material and Methods
The study was conducted at college farm, All India Coordinated Research Project on Integrated Farming Systems unit, Professor Jayashankar Telangana Sate Agricultural University, Rajendranagr, Hyderabad during 2017-18.

The soil was sandy loam, low in organic carbon (0.39%), available nitrogen (112 kg ha $^{-1}$), medium in available phosphorus (23.4 kg ha^{-1}) and available potassium (170 kg ha^{-1}). The treatments consisted of ten crop sequences. The experiment was laid out in RBD, replicated thrice and the site of the experimental field was same through out the experimentation. The varieties of different crops used were Rice - RNR - 15048, Groundnut – K 6, Greengram- MGG 295, Pigeon pea – PRG 176, Sesamum- Swetha thil, Finger millet – Hima, Fodder sorghum – CSH 24 MF and Fodder cowpea – Vijaya. Crops were raised under irrigated conditions with recommended package of practices of the region. In the context of identifying best crops and cropping systems that are suitable for farming systems of Southern Telangana Zone of Telangana state, various combination of crop sequences were studied. The ten combinations of cropping systems tested during *kharif*, *rabi* and summer seasons were grouped in to five subsets. They are pre-dominant cropping systems of the region (T_1 & T_2), T_1: rice - maize, T_2: Bt cotton, second sub set (T_3 and T_4) included ecological cropping systems involving pulses for improving soil health viz., T_3: Bt cotton + greengram (1:3) - groundnut, T_4: pigeonpea + greengram (1:6) - sesame, under cropping system involving cereals / pulses / oilseeds to meet the household nutritional security (T_5 & T_6) T_5 : pigeonpea + maize (1:3)-groundnut, T_6: pigeonpea + groundnut (1:7) - ragi, within cropping systems for round the year green / dry fodder production (T_7 & T_8) T_7: fodder sorghum + fodder cowpea (1:2) – horsegram - sunhemp, T_8: fodder maize - lucerne, under cropping systems involving vegetables and other high value crops for income enhancement (T_9 & T_{10}) T_9 : sweet corn -vegetables (tomato), T_{10}: okra – marigold – beetroot. All the *kharif* crops were sown on 13.07.2017 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 yields 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 grain equivalent yield on price basis. Hence, it was felt necessary to work out a location specific cropping system for Southern Telangana Zone (STZ) of Telangana, which can utilize resources judiciously to maximize return, protect the environment and meet the day-to-day nutritional requirements of human and livestock.

Results and Discussion

The performance of different crops in terms of rice grain equivalent yield during *kharif* 2017 indicated that sweet corn crop (T_9) recorded significantly higher rice grain equivalent yield over other crops evaluated in different cropping systems (Table 1). Sweet corn and okra were tested under cropping systems involving vegetables and other high value crops for income enhancement and sweet corn with RGEY of 10379 kg and net returns of Rs.1,06,628 was found to be more remunerative than okra with RGEY of 6317 kg ha^{-1} and net returns of 55,611 Rs ha^{-1}. Among the ecological cropping systems involving pulses for improving soil health, Bt cotton + greengram (1:3) cropping system recorded significantly higher rice grain equivalent yield (7012 kg ha^{-1}) and net returns (58436 Rs ha^{-1}) than pigeonpea + greengram (1:3) (5594 kg ha^{-1}) cropping system. However, both the systems generated on par net returns. Out of the two systems tested to meet the household nutritional security involving cereals / pulses / oilseeds, both pigeonpea + maize (1:3) and pigeonpea + groundnut (1:7) systems were on par with respect to rice grain equivalent yields (7406 and 7745 kg ha^{-1} respectively). Within the two fodder crops/cropping systems, fodder sorghum + fodder cowpea (1:2) (4521 kg ha^{-1}) and fodder maize (4523 kg ha^{-1}) systems were on par with each other in respect to RGEY. Rice and Bt cotton were the pre-dominant cropping systems of the region and recorded almost similar rice grain equivalent yields (6085 and 6108 kg ha^{-1} respectively). Sreerekha and Dhurva (2010) [7] reported that cotton hybrid - Bunny and variety - Narsimha inter cropped 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) were observed in cotton + mung intercropping than all other paired row cotton with intercrops (CICR, 2009 - 10) [2].

The performance of different crops in terms of rice grain equivalent yield during *rabi* and *summer* 2017-18 indicated that out of all the crops, tomato in sweet corn – vegetables (tomato) system was found to be more remunerative over other crops / cropping system evaluated during *rabi* (Table 2 & 4). Marigold – beetroot was tested under cropping systems involving vegetables and other high value crops for income enhancement, recorded higher RGEY and higher net returns (32,444 kg ha^{-1} with 2,67,758 Rs ha^{-1} net returns and 3.6 B: C ratio) compared to tomato in sweet corn – vegetables system(19,136 kg ha^{-1} with 2,51,412 Rs ha^{-1} net returns and 5.56 B: C ratio). However, because of having low cost of cultivation, tomato crop recorded higher B: C ratio compared to marigold – beetroot system. Among the ecological cropping systems involving pulses/green manures and other crops for improving soil health, groundnut crop recorded significantly higher rice grain equivalent yield (6281 kg ha^{-1}) and net returns (58612 Rs ha^{-1}) than sesame (2719 kg ha^{-1} and Rs.17396 Rs ha^{-1} respectively) crop. Out of the two systems tested to meet the household nutritional security involving cereals / pulses / oilseeds, groundnut crop recorded significantly higher rice grain equivalent yield (6444 kg ha^{-1}) and net returns (61135 Rs ha^{-1}) than ragi (2562 kg ha^{-1} RGEY with 16206 Rs ha^{-1} net returns). Out of the two fodder crops/cropping systems, lucerne crop (3937 kg ha^{-1}) resulted in higher rice grain equivalent yield compared to horsegram - sunhemp crops (2833 kg ha^{-1}). Maize and fallow were tested as pre-dominant cropping systems of the region in rabi after *kharif* rice and Bt cotton respectively and maize recorded higher rice grain equivalent yield of 5698 kgha^{-1} with net returns of 53,899 Rs ha^{-1}.

In the context of identifying best crops and cropping systems that are suitable for different farming systems of STZ of Telangana, various combinations of crop sequences were studied. Out of all the systems, okra - marigold - beet root system has given highest rice grain equivalent yield (38761 kg ha^{-1}) than other crop sequences. Sweet corn - vegetables (tomato) system was found to be the next best crop sequence with 29515 kg ha^{-1} rice grain equivalent yield, Rs.3,58,040 ha^{-1} net returns. Nevertheless, due to increased cost of cultivation in okra -marigold - beetroot cropping system, the sweet corn - vegetable system was more remunerative with BC ratio of 3.60 than okra – marigold - beetroot system in which BC ratio was 2.85. Among the ecological cropping systems involving pulses/green manures and other crops for improving soil

health, Bt cotton + greengram (1:3) - groundnut cropping system recorded significantly higher rice grain equivalent yield (13293 kg ha^{-1}) and net returns (117048 Rs ha^{-1}) than pigeonpea + greengram (1:6) - sesame (8313 kg ha^{-1} and Rs.75809 respectively) cropping system. Out of the two systems tested to meet the household nutritional security involving cereals / pulses / oilseeds, pigeonpea + maize (1:3) – groundnut system recorded higher rice grain equivalent yield (13850 kgha^{-1}) with high net returns (123506 Rs ha^{-1}) over pigeonpea + groundnut (1:7) - ragi system. Out of the two fodder crops/cropping systems, fodder maize – lucerne system resulted in higher B:C ratio (1.61) over fodder sorghum + fodder cow pea (1:2) - horsegram - sunhemp system (1.13). Rice – maize and Bt cotton were the pre-dominant cropping systems of the STZ, and recorded higher B:C ratio in case of rice – maize system (1.28) compared to Bt cotton alone (1.08). 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) [6]. 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) [2]. Banik and Sharma (2009) [1] also reported that cereal - legume intercropping systems were superior to mono cropping.

Table 1: Performance of crops in various cropping systems during *kharif*

Treatments Kharif-Rabi		Grain yield (kg ha^{-1})		Straw/ Stover yield (kg ha^{-1})		Productivity (Rice grain Equivalent Yield kg ha^{-1})			Profitability (Rs ha^{-1})			
						Grain	Straw	Total	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns	
											Rs. ha^{-1}	Rs. Re^{-1}
T1	Rice	5660	0	6592	0	5660	425	6085	45620	94322	48702	1.07
T2	Bt cotton	2162	0	5124	0	6026	83	6108	45570	94679	49109	1.08
T3	Bt cotton + Greengram (1:3)	2010	357	4765	737	6840	172	7012	50250	108686	58436	1.16
T4	Pigeonpea + Greengram (1:3)	1163	427	3817	875	5420	174	5594	28300	86713	58413	2.06
T5	Pigeon pea + Maize (1:3)	5752	475	7478	1636	6897	509	7406	52420	114791	62371	1.19
T6	Pigeon pea + Groundnut (1:7)	1212	1171	4089	1874	7316	429	7745	51250	120042	68792	1.34
T7	Fodder sorghum + Fodder Cow pea (1:2)	0	0	13523	14345	0	4521	4521	27230	70081	42851	1.57
T8	Fodder maize	0	0	35055	0	0	4523	4523	25120	70110	44990	1.79
T9	Sweet corn	13500	0	17252	0	8710	1670	10379	54250	160878	106628	1.97
T10	Bhendi	6500	0	1683	0	6290	27	6317	42310	97921	55611	1.31
S Em+								319				
CD (0.05)								955				
CV (%)								8.4				

Sale price for Grain (kg^{-1}) : Rice = Rs 15.5, Maize = Rs 14.25, Groundnut = Rs 42.50, Bhendi = Rs 15.00, Bt Cotton = Rs 43.20, Greengram = Rs 53.75, Pigeonpea = Rs 52.5, Sweet corn = Rs 10.00
Sale price for stover (kg^{-1}) : Rice = Rs 1.00 Maize = Rs 1.00, Bhendi = Rs 0.25, Groundnut = 3.00, Greengram = Rs 2.00, Bt cotton = 0.25, Pigeonpea = Rs 0.25, Fodder sorghum = Rs 2.00, Fodder cowpea = 3.00, Fodder maize = 2.00

Table 2: Performance of crops in various cropping systems during *rabi* and *summer*

Trt	Cropping sequence	Economic yield (kg ha^{-1})		Straw yield (kg ha^{-1})		Rice grain equivalent yield (kg ha^{-1})				
						Grain		Straw		Total
		Rabi	Summer	Rabi	Summer	Rabi	Summer	Rabi	Summer	
T1	Maize	5680	0	7384	0	5222	0	476	0	5698
T2	Fallow	0	0	0	0	0	0	0	0	0
T3	Groundnut	2112	0	2534	0	5791	0	490	0	6281
T4	Sesame	787	0	1739	0	2691	0	28	0	2719
T5	Groundnut	2166	0	2610	0	5939	0	505	0	6444
T6	Ragi	2031	0	4468	0	2490	0	72	0	2562
T7	Horsegram - Sunhemp	0	0	7520	19245	0	0	970	1863	2833
T8	Lucerne	0	0	30515	0	0	0	3937	0	3937
T9	Tomato	29512	0	5966	0	19040	0	96	0	19136
T10	Marie gold - Beetroot	11350	16000	6230	3300	21968	10322	100	54	32444
	SEm +									734
	CD (at 5%)									2198
	CV (%)									16

Sale price for grain (kg^{-1}) : Maize = Rs 14.25, Rice = Rs 15.50, Tomato = Rs 10.0, Groundnut = Rs 42.5, Sesame = Rs 53.0, Fingermillet = Rs 19.0, Marigold = Rs 30.00, Beetroot = Rs 10.00.
Sale price for stover (kg^{-1}) : Maize = Rs 1.00, Rice = Rs 1.00, Tomato = Rs 0.25, Groundnut =Rs 3.00, Sesame =Rs 0.25, Fingermillet = Rs 0.25, Horsegram = Rs 2.0, Sunhemp = Rs1.5, Lucerne = Rs 2.0, Marigold = Rs 0.25, Beetroot = Rs 1.00.

Table 3: Performance of crops in various cropping systems

Treatments		*Kharif* (2017)				*Rabi* (2017-18)		Summer (2017-18)		Rice Grain Equivalent Yield (kg ha^{-1})						Productivity			
Kharif-Rabi		Grain yield (kg ha^{-1})		Straw/ Stover yield (kg ha^{-1})		Grain Yield	Straw/Stalk/ Stover yield	Grain Yield	Stover yield	*Kharif*		*Rabi*		Summer		(RGEY kg ha^{-1})			
		Main crop	Inter crop	Main crop	Inter crop	(kg ha^{-1})	(kg ha^{-1})	(kg ha^{-1})	(kg ha^{-1})	Grain	Straw	Grain	Straw	Grain	Straw	*Kharif*	*Rabi*	*Summer*	*System*
T1	Rice-Maize	5660	0	6592	0	5680	7384	0	0	5660	425	5222	476	0	0	6085	5698	0	11783
T2	Bt Cotton	2162	0	5124	0	0	0	0	0	6026	83	0	0	0	0	6108	0	0	6108
T3	Bt.Cotton+Greengram (1:3)- Groundnut	2010	357	4765	737	2112	2534	0	0	6840	172	5791	490	0	0	7012	6281	0	13293
T4	Pigeon pea + Greengram (1:6) - Sesame	1163	427	3817	875	787	1739	0	0	5420	174	2691	28	0	0	5594	2719	0	8313
T5	Pigeonpea + Maize + (1:3) -Groundnut	475	5752	1636	7478	2166	2610	0	0	6897	509	5939	505	0	0	7406	6444	0	13850
T6	Pigeonpea + Groundnut (1:7) - Ragi	1212	1171	4089	1874	2031	4468	0	0	7316	429	2490	72	0	0	7745	2562	0	10307
T7	Fodder sorghum + Fodder cowpea (1:2) – Horsegram - Sunhemp	0	0	13523	14345	0	6520	0	19245	0	4521	0	841	0	1863	4521	841	1863	7225
T8	Fodder maize - Lucerne	0	0	35055	0	0	30515	0	0	0	4523	0	3937	0	0	4523	3937	0	8460
T9	Sweetcorn-Vegetables (Tomato)	13500	0	17252	0	29512	5966	0	0	8710	1670	19040	96	0	0	10379	19136	0	29515
T10	Okra – Marigold - Beetroot	6500	0	1683	0	11350	6230	16000	3300	6290	27	21968	100	10322	54	6317	22068	10376	38761
	S Em+															319	734		
	CD (0.05)															955	2198		
	CV (%)															8.4	16		

Sale price for Grain (kg^{-1}) : Rice = Rs 15.5, Maize = Rs 14.25, Groundnut = Rs 42.50, Bhendi = Rs 15.00, Bt Cotton = Rs 43.20, Greengram = Rs 53.75, Pigeonpea = Rs 52.5, Sweet corn = Rs 10.00, Maize = Rs 14.25, Tomato = Rs 10.0, Sesame = Rs 53.0, Fingermillet = Rs 19.0, Marigold = Rs 30.00, Beetroot = Rs 10.00.
Sale price for stover (kg^{-1}) : Rice = Rs 1.00 Maize = Rs 1.00, Bhendi = Rs 0.25, Groundnut = 3.00, Greengram = Rs 2.00, Bt cotton = 0.25, Pigeonpea = Rs 0.25, Fodder sorghum = Rs 2.00, Fodder cowpea = 3.00, Fodder maize = 2.00, Tomato = Rs 0.25 Sesame =Rs 0.25, Fingermillet = Rs 0.25, Horsegram = Rs 2.0, Sunhemp = Rs1.5, Lucerne = Rs 2.0, Marigold = Rs 0.25, Beetroot = Rs 1.00.

Table 4: Economics of crops in various cropping systems

Treatment		*Kharif*				*Rabi*				Summer				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		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. ha^{-1}	Rs. ha^{-1}	Rs. Re^{-1}	Rs ha^{-1}	Rs Re^{-1}
T1	Rice-Maize	45620	94322	48702	1.07	34425	88324	53899	1.57	0	0	0	0	102601	1.28
T2	Bt Cotton	45570	94679	49109	1.08	0	0	0	0.00	0	0	0	0	49109	1.08
T3	Bt.Cotton+Greengram (1:3)- Groundnut	50250	108686	58436	1.16	38750	97362	58612	1.51	0	0	0	0	117048	1.32
T4	Pigeon pea + Greengram (1:6) - Sesame	28300	86713	58413	2.06	24750	42146	17396	0.70	0	0	0	0	75809	1.43
T5	Pigeon pea+Maize (1:3)-Groundnut	52420	114791	62371	1.19	38750	99885	61135	1.58	0	0	0	0	123506	1.35
T6	Pigeonpea + Groundnut (1:7) - Ragi	51250	120042	68792	1.34	23500	39706	16206	0.69	0	0	0	0	84998	1.14
T7	Fodder sorghum + Fodder cowpea (1:2) – Horsegram - Sunhemp	27230	70081	42851	1.57	12875	11280	2165	0.17	13500	28868	15368	1.14	60384	1.13
T8	Fodder maize - Lucerne	25120	70110	44990	1.79	25120	61030	35910	1.43	0	0	0	0	80900	1.61
T9	Sweetcorn-Vegetables (Tomato)	54250	160878	106628	1.97	45200	296612	251412	5.56	0	0	0	0	358040	3.60
T10	Okra – Marigold - Beetroot	42310	97921	55611	1.31	74300	342058	267758	3.60	39500	160825	121325	3.07	444694	2.85

Sale price for Grain (kg^{-1}) : Rice = Rs 15.5, Maize = Rs 14.25, Groundnut = Rs 42.50, Bhendi = Rs 15.00, Bt Cotton = Rs 43.20, Greengram = Rs 53.75, Pigeonpea = Rs 52.5, Sweet corn = Rs 10.00, Maize = Rs 14.25, Tomato = Rs 10.0, Sesame = Rs 53.0, Fingermillet = Rs 19.0, Marigold = Rs 30.00, Beetroot = Rs 10.00.
Sale price for stover (kg^{-1}) : Rice = Rs 1.00 Maize = Rs 1.00, Bhendi = Rs 0.25, Groundnut = 3.00, Greengram = Rs 2.00, Bt cotton = 0.25, Pigeonpea = Rs 0.25, Fodder sorghum = Rs 2.00, Fodder cowpea = 3.00, Fodder maize = 2.00, Tomato = Rs 0.25 Sesame =Rs 0.25, Fingermillet = Rs 0.25, Horsegram = Rs 2.0, Sunhemp = Rs1.5, Lucerne = Rs 2.0, Marigold = Rs 0.25, Beetroot = Rs 1.00.

Conclusion

Under high value crops, sweet corn - vegetable system (tomato) was more remunerative followed by okra – marigold - beetroot system. Among the ecological cropping systems, Bt cotton + greengram (1:3) – groundnut, under the cropping systems for household nutritional security, pigeonpea + maize (1:3) - groundnut system, under two fodder crops/cropping systems, fodder maize – lucerne system and under pre-dominant cropping systems, rice – maize systems were most profitable and can be suggested for different farming systems of Southern Telangana Zone of Telangana.

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