Nutrient Efficient and Productive Cropping Systems forNorthern Telangana Zone, of Telangana

ABSTRACT

A field experiment was conducted during 2018-19 at AICRP on Integrated Farming Systems, Regional Sugarcane and Rice Research Station, Rudrur in vertisols of Northern Telangana Zone, Telangana state, India. The experiment was laid out with twelve cropping systems as treatments in Randomized Block Design (RBD) with three replications. The twelve combinations of cropping systems tested during *kharif* (June-october) and *rabi (November – March*) were rice-rice (check), maize-soybean(2:4)-tomato, maize-soybean (2:4) - rice, sunflower-chickpea (2:4), maize - chickpea, *Bt* cotton-soybean (1:2) on broadbed–sesame-groundnut(2:4), *Bt* cotton - sesame -blackgram (2:4), soybean-wheat, soybean-sunflower - chickpea (2:4), turmeric-sesame, turmeric-soybean (1:2) on flat bed-bajra and turmeric-soybean (1:2) on broadbed-sesame - blackgram (2:4).Cropping system turmeric-soybean(1:2) (on BBF) sesame – blackgram (2:4) recorded productivity in terms of rice equivalent yield of 23413kg ha^{-1} and production efficiency of 75.53Kg ha^{-1} day^{-1}followed by sole turmeric-sesame (22597 kg REY ha^{-1}) and 72.89Kg ha^{-1} day^{-1} and Bt.cotton+soybean (1:2) (on BBF) sesame+groundnut (2:4) (22568kg ha^{-1}) and 75.23 Kg ha^{-1} day^{-1} over existing rice-rice (14395 kg REY ha^{-1}) and 56.45Kg ha^{-1} day^{-1}. Higher nutrient uptake was recorded with maize+soybean (2:4)–tomato system with 361.73 kg N ha^{-1}, 114.43 kg P ha^{-1} and 318.89 kg K ha^{-1}. Hence under nutrient stressed environment and low input management system maize+soybean (2:4) –tomato, can be recommended in comparision to existing rice-rice cropping system in irrigated situations for vertisols of Telangana.

***Key words**:* Cropping systems, system productivity, production efficiency, nutrient uptake

Introduction

Intercropping can not only meet the ecological objectives of low-input agriculture, but also be a practical useful approach for food production and agro-ecological sustainable development in high-input agriculture (Li et al., **2020**). For example, Silberg et al., (**2019**) reported that

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intercropping of cereal crops with legumes had been practiced by smallholders to control weeds in African cereal-based systems. Also, in the semi-arid regions of Northeast China, strip intercropping of oats with maize, sunflower, and mung bean is being adopted owing to yield advantages and economic benefits (Qian et al., 2018). Moreover, intercropping as a multiple diversity cropping system could affect the crop productivity by species richness, functional diversity, species identity, and interspecific competition (Mahaut et al., 2019). Different crop combinations affect the light interception by intercrops under the intercropping system (Feng et al., 2019).

It is well known that the crop production is unstable and at times uneconomic due to vagaries of monsoon in dry land areas of scarcity zone. Almost all the concerns for agriculture (agriculture technologies, government farm policies, modern crop varieties and research efforts) are focused on the production of sole cropping, while some drawbacks in modern agriculture system force the farmers to take interest in intercropping for the production of fiber and food (Kirschenmann, 2007). Intercropping systems provide 15–20% of food supply to the world (Lithourgidis et al., 2011). In fact, intercropping has ecological, biological and socioeconomic advantages over sole cropping (He et al., 2012, Waktola et al., 2014). Appropriate intercropping systems besides meeting the varied requirements of farmer, provide stability in rainfed agriculture and improve the total productivity through better utilization of natural resource. Several studies have shown the importance of cereal and legume intercropping system, which is considered as an old practice in tropical agriculture (Ghanbari et al., 2010) .In the absence of nitrogen fertilizers, reduced N input decreases the demand for nitrogenous fertilizers in cereal and legume intercropping systems (Adu-Gyamfi et al., 2007; Chen et al., 2017). The analysis of numerous cereal and legume crops revealed that maize and soybean are best partners under intercropping conditions because both crops have complementary characteristics (Kocsy et al., 2001). Nowadays the intercropping procedure is being reevaluated due to advantages pointed previously . Considering that the productivity of a crop is limited by the amount of resources and is mainly determined by how efficiently the crop can use them, the species composing an intercropping should be contrasting in some of their agro botanical characteristics, such as size, architecture, cycle, growth rate, demand for nutrients, demand for light, etc. Natural resource management for sustainable agriculture development is important for India's food and nutritional security. Intercropping is a commonly used agronomic practice in many countries because it can use nutrient, light and water resources efficiently and enhance crop yield. Hamzei and Seyyedi, (2016). Diversification of agriculture in favour of commercial crops leads to greater market orientation of farm production. Crop diversification is intended to give a wider choice in the production of variety of crops in a given area. Depending on just one crop can have grave consequences and leave small farmers open to unnecessary hazards. Crop diversification in India is viewed as a shift from traditionally grown less remunerative crops to more remunerative crops (Hazara, 2000) .Crop diversification can be a useful means to increase farm output under different situations. The goal of sustainable intensification is to increase food production from existing farmland while minimizing pressure on the environment. It is a response to the challenges of increasing demand for food from a growing global population, in a world where land, water, energy and other inputs are in short supply, over exploited and used unsustainably. Increasing diversification of cereal cropping systems by alternating crops such as oilseed, pulse and forage crops is another option for managing plant disease risk (Krupinsky et al., 2002). It is a climate-smart agriculture strategy for food security, mitigation and adaptation. Both intensification and diversification of cropping systems may allow improving the productivity and sustainability of agricultural production in the Northern Telangana Zone of Telangana state but the choices to be made require integrated assessment of various cropping systems. The farmers for concerning higher per hectare production and income per unit area in a time frame can be overcome by adopting a cropping system which is profitable and economically viable. In the era of shrinking resource base of land, water and energy, resource use efficiency is an important aspect for considering the sustainability of a cropping system (Yadav, 2002). Ever increasing cost of energy would be an important constraint for increased use of chemical fertilizers in crop production.

Rice followed by rice is the predominant cropping followed in vertisols of Northern Telangana Zone, Telangana, India. During cultivation of rice, soil undergoes drastic changes, i.e. aerobic to anaerobic environment, leading to several physical and electro-chemical transformations. Crop diversification shows lot of promises in alleviating these problems besides, fulfilling basic needs for cereals, pulses, oilseeds and vegetables and, regulating farm income, withstanding weather aberrations, controlling price fluctuation, ensuring balanced food supply, conserving natural resources, reducing the chemical fertilizer and pesticide loads, ensuring environmental safety and creating employment opportunity Gill and Ahlawat, (2006). Avoiding resource depleting crop and identifying most productive, remunerative crops with less water requirement is necessary. Cropping system is one of the very important tool to augment the agricultural production. The approach involves sequential as well as intercropping and mixed cropping system aimed at efficient utilization of natural and man-made resources of production.

2. Materials and Methods

A field experiment was conducted during 2018-19 at (AICRP on Integrated Farming Systems, Regional Sugarcane and Rice Research Station Rudru), Nizamabad (Dist.), Telangana (state), India situated at an altitude of 286.3 m above mean sea level (MSL) at 180 49’41’ latitude and 78056’45” E longitude to diversify existing rice-rice cropping system with less water requiring crops under irrigated conditions for vertisols of Northern Telangana Zone. The experiment was laid out with twelve cropping systems as treatments in Randomized Block Design (RBD) with three replications. The twelve combinations of cropping systems tested during *kharif* and *rabi* seasons were rice–rice (check), maize–soybean(2:4)–tomato, maize–soybean (2:4)–rice, maize–sunflower–chickpea (2:4), maize–chickpea, *Bt* cotton–soybean (1:2) on broadbed-sesame–groundnut(2:4), *Bt* cotton–sesame-blackgram (2:4), soybean–wheat, soybean–sunflower–chickpea (2:4), turmeric–sesame, turmeric–soybean (1:2) on flat bed-bajra and turmeric–soybean (1:2) on broadbed–sesame–blackgram (2:4). All kharif crops were sown during last week of June after receipt of wetting rainfall and following sequence crops during rabi were taken up as and when the preceding kharif crops were harvested in the respective plots. Economic yield and stover/straw/stalk yield were recorded individually for all the crops in cropping systems. For comparison of different crop sequences, the yields of all the crops were converted in to rice equivalent yield on market price basis. Production efficiency (PE) was calculated by dividing the system productivity by total duration of the system and was expressed in kg REY/ha/day.

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$$PE = \frac{\text{Total productivity of the system (kg/ha)}}{\text{Duration of the crops in the system (Day)}}$$

The N, P and K content in grain and straw was estimated as described by Page (1982) and their uptakes were computed. Soil samples of 0-15 cm depth were collected at harvest of crop from individual plots. Soil sample was pounded and sieved through 2mm sieve and analyzed for OC, available N and P and K (Jackson 1973)).Soil of experimental site was clay loam in texture with neutral p^H and low in available nitrogen 169.54 kg ha^{-1} and high in available phosphorus 39.6 kg ha^{-1} and available potassium 305 kg ha^{-1} The treatments were compared using the F-test by calculating the critical difference at 5% level of.

Comment [aks13]: pH

3. Results and Discussion

The performance of different crops in terms of rice equivalent yield (REY) during *kharif*, indicated that higher productivity in terms of rice equivalent yield (19632 kg REY ha^{-1}) was recorded with sole turmeric. However it was found to be at par with turmeric+soybean(1:2) on broad bed (BBF) (16819 kg REY ha^{-1}) and (turmeric+soybean(1:2) on flat bed)(16128 kg ha^{-1}) .Lowest productivity was recorded with sole maize(5197 kg REY ha^{-1}) and rice (5952 kg ha^{-1}) (Table1). During *rabi*, tomato crop raised after maize+soybean(2:4), recorded significantly highest REY of 15992 kg ha^{-1} over other tested crops or cropping systems. However cropping systems sesame+groundnut (2:4) raised after Bt.cotton+soybean (1:2) on BBF (10954 kg ha^{-1}), sunflower+chickpea(2:4) raised after sole maize (10695 kg ha^{-1}) and sunflower+chickpea(2:4) raised after sole soybean (10410 kg ha^{-1}) also followed closely. Yuanfang Fan et al., 2020 reported high utilization efficiency of nitrogen, phosphorus, and potassium in maize+soybean intercropping system.(Rezende et al. , 2005) observed that in the intercropping of tomato and lettuce, the productivity of tomato was not reduced by lettuce in any of the times when intercropping was established (transplanting lettuce at 0, 14, 28, and 42 DAT tomato).Tomato being nontraditional crop provides excellent opportunities in raising the income of the farmers as it has capacity to yield 5-10 times more than cereals.(Singh et al, 2012) reported maximum ricey yield equivalent in rice–tomato–bottle gourd (40.44 t ha^{-1}) Hence inclusion of vegetables in cropping system nutrition security has become embedded in that of food security and the importance of dietary diversity for good health. Data for Cambodia, Niger, and Vietnam show that profits per hectare are 3–14 times higher in vegetable production than in rice production while profits per labor-day are double (Joosten et al., 2015). Vegetables also typically provide more employment per hectare than cereals (Weinberger and Lumpkin, 2007). On system basis turmeric+soybean on BBF (1:2) - sesame+blackgram (2:4) was more productive with productivity of 23413kg REY ha^{-1} followed by sole turmeric-sesame (22597 kg REY ha^{-1}) and Bt.cotton+soybean on BBF (1:2) sesame+groundnut (2:4) (22568kg REY ha^{-1}) over rice-rice (14395 kg REY ha^{-1}). Production efficiency was higher with turmeric-soybean (1:2) on BBF – Sesamum-blackgram(2:4) (75.53 kgha^{-1}day^{-1}) and Bt cotton+soybean 1:2 on BBF- sesame+groundnut (2:4) (75.23 kgha^{-1}day^{-1}) followed by turmeric-sesame (72.89 kgha^{-1} day^{-1}) Bt cotton- sesame- blackgram (2:4)(70.56 kgha^{-1}day^{-1}) while rice-rice recorded 56.25 kgha^{-1} day^{-1}.(Deka,et al., 2019) reported that rice (transplanted on June 20 under SRI method) – field pea (relay crop) - maize (fodder crop)+green gram intercrops was more efficient in utilizing the soil available nutrients resulting in the highest nutrient(NPK) removal.

Comment [aks14]: turmeric (Table 1?)

3.1. Nutrient uptake

3.1.1. Nitrogen uptake

Nutrient uptake by various crops and cropping systems varied significantly during kharif and rabi (Table 3). All cropping systems with turmeric or Bt cotton or soybean as component crop removed more nitrogen over other crops. During *kharif* cropping system turmeric-soybean on broad bed (1:2) (207.9 kg ha^{-1}) and turmeric+soybean on flat bed (1:2) (199.6 kg ha^{-1}) and turmeric-sesame (191.8 kg ha^{-1}) removed significantly higher nitrogen. During rabi, tomato raised after maize+soybean(2:4) removed significantly higher nitrogen 193.20 kg ha^{-1} followed by sunflower+chickpea (2:4) raised after sole maize(113.63 kg ha^{-1} and sunflower+chickpea (2:4) raised after sole soybean 109.12 kg ha^{-1} . On system basis, significantly higher nitrogen uptake was recorded with maize+soybean (1:2)–tomato 361.73 kg ha^{-1} followed by other cropping systems soybean-sunflower+chickpea(2:4)(267.22 kg ha^{-1})turmeric+soybean (BBF)(1:2)- sesame-black gram (2:4) (266.73 kg ha^{-1}) and turmeric+soybean(1:2)-bajra (265.28 kg ha^{-1}) and Bt cotton+soybean (BBF)(1:2)-sesame+groundnut (2:4),) with uptake of 262.44 kg ha^{-1}. (Nawalakhe et al. 2010;Modhavadia et al., 2012) reported that higher production of seed cotton and dry matter plant^{-1} ultimately increased total uptake of nitrogen by cotton plant .The nitrogen, phosphorus and potassium utilization increased by 27.9%, 13.3%, and 34.1%, with one row of maize and one row of soybean with a 100-cm row intercropping compared with the sole crops(Yuanfang Fan et al., 2020)

3.1.2. Phosphorus uptake

Phosphorus removal was also similar to nitrogen uptake. Significantly higher phosphorus uptake was with maize intercropped with soybean(1:2) 35.9 kg ha^{-1} and 32.5 kg ha^{-1} and sole maize 31.4 and 30.4 kg ha^{-1}Fageria and Santos (2008) also reported higher P uptake in the corn shoot compared to sunflower and soybean. Tomato raised after maize+soybean(2:4) removed significantly higher phosphorus of 78.76 kg ha^{-1}. Sunflower+chickpea (2:4) raised after sole soybean removed phosphorus to the extent of 36.36 kg ha^{-1} and 21.60 kg ha^{-1} was recorded with sunflower-chickpea (2:4) raised after sole maize. Cropping system maize-soybean (1:2) –tomato recorded significantly higher phosphorus uptake (114.43 kg ha^{-1}) followed by sunflower-chickpea (2:4)(59.86 kg ha^{-1}) and maize-soybean (1:2) (53.97 kg ha^{-1}

3.1.3. Potassium uptake

Significantly higher potassium uptake was with maize+soybean (1:2)146.7 kg ha^{-1} and 142.5 kg ha^{-1} on par with Turmeric-Soybean (1:2 on flat bed)(134.6 kg ha^{-1}) and Turmeric-Soybean (1:2 on Broad bed) (134.2 kg ha^{-1}). Potassium uptake was significantly higher with tomato

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176.78 kg ha^{-1} followed by rice raised after maize+soybean(2:4) 71.29 kg ha^{-1}.and rice raised after rice 71.29 kg ha^{-1}. Cropping system maize-soybean (1:2)–tomato also recorded significantly higher potassium uptake (318.89 kg ha^{-1}) followed by turmeric-soybean (1:2) on flat bed- bajra cropping system 206.65 kg ha^{-1}

Higher fruit yield of tomato can be attributed to higher nutrient uptake capacity of the root system (uptake efficiency) and/or a greater utilization of nutrients by the plant (utilization efficiency). The success of tomato in its ability to efficiently exploit upper soil horizon with a network of fibrous root system for water than other cultivars resulted higher nutrient uptake.

3.3. Soil fertility

The soil pH, EC, OC and available nutrient status (nitrogen ,phosphorus and potassium) values after the sequences differed significantly at the end of crop sequence .Electrical conductivity did not differ significantly between treatments but slight changes were observed between cropping sequences for pH and OC. Cultivation of rice after rice has decreased soil pH to 6.63 while other cropping systems have alleviated soil pH ranging from 7.09 to 7.32 more favourable for crop growth over initial value of 6.70. Inclusion of legumes in cropping sequence has increased soil organic carbon and soil available nitrogen and phosphorus over rice-rice cropping system. Soil available potassium increased compared to initial value and differed differently in different treatments .

Comment [aks16]: sequence (Table 5)

Comment [aks17]: treatments

4. Conclusion

Among twelve cropping systems studied, system productivity was higher in turmeric and cotton based cropping systems and it ranged from 70.56 kgha^{-1}day^{-1} to 75.5389 kgha^{-1}day^{-1}. This is important for cultivar's adaptation to nutrient stressed environment and low input management system. Maize-Soybean (2:4)–Tomato, Soybean-Sunflower-Chickpea (2:4) orTurmeric-Soybean (BBF) (1:2) Sesame-Black gram (2:4) and turmeric–soybean (1:2)–bajra and Bt cotton-soybean (BBF)(1:2)- Sesame-Groundnut (2:4) can be recommended over rice-rice cropping system

Comment [aks18]: Pls Different from those in Abstract? Please check!

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Table 1 : Productivity of crops under different cropping systems during 2018-19

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Treatments		*Kharif*				*Rabi*				Rice Equivalent Yield (kg ha^{-1})				Productivity			Production efficiency (kgha^{-1}**day^{-1}**)
Kharif	Rabi	Grain yield (Kg ha^{-1})		Straw/ Stover yield (Kg ha^{-1})		Grain yield (Kg ha^{-1})		Straw/Stalk/ Stover yield (kg ha^{-1})		*Kharif*		*Rabi*		(REY -kg ha^{-1})			
		Main Crop	Inter Crop	Main Crop	Inter Crop	Main Crop	Inter Crop	Main Crop	Inter Crop	Grain	Straw	Grain	Straw	Kharif	Rabi	System	
T1	T1	5539	0	5865	0	4866	0	3865	0	5573	378	5128	499	5952	8443	14395	56.45
T2	T2	5101	0	7870	0	1713	870	2616	965	4689	508	7065	62	5197	10694	15770	52.57
T3	T3	5314	376	5607	760	4993	0	3733	0	5626	386	5325	482	6012	8713	14725	61.35
T4	T4	4985	0	9034	0	431	822	731	947	12929	0	4340	61	12929	6604	19756	70.56
T5	T5	2474	0	1765	0	1667	892	2573	927	4867	57	6878	60	4924	10410	15425	54.12
T6	T6	4108	926	5105	942	593	1722	779	1694	12526	30	6969	328	12556	10954	22568	75.23
T7	T7	2514	0	2077	0	3915	0	1707	0	4947	67	4383	110	5014	6741	11427	50.79
T8	T8	5072	0	3599	0	484	0	971	0	19632	0	1656	0	19632	2484	22597	72.89
T9	T9	5236	0	7079	0	1816	0	2226	0	4814	457	5155	144	5271	7950	13156	62.65
T10	T10	3686	892	1937	1095	2320	0	3175	0	16092	35	2133	205	16128	3508	19568	59.30
T11	T11	5386	516	7214	736	16525		2287	0	5966	489	10661	0	6456	15992	22390	66.84
T12	T12	3854	951	2885	977	478	829	970	849	16788	32	4521	55	16819	6867	23413	75.53
SEm±		128.82	10.50	185.96	51.84	217.90	26.97	46.43	34.46	350.52	5.630	204.27	4.33	350.62	205.52	413.45	
CD (*p*=0.05)		380.25	30.98	548.91	153.01	643.21	79.62	137.04	101.74	1034.67	16.62	602.97	12.78	1034.98	606.68	1220.42	

	Kharif Treatments		Rabi Treatments
T1	Rice	T1	Rice
T2	Maize	T2	Sunflower-Chickpea
T3	Maize-Soybean	T3	Rice
T4	Bt Cotton	T4	Sesamum-Blackgram
T5	Soybean	T5	Sunflower-Chickpea
T6	Bt Cotton-Soybean (BBF)	T6	Sesamum-Groundnut (BBF)

T7	Soybean	T7	Wheat
T8	Turmeric	T8	Sesamum
T9	Maize	T9	Chickpea
T10	Turmeric-Soybean	T10	Bajra
T11	Maize-Soybean	T11	Tomato
T12	Turmeric-Soybean (BBF)	T12	Sesamum-Blackgram (BBF)

Table 2 : Nutrient uptake of different cropping systems during *Kharif*, 2018-19

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Treatment		Main Produce (kg ha^{-1})			Bi-Produce (kg ha^{-1})			Total *Kharif* (kg ha^{-1})		
		N	P	K	N	P	K	N	P	K
Rice	Rice	63.39	14.58	24.53	38.56	11.33	75.09	101.9	28.1	99.6
Maize	Sunflower-Chickpea(2:4)	80.43	20.90	40.47	48.72	17.35	76.00	129.2	30.4	128.5
Maize-Soybean(2:4)	Rice	104.00	23.41	49.31	47.73	12.36	79.39	151.7	35.9	146.7
Bt Cotton	Sesame-Black gram(2:4)	0.00	0.00	0.00	161.19	11.04	123.48	161.2	11.7	123.5
Soybean	Sunflower-Chickpea(2:4)	127.61	9.41	43.99	30.49	3.80	16.36	158.1	13.7	60.4
Bt Cotton-Soybean (BBF)(1:2)	Sesame-Groundnut (2:4)	48.30	2.93	12.90	109.89	12.04	86.54	158.2	14.2	99.4
Soybean	Wheat	131.60	9.94	42.97	34.75	3.42	16.98	166.3	17.7	60.0
Turmeric	Sesame	163.70	20.79	83.77	28.08	4.26	50.54	191.8	28.5	134.3
Maize	Chickpea	82.18	21.49	41.40	44.16	14.12	93.15	126.3	31.4	134.6
Turmeric-Soybean(1:2)	Bajra	165.08	16.19	74.92	34.55	4.48	36.39	199.6	25.6	111.3
Maize-Soybean(2:4)	Tomato	111.98	23.49	52.50	56.47	14.18	100.00	168.5	32.5	142.5
Turmeric-Soybean (BBF)(1:2)	Sesame-Black gram (2:4)	170.05	17.74	84.96	37.88	5.10	49.28	207.9	15.4	134.2
SEm±		5.88	0.96	2.74	3.26	0.73	3.59	6.99	1.32	4.16
CD (*p*=0.05)		17.35	2.84	8.08	9.63	2.15	10.61	20.63	3.89	12.27

*N-Nitrogen,P-Phosphorus,K-Potassium

Table.3 Nutrient uptake of different cropping systems during Rabi, 2018-19:

Treatment		Main Produce(kg ha^{-1})			Bi-Produce(kg ha^{-1})			Total rabi(kg ha^{-1})		
Kharif	Rabi	N	P	K	N	P	K	N	P	K
Rice	Rice	59.367	13.800	22.800	24.360	6.963	47.683	83.710	20.740	70.473
Maize	Sunflower-Chickpea(2:4)	84.533	9.533	20.433	29.090	12.097	32.960	113.627	21.610	53.370
Maize-Soybean(2:4)	Rice	58.033	11.933	23.967	21.807	5.743	47.313	79.827	17.703	71.290
Bt Cotton	Sesame-Black gram(2:4)	34.200	3.767	10.500	23.997	3.143	18.253	58.200	6.930	28.743
Soybean	Sunflower-Chickpea(2:4)	81.267	25.567	16.867	27.847	10.817	33.460	109.117	36.363	50.340
Bt Cotton-Soybean (BBF)(1:2)	Sesame-Groundnut (2:4)	74.133	11.700	12.767	30.083	4.233	21.710	104.243	15.960	34.467
Soybean	Wheat	68.400	10.267	17.533	10.317	2.237	24.700	78.727	12.523	42.213
Turmeric	Sesame	9.567	2.200	1.733	9.183	1.667	7.057	18.730	3.857	8.797
Maize	Chickpea	53.767	6.733	11.633	18.253	5.667	34.403	72.027	12.397	46.037
Turmeric-Soybean(1:2)	Bajra	40.900	3.867	16.900	24.767	10.493	78.420	65.650	14.357	95.353
Maize-Soybean(2:4)	Tomato	483.233	75.767	140.800	35.297	2.973	35.580	193.203	78.757	176.383
Turmeric-Soybean (BBF)(1:2)	Sesame-Black gram (2:4)	34.500	4.100	11.333	24.280	3.153	18.690	58.797	7.240	30.037
SEm±		5.887	5.573	2.963	1.377	0.450	1.758	6.204	5.537	3.193
CD (*p*=0.05)		17.377	16.450	8.747	4.066	1.327	5.188	18.313	16.346	9.424

*N-Nitrogen,P-Phosphorus,K-Potassium

Table.4 System nutrient uptake of different cropping systems during 2018-19

Treatment		Nitrogen(kg ha^{-1})			Phosphorus (kg ha^{-1})			Potassium(kg ha^{-1})		
		G	S	T	G	S	T	G	S	T
Rice	Rice	122.74	62.97	185.66	28.36	18.29	46.65	47.31	122.77	170.08
Maize	Sunflower-Chickpea (2:4)	164.97	77.81	242.78	30.43	29.45	59.86	60.88	108.96	169.84
Maize-Soybean (2 :4)	Rice	162.01	69.54	231.54	35.36	18.10	53.46	73.29	126.71	199.99
Bt Cotton	Sesame-Blackgram (2:4)	34.20	185.18	219.39	3.78	14.19	17.97	10.49	141.73	152.22
Soybean	Sunflower-Chickpea	208.88	58.33	267.22	34.96	14.62	49.58	60.87	49.82	110.69
Bt Cotton-Soybean (BBF) (1: 2)	Sesame-Groundnut (BBF) (2:4)	122.46	139.98	262.44	14.66	16.27	30.94	25.67	108.24	133.91
Soybean	Wheat	200.00	45.06	245.07	20.23	5.657	25.88	60.48	41.68	102.16
Turmeric	Sesame	173.24	37.26	210.50	22.90	5.927	28.90	85.51	57.59	143.11
Maize	Chickpea	135.95	62.41	198.36	28.21	19.787	48.00	53.03	127.55	180.59
Turmeric-Soybean (1: 2)	Bajra	205.96	59.31	265.28	20.06	14.97	35.03	91.85	114.80	206.65
Maize-Soybean (2 :4)	Tomato	595.20	91.76	361.73	99.27	17.15	111.43	193.30	135.58	318.88
Turmeric-Soybean (BBF) (1: 2)	Sesame-Blackgram (BBF) (2:4)	204.57	62.16	266.73	21.83	8.25	30.08	96.31	67.97	164.28
SEm±		8.24	3.83	9.46	5.75	0.96	5.97	8.74	3.63	4.93
CD (*p*=0.05)		24.33	11.33	27.93	16.98	2.83	17.63	2.96	10.73	14.56

*G-Grain, S- Straw, T-Total

Comment [aks21]: Not referred in the Result & Discussion?

Table.5Soil fertility status in post-harvest soils after *rabi* 2018-19

Cropping system		pH	E C (dS m^{-1})	OC (%)	Avail. N kg ha^{-1}	Avail. P kg ha^{-1}	Avail. K kg ha^{-1}
Initial		6. 70	0.55	0.46	169.54	39.6	305
Rice	Rice	6.63	0.55	0.55	159.2	35.3	422.1
Maize	Sunflower-Chickpea(2:4)	7.31	0.62	0.59	205.6	36.1	436.5
Maize-Soybean(2:4)	Rice	7.09	0.58	0.57	189.4	39.2	485.4
Bt Cotton	Sesame-Black gram(2:4)	7.21	0.61	0.62	219.5	43.9	376.4
Soybean	Sunflower-Chickpea	7.20	0.60	0.53	216.3	35.4	325.7
Bt Cotton-Soybean (BBF)(1:2)	Sesame-Groundnut (2:4)	7.22	0.58	0.65	228.4	45.8	405.4
Soybean	Wheat	7.16	0.64	0.60	188.3	36.7	408.7
Turmeric	Sesame	7.25	0.59	0.57	171.2	38.56	426.1
Maize	Chickpea	7.18	0.64	0.61	181.5	43.42	412.2
Turmeric-Soybean(1:2)	Bajra	7.32	0.60	0.49	197.2	38.85	462.3
Maize-Soybean	Tomato	7.23	0.65	0.64	192.75	36.54	425.0
Turmeric-Soybean (BBF)(1:2)	Sesame-Black gram (2:4)	7.21	0.69	0.63	220.56	43.87	406.3
	SEm±	0.04	0.01	0.03	5.88	2.79	18.13
	CD (*p*=0.05)	0.12	NS	0.08	17.35	NS	53.52

Comment [aks22]: No referred?