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Yield, nutrient content and nutrient uptake of rice as influenced by rice based cropping system in Varanasi of Eastern Uttar Pradesh, India

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ABSTRACT

Continuous adoption of cereal-cereal cropping system has led to deterioration of soil quality resulting in a serious threat to its sustainability and food security in hot sub-humid region of eastern Varanasi, India. Therefore crop diversification with wider choice in the production of a variety of crops is being promoted meet the demand of balanced food for increasing population. Ten rice- based crop sequences were tested to found the influence of different crop sequences on yield, nutrient content and uptake of nutrient by rice. Rice in rice-wheat-*sesbania* crop sequence recorded highest number of effective tiller (414.6 m^{-2}) than other crop sequences whereas, number of non effective tiller (m^{-2}) of rice was found maximum (53.33 m^{-2}) in rice-wheat-green gram sequence followed by rice-wheat sequence (52.33 m^{-2}). Grain filling % of rice was recorded maximum in sequence (58.9) but test weight (g) of rice was found maximum (28.17) in rice-mustard-green gram sequence. Grain and straw yield (q ha^{-1}) of rice was reported highest in rice-wheat-*sesbania* and rice-potato green gram sequence respectively. However, highest harvest index (35.62) was reported in crop sequence. N, P, and K content of rice grain was found highest in rice-maize (green cob)+ veg. pea (1:2)-cow pea(f), rice-wheat+mustard (5:1)-black gram and rice-veg. pea-lady's finger sequence respectively. Rice-wheat-*sesbania* crop sequence recorded highest N and P uptake (*i.e.* 89.1 and 20.07 kg ha^{-1}, respectively) of rice among all the sequences.

Key words *: Nutrient uptake, Nutrient content, Rice based crop sequences.*

Introduction

Rice *(Oryza sativa)* is the major staple food crop of the tropical area and rice-based cropping patterns are prevalent in much of the tropics (George *et al.* 1992).it contributing nearly 45% to the total food grain production in India. The crop ranks first in the use of land (> 44 M. ha) and water resources (> 50% irrigation water), and inputs (38-40% of fertilizers and 17 – 18% of pesticides) though the use efficiency is considerably low. Current crop production systems are characterized by inadequate and imbalanced use of fertilizers; blanket fertilizer recommendations over large domains with least regard to the variability in soil fertility and productivity. Under best crop management strategies with improved nutrient use efficiency and without deteriorating soil and environmental quality is the most ideal system that needs to be practiced to achieve the targeted goals. Diversification and intensification of rice-based system to increase productivity per unit resource is pertinent. Crop diversification

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has been recognized as an effective strategy for achieving the objectives of food security, nutrition security, income growth, poverty alleviation, employment generation, and judicious use of land and water resources, sustainable agricultural development and environmental improvement (Hedge *et al.* 2003). It is, therefore, imperative to explore the possibility of crop diversification of rice-wheat system at least partially, if not fully, with more remunerative crops.

Materials and Methods

The experiment was conducted at the Agricultural Research Farm, B.H.U., Varanasi, Uttar Pradesh (25°18 N latitude and 83°03' E longitude at an altitude of 128.93 m from the mean sea level) during *kharif*, *rabi* and *summer* seasons of 2011-12. The experimental soil was sandy loam with pH 7.4, low in organic carbon (0.35%) and available nitrogen (214 kg ha^{-1}). Whereas, medium in available phosphorus (24.3 kg ha^{-1}) and potassium (208.5 kg ha^{-1}). The experiment was laid out in randomized block design with 3 replications. Ten crop sequences viz., rice-wheat (T_1), rice-wheat-green gram (T_2), rice-wheat-*Sesbania* (T_3), rice-wheat + mustard (5:1)-black gram (T_4), rice-wheat + mustard (5:1)-cowpea (dual purpose) (T_5), rice-mustard-green gram (T_6), rice-*toria*-lady's finger (T_7), rice-veg. pea-lady's finger (T_8), rice-maize (cob) + veg. pea (1:2) - cowpea fodder (T_9) and rice-potato-green gram (T_{10}) were tested. The variety used for rice was 'Pusa Sugandha-4' in *kharif*. Full recommended dose of nutrients i.e. 150 kg N and 75 kg each of P_2O_5 and K_2O was applied to the experimental rice crop. The whole amount of P_2O_5 and K_2O along with half of the nitrogen was applied as basal through urea, DAP and Muriate of Potash (MOP). The rest of the half amount of nitrogen was top dressed in two equal splits through urea. General recommended dose of fertilizer were applied to other crops in different seasons. Four week old seedlings were transplanted in the puddle field at the rate of 2-3 seedlings $hill^{-1}$ on 5th July 2011. Row spacing of 20 cm and hill-to-hill spacing 15 cm was maintained. About 5 cm of water was maintained in plots at the time of transplanting. Weed management was comprised of both chemical and manual means. Butachlor 50EC @ 2.5 L $ha^{-1}$was applied as pre-emergence spray on 4th day of transplanting. This was followed by one manual weeding at 25 days after transplanting (DAT). Irrigation was given to the crop as and when needed according to crop requirement and rainfall pattern. During crop period, one pre sowing and one post sowing irrigation were given. The crop from net plot area was harvested, bundled and tagged separately. Weight of each bundle was taken after complete drying and threshing was done through plot- thresher. After winnowing and cleaning, yield of grain was recorded. The straw yield was calculated by subtracting grain yield from bundle weight and the net plot yield was converted into q ha^{-1}. Number of effective tiller bearing panicle were counted from four tagged hills in each plot and averaged. The number of tillers which did not bear panicle was counted from four tagged hills and the mean was computed. Twelve panicles were randomly selected from tagged plant and the length was measured from neck node to tip of the upper most spikelet and mean length was recorded. The Grain filling (%) was calculated by using the formula

$$\text{Grain filling (\%)} = \frac{\text{Number of filled grain panicle}^{-1}}{\text{Total number of grain panicle}^{-1}} \times 100$$

Grain sample were taken from the threshed and cleaned produce of each net plot and 1000 grain were counted and weighed. The harvest index was calculated by using the formula as

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (grain kg ha}^{-1})}{\text{Biological yield (grain + straw) kg ha}^{-1}} \times 100$$

The nitrogen, phosphorus and potassium content in grain and straw of rice were estimated at maturity. The grain and straw samples were dried at 70°c for 48 hours and plant material thus obtained was ground with the help of grinder and passed through 40 mesh sieve. The nutrient uptake was computed by multiplying nutrient content of grain and straw with respective dry weight (kg ha^{-1}). All variables were analyzed. The significance of treatment differences were judged by F-test as out lined by (Gomez and Gomez, 1984). To evaluate the significance of difference between two treatment means, critical difference (C.D.) at 5 per cent level was worked out. The standard errors of mean were computed in all cases.

Results

Yield attribute and yield

Number of effective tiller m^{-2} of rice in rice-wheat-

Sesbania was significantly higher than rice-wheat and being at par with rice-wheat-green gram, rice-wheat + mustard (5:1), cowpea (DP), rice-mustard-green gram and rice-potato green gram sequences. However, lowest number of effective tiller was noticed in rice-wheat closely followed by rice-maize (green cob) + veg. pea (1:2)-cowpea fodder and rice-*toria*-lady's finger sequences (Table 1). Significantly lower number of non-effective tiller m^{-2} of rice in rice-potato-green gram than rice-wheat and rice-wheat sequences and being at par with rest of the sequences. However, highest number of non-effective tiller m^{-2} was recorded in rice-wheat-green gram (54.33) followed by rice-wheat (52.33) sequence which were remain comparable with each other. The maximum and minimum grain filling per cent of rice was recorded in rice-wheat + mustard (5:1)-black gram and rice-veg. Pea lady's finger sequence, respectively but differences were not at the level of significance. Further, number of unfilled spikelet $panicle^{-1}$ (i.e. grain filling %) of rice in rice-veg. pea-lady's finger recorded lowest among all the sequences. However, differences were not at the level of significance. In general, comparatively higher test weight of rice was recorded in sequences involving legume component. The lowest test weight (25.62) was noticed in rice-*toria*-lady's finger sequence closely followed by rice-wheat (26.18). Nevertheless, the test weight of rice in rice-mustard-green gram, rice-wheat-*Sesbania* (GM) and rice-potato-green gram sequences was significantly higher than rice-wheat. As compare to rice-wheat sequence, significantly higher grain yield was recorded in crop sequences *viz.*, rice-wheat-*Sesbania*, rice-wheat + mustard (5:1)-cow pea (DP), rice-potato-green gram. Marked variation in yield of rice due to different rice based crop sequences was recorded during course of the experiment. The maximum rice grain yield is found in T_3 (rice-wheat-*Sesbania*) and crop sequences *viz.*, T_3, T_5, T_{10}, T_6, T_2, T_4, T_7, T_9 and T_8 recorded 23.07, 18.23, 13.10, 11.04, 8.43, 7.32, , 6.69, 6.35 and 4.96 per cent higher grain yield respectively, over T_1 (rice - wheat) sequence (Fig. 1). All the crop sequences registered higher straw yield of rice than rice - wheat sequence. The highest rice straw yield was found in rice-wheat-green gram followed by rice-wheat-*Sesbania* and rice-wheat-green gram sequences. However, the differences did not turn significant. the highest harvest index of rice in different sequences though differs but the differences failed to touch the level of significance.

Nutrient content and uptake

Nitrogen (N) content in grain of rice under different sequences did not differ to the level of significance. However, N content in straw was found significantly higher in rice-wheat-green gram over all other except rice- maize (cob) + veg. pea (1:2)-cowpea (F) sequence. Marked variation in N uptake by grain and straw of rice (Table 2). The lowest N uptake by rice grain was observed in rice-wheat sequence and being at par with T_4, T_7 and T_8 it recorded significantly less N uptake than other sequences. The highest being associated with rice-

Table 1. Effect of crop sequences on yield attributing characters of rice.

Treatments	No. of effective tiller (m^{-2})	No. of Non-effective tiller (m^{-2})	Panicle length (cm)	Grain filling (%)	No. of unfilled Spikelet $panicle^{-1}$	Test weight (g)
T_1	392.0	52.33	23.07	57.0	12.8	26.18
T_2	412.3	54.33	23.16	57.7	13.4	26.36
T_3	414.6	51.67	22.85	57.9	13.4	27.23
T_4	394.7	50.33	22.96	58.9	12.9	26.63
T_5	407.7	51.33	22.88	58.2	13.5	26.25
T_6	409.7	52.00	23.11	58.1	13.5	28.17
T_7	394.3	49.33	22.95	57.1	13.4	25.02
T_8	396.3	48.33	23.55	57.2	12.5	26.23
T_9	393.3	51.67	28.80	57.6	13.5	26.54
T_{10}	410.3	49.00	23.18	57.9	13.2	27.05
SEm±	3.92	1.31	1.78	1.08	0.22	0.25
CD (P = 0.05)	11.65	3.90	NS	NS	NS	NS

Table 2. Effect of different crop sequences on N, P, K content and uptake of grain and straw of rice.

Treatments	Nutrient content (%)						Nutrient uptake (kg ha^{-1})						Total Nutrient uptake (kg ha^{-1})		
	Grain			Straw			Grain			Straw					
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
T_1	1.18	0.239	0.351	0.462	0.094	1.21	42.5	8.60	12.66	31.19	6.33	81.88	73.7	14.93	94.5
T_2	1.18	0.223	0.341	0.494	0.103	1.23	45.9	8.66	13.30	40.00	8.37	99.84	85.9	17.03	113.1
T_3	1.18	0.253	0.336	0.449	0.108	1.21	52.2	11.18	14.87	36.9	8.89	99.31	89.1	20.07	114.2
T_4	1.21	0.261	0.343	0.466	0.103	1.25	46.6	10.08	13.23	32.5	7.15	87.08	79.0	17.23	100.3
T_5	1.19	0.261	0.343	0.432	0.096	1.20	50.5	11.12	14.60	34.7	7.67	96.64	85.2	18.79	111.3
T_6	1.23	0.245	0.348	0.446	0.100	1.22	49.1	9.79	13.91	35.3	7.93	96.97	84.4	17.72	110.9
T_7	1.22	0.222	0.351	0.452	0.099	1.26	47.0	8.58	13.47	32.9	7.17	91.94	79.8	15.70	105.4
T_8	1.18	0.260	0.356	0.449	0.103	1.20	44.4	9.83	13.45	34.0	7.75	91.11	78.4	17.58	104.6
T_9	1.28	0.247	0.344	0.473	0.094	1.21	49.0	9.44	13.21	37.4	7.41	95.68	86.4	16.85	108.9
T_{10}	1.23	0.249	0.346	0.460	0.103	1.222	50.1	10.17	14.07	38.6	8.68	102.48	88.7	18.84	116.6
SEm±	0.034	0.004	0.004	0.008	0.004	0.024	2.2	0.39	0.53	1.8	0.40	5.41	2.71	0.56	5.45
CD (P = 0.05)	NS	0.013	NS	0.025	0.010	NS	6.5	1.16	1.59	5.40	1.20	16.08	8.1	1.67	16.20

wheat-*Sesbania* (GM). Similarly, crop sequences T_4, T_5, T_6, T_7 and T_8 did not differ significantly with rice-wheat (T_1) as regards the N uptake by straw but T_2. Total N uptake by rice in different sequences differed significantly. Crop sequences i.e. T_2, T_3, T_5, T_6, T_9 and T_{10} though remained at par among themselves had significantly higher total N uptake than rice-wheat sequence. However, crop sequences *viz.*, T_4, T_7 and T_8 though recorded higher total N uptake than rice-wheat sequence but the difference failed to touch the level of significance. crop sequences *viz.*, rice-wheat-*Sesbania*, rice-wheat + mustard (5:1)-black gram, rice-wheat + mustard (5:1)-cowpea (DP), and rice-veg. pea- lady's finger though remained comparable recorded significantly higher grain P content over rice-wheat and other sequences. The lowest grain P content in rice was recorded in rice-*toria*-lady's finger sequences. In respect to P content of straw in rice the maximum P content in straw was recorded in rice-wheat-*Sesbania* sequence and being at par with T_2, T_6, T_7, and T_8, it recorded significantly higher P content of straw than other sequences. Comparing with rice-wheat sequence, significantly higher total P uptake by rice grain was recorded in T_3, T_4, T_5, T_6, T_8 and T_{10} sequences. However, highest P uptake by grain was found in T_3 closely followed by T_5 and both proved significantly superior to other sequences except T_{10}. As regards the P uptake by straw, rice-wheat-*Sesbania* (GM) though remained comparable to T_{10}, T_2, T_6 and T_8 resulted in significantly higher P uptake by rice straw than other crop sequences. Nevertheless, the lowest P uptake by straw was found associated with rice-wheat sequence. Further examination of the data showed that total uptake of P by rice was highest in rice-wheat-*Sesbania* (GM) followed by T_{10} and T_5. All the crop sequences recorded significantly higher total P uptake than rice-wheat sequence except rice-*toria*-lady's finger.

An analysis of the data revealed that though there was some variation in K content of rice grain and straw in different sequences, the differences failed to touch the level of significance. All the crop sequences had marked variation on K uptake by grain, straw as well as total uptake. In comparison to rice-wheat sequence, significantly higher K uptake in grain was recorded in rice-wheat-*Sesbania* and rice-wheat + mustard (5:1) - cow pea (DP) sequences and remaining sequences though recorded higher K uptake by rice grain but the differences failed to touch the level of significance. In case of K uptake in

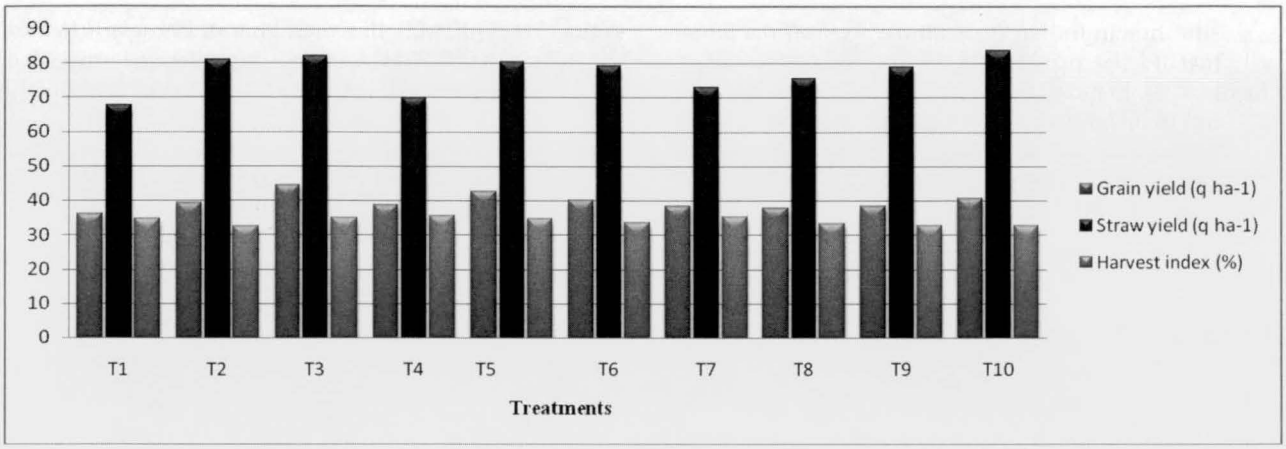

Fig. 1. Effect of crop sequences on grain and straw yield and harvest index of rice.

straw, maximum was noted in T_{10} followed by T_2 and T_3. Which being at par among themselves established significant increase over rice-wheat sequence. However, with respect to total K uptake by rice, all the crop sequences recorded higher K uptake than rice-wheat sequence but the sequences T_4, T_8 and T_9 failed to establish significant superiority over rice-wheat sequence.

Discussion

Yield attribute and yield

Marked variation in yield attributes of rice due to different rice based crop sequences. As compared to rice-wheat sequence, having summer legume as a component crop in rice-based sequence, resulted in significantly higher number of effective tiller m^{-2}, grain filling (%) and test weight of rice. However, maximum number of effective tiller m^{-2} of rice was noticed in rice-wheat-*Sesbania* sequence followed by rice-wheat green gram, rice-potato-green gram and rice- wheat + mustard- cowpea (DP) sequence. This may be attributed due to the beneficial effect of legume crops taken in summer that ultimately help to succeeding rice in production of higher number of effective tillers and test weight and finally the grain yield. Substitution of rice-wheat crop sequence by *rabi* or summer legume has been reported to improve the soil physical properties as well as NPK status of soil and which improved yield attributing characters and yield of rice (Bastia *et al.* 2008 and Zamir *et al.* 2005).

Nutrient content and uptake

All the crop sequences involving summer legumes, green manuring recorded higher N, P and K uptake than rice-wheat sequence. The maximum nitrogen uptake by rice was recorded in rice-wheat-*Sesbania* followed by rice-potato-green gram and rice-maize (green cob) + veg. pea (1:2)-cowpea (F) sequences. This can be ascribed to the better soil and nutrient status in these sequences because inclusion of legume component and thereby the legume effect. However, the lowest N uptake was noticed in rice-wheat sequence. These findings are in close agreement with the results of Khanda *et al.* (2005) and Walia *et al.* (2011). As regard the phosphorus uptake by rice, all the sequences having grain fodder legume and *Sesbania* (GM) recorded higher P uptake than rice-wheat sequence alone. However, the maximum P uptake by rice was noticed in rice-wheat-*Sesbania* (GM), which remained comparable with T_5 and T_{10} sequences. Similarly, K uptake by rice was highest in rice-potato-green gram followed by rice-wheat-*Sesbania* (GM) and rice-wheat-green gram sequences.

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