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Ch. Pragathi Kumari
Senior Scientist (Agronomy), AICRP on Integrated Farming Systems, PJTSAU, Hyderabad, Telangana, India

M Goverdhan
Principal Scientist (Agronomy) & Head, AICRP on IFS, PJTSAU, Hyderabad, Telangana, India

S Sridevi
Principal, Agricultural Polytechnic, Tornala, Siddipet District., PJTSAU, Hyderabad, Telangana, India

MV Ramana
Principal Scientist (Agronomy) & Head, Rice section, ARI, PJTSAU, Hyderabad, Telangana, India

G Kiran Reddy
Scientist (Soil Science), AICRP on IFS, PJTSAU, Hyderabad, Telangana, India

Md. Latheef Pasha
Senior Scientist (Agronomy), OFR Scheme, AICRP on IFS, PJTSAU, Hyderabad, Telangana, India

Correspondence
Ch. Pragathi Kumari
Senior Scientist (Agronomy), AICRP on Integrated Farming Systems, PJTSAU, Hyderabad, Telangana, India

Studies on productivity, nutrient uptake and post harvest nutrient availability in different cropping systems module for different farming systems in Telangana state

Ch. Pragathi Kumari, M Goverdhan, S Sridevi, MV Ramana, G Kiran Reddy and Md. Latheef Pasha

Abstract
A field experiment was conducted during the year 2017-18 at College farm, AICRP on Integrated Farming Systems unit, PJTSAU, Hyderabad to study the productivity, nutrient uptake and post harvest soil nutrient status in cropping systems for different farming systems under irrigated dry situation in light textured soils of Southern Telangana Zone (STZ), Telangana state. In the context of farming systems, under high value crops, okra–marigold–beetroot system recorded significantly higher rice grain equivalent yield (RGEY) (38761 kg ha^{-1}) over other systems. Among the ecological cropping systems for improving soil health, Bt cotton + greengram (1:3) - groundnut cropping system was recorded significantly higher RGEY (13,293 kg 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 RGEY (13850 kg ha^{-1}). Within the two fodder crops/cropping systems, fodder maize – lucerne system was resulted in higher RGEY (8460 kg ha^{-1}). Rice - maize and Bt cotton which were the pre-dominant cropping systems of the region wherein rice – maize system recorded comparatively higher RGEY (11783 kg ha^{-1}) than Bt cotton (1.08). Fodder systems were found to be more exhaustive than all other cropping systems. However, the changes in physic-chemical properties and soil fertility status were not significantly affected at the end of crop season.

Keywords: Crop diversification, rice grain equivalent yield (RGEY), system productivity, nutrient uptake, post harvest soil nutrient status

1. Introduction

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) [6]. Intercropping in different cropping systems is potentially beneficial system showing sustainable yield advantage over sole cropping and reduced risk. Intercropping of short duration cereals and pulses provides an opportunity to utilize of available resources more efficiently with enhancement of productivity of different cropping systems. Gangwar and Ram (2005) [5] 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. 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 sustainability in cropping system module. Several workers (Ravisankar *et al*., 2007, Jayanthi *et al*., 2003 and Rangaswamy *et al*., 1995) [10, 7, 9] in the recent past reported that the productivity and income is far higher when integrated farming systems are practiced than crops alone. Demand of fodder has been increased due to increase in dairy, sheep and goat units during last few decades in different farming systems. So, there is possibility of growing crops like fodder cowpea and fodder maize to solve the problem of fodder scarcity.

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 current 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 *kharif*, *rabi* and summer of 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 Randomised Block Design, replicated thrice and the site of the experimental field was same throughout the experimentation. The varieties of different crops used were rice - RNR - 15048, groundnut – K 6, greengram- MGG 295, pigeonpea – 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, 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 state, which can utilize resources judiciously to maximize returns, protect the environment and meet the day-to-day nutritional requirements of human and livestock. Grain and seed samples at harvesting stage were collected, oven dried and ground for analysis of nitrogen, phosphorous and potassium uptake. The total nitrogen content (%) in the dried plant sample was determined by microkjeldahl distillation method (Piper, 1966) [8]. The diacid extract (9:4 nitric acid: perchloric acid) was used for analysis of total phosphorus and potassium in plant samples. Concentration of nutrient was multiplied by yield for calculation of nutrient uptake.

Results and Discussion

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 higher RGEY (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} RGEY. 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 RGEY (13293 kg ha^{-1}) than pigeonpea + greengram (1:6) - sesame (8313 kg ha^{-1}) 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 RGEY (13850 kgha^{-1}) over pigeonpea + groundnut (1:7) - ragi system. Out of the two fodder crops/cropping systems, fodder maize – lucerne system resulted in higher RGEY (8460 kgha^{-1}) over fodder sorghum + fodder cow pea (1:2) - horsegram - sunhemp system. Rice – maize and Bt cotton were the pre-dominant cropping systems of the STZ, and recorded higher RGEY (11783 kgha^{-1}) in case of rice – maize system compared to Bt cotton alone (6108 kgha^{-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) [11]. 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 and Sharma (2009) [3] also reported that cereal - legume intercropping systems were superior to mono cropping. For instance, studies in the semi-arid tropics of India revealed that the addition of pigeonpea, as a sole crop or as an intercrop in a cropping system, not only helps in improving soil N fertility, but also makes more phosphorus reserves available for subsequent crops (Ae *et al*. 1991) [2].

During kharif, among the crops and cropping systems, fodder crops were found to be more exhaustive (Table 2.1). Out of the two fodder crops/cropping systems, fodder sorghum + fodder cow pea (1:2) system removed maximum nitrogen (259.3 kg ha^{-1}) and was followed by fodder maize (185.0 kg ha^{-1}). Among the ecological cropping systems involving pulses/green manures and other crops for improving soil health, nitrogen removal by both the systems was statistically on par. However, Bt cotton + greengram (1:3) cropping system removed slightly higher quantities of nitrogen (100 kg ha^{-1}) than pigeonpea + greengram (1:3) cropping system (85.5 kg ha^{-1}). 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 removed almost similar quantities of nitrogen with 132.5 and 130.0 kg ha^{-1} respectively. Sweet corn and okra were tested under cropping systems involving vegetables and other high value crops for income enhancement and sweet corn was found to be more exhaustive with 155.3 kg ha^{-1} nitrogen removal than okra (43.0 kg ha^{-1}). Rice and Bt cotton were tested as pre-dominant cropping systems (Check) of the region and nitrogen removal by both the crops was at par.

During *rabi* and summer (Table 2.4), marigold - beetroot removed maximum nitrogen (237.2 kg ha^{-1}) and was closely followed by lucerne crop (229.1 kg ha^{-1}). Lowest nutrient uptake was observed with sesame (32.0 kg ha^{-1}). In terms of system uptake, rice - maize and Bt cotton were tested as pre-dominant cropping systems (Check) of the region and nitrogen removal by rice -maize was higher (165.8 kg ha^{-1}). The system nitrogen uptake out of the two fodder crops/cropping systems was maximum with fodder sorghum + fodder cowpea (1:2) – horsegram - sunhemp fodder system (441.4 kg ha^{-1}) and was followed by fodder maize - lucerne system (414.1 kg ha^{-1}). Among the ecological cropping systems involving pulses/green manures and other crops for improving soil health, nitrogen removal by Bt cotton + greengram (1:3)- groundnut cropping system was slightly higher (162.1 kg ha^{-1}) than pigeonpea + greengram (1:6) – sesame cropping system (117.5 kg ha^{-1}). Out of the two systems tested to meet the household nutritional security, both pigeonpea+maize (1:3) - groundnut and pigeonpea + groundnut (1:7) – ragi systems removed almost similar quantities of nitrogen with 196.6 and 193.2 kg ha^{-1} respectively. Sweet corn - vegetables (tomato) system (342.6 kg ha^{-1}) and okra – marigold – beetroot (280.2 kg ha^{-1}) systems were tested under cropping systems involving vegetables and other high value crops for income enhancement and the former was found to be more exhaustive.

Phosphorus uptake

During *kharif*, among the crops and cropping systems tested sweet corn was found to be more exhaustive with higher phosphorus removal (Table 2.2). In case of fodder crops, both fodder sorghum + fodder cow pea (1:2) (22.5 kg ha^{-1}) and fodder maize (28.2 kg ha^{-1}) removed on par quantities of phosphorus. Among the ecological cropping systems for improving soil health, phosphorus removal by both the systems was statistically on par. However, Bt cotton + greengram (1:3) cropping system removed slightly higher quantities of phosphorus (10.7 kg ha^{-1}) than pigeonpea + greengram (1:3) cropping system (9.7 kg ha^{-1}). Out of the two systems tested to meet the household nutritional security, pigeonpea + maize (1:3) system removed significantly higher quantities of phosphorus (31.4 kg ha^{-1}) than pigeonpea + groundnut (1:7) system (14.3 kg ha^{-1}). Sweet corn and okra were tested under cropping systems for income enhancement and sweet corn was found to be more exhaustive with eight times higher phosphorus removal (71.4 kg ha^{-1}) than okra (9.0 kg ha^{-1}). Rice and Bt cotton were tested as pre-dominant cropping system of the region and phosphorus removal by rice (26.1 kg ha^{-1}) was significantly higher than Bt cotton (9.6 kg ha^{-1}).

During *rabi* and summer (Table 2.5), marigold - beetroot removed maximum phosphorus (38.3 kg ha^{-1}) and was closely followed by maize crop (30.7 kg ha^{-1}). Lowest nutrient uptake was observed with sesame (6.7 kg ha^{-1}). In terms of system uptake (Table 2.7), rice-maize and Bt cotton were tested as pre-dominant cropping systems (Check) of the region and phosphorus removal by rice-maize was (30.7 kg ha^{-1}). The system phosphorus uptake out of the two fodder crops was maximum with fodder maize - Lucerne system (41.2 kg ha^{-1}) and was followed by fodder sorghum + fodder cowpea (1:2) – horsegram - sunhemp fodder system (35.4 kg ha^{-1}), However statistically both the systems were at par. Among the ecological cropping systems for improving soil health, phosphorus removal by Bt cotton+greengram (1:3)- groundnut cropping system slightly higher (18.0 kg ha^{-1}) than pigeonpea + greengram (1:6) – sesame cropping system (16.4 kg ha^{-1}) and both were on par. Out of the two systems tested to meet the household nutritional security, pigeonpea+maize (1:3) - groundnut (38.7 kg ha^{-1}) removed significantly more phosphorus than pigeonpea + groundnut (1:7) – ragi system (23.0 kg ha^{-1}). Sweet corn-vegetables (tomato) system (94.9 kg ha^{-1}) and okra – marigold – beetroot (47.3 kg ha^{-1}) systems were tested under cropping systems involving vegetables and other high value crops for income enhancement and the former was found to be more exhaustive.

Potassium uptake

During *kharif*, similar to nitrogen removal, fodder crops were found to be more exhaustive among the crops and cropping systems with more potassium removal (Table 2.3). Out of the two fodder crops, fodder maize (344.5 kg ha^{-1}) removed significantly higher potassium than fodder sorghum + fodder Cow pea (1:2) system (155.1 kg ha^{-1}). Among the ecological cropping systems involving crops for improving soil health, Bt cotton + greengram (1:3) cropping system removed significantly higher quantities of potassium (62.7 kg ha^{-1}) than pigeonpea + greengram (1:3) cropping system (44.9 kg ha^{-1}). Out of the two systems tested to meet the household nutritional security, both pigeonpea + maize (1:3) removed significantly higher quantities of potassium (97.3 kg ha^{-1}) than pigeonpea + groundnut (1:7) system (55.7 kg ha^{-1}). Sweet corn and okra were tested under cropping systems for income enhancement and sweet corn was found to be three times more exhaustive with 209.7 kg ha^{-1} potassium removal than okra (63.9 kg ha^{-1}). Rice and Bt cotton were tested as pre-dominant cropping system of the region and potassium removal by rice crop (119.4 kg ha^{-1}) was two times higher than Bt cotton (62.3 kg ha^{-1}).

During *rabi* and summer (Table 2.6), horsegram - sunhemp (170.2 kg ha^{-1}) system removed maximum potassium and was followed by lucerne crop (154.4 kg ha^{-1}). Lowest nutrient uptake was observed with sesame (14.2 kg ha^{-1}). In terms of system uptake, rice-maize and Bt cotton were tested as pre-dominant cropping systems (Check) of the region and potassium removal by rice-maize was higher (202.5 kg ha^{-1}). The system potassium uptake, out of the two fodder crops/cropping systems was maximum with fodder maize – lucerne system (498.9 kg ha^{-1}) and was followed by fodder sorghum + fodder cowpea (1:2) – horsegram - sunhemp (325.3 kg ha^{-1}). Among the ecological cropping systems for improving soil health, potassium removal by Bt cotton+greengram (1:3)- groundnut cropping system slightly higher (79.3 kg ha^{-1}) than pigeonpea + greengram (1:6) – sesame cropping system (59.1 kg ha^{-1}). Among the two systems tested to meet the household nutritional, both pigeonpea + maize (1:3) - groundnut (114.6 kg ha^{-1}) removed higher quantities of potassium than pigeonpea + groundnut (1:7) – ragi system (78.8 kg ha^{-1}). Sweet corn-vegetables (tomato) system (304.2 kg ha^{-1}) and okra – marigold – beetroot (200.4 kg ha^{-1}) systems were tested under cropping systems involving vegetables and other high value crops for income enhancement and the former was found to be significantly more exhaustive.

Soil Fertility

The soil pH, EC, OC and available nutrient status of experiment were studied at the end of crop sequence (Table 3). Within one year of experimentation the changes in physic-chemical properties and soil fertility status were not significantly affected.

Table 1: 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	Pigeonpea + 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 2.1: Nitrogen uptake (kg ha^{-1}) by crops in various cropping systems during *kharif*.

Treatment		Grain			Stover			Total G+S
Crop /Cropping System (kharif)		Main crop	Inter crop	Total	Main crop	Inter crop	Total	
T1	Rice	56.5	0.0	56.5	37.6	0.0	37.6	94.1
T2	Bt cotton	36.1	0.0	36.1	55.5	0.0	55.5	91.6
T3	Bt cotton + Greengram (1:3)	31.4	9.3	40.7	51.1	8.2	59.3	100.0
T4	Pigeonpea + Greengram (1:3)	28.4	11.9	40.3	35.4	9.8	45.2	85.5
T5	Maize + Pigeonpea (1:3)	63.1	12.5	75.5	42.1	14.8	56.9	132.5
T6	Pigeonpea + Groundnut (1:7)	30.5	35.6	66.0	40.2	23.8	64.0	130.0
T7	Fodder sorghum + Fodder Cow pea (1:2)	0.0	0.0	0.0	118.8	140.5	259.3	259.3
T8	Fodder maize	0.0	0.0	0.0	185.0	0.0	185.0	185.0
T9	Sweet corn	68.8	0.0	68.8	86.5	0.0	86.5	155.3
T10	Bhendi	38.4	0.0	38.4	4.7	0.0	4.7	43.0
	SE(m)±						SE(m)	5.86
	CD @ 5%						C.D.	17.55
	CV(%)						C.V.	7.94

Table 2.2: Phosphorus uptake (kg ha^{-1}) by crops in various cropping systems during *kharif*.

Treatment		Grain			Stover			Total G+S
Crop /Cropping System (kharif)		Main crop	Inter crop	Total	Main crop	Inter crop	Total	
T1	Rice	17.3	0.0	17.3	8.8	0.0	8.8	26.1
T2	Bt cotton	5.0	0.0	5.0	4.6	0.0	4.6	9.6
T3	Bt cotton + Greengram (1:3)	4.9	1.0	5.8	4.2	0.7	4.9	10.7
T4	Pigeonpea + Greengram (1:3)	3.7	1.3	5.0	3.8	0.9	4.7	9.7
T5	Maize + Pigeonpea (3:1)	16.1	1.5	17.6	12.1	1.7	13.8	31.4
T6	Pigeonpea + Groundnut (1:7)	3.6	3.9	7.4	5.5	1.4	6.8	14.3
T7	Fodder sorghum + Fodder Cow pea (1:2)	0.0	0.0	0.0	9.0	13.5	22.5	22.5
T8	Fodder maize	0.0	0.0	0.0	28.2	0.0	28.2	28.2
T9	Sweet corn	14.3	0.0	14.3	57.2	0.0	57.2	71.4
T10	Bhendi	7.4	0.0	7.4	1.5	0.0	1.5	9.0
	SE(m)±							2.03
	CD @ 5%							6.07
	CV(%)							15.07

Table 2.3: Potassium uptake (kg ha^{-1}) by crops in various cropping systems during *kharif*.

Treatment		Grain			Stover			Total G+S
Crop /Cropping System (kharif)		Main crop	Inter crop	Total	Main crop	Inter crop	Total	
T1	Rice	27.6	0.0	27.6	91.9	0.0	91.9	119.4
T2	Bt cotton	16.5	0.0	16.5	45.8	0.0	45.8	62.3
T3	Bt cotton + Greengram (1:3)	15.6	2.7	18.3	41.5	2.9	44.4	62.7
T4	Pigeonpea + Greengram (1:3)	8.9	3.2	12.2	29.2	3.5	32.7	44.9
T5	Maize + Pigeonpea (1:3)	22.1	3.6	25.7	65.3	6.3	71.6	97.3
T6	Pigeonpea + Groundnut (1:7)	9.0	6.3	15.3	33.8	6.6	40.4	55.7
T7	Fodder sorghum + Fodder Cow pea (1:2)	0.0	0.0	0.0	106.3	48.8	155.1	155.1
T8	Fodder maize	0.0	0.0	0.0	344.5	0.0	344.5	344.5
T9	Sweet corn	20.8	0.0	20.8	188.8	0.0	188.8	209.7
T10	Bhendi	55.3	0.0	55.3	8.6	0.0	8.6	63.9
	SE(m)±							5.94
	CD @ 5%							17.78
	CV(%)							8.46

Table 2.4: Nitrogen uptake (kg ha^{-1}) by crops in various cropping systems during *rabi and summer*.

Treatment		Grain			Stover			Total (G+S)
Crop / CS (Rabi / Summer)		Rabi	Summer	Total	Rabi	Summer	Total	
T1	Maize	34.7	0.0	34.7	37.1	0.0	37.1	71.7
T2	Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Groundnut	53.3	0.0	53.3	8.8	0.0	8.8	62.1
T4	Sesame	17.8	0.0	17.8	14.2	0.0	14.2	32.0
T5	Groundnut	55.2	0.0	55.2	9.0	0.0	9.0	64.2
T6	Ragi	25.9	0.0	25.9	37.2	0.0	37.2	63.1
T7	Horsegram-Sunhemp	0.0	0.0	0.0	24.5	157.6	182.1	182.1
T8	Lucerne	0.0	0.0	0.0	229.1	0.0	229.1	229.1
T9	Tomato	175.8	0.0	175.8	11.4	0.0	11.4	187.2
T10	Marigold-Beetroot	65.6	129.3	194.9	31.6	10.7	42.2	237.2
	SE(m)±							6.16
	CD @ 5%							18.31
	CV(%)							9.46

Table 2.5: Phosphorus uptake (kg ha^{-1}) by crops in various cropping systems during *rabi and summer*.

Treatment		Grain			Stover			Total (G+S)
Rabi & summer		Rabi	Summer	Total	Rabi	Summer	Total	
T1	Maize	17.0	0.0	17.0	13.7	0.0	13.7	30.7
T2	Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Groundnut	6.1	0.0	6.1	1.2	0.0	1.2	7.3
T4	Sesame	2.8	0.0	2.8	3.9	0.0	3.9	6.7
T5	Groundnut	5.8	0.0	5.8	1.6	0.0	1.6	7.3
T6	Ragi	5.0	0.0	5.0	3.8	0.0	3.8	8.7
T7	Horsegram-Sunhemp	0.0	0.0	0.0	4.7	8.2	12.9	12.9
T8	Lucerne	0.0	0.0	0.0	12.9	0.0	12.9	12.9
T9	Tomato	22.2	0.0	22.2	1.3	0.0	1.3	23.5
T10	Marigold-Beetroot	12.4	22.5	35.0	2.0	1.4	3.4	38.3
	SE(m)±							0.71
	CD @ 5%							2.10
	CV(%)							8.23

Table 2.6: Potassium uptake (kg ha^{-1}) by crops in various cropping systems during *rabi and summer*.

Treatment		Grain			Stover			Total (G+S)
Crop / Crop System		Rabi	Summer	Total	Rabi	Summer	Total	
T1	Maize	27.2	0.0	27.2	55.9	0.0	55.9	83.0
T2	Fallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Groundnut	9.7	0.0	9.7	7.0	0.0	7.0	16.6
T4	Sesame	2.3	0.0	2.3	11.9	0.0	11.9	14.2
T5	Groundnut	10.0	0.0	10.0	7.3	0.0	7.3	17.3
T6	Ragi	5.4	0.0	5.4	17.7	0.0	17.7	23.0
T7	Horsegram-Sunhemp	0.0	0.0	0.0	30.0	140.2	170.2	170.2
T8	Lucerne	0.0	0.0	0.0	154.4	0.0	154.4	154.4
T9	Tomato	78.3	0.0	78.3	16.2	0.0	16.2	94.5
T10	Marigold-Beetroot	76.3	36.3	112.6	15.5	8.4	23.9	136.5
	SE(m)±							4.28
	CD @ 5%							12.73
	CV(%)							10.45

Table 2.7: Nutrient (Nitrogen, Phosphorus and Potassium) uptake by crops in various cropping systems during *kharif, rabi and summer*.

Treatment		Kharif uptake			Rabi uptake			System uptake		
		N	P	K	N	P	K	N	P	K
T1	Rice-Maize	94.1	26.1	119.4	71.7	30.7	83.0	165.8	56.8	202.5
T2	Bt Cotton	91.6	9.6	62.3	0.0	0.0	0.0	91.6	9.6	62.3
T3	Bt.Cotton+Greengram (1:3)- Groundnut	100.0	10.7	62.7	62.1	7.3	16.6	162.1	18.0	79.3
T4	Pigeon pea + Greengram (1:6) - Sesame	85.5	9.7	44.9	32.0	6.7	14.2	117.5	16.4	59.1
T5	Pigeon pea+Maize (1:3)-Groundnut	132.5	31.4	97.3	64.2	7.3	17.3	196.6	38.7	114.6
T6	Pigeonpea + Groundnut (1:7) - Ragi	130.0	14.3	55.7	63.1	8.7	23.0	193.2	23.0	78.8
T7	Fodder sorghum + Fodder cowpea (1:2) – Horsegram - Sunhemp	259.3	22.5	155.1	182.1	12.9	170.2	441.4	35.4	325.3
T8	Fodder maize - Lucerne	185.0	28.2	344.5	229.1	12.9	154.4	414.1	41.2	498.9
T9	Sweetcorn-Vegetables(Tomato)	155.3	71.4	209.7	187.2	23.5	94.5	342.6	94.9	304.2
T10	Okra – Marigold - Beetroot	43.0	9.0	63.9	237.2	38.3	136.5	280.2	47.3	200.4
	SE(m)±	5.9	6.5	5.9	6.2	0.7	4.3	9.5	2.1	6.0
	CD @ 5%	17.6	15.7	17.8	18.3	2.1	12.7	28.1	6.1	17.8
	CV(%)	8.0	15.7	8.5	9.5	8.2	10.5	6.8	9.4	5.4

Table 3: Changes in soil properties at the end of crop sequence.

Trt	Cropping sequence	pH	EC	OC	Avail. N	Avail. P	Avail. K
			(dS m^{-1})	(%)	kg ha^{-1}	kg ha^{-1}	kg ha^{-1}
	Initial	7.81	0.11	0.39	112.2	23.4	170.3
T1	Rice-Maize	7.48	0.18	0.30	106.2	19.1	180.8
T2	Bt Cotton	7.46	0.16	0.37	111.0	22.2	182.3
T3	Bt.Cotton+Greengram (1:3)- Groundnut	7.47	0.18	0.41	102.4	23.7	189.4
T4	Pigeonpea + Greengram (1:6) - Sesame	7.62	0.14	0.39	115.2	21.5	165.8
T5	Pigeonpea+Maize (1:3)-Groundnut	7.47	0.16	0.35	112.9	20.0	156.5
T6	Pigeonpea + Groundnut (1:7) - Ragi	7.62	0.15	0.40	101.6	20.6	162.1
T7	Fodder sorghum + Fodder cowpea (1:2) – Horsegram - Sunhemp	7.79	0.17	0.36	105.6	21.4	177.8
T8	Fodder maize - Lucerne	7.48	0.17	0.41	106.6	26.0	174.0
T9	Sweetcorn-Vegetables(Tomato)	7.62	0.14	0.37	105.0	26.0	200.2
T10	Okra – Marigold - Beetroot	7.45	0.17	0.42	110.0	24.3	158.7
	SEm ±	0.17	0.05	0.05	1.9	1.9	6.7
	CD @ 5%	NS	NS	NS	NS	NS	NS
	CV (%)	3.97	5.68	23.80	14.5	14.5	10.8

Conclusion

Among the various cropping systems studied for farming systems, under high value crops, 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 found most profitable and can be suggested for different farming systems of Southern Telangana Zone of Telangana.

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