Original Research Article

Nutrient Uptake Patterns and Soil Fertility Assessment in Diverse Crop Rotations under Irrigated Dry Conditions in Telangana, India

Abstract:

An experiment was conducted during the 2023-24 *kharif* and *rabi* seasons at the College Farm, AICRP on the IFS unit, PJTSAU, Hyderabad. To develop efficient cropping systems for the Telangana region, it is essential to evaluate them based on productivity, nutrient uptake and economic viability. This study assessed various cropping sequences with regard to nutrient absorption and soil fertility status specific to Telangana and the findings were presented here. The rice-maize cropping system demonstrated higher nutrient uptake, resulting in a higher rice grain equivalent yield compared to *Bt* cotton under region-specific system. The *Bt* cotton + greengram (1:2) - sesame cropping system exhibited significantly higher nutrient uptake compared to the pigeonpea + foxtail millet (2:5) - sweet corn, making it more effective for sustaining long-term soil health. Among the crops cultivated for family nutritional security, the fingermillet – groundnut demonstrated significantly higher nutrient uptake compared to the pigeonpea + sorghum (2:3) - sesame. The nutrient uptake in the fodder bajra - lucerne system was higher than that in the fodder sorghum - fodder oats system when comparing the two fodder cropping systems. It has been observed that fodder systems required a greater amount of nutrients for their growth and development compared to other cropping systems.

Keywords: Cropping systems, nutrient uptake, soil health and crop diversification.

Introduction:

The modern production systems have adversely affected on both nutrient balances and soil fertility [1]. To ensure food and nutritional security for a rapidly growing population while maintaining sustainability, crop diversification is essential. Diverse crop rotations under irrigated dry circumstances in Telangana have a substantial impact on nutrient uptake patterns and soil fertility by increasing nutrient availability, reducing soil degradation and increasing crop productivity when compared to monoculture cropping systems. This can be achieved by cultivating pulses, oilseeds, vegetables and fodder crops along with cereals, which is the primary goal of crop diversification. Greater emphasis should be placed on crop diversification, although it poses challenges from the farmer's perspective. Crop diversification is a powerful strategy for achieving food and nutritional security, fostering economic growth, reducing poverty, creating jobs and promoting responsible management of land and water resources, alongside advancing sustainable agricultural development and enhancing environmental quality [2]. Incorporating legumes into a cropping system and enhancing the organic matter content of the soil through biological nitrogen fixation can enhance soil quality and improve the physical and microbiological environment, resulting in a higher buffering capacity [3]. Diversified cropping systems provide various food sources, boost land productivity and reduce pest and disease pressures. The inclusion of legumes in these systems positively influences soil properties and contributes to the long-term health of the soil [4]. Intercropping short-duration cereals and pulses enables farmers to utilize available resources more efficiently while enhancing productivity. This is attributed to the increased nitrogen (N) and organic matter (OM) contributions from legumes to the soil. Rice, maize and *Bt* cotton are the main crops grown in the Southern Telangana Zone, either as sole crops or in rotation with others. Since these crops are non-leguminous, incorporating different cropping systems into the module is essential to enhance soil sustainability and complement the current crops. Various studies [5] and [6] have observed that diversified farming systems lead to increased productivity, ultimately resulting in higher income compared to monocropping. The effectiveness of nutrients is influenced by the selection of appropriate nutrient management practices and crop sequencing. A crop's nutrient uptake relies on both the soil's nutrient supply and the addition of external sources. This study is important over the other researches as earlier researches studied only one crop cropping systems nutrient uptakes but in this study multiple cropping systems nutrient uptake had been discussed in detail which is useful for further research study. During the growing season, nutrients were absorbed in proportion to the crop's increasing biomass and corresponding nutrient demands. This study aims to assess nutrient uptake and soil fertility across various crops in cropping systems that are suitable for Telangana region. With this objective, the present investigation was carried out.

Material and methods:

The study was carried out during the 2023-2024 *kharif* and *rabi* seasons at the College Farm of Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, under the AICRP on IFS. The field soil was sandy loam with a slightly alkaline pH of 7.78. It had low organic carbon content (0.40 %), low available nitrogen (175 kg ha^{-1}) and medium levels of available phosphorus (31.8 kg ha^{-1}) and potassium (187.1 kg ha^{-1}). The research study was conducted using a randomized block design (RBD) with three replications, and the same experimental field was consistently used for the entire duration of the experiment. The experiment involved eight different cropping sequences, utilizing the following crop varieties: rice (KNM-1638), *Bt* cotton (Jadoo KCH-14K59), pigeonpea (WRGE-97), finger millet (CFMV-1), fodder sorghum (CSH-24 multi-cut), fodder bajra (Moti bajra), maize (Pioneer P3302), sesame (JCS-1020), sweet corn (Sugar75), groundnut (Kadiri-6), fodder oats (Kent) and lucerne (RL-88). All crops were cultivated under irrigated conditions, following the recommended regional agronomic practices. The study explored different crop sequence combinations for nutrient uptake patterns and soil fertility assessment in diverse crop rotations under Telangana's irrigated dry conditions**.** It evaluated eight cropping system combinations during the *kharif* and *rabi* seasons, which were categorized into four thematic groups. The first theme was region-specific dominant cropping systems, categorized as follows: T_1: rice - maize and T_2: *Bt* cotton - fallow. The second theme focused on agroecological cropping systems aimed at enhancing soil quality, including T_3: *Bt* cotton + greengram (1:2) - sesame and T_4: pigeonpea + foxtail millet (2:5) - sweet corn. The third theme targeted cropping systems to meet household nutritional needs, featuring T_5: fingermillet - groundnut and T_6: pigeonpea + sorghum (2:3) - sesame. Lastly, the fourth theme included cropping systems for year-round production of dry and green fodder, represented by T_7: fodder sorghum - fodder oats and T_8: fodder bajra - lucerne. Both the economic and biological yields of all crops were documented. The rice grain equivalent yield (RGEY) was determined to assess system performance by converting the yields of non-rice crops into equivalent rice yield based on their prices, utilizing a specific formula. Both the economic and biological yields of all crops were documented. The rice grain equivalent yield (RGEY) was determined to assess system performance by converting the yields of non-rice crops into equivalent rice yield based on their prices, utilizing a specific 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.

After harvesting, both grain and plant samples were collected and subsequently oven-dried for the analysis of nitrogen, phosphorus, and potassium uptake. The total nitrogen content

(%) in the dried plant samples was measured using the micro-Kjeldahl distillation method [7]. For assessing total phosphorus and potassium in the plant samples, a diacid extract consisting of 9 parts nitric acid and 4 parts perchloric acid was used. Nutrient uptake was calculated by multiplying the nutrient content by the biomass. The data obtained from the field experiment were analyzed using a randomized block design [8]., involving three replications and ten treatments, through analysis of variance (ANOVA).

Results and Discussion:

A. N uptake:

Fodder crops typically demand more nutrients than other crops, leading to higher nutrient uptake. Among year-round fodder cropping systems, fodder sorghum has removed more amount of N (95.30 kg ha^{-1}) (Table 2) due to multiple cuttings of sorghum crop over the fodder bajra (52.84 kg ha^{-1}) during the *kharif* season of 2023. among pre-dominant cropping systems, rice crop has taken higher amount of nitrogen (111.02 kg ha^{-1}) over the *Bt* cotton (82.98 kg ha^{-1}) due to higher productivity and more nitrogen requirement for rice crop growth and development, then between cropping systems for improving soil health, *Bt* cotton intercropped with greengram in 1:2 ratio has taken up more amount of N (106.31 kg ha^{-1}) than the pigeonpea (pair) + foxtail millet in 2:5 (58.16 kg ha^{-1}) due to long duration and exhaustive nature of *Bt* cotton crop as reported by Singh and Singh [9]. In systems to meet household nutritional requirements, both treatments were on par to each other *i.e*, finger millet (46.93 kg ha^{-1}) and pigeonpea (pair) + sorghum (2:3) (45.50 kg ha^{-1}).

In the *rabi* season, maize absorbed the highest nitrogen (110.10 kg ha^{-1}) among predominant cropping systems. For soil health, sweet corn removed more nitrogen (111.06 kg ha^{-1}) compared to sesame (32.46 kg ha^{-1}), as it requires more amount of nutrients for its growth and development to produce more productivity, similar findings were reported by Kumari *et al.* [10]. Groundnut absorbed more nitrogen (64.25 kg ha^{-1}) than sesame (31.13 kg ha^{-1}) in systems focused on household nutrition. Lucerne had the highest nitrogen uptake (224.01 kg ha^{-1}) due to multiple cuttings, compared to fodder oats (87.49 kg ha^{-1}) in year-round fodder production systems.

In overall nitrogen uptake (Table 5) and Fig 1, the rice-maize system removed more nitrogen (221.12 kg ha^{-1}) compared to the *Bt* cotton-fallow system (82.98 kg ha^{-1}), as rice and maize occupy the soil longer and require more nitrogen. In ecological systems for soil health, pigeonpea + foxtail millet - sweet corn removed more nitrogen (169.22 kg ha^{-1}) than *Bt* cotton + greengram – sesame (138.77 kg ha^{-1}), driven by sweet corn's removes more N from the soil which has resulted in higher productivity compared to other crops [11]. For household nutrition, the finger millet – groundnut system absorbed more nitrogen (111.18 kg ha^{-1}) compared to pigeonpea + sorghum – sesame (76.63 kg ha^{-1}). Among all themes, fodder crops, particularly fodder bajra – lucerne (276.85 kg ha^{-1}), removed the most nitrogen as reported by Kumari *et al* [12], Liu *et al.* [13] and Kumari *et al.* [14].

B. P uptake:

In the *kharif* season (Table 3), rice consumed more phosphorus (29.96 kg ha^{-1}) than *Bt* cotton (9.25 kg ha^{-1}) due to its higher demand in flooded conditions. *Bt* cotton intercropped with greengram (1:2) took more P (12.29 kg ha^{-1}) compared to pigeonpea + foxtail millet (2:5) (8.79 kg ha^{-1}) due to competition in intercropping. Systems like fingermillet (8.91 kg ha^{-1}) and pigeonpea + sorghum (2:3) (9.39 kg ha^{-1}) showed no significant difference in P uptake. In fodder systems, fodder bajra (15.47 kg ha^{-1}) had higher P uptake than fodder sorghum (8.69 kg ha^{-1}) due to its better root growth and P use efficiency as reported by Talpur *et al.* [15] and Majeed *et al.* [16].

In the *rabi* season, maize removed more phosphorus (34.14 kg ha^{-1}) than fallow systems due to its high P requirement for energy transfer and biomass production. Sweet corn took up more P (20.66 kg ha^{-1}) than sesame (6.66 kg ha^{-1}) in systems for soil health. Groundnut (7.90 kg ha^{-1}) had slightly higher P uptake than sesame (6.68 kg ha^{-1}) in nutritional security systems. Fodder oats removed more P (18.58 kg ha^{-1}) than lucerne (12.50 kg ha^{-1}) in fodder systems.

In overall system phosphorus uptake (Table 5) and Fig 2, rice followed by maize system had removed very higher amount of P (64.10 kg ha^{-1}) over *Bt* cotton - fallow (9.25 kg ha^{-1}) among the major cropping systems as both rice and maize are cereals and high P feeder than *Bt* cotton. Among ecological cropping systems to enhance soil health, pigeonpea (pair) + foxtail millet (2:5) - sweet corn (29.45 kg ha^{-1}) due to high P requirement for production of more cob productivity over the *Bt* cotton + greengram (1:2) – sesame system (18.95 kg ha^{-1}) as reported by Ghosh *et al.* [17]. In systems of meeting household nutritional requirements, both systems were not significantly differed, so there are on par to each other *i.e*, fingermillet – groundnut (16.81 kg ha^{-1}) and pigeonpea (pair) + sorghum (2:3) – sesame (16.07 kg ha^{-1}). Both fodder sorghum - fodder oats (27.27 kg ha^{-1}) and fodder bajra – lucerne (27.98 kg ha^{-1}) systems were similar in P uptake, hence they are on par to each others.

C. K uptake:

In the *kharif* season (Table 4), rice consumed more potassium (132.93 kg ha^{-1}) than *Bt* cotton (56.01 kg ha^{-1}) due to its higher K requirement for water efficiency and disease resistance. Bt cotton + greengram (1:2) removed more K (60.92 kg ha^{-1}) than pigeonpea + foxtail millet (2:5) (33.99 kg ha^{-1}) due to cotton's need for fiber production. Fingermillet (64.75 kg ha^{-1}) and pigeonpea + sorghum (53.97 kg ha^{-1}) showed similar K uptake. In fodder systems, fodder sorghum (104.38 kg ha^{-1}) and fodder bajra (96.14 kg ha^{-1}) had similar K uptake.

In the *rabi* season, maize consumed more potassium (90.86 kg ha^{-1}) due to its high nutrient demand for yield. Sweetcorn removed more K (148.05 kg ha^{-1}) than sesame (15.24 kg ha^{-1}) for cob and carbohydrate production. Groundnut (19.58 kg ha^{-1}) and sesame (14.06 kg ha^{-1}) had similar K uptake as both are oilseeds. In fodder systems, lucerne removed more K (146.69 kg ha^{-1}) than fodder oats (77.16 kg ha^{-1}) due to its deep roots and higher nutrient demand as reported by Undersander *et al.* [18].

In Table 5 and Fig 3, the rice-maize system removed more potassium (223.79 kg ha^{-1}) than the *Bt* cotton-fallow system (56.01 kg ha^{-1}) due to its intensive cropping and higher nutrient demand as reported by Makhdum *et al.* [19]. The pigeonpea + foxtail millet - sweet corn system (182.04 kg ha^{-1}) had higher K uptake than the *Bt* cotton + greengram - sesame system (76.16 kg ha^{-1}) due to its intensive cereal cropping. For household nutritional security, the fingermillet-groundnut system (84.33 kg ha^{-1}) took up more K than pigeonpea + sorghum - sesame (68.03 kg ha^{-1}). In fodder systems, fodder bajra-lucerne (242.83 kg ha^{-1}) removed more K than fodder sorghum-fodder oats (181.54 kg ha^{-1}) due to bajra's nutrient demand and lucerne's frequent cuttings as reported by Sheaffer *et al.* [20].

D. Soil fertility:

The soil samples were collected after harvesting of *rabi* season crops and were analysed in the laboratory. The soil physico-chemical properties (Table 6) like soil pH, EC, OC and available N, P and K were remained constant without any difference among the treatments.

E. System productivity

In terms of system productivity (Table 1), in the subset of pre-dominant cropping system, rice – maize cropping system recorded higher rice grain equivalent yield (12381 kg ha^{-1}) over the *Bt* cotton – fallow system, under the ecological cropping systems involving pulses for improving soil health, *Bt* cotton + greengram (1:2) – sesame cropping system recorded higher rice grain equivalent yield (10990 kg ha^{-1}) than the pigeonpea (pair) + foxtail millet (2:5) - sweet corn system (7395 kg ha^{-1}). Among the two systems evaluated for ensuring household nutritional security including cereals, pulses and oilseeds, finger millet – groundnut system reported higher rice grain equivalent yield (9846 kg ha^{-1}) when compared to the pigeonpea (pair) + sorghum (2:3) – sesame system (5320 kg ha^{-1}). Out of the two cropping systems for round the year green/dry fodder production, fodder bajra – lucerne system had shown higher rice grain equivalent yield in green fodder (5595 kg ha^{-1}) and dry fodder yield (14351 kg ha^{-1}) than the fodder sorghum - fodder oats system green fodder yield (4411 kg ha^{-1}) and dry fodder yield (12241 kg ha^{-1}).

Conclusion:

It is essential to develop region-specific cropping sequences as part of crop diversification strategies. These tailored cropping systems can enhance productivity and income while preserving environmental health. Among these systems, the rice-maize rotation demonstrated the highest nutrient uptake, resulting in superior rice grain equivalent yields compared to many other systems. In ecological cropping, the *Bt* cotton + greengram (1:2) – sesame sequence stands out. For improving family nutritional security, the fingermillet-groundnut rotation is effective. In fodder cropping systems, the fodder bajra-lucerne sequence has shown promising results.

Future scope of study:

- Long-term soil health monitoring of various cropping systems have been needed.
- Optimization of crop rotations and nutrient management strategies should be discussed in future study.
- Environmental impact assessment and response to climate change by different cropping systems should be studied.

Disclaimer (Artificial intelligence)

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Details of the AI usage are given below:

1.

2.

3.

Table 1. Influence of various cropping systems on Rice Grain Equivalent Yield (RGEY kg ha^{-1})

Treatment notation		Treatments	*Kharif* Productivity			*Rabi* Productivity			System productivity
			Grain	Straw	Total	Grain	Straw	Total	
A_1	T_1	Rice - Maize	5899	324	6223	5806	352	6158	12381
	T_2	*Bt* cotton - Fallow	5892	46	5938	0	0	0	5938
A_2	T_3	*Bt* cotton + Greengram (1:2) – Sesame	7892	149	8041	2928	21	2949	10990
	T_4	Pigeonpea (pair) + Foxtail millet (2:5) - Sweet corn	2392	104	2495	4039	860	4899	7395
A_3	T_5	Finger millet - Groundnut	3324	154	3478	5711	657	6368	9846
	T_6	Pigeonpea (pair) + Sorghum (2:3) - Sesame	2415	90	2505	2795	20	2815	5320
A_4	T_7	Fodder sorghum - Fodder oats	0	3111	3111	0	1300	1300	4411
	T_8	Fodder bajra - Lucerne	0	2939	2939	0	2656	2656	5595
SEm (±)			-	-	185	-	-	209	314
CD (p=0.05)			-	-	561	-	-	634	952
CV (%)			-	-	7	-	-	11	7

Grain sale price (₹ kg^{-1}): Rice = 22.03, *Bt* cotton = 70.2, Greengram = 85.58, Pigeonpea = 70.0, Foxtail millet = 25.00, Finger millet = 38.46, Sorghum = 31.80, Maize = 20.9, Sesame = 86.35, Sweet corn = 9.00, Groundnut = 63.77.

Stover sale price (₹ kg^{-1}): Rice = 1.00, *Bt* cotton = 0.25, Greengram = 2.00, Pigeonpea = 0.25, Foxtail millet = 1.00, Finger millet = 1.00, Sorghum = 1.00, Fodder sorghum = 2.00, Fodder bajra = 2.00, Maize= 1.00, Sesame = 0.25, Sweet corn = 1.5, Groundnut = 5.00, Fodder oats = 2.00, Lucerne = 2.00

Table 2. Influence of various cropping systems on nitrogen uptake (kg ha^{-1})

Treatment notation	Treatments		*Kharif*					*Rabi*		
			Grain uptake		Stover uptake		Total uptake (G + S)	Grain uptake	Stover uptake	Total uptake (G + S)
			Main crop	Inter crop	Main crop	Inter crop				
A$_1$	T$_1$	Rice - Maize	65.78	0.00	45.23	0.00	111.02	64.57	45.54	110.10
	T$_2$	*Bt* cotton - Fallow	33.51	0.00	49.47	0.00	82.98	0.00	0.00	0.00
A$_2$	T$_3$	*Bt* cotton + Greengram (1:2) – Sesame	31.41	14.69	46.22	13.99	106.31	17.19	15.27	32.46
	T$_4$	Pigeonpea (pair) + Foxtail millet (2:5) - Sweet corn	11.31	15.79	15.38	15.69	58.16	46.94	64.12	111.06
A$_3$	T$_5$	Finger millet - Groundnut	22.62	0.00	24.31	0.00	46.93	50.71	13.54	64.25
	T$_6$	Pigeonpea (pair) + Sorghum (2:3) - Sesame	13.35	4.89	18.20	9.06	45.50	16.28	14.85	31.13
A$_4$	T$_7$	Fodder sorghum - Fodder oats	0.00	0.00	95.30	0.00	95.30	0.00	87.49	87.49
	T$_8$	Fodder bajra - Lucerne	0.00	0.00	52.84	0.00	52.84	0.00	224.01	224.01
SEm (±)			-	-	-	-	2.77	-	-	3.07
CD (p=0.05)			-	-	-	-	8.41	-	-	9.31
CV (%)			-	-	-	-	6.41	-	-	6.44

Table 3. Influence of various cropping systems on phosphorus uptake (kg ha^{-1})

Treatment notation	Treatments		*Kharif*					*Rabi*		
			Grain uptake		Stover uptake		Total uptake (G + S)	Grain uptake	Stover uptake	Total uptake (G + S)
			Main crop	Inter crop	Main crop	Inter crop				
A$_1$	T$_1$	Rice - Maize	19.09	0.00	10.87	0.00	29.96	19.30	14.84	34.14
	T$_2$	*Bt* cotton - Fallow	5.01	0.00	4.23	0.00	9.25	0.00	0.00	0.00
A$_2$	T$_3$	*Bt* cotton + Greengram (1:2) – Sesame	5.05	1.96	4.03	1.25	12.29	2.78	3.88	6.66
	T$_4$	Pigeonpea (pair) + Foxtail millet (2:5) - Sweet corn	1.46	2.51	1.66	3.16	8.79	10.67	9.99	20.66
A$_3$	T$_5$	Finger millet - Groundnut	4.43	0.00	4.48	0.00	8.91	6.00	1.89	7.90
	T$_6$	Pigeonpea (pair) + Sorghum (2:3) - Sesame	1.68	2.31	2.14	3.26	9.39	2.67	4.01	6.68
A$_4$	T$_7$	Fodder sorghum - Fodder oats	0.00	0.00	8.69	0.00	8.69	0.00	18.58	18.58
	T$_8$	Fodder bajra - Lucerne	0.00	0.00	15.47	0.00	15.47	0.00	12.50	12.50
SEm (±)			-	-	-	-	0.26	-	-	0.38
CD (p=0.05)			-	-	-	-	0.79	-	-	1.16
CV (%)			-	-	-	-	3.53	-	-	4.93

Table 4. Influence of various cropping systems on potassium uptake (kg ha^{-1})

Treatment notation	Treatments		*Kharif*					*Rabi*		
			Grain uptake		Stover uptake		Total uptake (G + S)	Grain uptake	Stover uptake	Total uptake (G + S)
			Main crop	Inter crop	Main crop	Inter crop				
A_1	T_1	Rice - Maize	32.07	0.00	100.87	0.00	132.93	30.68	60.18	90.86
	T_2	*Bt* cotton - Fallow	15.26	0.00	40.75	0.00	56.01	0.00	0.00	0.00
A_2	T_3	*Bt c*otton + Greengram (1:2) – Sesame	14.91	4.69	35.66	5.67	60.92	2.28	12.96	15.24
	T_4	Pigeonpea (pair) + Foxtail millet (2:5) - Sweet corn	3.86	6.58	12.13	11.42	33.99	15.98	132.07	148.05
A_3	T_5	Finger millet - Groundnut	8.08	0.00	56.67	0.00	64.75	9.44	10.13	19.58
	T_6	Pigeonpea (pair) + Sorghum (2:3) - Sesame	4.35	9.42	16.53	23.67	53.97	2.16	11.90	14.06
A_4	T_7	Fodder sorghum - Fodder oats	0.00	0.00	104.38	0.00	104.38	0.00	77.16	77.16
	T_8	Fodder bajra - Lucerne	0.00	0.00	96.14	0.00	96.14	0.00	146.69	146.69
SEm (±)			-	-	-	-	3.76	-	-	2.01
CD (p=0.05)			-	-	-	-	11.41	-	-	6.10
CV (%)			-	-	-	-	8.64	-	-	5.44

Table 5. Influence of various cropping systems on total nutrient (nitrogen, phosphorus and potassium) uptake (kg ha^{-1})

Treatment notation	Treatments		*Kharif* uptake			*Rabi* uptake			System uptake		
			N	P	K	N	P	K	N	P	K
A_1	T_1	Rice – Maize	111.02	29.96	132.93	110.1	34.14	90.86	221.12	64.10	223.79
	T_2	*Bt* cotton - Fallow	82.98	9.25	56.01	0	0	0	82.98	9.25	56.01
A_2	T_3	*Bt c*otton + Greengram (1:2) – Sesame	106.31	12.29	60.92	32.46	6.66	15.24	138.77	18.95	76.16
	T_4	Pigeonpea (pair) + Foxtail millet (2:5) - Sweet corn	58.16	8.79	33.99	111.06	20.66	148.05	169.22	29.45	182.04
A_3	T_5	Finger millet – Groundnut	46.93	8.91	64.75	64.25	7.9	19.58	111.18	16.81	84.33
	T_6	Pigeonpea (pair) + Sorghum (2:3) - Sesame	45.5	9.39	53.97	31.13	6.68	14.06	76.63	16.07	68.03
A_4	T_7	Fodder sorghum - Fodder Oats	95.30	8.69	104.38	87.49	18.58	77.16	182.79	27.27	181.54
	T_8	Fodder bajra - Lucerne	52.84	15.47	96.14	224.01	12.50	146.69	276.85	27.98	242.83
	SEm (±)		2.77	0.26	3.76	3.07	0.38	2.01	4.26	0.55	4.11
	CD (p=0.05)		8.41	0.79	11.41	9.31	1.16	6.10	12.93	1.67	12.47
	CV (%)		6.41	3.53	8.64	6.44	4.93	5.44	4.69	3.64	5.11

Table 6. Influence of various cropping systems on soil physico – chemical and chemical parameters after harvest of *rabi* crops.

Treatment notation	Treatments		p^H	EC (dS m^{-1})	OC (%)	Avail. N (kg ha^{-1})	Avail. P (kg ha^{-1})	Avail. K (kg ha^{-1})
A_1	T_1	Rice - Maize	7.99	0.51	0.40	174.67	31.93	189.80
	T_2	*Bt* cotton - Fallow	7.73	0.47	0.39	171.00	31.17	186.97
A_2	T_3	*Bt c*otton + Greengram (1:2) - Sesame	7.77	0.48	0.40	179.33	32.50	191.23
	T_4	Pigeonpea (pair) + Foxtail millet (2:5) - Sweet corn	7.87	0.50	0.40	175.00	32.70	191.97
A_3	T_5	Finger millet - Groundnut	7.74	0.48	0.41	187.67	33.40	194.70
	T_6	Pigeonpea (pair) + Sorghum (2:3) - Sesame	7.81	0.49	0.40	183.33	32.43	191.73
A_4	T_7	Fodder sorghum - Fodder oats	7.74	0.48	0.41	191.67	32.87	195.13
	T_8	Fodder bajra - Lucerne	7.76	0.48	0.41	187.33	32.50	193.47
	SEm (±)		0.14	0.03	0.02	12.51	1.86	11.01
	CD (p=0.05)		NS	NS	NS	NS	NS	NS
	CV (%)		3.09	8.19	9.41	11.96	9.91	9.94
	Initial		**7.78**	**0.47**	**0.40**	**175.00**	**31.8**	**187.1**

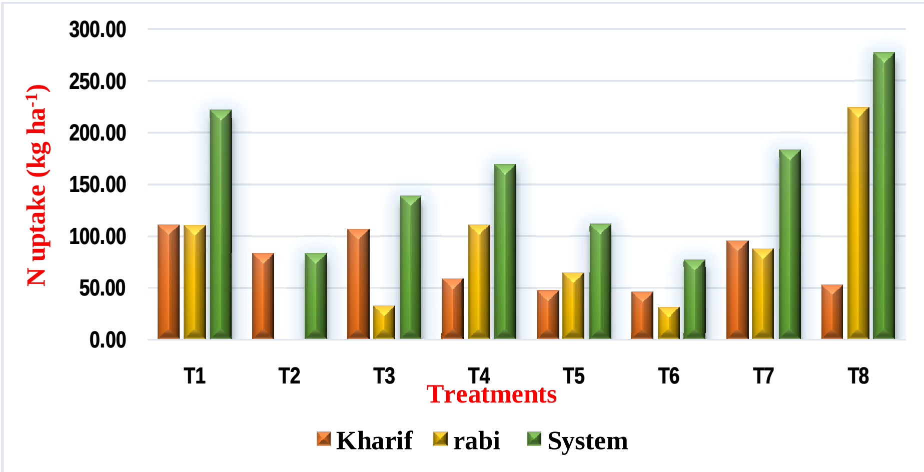

Fig 1: Influence of various cropping systems on nitrogen uptake (kg ha^{-1})

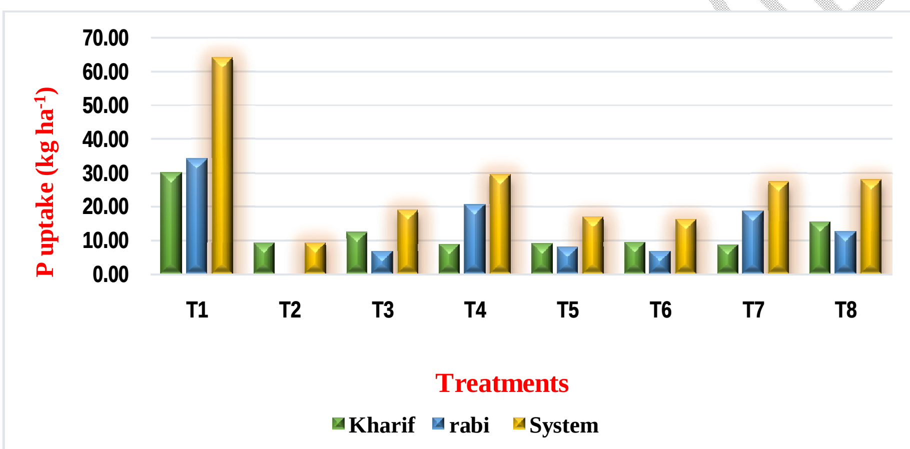

Fig 2: Influence of various cropping systems on phosphorus uptake (kg ha^{-1})

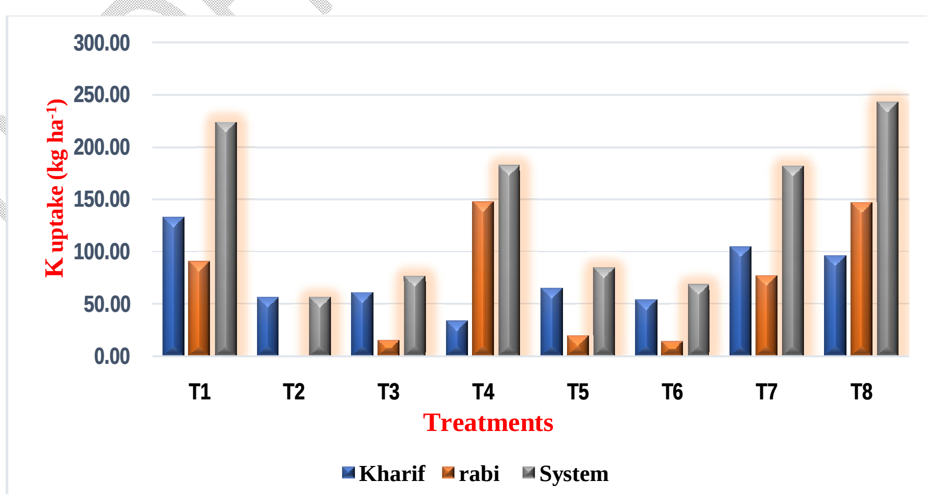

Fig 3: Influence of various cropping systems on potassium uptake (kg ha^{-1})

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