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Cropping System Diversification for various Integrated Farming System Models in Telangana

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ABSTRACT: There is a need to develop location specific cropping systems as they are one of the best possible solutions to existing farming constraints. Diversified cropping systems provide stable and better income to farmers and helps in maintaining the sustainability. In this context, experimentation on determining system productivity and economics of diverse cropping systems for various farming systems under irrigated conditions in light textured soils of Southern Telangana Zone (STZ) was carried out at college farm, PJTSAU, Rajendranagar, Hyderabad, Telangana. Ten cropping systems were divided into five subsets in a Randomized Block Design (RBD) and replicated thrice. Sweet corn – vegetable (tomato) system was more profitable with highest B:C ratio (3.35) followed by okra –marigold - beetroot (2.66) among the all cropping systems. Bt cotton + greengram (1:3) – groundnut cropping system has obtained higher rice grain equivalent yield (15252 kg ha^{-1}) and net returns (Rs. 186368 ha^{-1}) over pigeonpea + greengram (1:6) – sesame cropping system between the two ecological cropping systems for improving soil health. Pigeonpea + maize (1:3) – groundnut system recorded higher rice grain equivalent yield (15492 kg ha^{-1}) with higher net returns (Rs. 194191 ha^{-1}) between the two systems tested to meet the household nutritional security. Fodder maize – lucerne system has recorded higher B:C ratio (1.87) between the two fodder crops/cropping systems. Rice - maize cropping system has recorded higher B:C ratio (1.54) compared to Bt cotton(1.53).

Keywords: Farming systems, Nutritional security, Telangana.

INTRODUCTION

Improvement of competent cropping systems, crop micro-environment alteration, and other support services are all essential adaptation measures for reducing the influence of natural hazards on crop growth, stabilizing crop production, and increasing farm profitability. The type of soil and climatic conditions in a region are crucial factors for sustenance and the acceptability of a crop, cropping system and cropping pattern. When choosing a crop or cropping system for region, overall agro-ecological environment along with potential production and monetary gain serve as guiding principles.

Crop diversification improves the profitability, reduces the pests, spreads out the labour more evenly, lessen risks from unusual weather by planting and harvesting at different times, and provide new sources of high value products (Reddy and Suresh 2009). Crop diversification holds a lot of promise, such as meeting basic needs for cereals, pulses, oilseeds, and vegetables, as well as regulating farm income, weather resiliency, ensuring a balanced food supply, conserving natural resources, reducing chemical fertilizer and pesticide loads, ensuring environmental safety, and creating job opportunities (Gill and Ahlawat 2006). Higher farm productivity could be attained along with nutritional security, social, economical and environmental benefits with the inclusion of more farm enterprises (Mynavathi and Jayanthi 2015).

The use of biological nitrogen fixation via legumes in a cropping system, as well as the maintenance of

increased soil organic matter, will aid in the development of soil fertility and a better physical and microbiological environment with better buffering capacity. Incorporating legumes into agricultural systems under intensification and interruptive techniques, depending on resource availability, resulted in significant increases in productivity and profitability on the one hand, as well as soil fertility on the other (Gangwar and Ram 2005).

Cultivars are currently heavy feeders, which has a negative impact on soil production sustainability. There is a pressing need to meet the diverse food grain and other nutritional needs of the rising population while also maintaining a greater level of output. As a result, there is a pressing need to expand current cropping patterns to include additional crops such as vegetables, feed, oilseeds, pulses, and associated field crops. Crop sequencing can help boost synergistic relationships between plants (Tanaka *et al*., 2005). As a result, component crop choices must be carefully planned in order to reap the benefits of synergy between them, resulting in more efficient resource utilization and increased total output (Anderson, 2005). Rice, maize, and Bt cotton are the most common crops farmed in the Sothern Telangana Zone, either alone or in rotation with other crops. Non–leguminous in nature cropping systems must be discovered to complement the crops and increase soil suitability in the cropping system module, since they are exhaustive. Several workers have recently stated that when integrated farming methods are used, productivity and income are significantly higher than when crops alone are used (Ravishankar *et al*., 2007; Jayanthi *et al*., 2003; Rangaswamy *et al*., 1995). In light of this farming system perspective, ecological cropping systems involving pulses/green manures and other crops for improving soil health, cropping systems involving cereals/pulses/oilseeds to meet household nutritional security, cropping systems for year-round green/dry fodder production, and cropping systems involving vegetables and other high-value crops should all be investigated for their productivity and sustainability.

MATERIALS AND METHODS

During 2020-21, the research was carried out at the college farm, PJTSAU, Rajendranagar, Hyderabad. Ten crop sequences were used in the treatments. The experiment was planned in RBD, duplicated three times. The soil was sandy loam, low in organic carbon (0.38%), available nitrogen (111 kg ha^{-1}), medium in available phosphorus (22.4 kg ha^{-1}) and available potassium (169 kg ha^{-1}). Various combinations of crop sequences were researched in the goal of discovering ideal cropping systems suitable for Southern Telangana Zone. The ten combinations of cropping systems (five sub sets) were examined during *kharif*, *rabi* and *summer* seasons. They are pre-dominant cropping systems of the region (T_1& T_2), T_1: rice - maize, T_2: Bt cotton alone, ecological cropping systems involving pulses for improving soil health (T_3 & T_4) T_3: Bt cotton + greengram (1:3) - groundnut, T_4: pigeonpea + greengram (1:6) - sesame, 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, 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, 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. *Kharif* crops were sown on 25-07-2020 and *rabi* crops were sown after the harvesting of *kharif* crops in respective plots. Yields were recorded at the end of each season and rice equivalent yield (REY) was calculated at the end of the cropping system cycle. System yield was obtained by adding REY of component crops and system economics was calculated on the basis of prevailing cost of inputs and market price of the produce. The objective of the study was to find out a profitable and location specific cropping systems for various farming systems of Telangana which are economical, eco-friendly with proper resource utilization.

RESULTS AND DISCUSSION

In *kharif* 2020, Bhendi has obtained higher rice grain equivalent yield (8902 kg ha^{-1}) compared to other crops tested in various cropping systems. Bhendi (8902 kg ha^{-1} with 123399 Rs. ha^{-1} net returns) was reported to be more profitable compared to sweet corn (8135 kg ha^{-1} and Rs.101585 net returns) between sweet corn and bhendi. Inclusion of vegetables like bhendi, tomato in cropping systems will lead to higher production efficiency as well as higher net returns which is because of grater production potential of vegetables (Jat *et al*., 2012). Bt cotton + greengram (1:3) cropping system has obtained higher rice grain equivalent yield (7923 kg ha^{-1} with Rs. 95973 ha^{-1}) compared to pigeon pea + greengram (1:3) (5388 kg ha^{-1} with 70,494 Rs. ha^{-1}) cropping system between the cropping systems for enhancing soil health. Between the intercropping systems, cotton + greengram has recorded significantly higher yield as well as productivity over the sole cotton crop and Kumar *et al*. (2016) reported that cotton + legumes intercropping system is highly beneficial because it only gives extra profit to farmers but also fixes atmospheric nitrogen. Pigeon pea + maize (1:3) and pigeon pea + groundnut (1:7) systems have recorded similar rice grain equivalent yields of 8022 and 7858 kg ha^{-1} respectively and at par with each other between the two systems tested to meet the household nutritional security. Legume + cereal based cropping system is always profitable and sustainable over other crop rotations (Yadav *et al*., 2017). Fodder sorghum + fodder cow pea (1:2) (4330 kg ha^{-1}) and fodder maize

(4019 kg ha^{-1}) systems were at par with each other between the two fodder cropping systems. Rice and Bt cotton have recorded similar rice grain equivalent yields with 5790 and 6342 kg ha^{-1} respectively (Table 1).

In *rabi* and *summer* 2020-21, marigold - beetroot has obtained higher rice grain equivalent yield (23959 kg ha^{-1}) as well as net returns (317034 Rs. ha^{-1}) compared to remaining crops (Table 2). Groundnut has obtained higher rice grain equivalent yield (7329 kg ha^{-1}) and net returns (90396 Rs. ha^{-1}) compared to sesame (3041 kg ha^{-1} with net returns of 30611 Rs. ha^{-1}) crop between the crops for improving soil health. Groundnut has obtained higher rice grain equivalent yield (7470 kg ha^{-1}) as well as net returns (Rs. 92983 ha^{-1}) compared to ragi between the two systems tested to meet the household nutritional security. Lucerne crop has obtained higher rice grain equivalent yield (4451 kg ha^{-1}) over horsegram-sunhemp crops between fodder cropping systems. Rice – Maize has obtained rice grain equivalent yield of 6450 kg ha^{-1} with net returns of Rs. 136919 ha^{-1}. Pragathi Kumari *et al.* (2020) have reported similar results on the study which was conducted with the same cropping systems.

Identification of different cropping systems module for different farming systems experiment at AICRP on IFS unit

Overall view of *Rabi* crops at AICRP on IFS unit

Pigeonpea (1)+Groundnut(7) intercropping

Highest rice grain equivalent yield was obtained in the okra–marigold–beetroot system (33145 kg ha^{-1}) compared to other cropping systems (Table 3 & 4). Okra–marigold–beetroot system has obtained rice grain equivalent yield of 33145 kg ha^{-1} with net returns of Rs. 440433 which is higher than sweet corn-tomato (23535 kg ha^{-1} & Rs. 335837) among the cropping systems with high value crops. Bt cotton + greengram (1:3) - groundnut cropping system has obtained higher rice grain equivalent yield (15252 kg ha^{-1}) and net returns (Rs. 186368 ha^{-1}) compared to pigeonpea + greengram (1:6) - sesame (Rs. 101105, 8429 kg ha^{-1}) system between the ecological cropping systems. However, due to lower cost of cultivation, pigeonpea + greengram (1:6) – sesame system has obtained higher B:C ratio compared to *Bt* cotton + greengram (1:3) - groundnut cropping system. Pigeonpea + maize (1:3) – groundnut system reported to be more profitable (15492 kg ha^{-1} RGEY with Rs. 194191 ha^{-1} net returns) than pigeonpea + groundnut (1:7) - ragi system (10937 kg ha^{-1} RGEY with Rs. 125635 ha^{-1} net returns) between the two systems to meet the household nutritional security. Fodder maize – lucerne system has obtained higher rice grain equivalent yield (8470 kg ha^{-1}) and net returns (Rs. 102728 ha^{-1}) than fodder sorghum + fodder cow pea (1:2) - horsegram – sunhemp system (6518 kg ha^{-1} with Rs. 64017) between the two fodder cropping systems Pragathi Kumari *et al*. (2019) reported similar findings with same cropping systems. Rice – maize system has obtained higher rice grain equivalent yield (12240 kg ha^{-1}) compared to Bt cotton-fallow (6342 kgha^{-1}).

Table 1: Performance of crops in various cropping systems during *kharif*, 2020.

Treatments			Grain Yield (kg ha^{-1})		Straw/ Stover yield (kg ha^{-1})		Productivity (Rice grain Equivalent Yield kg ha^{-1})			Profitability (Rs ha^{-1})			
										Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns	
							Grain	Straw	Total			Rs. ha^{-1}	Rs. Re^{-1}
A1	T1	Rice	5461	0	6207	0	5461	329	5790	46137	109311	63174	1.37
	T2	Bt cotton	2035	0	4685	0	6280	62	6342	47244	119729	72485	1.53
A2	T1	Bt cotton + Greengram (1:3)	1948	461	4451	926	7766	157	7923	53617	149590	95973	1.79
	T2	Pigeon pea + Greengram (1:6)	920	601	2928	1263	5215	173	5388	31233	101727	70494	2.26
A3	T1	Pigeon pea + Maize (1:3)	596	5823	1894	7463	7601	420	8022	50240	151449	101209	2.01
	T2	Pigeon pea + Groundnut (1:7)	869	1573	2751	2511	7157	701	7858	53499	148361	94862	1.77
A4	T1	Fodder sorghum + Fodder Cow pea (1:2)	0	0	12321	19034	0	4330	4330	30290	81746	51456	1.70
	T2	Fodder maize	0	0	37936	0	0	4019	4019	28644	75871	47227	1.65
A5	T1	Sweet corn	14217	0	17092	0	6777	1358	8135	52007	153592	101585	1.95
	T2	Bhendi	8375	0	2280	0	8872	30	8902	44671	168070	123399	2.76
	S Em+								472.0				
	CD (0.05)								1415.0				
	CV (%)								12.3				

Sale price for Grain (kg^{-1}) : Rice = Rs. 18.88, Maize = Rs. 18.5, Groundnut = Rs. 52.75, Bhendi = Rs. 20.00, Bt Cotton = Rs. 58.25, Greengram = Rs. 71.96, Pigeonpea = Rs. 60.0, Sweet corn = Rs. 9.00
Sale price for stover (kg^{-1}) : Rice = Rs. 1.00 Maize = Rs. 1.00, Bhendi = Rs. 0.25, Groundnut = 5.00, Greengram = Rs. 2.00, Sweet corn = Rs. 1.5, 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*, 2020-21.

Trt	Cropping sequence	Economic yield (kg ha^{-1})		Straw yield (kg ha^{-1})		Rice grain equivalent yield (kg ha^{-1})				
		Rabi	*Summer*	*Rabi*	*Summer*	Grain *Rabi*	*Summer*	Straw *Rabi*	*Summer*	Total
T1	Maize	6024		6916		6073		377		6450
T2	Fallow	0		0		0		0		0
T3	Groundnut	2192		3770		6032		1027		7329
T4	Sesame	806		2121		3012		29		3041
T5	Groundnut	2230		3890		6410		1060		7470
T6	Ragi	1717		3048		3038		42		3079
T7	Horsegram– Sunhemp			8401	15560	0		916	1272	2242
T8	Lucerne			40837		0		4451		4451
T9	Tomato	28120		5544		15324		76		15400
T10	Mariegold– Beetroot	12199	19266	6839	5190	13296	10499	93	71	23959
	CD (at 5%)									1493
	SEm+									499
	CV (%)									12

Sale price for grain (kg^{-1}): Maize = Rs. 18.5, Rice = Rs. 18.35, Tomato = Rs. 10.0, Groundnut = Rs. 52.75, Sesame = Rs. 68.55
Fingermillet = Rs. 31.5, Marigold = Rs. 20.00, Beetroot = Rs 10.00.
Sale price for stover (kg^{-1}): Maize = Rs. 1.00, Rice = Rs. 1.00, Tomato = Rs. 0.25, Groundnut = Rs. 5.00, Sesame = Rs. 0.25, Fingermillet = Rs. 0.25, Horsegram = Rs. 2.0, Sunhemp = Rs. 1.5, Lucerne = Rs. 2.0, Marigold = Rs. 0.25, Beetroot = Rs. 0.25

Table 3: Performance of crops in various cropping systems during 2020-21.

Treatments		*Kharif*(2020)				*Rabi* (2020-21)		Summer (2020-21)		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	5461	0	6207	0	6024	6916			5461	329	6073	377			5790	6450	0	12240
T2	Bt Cotton	2035	0	4685	0	0	0			6280	62	0	0			6342	0		6342
T3	Btcotton+Greengram (1:3)- Groundnut	1948	461	4451	926	2192	3770			7766	157	6302	1027			7923	7329	0	15252
T4	Pigeon pea + Greengram (1:6) – Sesame	920	601	2928	1263	806	2121			5215	173	3012	29			5388	3041	0	8429
T5	Pigeon pea+Maize (1:3)-Groundnut	596	5823	1894	7463	2230	3890			7601	420	6410	1060			8022	7470	0	15492
T6	Pigeonpea + Groundnut (1:7) – Ragi	869	1573	2751	2511	1770	3048			7157	701	3038	42			7858	3079	0	10937
T7	Fodder sorghum + Fodder cowpea (1:2) – Horsegram– Sunhemp	0	0	12321	19034		8401		15560	0	4330	0	916		1272	4330	916	1272	6518
T8	Fodder maize – Lucerne	0	0	37936	0		40837			0	4019	0	4451			4019	4451	0	8470
T9	Sweetcorn-Vegetables (Tomato)	14217	0	17092	0	28120	5544			6777	1358	15324	76			8135	15400	0	23535
T10	Okra – Marigold – Beetroot	8375	0	2280	0	12199	6839	19266	5190	8872	30	13296	93	10499	71	8902	13389	10570	33145
	S Em+															472	499		779
	CD (0.05)															1415	1493		2334
	CV (%)															12.3	12		9.61

Sale price for Grain (kg^{-1}) : Rice = Rs. 18.88, Maize = Rs. 18.5, Groundnut = Rs. 52.75, Bhendi = Rs. 20.00, Bt Cotton = Rs. 58.25, Greengram = Rs. 71.96, Pigeonpea = Rs. 60.0, Sweet corn = Rs 9.00, Sesame = Rs. 68.55, Fingermillet = Rs. 31.5, Marigold = Rs. 20.00, Beetroot = Rs 10.00.
Sale price for stover (kg^{-1}): Rice = Rs. 1.00 Maize = Rs. 1.00, Bhendi = Rs. 0.25, Groundnut = 5.00, Greengram = Rs. 2.00, Sweet corn = Rs. 1.5, 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 = Rs.1.5, Lucerne = Rs. 2.0, Marigold = Rs. 0.25, and Beetroot = Rs. 0.25

Table 4: Economics of crops in various cropping systems during 2020-21.

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	46137	109311	63174	1.37	42502	118360	75858	1.78	0	0	0	0	136919	1.54
T2	Bt Cotton	47244	119729	72485	1.53	0	0	0	0.00	0	0	0	0	72485	1.53
T3	Btcotton+Greengram (1:3)-Groundnut	53617	149590	95973	1.79	44100	134496	90396	2.05	0	0	0	0	186368	1.91
T4	Pigeon pea + Greengram (1:6) - Sesame	31233	101727	70494	2.26	25193	55804	30611	1.22	0	0	0	0	101105	1.79
T5	Pigeon pea+Maize (1:3)-Groundnut	50240	151449	101209	2.01	44100	137083	92983	2.11	0	0	0	0	194191	2.06
T6	Pigeonpea + Groundnut (1:7) –Ragi	53499	148361	94862	1.77	25733	56506	30773	1.20	0	0	0	0	125635	1.59
T7	Fodder sorghum + Fodder cowpea (1:2) – Horsegram - Sunhemp	30290	81746	51456	1.70	14994	16802	1808	0.12	12587	23340	10753	0.85	64017	1.11
T8	Fodder maize - Lucerne	28644	75871	47227	1.65	26173	81673	55500	2.12	0	0	0	0	102728	1.87
T9	Sweetcorn-Vegetables (Tomato)	52007	153592	101585	1.95	48330	282583	234253	4.85	0	0	0	0	335837	3.35
T10	Okra – Marigold - Beetroot	44671	168070	123399	2.76	75717	243980	168263,	2.22,	45186	192660	148771	3.29	440433	2.66

Sale price for Grain (kg^{-1}) : Rice = Rs. 18.35, Maize = Rs. 18.5, Groundnut = Rs. 52.75, Bhendi = Rs. 20.00, Bt Cotton = Rs. 58.25, Greengram = Rs. 71.96, Pigeonpea = Rs. 60.0, Sweet corn = Rs 9.0, Tomato = Rs. 10.0, Sesame = Rs. 68.55, Fingermillet = Rs. 31.5, Marigold = Rs. 20.00, Beetroot = Rs. 10.00. Sale price for stover (kg^{-1}) : Rice = Rs. 1.00 Maize = Rs. 1.00, Bhendi = Rs. 0.25, Groundnut = 5.00, 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 = Rs. 1.5, Lucerne = Rs. 2.0, Marigold = Rs. 0.25, Beetroot = Rs. 0.2

CONCLUSION

Global agriculture is impacted by climate change, urbanization, soaring population & demand. Crop diversification, more efficient water use, improved soil management practices, together with the development of suitable crops can help reduce some of the negative impacts. There is a need to develop cropping systems which are remunerative and will be suitable to local areas. Okra – marigold – beetroot system was more profitable followed by sweet corn - tomato system under commercial crops. Bt cotton + greengram (1:3) – groundnut, pigeonpea + maize (1:3) - groundnut, fodder maize – lucerne and rice – maize systems were found most remunerative in their respective subsets and could be well recommended for different farming systems under irrigated dry situation of Southern Telangana Zone.

FUTURE SCOPE

If the diversified cropping systems are developed, there is good opportunity to enhance farmer's income along with maintenance of sustainability. Further studies shall be done on development of location specific cropping systems which could be incorporated into farming systems. As climate change is the biggest challenge for farming community, it needs to mitigated with the help of cropping systems on which more studies can be done.

Conflict of Interest. None.

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