Biological Forum – An International Journal **14(2): 1034-1040(2022)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Nutrient Uptake and Soil Fertility Status in Crop Sequences Module for different Integrated Farming System Models of Telangana State

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(Received 21 March 2022, Accepted 20 May, 2022)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: In order to develop the efficient integrated farming system models, cropping systems needs to be evaluated in terms of productivity, nutrient uptake and economics. Different cropping sequences in terms of nutrient uptake as well as soil fertility status in crop sequences module for different integrated farming system models in Telangana state were evaluated as a part of this study and results are presented here. Rice - maize and Bt cotton are grown by majority of farmers across the Telangana. Rice – maize system has attained higher nutrient uptake comparatively which has lead to higher rice grain equivalent yield than Bt cotton. Bt cotton + green gram (1:3) - groundnut cropping system has obtained significantly greater nutrient uptake as compared to redgram + green gram (1:6) – sesame cropping system in the cropping systems for protecting long term soil health. Among the crops growing for family nutritional security giving, pigeonpea + groundnut (1:7) - ragi has obtained significantly higher nutrient uptake as compared to redgram + maize (1:3) – groundnut system. Nutrient uptake of fodder maize – lucerne system was greater compared to fodder sorghum + fodder cowpea (1:2) – horsegram – sunhemp system between the two fodder cropping systems. In high value crops, okra–marigold–beetroot system has recorded higher N uptake whereas sweetcorn-vegetables (tomato) has obtained highest P & K uptake in the perspective of farming systems. It is found that fodder systems needs more amount of nutrients for their growth and development among all other cropping systems. Rice- maize, Bt cotton + green gram - groundnut, pigeonpea + groundnut - ragi, fodder maize – lucerne and sweet corn-vegetables (tomato) systems were found efficient and could be incorporated in different integrated farming system models in Telangana state.

Keywords: Nutrient uptake, Nutritional security, Telangana.

INTRODUCTION

The modern production systems have negatively impacted the nutrient balance as well as soil fertility (Karthik *et al.*, 2021). There is a need to provide food as well as nutritional security to ever burgeoning population while maintaining the sustainability which can be achieved through crop diversification. Pulses, oilseeds, vegetables and fodder crops need to be grown along with cereals to achieve food as well as nutritional security which is the main objective of crop diversification. More attention should be given to crop diversification which is a challenging aspect from farmer's point of view. Crop diversification is an effective method for obtaining food as well as nutritional security, economic growth, poverty alleviation, job creation, and sensible land and water resource management, as well as sustainable agriculture development and environmental improvement (Hedge *et al.*, 2003). Diversified cropping systems give multiple sources for food, enhance the land productivity and lessen the pest & disease infestation. Inclusion of legumes in cropping systems will have a positive impact on soil properties and protects the long term health of soil (Gangwar and Ram 2005). Intercropping short-duration cereals and pulses allows farmers to make better use of available resources while increasing the productivity and profitability of various cropping systems. Intercropping of redgram with groundnut protects the soil health and enhances the productivity (Kanyama-Phiri *et al*., 2008). This has been ascribed to the legumes' enhanced nitrogen (N) and organic matter (OM) input into the soil. The demand for fodder has increased in recent decades as the number of dairy units has increased in various farming systems. As a result, crops such as fodder cowpea and fodder maize might be grown to alleviate the problem of fodder scarcity.

Rice, maize, and Bt cotton are the primary crops being cultivated in the Southern Telangana Zone either alone or in rotation with other crops. As all the crops are non–leguminous in nature, some other cropping systems should be incorporated in the cropping system module to complement the crops and promote soil sustainability. Several workers (Ravishankar *et al.*, 2007; Jayanthi *et al.*, 2003; Rangaswamy *et al*., 1995) noticed that farming systems would improve the productivity which ultimately results in higher income compared to monocropping. Ecological cropping systems involving pulses for soil health, cereals, pulses, and oilseeds for family nutritional security, cropping systems for year-round green fodder production, and cropping systems involving vegetables and other high-value crops should all be investigated for their productivity and sustainability in light of this farming system perspective. The effectiveness of nutrients is determined by the choice of suitable nutrient management and crop sequencing. Nutrient uptake of any crop depends upon nutrient supply from soil along with application of external sources. Nutrients are used during the growth season in proportion to the demand for nutrients defined by the rising crop biomass. This investigation was conducted to find out the nutrient uptake and soil fertility status of various crops in cropping systems suitable for different farming system models in Telangana. Keeping this in mind, present study was conducted.

MATERIALS AND METHODS

A. Experimental site description

The study was conducted at college farm, AICRP on IFS unit, PJTSAU, Rajendranagar, Hyderabad during 2020-21. 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}).

B. Experimental design and treatments

The ten treatments were laid out in RBD, replicated thrice and the site of the experimental field was same throughout the experimentation and all crops were grown under irrigated conditions. The varieties of different crops used were rice - RNR -15048, pigeonpea – PRG 176, groundnut – K 6, greengram- MGG 295, Sesame - Swethathil, fodder sorghum – CSH 24 MF, finger millet – Hima and fodder cowpea – Vijaya. Different cropping sequences were grown to find out the highly productive as well as sustainable cropping systems suitable for Southern Telangana Zone. The ten treatments of cropping systems tested round the year which were divided 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 alone, 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 family 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 high value crops for income augmentation (T_9 & T_{10}) T_9: sweet corn -vegetables (tomato), T_{10}: okra –marigold–beetroot. Economics as well as biological yields of all crops were recorded. Rice grain equivalent yield (RGEY) was calculated to evaluate system performance by converting the yield of non-rice crops into equivalent rice yield on a price basis, using the formula,

$$RGEY = Y_x(P_x/P_r),$$

Where, Y_x is the yield of non-rice crops (kg ha^{-1}), P_x is the price of non-rice crops (Rs) and P_r is the price of rice crop.

C. Observation and analysis

After harvesting, grain as well as plant samples were collected thereafter oven dried for the analysis of N, P & K uptake. The total nitrogen content (%) in the dried plant sample was determined by microkjeldahl distillation method (Piper, 1996). The diacid extract (9:4 nitric acid: perchloric acid) was utilized for investigation of total phosphorus and potassium in plant samples. Nutrient uptake is calculated by multiplying nutrient content with biomass.

D. Statistical analysis

The data generated from field experiment were analyzed in randomized block design (Gomez and Gomez, 1984) in three replications with ten treatments by analysis of variance (ANOVA). The significance of different sources of variation was tested by the error mean square of Fisher Snedecor's 'F' test at probability level 0.05. Standard error of mean (SE) and least significant difference (LSD) at 0.05 level of significance were used to compare treatments.

RESULTS AND DISCUSSION

Regarding system productivity, okra–marigold–beetroot system has obtained higher RGEY (33145 kg ha^{-1}) compared to remaining cropping systems (Table 1). Among the ecological cropping systems, *Bt* cotton + greengram (1:3)- groundnut cropping system recorded significantly higher rice grain equivalent yield (15252 kgha^{-1}) than redgram + greengram (1:6) - sesame (8429 kg ha^{-1}) cropping system. Out of the two systems tested to meet the family nutritional security, redgram + maize (1:3) – groundnut system reported higher rice grain equivalent yield (15492 kgha^{-1}) than redgram + groundnut (1:7) - ragi system (10937 kgha^{-1}). Out of the two fodder crops/cropping systems, fodder maize – lucerne system resulted in higher rice grain equivalent yield (8470 kgha^{-1}) than fodder sorghum + fodder cow pea (1:2) - horsegram –sunhemp system (6518 kg ha^{-1}). Among the predominant cropping systems of the region, rice – maize system has attained higher RGEY (12240 kgha^{-1}) than sole Bt cotton (6342 kgha^{-1}).

A. N uptake

Fodder crops generally require more nutrients compared to other crops which is why uptake of fodder crops is high. Out of the fodder cropping systems, fodder sorghum + fodder cow pea (1:2) system takes higher amount of N (311.7 kg ha^{-1}) followed by fodder maize (202.9 kg ha^{-1}) during *kharif* 2020. Among the ecological cropping systems involving crops for protecting long term soil health, nitrogen removal by both the systems was statistically on par. Bt cotton + greengram (1:3) cropping system removed slightly higher quantities of N (101.4 kg ha^{-1}) over redgram + greengram (1:3) cropping system (96.0 kg ha^{-1}). Out of the two systems tested to meet the family nutritional security, redgram + groundnut (1:7) has obtained higher N uptake (129.7 kg ha^{-1}) compared to redgram + maize (1:3) (63.0 kg ha^{-1}) which might be due to N fixation by the redgram and groundnut as reported by Singh and Srivastava (2018). Sweetcorn requires more amount of nutrients for its growth and development and it is regarded as a high value crop by farmers as its investment is high. Sweet corn has removed 143.3 kg ha^{-1} N which is higher than bhendi (70.4 kg ha^{-1}) among the income augmentation crops. Sweet corn removes more N from the soil which has resulted in higher productivity compared to other crops (Pragathi Kumari *et al.,* 2020). N removal by rice and Bt cotton was 93.9 and 108.1 kg ha^{-1}, respectively and at par with each other. Higher amount of N uptake was recorded by Lucerne crop (312.5 kg ha^{-1}) followed by Marigold-Beetroot (274.4 kg ha^{-1}) during rabi and summer seasons of 2019-20 while sesame has obtained lowest N uptake (35.4 kg ha^{-1}) (Table 5).

N removal by rice-maize was higher (201.9 kg ha^{-1}) followed by sole Bt cotton (108.1 kg ha^{-1}) among the major cropping systems as former system occupies the soil for longer duration and cereals requires much amount of N. Fodder maize – lucerne system (515.4 kg ha^{-1}) followed by fodder sorghum + fodder cowpea (1:2) – horsegram - sunhemp fodder system (489.6 kg ha^{-1}) has recorded the significant amount of N uptake. Among the ecological cropping systems involving crops for enhancing soil strength, N removal by Btcotton + greengram (1:3)- groundnut cropping system slightly higher (175.7 kg ha^{-1}) than redgram + greengram (1:6) – sesame cropping system (131.4 kg ha^{-1}) because Bt cotton, groundnut crops are little bit exhaustive in nature. Maize feeds upon more amount of N compared to ragi which is why redgram + maize (1:3)-groundnut has removed higher N than redgram + groundnut (1:7) – ragi systems, with N removal of 183.8 and 139.2 kg ha^{-1} respectively between the two systems tested to meet the family nutritional security. Sweet corn is a heavy feeder of N which might be the reason for higher N uptake of sweet corn-vegetables (tomato) system (253.3 kg ha^{-1}) over okra – marigold – beetroot (344.8 kg ha^{-1}) systems between cropping systems involving high value crops for income enhancement.

B. P uptake

Sweet corn has removed more P among the crops and cropping systems tested in the kharif season (Table 3). The P removal by both fodder sorghum + fodder cow pea (1:2) (28.9 kg ha^{-1}) and fodder maize (33.5 kg ha^{-1}) was at par with each other. Bt cotton + greengram (1:3) cropping system removed somewhat more amount of P (11.6 kg ha^{-1}) compared to redgram + greengram (1:3) cropping system (9.3 kg ha^{-1}) between the cropping systems involving crops for protecting long term soil health. Between the two systems tested to meet the family nutritional security, redgram + maize (1:3) system removed lesser quantities of P (9.8 kg ha^{-1}) than redgram + groundnut (1:7) system (13.5 kg ha^{-1}). Sweet corn is a heavy feeder of nutrients which is why sweet corn has removed higher amount of P (34.0 kg ha^{-1}) than bhendi (12.4 kg ha^{-1}) between the crops evaluated for income enhancement. Rice has removed more P (26.0 kg ha^{-1}) which is significantly higher compared to Bt cotton (9.4 kg ha^{-1}) which might be attributed to exhaustive nature of cereals. Marigold-beetroot removed maximum P (47.3 kg ha^{-1}) followed by maize crop (31.0 kg ha^{-1}) in *rabi* and *summer* seasons (Table 6). The P uptake by marigold-beetroot system is 47.3 kg ha^{-1} which is higher compared to maize crop (31.0 kg ha^{-1}). P uptake was found lowest in ragi crop (8.1 kg ha^{-1}).

Rice-maize system has removed the higher amounts of P (56.9 kg ha^{-1}) compared to sole Bt cotton (9.4 kg ha^{-1}) (Table 8) as rice and maize takes more amount of nutrients from soil. Fodder maize - lucerne system (50.8 kg ha^{-1}) has removed more amount of P compared to fodder sorghum + fodder cowpea (1:2) – horsegram - sunhemp system (44.0 kg ha^{-1}). Bt cotton + greengram (1:3)- groundnut cropping system has removed somewhat higher amounts of P (20.3 kg ha^{-1}) over redgram + greengram (1:6) – sesame cropping system (17.7 kg ha^{-1}) between the cropping systems for protecting long term soil health. Redgram + groundnut (1:7) – ragi system (21.6 kg ha^{-1}) has removed more P than redgram + maize (1:3)-groundnut (18.5 kg ha^{-1}) system between the two systems tested to meet the family nutritional security. The P uptake of sweet corn-(Tomato) system (61.7 kg ha^{-1}) is higher compared tookra – marigold – beetroot (59.8 kg ha^{-1}) systems as sweet corn is a heavy feeder of nutrients.

C. K uptake

Generally fodder crops removes maximum amount of nutrients compared to other crops. Fodder maize has removed significantly higher K (373.3 kg ha^{-1}) (Table 7) than fodder sorghum + fodder cowpea (1:2) system (174.2 kg ha^{-1}) between the two fodders crops/cropping systems in kharif season which might be due to high K requirement of maize crop. Between the cropping systems crops for protecting long term soil health, highest K uptake was recorded by Bt cotton + greengram (1:3) cropping system (63.1 kg ha^{-1}) compared to redgram + greengram (1:3) cropping system (40.5 kg ha^{-1}). Sankaranarayanan *et al.* (2010) reported that inclusion of legumes as a intercrop in Bt cotton gives higher yield over sole cotton which might be due to higher nutrient uptake. Redgram + maize (1:3) system has removed K content of 46.3 kg ha^{-1} which is significantly at par with K uptake of redgram + groundnut (1:7) system (48.8 kg ha^{-1}) between the two systems tested to meet the family nutritional security. The K uptake of sweet corn (205.8 kg ha^{-1}) was 2.5 times more than that of bhendi (80.5 kg ha^{-1}) which is because of heavy K requirement of sweet corn. Kuptake by rice (113.5 kg ha^{-1}) is almost double than that of Bt cotton (59.5 kg ha^{-1}). Lucerne has removed K content of 202.1 kg ha^{-1} which is higher compared to marigold - beetroot (157.8 kg ha^{-1}) in rabi as well as summer seasons of 2020-21 (Table 7) while sesame has recorded lowest nutrient uptake (17.3 kg ha^{-1}). The K removal of rice-maize was higher (199.7 kg ha^{-1}) compared to sole Bt cotton (59.5 kg ha^{-1}) in terms of system uptake. K uptake was maximum with fodder maize – lucerne system (575.4 kg ha^{-1}) which is higher than fodder sorghum + fodder cowpea (1:2) – horsegram - sunhemp system (326.8 kg ha^{-1}) between the two fodder cropping systems.

Among the ecological cropping systems involving crops for protecting long term soil health, Kuptake of Bt cotton + greengram (1:3)- groundnut cropping system is slightly higher (83.8 kg ha^{-1}) than that of pigeonpea + greengram (1:6) – sesame cropping system (57.8 kg ha^{-1}). The K uptake of pigeonpea + maize (1:3)-groundnut (67.3 kg ha^{-1}) and pigeonpea + groundnut (1:7) – ragi systems (67.8 kg ha^{-1}) were significantly at par with each other between the two systems tested to meet the family nutritional security. The K uptake of sweet corn-vegetables (tomato) system (304.8 kg ha^{-1}) is higher compared to okra – marigold – beetroot system (238.3 kg ha^{-1}) between cropping two cropping systems involving high value crops for income augmentation.

D. Soil fertility

The soil pH, EC, OC and available N, K was at par at the end of the eight crop cycles (Table 9). But available P was higher for fodder maize (48.60 kg ha^{-1}) and it is statically at par with redgram + maize (1:3) and redgram + greengram (1:3).

Table 1: 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	Redgram + Greengram (1:6) – Sesame	920	601	2928	1263	806	2121			5215	173	3012	29			5388	3041	0	8429
T5	Redgram+Maize (1:3)-Groundnut	596	5823	1894	7463	2230	3890			7601	420	6410	1060			8022	7470	0	15492
T6	Redgram + 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

Table 2: Nitrogen uptake (kg ha^{-1}) by crops in different cropping systems during *kharif*, 2020.

Treatment		Grain			Stover			Total G+S
Crop /Cropping System (kharif)		Main crop	Inter crop	Total	Main crop	Inter crop	Total	
T1	Rice	57.2	0	57.2	36.7	0	36.7	93.9
T2	Bt cotton	54.8	0	54.8	53.3	0	53.3	108.1
T3	Bt cotton + Greengram (1:3)	28.6	12.4	41.0	49.5	10.9	60.4	101.4
T4	Redgram + Greengram (1:3)	35.1	16.8	52.0	28.9	15.1	44.0	96.0
T5	Redgram + Maize (1:3)	7.5	15.7	23.2	11.3	28.5	39.8	63.0
T6	Redgram + Groundnut (1:7)	19.9	48.9	68.8	27.2	33.8	60.9	129.7
T7	Fodder sorghum + Fodder Cow pea (1:2)	0	0	0	116.9	194.8	311.7	311.7
T8	Fodder maize	0	0	0	202.9	0.0	202.9	202.9
T9	Sweet corn	49.7	0.0	49.7	93.6	0.0	93.6	143.3
T10	Bhendi	63.5	0.0	63.5	6.9	0.0	6.9	70.4
	SE(m)±						SE(m)	14.8
	CD @ 5%						C.D.	44.3

Table 3: Phosphorus uptake (kg ha^{-1}) by crops in different cropping systems during *kharif*, 2020.

Treatment		Grain			Stover			Total G+S
Crop /Cropping System (kharif)		Main crop	Inter crop	Total	Main crop	Inter crop	Total	
T1	Rice	17.2	0.0	17.2	8.8	0.0	8.8	26.0
T2	Bt cotton	5.0	0.0	5.0	4.4	0.0	4.4	9.4
T3	Bt cotton + Greengram (1:3)	5.0	1.5	6.4	4.2	0.9	5.1	11.6
T4	Redgram + Greengram (1:3)	3.0	1.9	4.9	3.0	1.4	4.4	9.3
T5	Redgram + Maize (1:3)	1.8	1.9	3.7	3.0	3.1	6.2	9.8
T6	Redgram + Groundnut (1:7)	2.6	5.3	8.0	3.4	2.1	5.5	13.5
T7	Fodder sorghum + Fodder Cow pea (1:2)	0	0	0	9.7	19.2	28.9	28.9
T8	Fodder maize	0	0	0	33.5	0.0	33.5	33.5
T9	Sweet corn	16.7	0.0	16.7	17.3	0.0	17.3	34.0
T10	Bhendi	10.4	0.0	10.4	2.1	0.0	2.1	12.4
	SE(m)±							2.1
	CD @ 5%							6.4

Table 4: Potassium uptake (kg ha^{-1}) by crops in different cropping systems during *kharif*, 2020.

Treatment		Grain			Stover			Total G+S
Crop /Cropping System (kharif)		Main crop	Inter crop	Total	Main crop	Inter crop	Total	
T1	Rice	28.1	0.0	28.1	85.4	0.0	85.4	113.5
T2	Bt cotton	16.0	0.0	16.0	43.5	0.0	43.5	59.5
T3	Bt cotton + Greengram (1:3)	15.7	3.9	19.5	39.5	4.1	43.6	63.1
T4	Redgram + Greengram (1:3)	7.4	4.6	12.0	23.1	5.4	28.5	40.5
T5	Redgram + Maize (1:3)	2.5	4.5	7.0	17.1	22.1	39.3	46.3
T6	Redgram + Groundnut (1:7)	6.8	9.3	16.0	23.6	9.3	32.8	48.8
T7	Fodder sorghum + Fodder Cow pea (1:2)	0	0	0	102.8	71.5	174.2	174.2
T8	Fodder maize	0	0	0	373.3	0.0	373.3	373.3
T9	Sweet corn	25.6	0.0	25.6	180.2	0.0	180.2	205.8
T10	Bhendi	67.9	0.0	67.9	12.6	0.0	12.6	80.5
	SE(m)±							12.6
	CD @ 5%							37.7

Table 5: Nitrogen uptake (kg ha^{-1}) by crops in different cropping systems during *rabi and summer*, 2020-21.

	Treatment	Grain			Stover			Total
	Crop / CS (Rabi / Summer)	Rabi	Summer	Total	Rabi	Summer	Total	(G+S)
T1	Maize	69.0	0	69.0	39.0	0	39.0	108.0
T2	Fallow	0	0	0	0	0	0	0
T3	Groundnut	61.9	0	61.9	12.4	0	12.4	74.3
T4	Sesame	18.6	0	18.6	16.8	0	16.8	35.4
T5	Groundnut	63.7	0	63.7	12.5	0	12.5	76.2
T6	Ragi	23.1	0	23.1	31.0	0	31.0	54.1
T7	Horsegram-Sunhemp	0	0	0	29.1	148.7	177.8	177.8
T8	Lucerne	0	0	0	312.5	0	312.5	312.5
T9	Tomato	99.6	0	99.6	10.3	0	10.3	109.9
T10	Marigold-Beetroot	72.2	155.7	227.9	31.3	15.2	46.5	274.4
	SE(m)±							14.7
	CD @ 5%							44.0

Table 6: Phosphorus uptake (kg ha^{-1}) by crops in different cropping systems during *rabi and summer*, 2020-21.

	Treatment	Grain			Stover			Total
	Rabi & summer	Rabi	Summer	Total	Rabi	Summer	Total	(G+S)
T1	Maize	18.5	0	18.5	12.5	0	12.5	31.0
T2	Fallow	0.0	0	0	0	0	0	0
T3	Groundnut	6.6	0	6.6	2.1	0	2.1	8.7
T4	Sesame	3.0	0	3.0	5.4	0	5.4	8.4
T5	Groundnut	6.7	0	6.7	2.0	0	2.0	8.7
T6	Ragi	4.6	0	4.6	3.6	0	3.6	8.1
T7	Horsegram-Sunhemp	0.0	0	0.0	5.2	9.9	15.1	15.1
T8	Lucerne	0.0	0	0.0	17.3	0	17.3	17.3
T9	Tomato	26.5	0.0	26.5	1.1	0	1.1	27.7
T10	Marigold-Beetroot	14.5	28.6	43.1	2.2	2.1	4.2	47.3
	SE(m)±							0.9
	CD @ 5%							2.7

Table 7: Potassium uptake (kg ha^{-1}) by crops in different cropping systems during *rabi and summer*, 2020-21.

	Treatment	Grain			Stover			Total
	Crop / Crop System	Rabi	Summer	Total	Rabi	Summer	Total	(G+S)
T1	Maize	28.4	0	28.4	57.8	0	57.8	86.2
T2	Fallow	0.0	0	0	0	0	0	0
T3	Groundnut	11.3	0	11.3	9.4	0	9.4	20.7
T4	Sesame	2.4	0	2.4	14.9	0	14.9	17.3
T5	Groundnut	11.2	0	11.2	9.7	0	9.7	21.0
T6	Ragi	4.7	0	4.7	14.2	0	14.2	19.0
T7	Horsegram-Sunhemp	0	0	0	33.5	119.1	152.6	152.6
T8	Lucerne	0	0	0	202.1	0	202.1	202.1
T9	Tomato	84.2	0	84.2	14.8	0	14.8	99.0
T10	Marigold-Beetroot	79.2	49.1	128.3	16.5	13.1	29.6	157.8
	SE(m)±							11.1
	CD @ 5%							33.3

Table 8: Nutrient (Nitrogen, Phosphorus and Potassium) uptake by crops in different cropping systems during *kharif*, *rabi and summer*, 2020-21.

Treatment		Kharif uptake			Rabi uptake			Total uptake		
		N	P	K	N	P	K	N	P	K
T1	Rice-Maize	93.9	26.0	113.5	108.0	31.0	86.2	201.9	56.9	199.7
T2	Bt Cotton	108.1	9.4	59.5	0.0	0.0	0.0	108.1	9.4	59.5
T3	Btcotton+Greengram (1:3)- Groundnut	101.4	11.6	63.1	74.3	8.7	20.7	175.7	20.3	83.8
T4	Redgram + Greengram (1:6) - Sesame	96.0	9.3	40.5	35.4	8.4	17.3	131.4	17.7	57.8
T5	Redgram+Maize (1:3)-Groundnut	63.0	9.8	46.3	76.2	8.7	21.0	139.2	18.5	67.3
T6	Redgram + Groundnut (1:7) - Ragi	129.7	13.5	48.8	54.1	8.1	19.0	183.8	21.6	67.8
T7	Fodder sorghum + Fodder cowpea (1:2) – Horsegram - Sunhemp	311.7	28.9	174.2	177.8	15.1	152.6	489.6	44.0	326.8
T8	Fodder maize - Lucerne	202.9	33.5	373.3	312.5	17.3	202.1	515.4	50.8	575.4
T9	Sweetcorn-Vegetables(Tomato)	143.3	34.0	205.8	109.9	27.7	99.0	253.3	61.7	304.8
T10	Okra – Marigold - Beetroot	70.4	12.4	80.5	274.4	47.3	157.8	344.8	59.8	238.3
	SE(m)±	14.8	2.1	12.6	14.7	0.9	11.1	20.1	2.2	11.9
	CD @ 5%	44.3	6.4	37.7	44.0	2.7	33.3	62.0	6.6	35.8

Table 9: Changes in soil properties at the end of crop sequence during 2020-21.

Crop /Cropping System (kharif)		pH	EC (ds m^{-1})	OC (%)	Avail. N kg ha^{-1}	Avail. P kg ha^{-1}	Avail. K kg ha^{-1}
	Initial	7.81	0.11	0.39	112.2	23.4	170.3
T1	Rice	7.59	0.40	0.41	192.4	34.27	219.17
T2	Bt cotton	7.89	0.37	0.39	175.9	33.27	204.73
T3	Bt cotton + Greengram (1:3)	7.55	0.38	0.43	221.6	43.63	207.70
T4	Redgram + Greengram (1:3)	7.84	0.48	0.46	234.2	45.40	212.37
T5	Maize + Redgram (1:3)	7.67	0.42	0.43	209.3	47.67	210.83
T6	Redgram + Groundnut (1:7)	7.73	0.43	0.44	205.2	40.60	206.73
T7	Fodder sorghum + Fodder Cow pea (1:2)	7.59	0.41	0.46	230.1	41.53	200.00
T8	Fodder maize	7.50	0.48	0.44	221.7	48.60	213.57
T9	Sweet corn	7.43	0.44	0.40	200.9	36.07	194.83
T10	Bhendi	7.58	0.48	0.39	184.2	40.03	192.07
	SE(m)±	0.12	0.03	0.04	18.60	2.011	10.56
	CD @ 5%	N/A	N/A	N/A	N/A	6.02	N/A

CONCLUSION

There is a need to develop cropping sequences suitable for various regions as a part of crop diversification. These location specific cropping systems shall not only improve the productivity and income but also maintains the environmental sustainability. Under high value crops, sweetcorn - tomato system, among the ecological cropping systems, Bt cotton + greengram (1:3) – groundnut, under the cropping systems for family nutritional security, Redgram + Groundnut (1:7) - Ragi system, under two fodder crops/cropping systems, fodder maize – lucerne system and under pre-dominant cropping systems, rice – maize systems have obtained the highest nutrient uptakes which might resulted in the highest rice grain equivalent yields in most of the cropping systems.

Acknowledgement. I am grateful to the Professor Jayashankar Telangana State Agricultural University and IIFSR, Modipuram for providing the financial funding for conducting research work.

Conflict of Interest. None.

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How to cite this article: Ch. Pragathi Kumari, M. Venkata Ramana, M. Goverdhan, G. Kiran Reddy, G. Vinay, M. Santhosh Kumar and R. Karthik (2022). Nutrient Uptake and Soil Fertility Status in Crop Sequences Module for different Integrated Farming System Models of Telangana State. *Biological Forum – An International Journal*, *14*(2): 1034-1040.