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IMPACT OF COMBINED ORGANIC AND INORGANICS ON NUTRIENTS UPTAKE AND ACHIEVING TARGETED RICE YIELD IN RICE BASED CROPPING SYSTEMS IN CALCAREOUS SOIL

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ABSTRACT

This study evaluated the effects of combining organic and inorganic nutrient management strategies on nutrient uptake and rice yield within calcareous soil conditions in Bihar, India. Conducted as part of the AICRP on Soil Test Crop Response, the experiment nine treatments, incorporating various levels of nitrogen (N), phosphorus (P), potassium (K), and sulphur (S) using the Integrated Plant Nutrient System (IPNS) under examined three cropping systems Rice-Wheat, Rice-Mustard, and Rice-Winter Maize and a control setup without IPNS. The experimental design was a split-plot setup with 81 treatment combinations, implemented with nine treatments, including IPNS applications (T7, T8, and T9). Among these, Treatment T9 (Y3 with IPNS) consistently achieved the highest nutrient uptake and yields. The IPNS treatment significantly improved nutrient availability, resulting in enhanced yields, with T9 producing 46.64 q ha^{-1} in grain yield, meeting and exceeding the target yield of 45 q ha^{-1}. The analysis revealed that the Rice-Winter Maize system had superior nutrient uptake and yield, with the Rice-Wheat system showing comparatively lower values. Statistical analyses, including ANOVA, highlighted significant differences among treatments and cropping systems. Notably, the IPNS treatments led to higher plant height, increased tiller count, and a greater number of grains per panicle, all essential factors contributing to higher yields. T9 recorded the highest straw yield (6.20 t ha^{-1}), biological yield (10.58 t ha^{-1}), and the tallest plants (111.7 cm). Furthermore, IPNS treatments demonstrated efficient nutrient recovery, particularly for N and P, critical in calcareous soils with limited nutrient availability. This study underscores the efficacy of IPNS in calcareous soils for optimizing nutrient uptake, achieving yield targets, and promoting sustainable agriculture. Findings suggest that incorporating organic inputs with inorganic fertilizers can significantly enhance rice productivity, especially in systems prone to nutrient constraints. The IPNS approach, especially T9, emerges as a promising strategy for improving soil fertility and achieving high yields, supporting sustainable agriculture in nutrient-deficient calcareous soils. These findings underscore the importance of balanced nutrient management for sustainable agriculture.

Keywords: Integrated Plant Nutrient System, STCR - Soil Test Crop Response, rice yield, calcareous soil, cropping systems.

Introduction

Rice is the staple food of south Asia and it is repeatedly cultivated in the regions of tropical and sub-tropical. We can consider it as a staple food for more than three billion people on this earth that too especially for South Asia, India and Bihar where the rice is treated as the upper most priority for nutritional source. Due to uneven fertilizer use over a longer period of time, the green revolution's success was followed by diminishing soil health, which created a significant gap between removing of crop and delivery of fertilizer (Kumar *et al.,* 2011). The most important strategy for reducing this gap is to utilize fertilizers in a balanced way. To know the status of the nutrients and their imbalances in the soil and to supply the adequate quantity of the nutrients in according to the gap supply, conventional fertilizer application based on soil testing is recommended around the world (Gautam *et al.,* 2020). It offers a scientific foundation for balanced fertilization that takes into account both the nutrients in the fertilizer and the nutrients already existing in the soil (Ammal *et al.,* 2022). In order to achieve a targeted yield, "fertilizing the crop and fertilizing the soil" must coexist in harmony. Therefore, this study was conducted to assess the impact of STCR approach-based fertilizer application on growth, yield attributing characters of rice crop and uptake of nutrients (N, P, K, S) by rice crop in rice-based cropping systems of calcareous soil under various organic and inorganic fertilizer application methodologies through IPNS (integrated plant nutrient system).

Materials and Methods

A field experiment was conducted at Dr. Rajendra Prasad Central Agricultural University (RPCAU), Pusa, Bihar, situated in the northern part of Samastipur district. The farm is located at 25°57’08”–25°57’44” N latitude and 85°40’13”–85°40’57” E longitude, with an elevation of approximately 52 meters above mean sea level. The region experiences a hot and humid climate in summer and cold conditions in winter, with an average annual rainfall of 1200 mm. The area is prone to frequent flooding during the monsoon. Detailed weather data for the cropping period. The experiment was part of the AICRP on STCR, initiated in 2013 (Kharif season). The study focused on rice-based cropping systems, including Rice-Wheat, Rice-Mustard, and Rice-Winter Maize rotations. The experimental design was a split-plot with 9 treatments and 3 subplots, replicated thrice, total 81 treatment combinations. The rice variety used was 'Rajendra Bhagawati'. The treatments (total 9) involved control plot and varying levels of NPK as inorganics (in 8 treatments) and compost as organic (in 3 treatments), those are T1 – Control, T2 – Farmers Practice*, T3 – General Recommended Dose**, T4 – Y1 without IPNS, T5 – Y2 without IPNS, T6 – Y3 without IPNS, T7 – Y1 with IPNS***, T8 – Y2 with IPNS, T9 – Y3 with IPNS [*97:57:33 (N: P_2O_5: K_2O) kg ha^{-1}, **120:60:40 (N: P_2O_5: K_2O) kg ha^{-1}, ***IPNS (Integrated Plant Nutrient System) with addition of 5 t ha^{-1} compost].

Plant Growth Characters Observation

Plant height was characterized as the length between the stem base touching the ground level to the top point of topmost leaf with the help of a normal wooden scale used for agronomic measurement purposes. Data was taken at the time of harvest. During harvest stage, a quadrate of (100 * 100) square cm dimension was placed at 3 random places per plot and total number of tillers/ m^2 were counted. At maturity stage of crop, five panicles were collected from each plot to count the Chaffy grains within each panicle. After that, values were averaged.

Yield and Yield Attributing Characters Observation

At maturity, five panicles were collected from each plot to count the filled grains within each panicle. After that, values were averaged. From every plot, random samples were prepared by including cleaned grains. 1000 grains were counted from the sample of grains from each plot. At 14% moisture level, weight of the grains was precisely measured by an electronic weighing balance. Harvested produce from every plot kept separately according to treatment wise for sun drying and its total bundle lot were weighed. The values were in kg/net plot after that those were transformed into t/ha. Produce obtained from each net plot was subjected to threshing separately and carefully. Clean grains were then put to sunlight for drying and maintaining the moisture level at a standard 14%. Using traditional balance these grains were weighed. Result came in kg/net plot and by applying conversion factor, these values were converted to t/ha. The weight of grains of each plot was subtracted from the weight of total harvestable produce from every plot. The values were in kg/net plot after that those were transformed in to t/ha.

Methods of Plant Analysis for Uptake of Nutrients.

Wet washing method Described by Jackson (1978), Binary acid mixture of Nitric Acid and Perchloric Acid, in a ratio of 10:4, was prepared. 15 ml of this mixture was used to digest plant sample of 0.5 g weight. After digestion, volume makeup of the digested sample (residue) was made up to 50 ml with distilled water and the solutions were stored for future analysis. Nitrogen Method was outlined by Jackson (1973) Soil sample was digested in concentrated sulphuric acid with digestion mixture inside digestion tubes and finally, distilled in an alkaline medium (sodium hydroxide). N content was estimated by titrating the distillate with 0.01 N sulphuric acid. Phosphorus Method suggested by Jackson (1973) After di-acid digestion, Phosphorous was determined with the help of colorimeter using Vanado-Molybdate Phosphoric yellow colour method. Potassium Method referred by Jackson (1973) After di-acid digestion of plant samples, Potassium was detected using flame photometer. Sulphur After di-acid digestion, sulphur was analysed through turbidimetric method (Chesnin and Yien, 1951) using Williams and Steinbergs reagent (calcium chloride 0.15%) and reading was taken in a spectrophotometer, as outlined by Jackson (1973).

Nutrient Uptake Calculation

Uptake of Nitrogen by grain and straw was evaluated using formulas

$$\text{Nitrogen uptake by grain} = \frac{\%\ \text{Nitrogen} \times \text{grain yield}\left(\frac{q}{ha}\right)}{100}$$

$$\text{Nitrogen uptake by straw} = \frac{\%\ \text{Nitrogen} \times \text{straw yield}\left(\frac{q}{ha}\right)}{100}$$

Total uptake was thereafter calculated through addition of those two values.

Phosphorous content (kg/ha) in grain and straw was multiplied with grain and straw yield respectively. Total uptake was thereafter calculated through addition of those two values.

Potassium content (kg/ha) in grain and straw was multiplied with grain and straw yield respectively. Total uptake was thereafter calculated through addition of those two values. Sulphur content (kg/ha) in grain and straw was multiplied with grain and straw yield respectively. Total uptake was thereafter calculated through addition of those two values.

Statistical analysis

The results were analysed statistically following the principles given by Panse and Sukhatme (1985). Various sulphur fractions and yield attributing characters resulted from different treatments, were validated by analysis like ANOVA using OP-STAT website.

Results and Discussion

The results of this study provide insights into the impact of combined organic and inorganic nutrient management on achieving targeted rice yields in rice-based cropping systems on calcareous soil. The treatments aimed to achieve specific yield targets: Y1 = 35 q ha^{-1}, Y2 = 40 q ha^{-1}, and Y3 = 45 q ha^{-1}. Significant variations were observed in grain yield, straw yield, biological yield, plant height, tillers per m², and grains per panicle across the treatments and cropping systems.

The analysis of variance (ANOVA) demonstrated a highly significant effect of Factor A (Treatment) on grain yield (F calculated=21.051; p=0.00), while Factor B (Cropping System) and the interaction term were non-significant. Treatment T9 (Y3 with IPNS) recorded the highest grain yield (4.43 t ha^{-1}), followed by T6 (Y3 without IPNS) at 4.30 t ha^{-1}. These results suggest that IPNS treatments, especially T9, effectively achieved the target yield of 45 q/ha for Y3. This indicates that long-term use of the Integrated Plant Nutrient System (IPNS) effectively supports achieving high yields by improving nutrient availability and uptake, as observed in previous studies (Pandey *et al.,* 2016).

Straw yield followed a similar pattern to grain yield, with significant effect (F calculated = 48.03 p = 0.). Again, T9 achieved the highest straw yield (6.20 t ha^{-1}), reflecting the positive influence of IPNS. The addition of organic matter appears to have improved water retention and nutrient cycling, suggesting that IPNS improves the availability of nutrients, not only for grain development but also for vegetative growth (Singh *et al.,* 2013)

The biological yield, representing the total grain and straw output, showed that Treatment T9 (Y3 with IPNS) had the highest biological yield of 10.58 t ha^{-1}, which aligns well with the Y3 target. Factor A also had a significant effect on biological yield (F calculated = 65.343; p=0.00), with other IPNS treatments also performing well. indicate that IPNS combined with efficient cropping systems enhances both grain and straw yields, leading to higher overall productivity Kumar and Prasad (2008).

Plant height at harvest was significantly influenced by the treatments (Factor A: F = 3.87, p =0.01). The tallest plants were observed in Treatment T9 (Y3 with IPNS), averaging 111.72 cm., which aligns with previous findings that nutrient-rich rotations promote better plant growth (Rao *et al.,* 2019).

The number of tillers per m² was significantly affected by treatments (Factor A: F = 44.298, p =0.00), Treatment T9 (Y3 with IPNS) produced the highest number of tillers (333 tillers/m²), IPNS treatments consistently performed better, highlighting the importance of balanced nutrient supply for tiller production, which directly influences yield ((Lv *et al.,* 2011).).

The number of grains per panicle was highest in Treatment T9 (Y3 with IPNS), with an average of 196 grains per panicle (F calculated =16.203, p = 0.00). Treatments without IPNS recorded significantly fewer grains per panicle, further underscoring the role of organic inputs in improving grain filling and reducing sterility (Bandyopadhyay *et al.,* 2010)

The number of chaffy grains was significantly lower in Treatment T9 (Y3 with IPNS), indicating better grain filling efficiency (F calculated = 97.099, p=0.00). The higher nutrient uptake facilitated by IPNS likely contributed to this result, reducing sterility and increasing the proportion of fully developed grains (Sheoran *et al.,* 2021)

The test weight, which reflects grain quality, not significantly affected by Treatment (p=0.93p = 0.93p=0.93), suggesting that while yield components improved, the 1000-seed weight remained relatively stable across treatments. This is consistent with findings by Ahmed *et al.* (2015) who found that yield improvements in IPNS systems often do not alter seed weight Ashwini *et al.* (2016).

The results indicate a significant impact of the combined application of organic and inorganic fertilizers, specifically under the Integrated Plant Nutrient System (IPNS), on nutrient uptake and rice yield in rice-based cropping systems on calcareous soil. The study evaluated nitrogen (N), phosphorus (P), potassium (K), and sulphur (S) uptake in both straw and grain, considering different treatments (Factor A) and cropping systems (Factor B). Significant interactions between the factors highlight the importance of using an integrated approach to improve nutrient uptake and crop productivity.

Nitrogen uptake in straw varied significantly among treatments and cropping systems, with an interaction effect ($p < 0.01$). The highest N uptake was observed in Treatment T9 (Y3 with IPNS), with an average of 24 kg ha^{-1}across cropping systems. The treatments with IPNS (T7, T8, and T9) consistently performed better than non-IPNS treatments. Among cropping systems, C1 (Rice-Wheat) had lower N uptake (14.44 kg ha^{-1}) compared to C2 (Rice-Mustard) and C3 (Rice-Winter Maize). This is consistent with findings from Khan *et al., (*2020), who reported improved N efficiency in rice systems with IPNS due to enhanced mineralization of composted organic matter combined with inorganic nutrients. This suggests that IPNS is critical for maximizing N uptake and achieving higher yields on calcareous soils. Nitrogen uptake in grain also followed a similar trend, with Treatment T9 (Y3 with IPNS) achieving the highest N uptake (46.64 kg ha^{-1}), significantly surpassing other treatments ($p < 0.01$). Cropping system C2 (Rice-Mustard) had slightly higher N uptake (31.79 kg ha^{-1}) than C3 (Rice-Winter Maize), indicating a potential benefit of the mustard rotation in N recovery from the soil. These results are consistent with the work of (Dotaniya *et al*., 2013), who observed that IPNS improved N recovery in rice-based systems due to better synchronization between N release from organic sources and crop demand. This clearly demonstrates the efficiency of IPNS in enhancing N uptake, particularly in intensive rice rotations.

Phosphorus uptake in straw was highest in Treatment T9 (Y3 with IPNS), with a mean uptake of 6.97 kg ha^{-1}, demonstrating a significant ($p < 0.01$) advantage of the IPNS over non-IPNS treatments. Similarly, The cropping system effect was less pronounced for phosphorus uptake ($p > 0.05$), suggesting that phosphorus application through IPNS was uniformly beneficial across cropping systems. The enhanced P availability in the IPNS treatments can be attributed to the organic component's ability to solubilize bound phosphorus in calcareous soils, as supported by Kakraliya *et al.*, (2017). In terms of P uptake in grain, Treatment T9 again led with 11.44 kg ha^{-1}, followed closely by T8 (Y2 with IPNS), confirming the superiority of IPNS in enhancing P availability and uptake. Cropping system C3 (Rice-Winter Maize) also had the highest P uptake in grain, reflecting the trend seen in straw. These findings align with Jha *et al.,* (2011), who reported improved P availability and uptake in rice-maize systems when using IPNS.

Potassium uptake in straw was markedly higher in IPNS treatments, particularly T9, which achieved 116.80 kg ha^{-1}. Across cropping systems, C3 (Rice-Winter Maize) had the highest K uptake 83.36 kg ha^{-1}, consistent with the findings by Singh and Pandey (2006).), who reported that maize rotations improved soil K availability due to the deeper rooting systems of maize plants highlights the necessity of adjusting fertilizer strategies according to the cropping system to maximize K uptake. The K uptake in grain also followed this trend, with T9 and C3 showing the highest values. Treatment T9 (Y3 with IPNS) had 7.67 kg ha^{-1}K uptake, suggesting that the combination of organic and inorganic K sources is crucial for K replenishment, particularly on calcareous soils that are prone to nutrient fixation. Studies by Mahajan *et al.* (2013) have demonstrated similar improvements in K uptake under IPNS, particularly in rice-based cropping systems.

Sulphur uptake in straw and grain was significantly higher in IPNS treatments. The highest S uptake was observed in Treatment T9 (Y3 with IPNS) for both straw (2.94 kg ha^{-1}) and grain (1.87 kg ha^{-1}), which was significantly higher ($p < 0.01$) than other treatments. Cropping system C3 (Rice-Winter Maize) consistently showed higher S uptake, which is in line with findings by Gourav *et al.* (2018), who highlighted the role of Sulphur in protein synthesis and nutrient mobilization in calcareous soils. The superior performance of IPNS treatments in S uptake further corroborates the importance of organic amendments in enhancing S availability in calcareous soils.

Summary

The study explores the efficacy of using a combined organic-inorganic approach to nutrient management in calcareous soils, Integrated Plant Nutrient System (IPNS) that includes compost application was compared to traditional practices, with focus on its impact on nutrient uptake (N, P, K, S) and yield in rice-based cropping systems. Conducted in Bihar, India, the experiment analysed nine treatments across three rice-based cropping systems. Treatments involving IPNS, particularly T9 (Y3 with IPNS), demonstrated significant improvements in nutrient uptake and crop yields. The study conclusively found that IPNS effectively overcomes the nutrient constraints of calcareous soils, improving both grain and straw yields, especially in the Rice-Winter Maize cropping system. These findings emphasize the need for integrated approaches in nutrient management to improve the sustainability of rice production in challenging soil conditions.

Conclusion

The study demonstrates that the Integrated Plant Nutrient System (IPNS), particularly in Treatment T9 (Y3 with IPNS), was highly successful in achieving and surpassing the targeted rice yields across all cropping systems. Among the systems, Rice-Winter Maize emerged as the most productive, benefiting the most from the IPNS approach. In contrast, treatments without IPNS consistently failed to meet yield targets, emphasizing the importance of incorporating organic inputs for sustainable yield improvement. The results underscore the critical role of combining organic and inorganic nutrients to optimize nutrient uptake, particularly nitrogen (N), phosphorus (P), and potassium (K), in rice-based cropping systems on calcareous soils. The IPNS treatments (T7, T8, and T9) consistently outperformed non-IPNS approaches, with T9 demonstrating the highest nutrient uptake and yield. This highlights the essential role of IPNS in enhancing soil fertility and crop performance, particularly in nutrient-deficient calcareous soils. The study concludes that adopting IPNS is crucial for achieving high and sustainable rice yields, especially in environments where nutrient availability is compromised. The findings strongly advocate for integrating organic amendments with inorganic fertilizers to maintain long-term soil health and improve rice productivity.

Table 1 : Equations used for calculating the amount of fertilizers as per yield target

S. No	Cropping System	Equation Used
1	Rice-Wheat cropping system	**With IPNS** **Rice** $FN = 5.35T - 0.43\ SN - 0.61\ Compost\ N$ $FP_2O_5 = 1.46T - 1.94\ SP_2O_5 - 0.22\ Compost\ P_2O_5$ $FK_2O = 1.73T - 0.24\ SK_2O - 0.24\ Compost\ K_2O$ **Wheat** $FN = 6.86T - 0.53\ SN - 0.75\ Compost\ N$ $FP_2O_5 = 1.37T - 1.29\ SP_2O_5 - 0.30\ Compost\ P_2O_5$ $FK_2O = 1.91T - 0.33\ SK_2O - 0.20\ Compost\ K_2O$
2	Rice-Mustard cropping system	**Rice** $FN = 5.35T - 0.43\ SN - 0.61\ Compost\ N$ $FP_2O_5 = 1.46T - 1.94\ SP_2O_5 - 0.22\ Compost\ P_2O_5$ $FK_2O = 1.73T - 0.24\ SK_2O - 0.24\ Compost\ K_2O$ **Mustard** $FN = 6.35T - 0.53\ SN - 0.54\ Compost\ N$ $FP_2O_5 = 1.46T - 1.80\ SP_2O_5 - 0.25\ Compost\ P_2O_5$ $FK_2O = 1.75T - 0.20\ SK_2O - 0.15\ Compost\ K_2O$
3.	Rice- winter Maize cropping system	**Rice** $FN = 5.35T - 0.43\ SN - 0.61\ Compost\ N$ $FP_2O_5 = 1.46T - 1.94\ SP_2O_5 - 0.22\ Compost\ P_2O_5$ $FK_2O = 1.73T - 0.24\ SK_2O - 0.24\ Compost\ K_2O$ **Winter Maize** $FN = 4.63T - 0.35\ SN - 0.54\ Compost\ N$ $FP_2O_5 = 1.20T - 1.57\ SP_2O_5 - 0.18\ Compost\ P_2O_5$ $FK_2O = 1.56T - 0.41\ SK_2O - 0.13\ Compost\ K_2O$

Table 2: Treatment details and combinations

Main Plot Treatments	Sub Plot treatments
T1 - Control plot	Rice - Wheat
T2 - Farmer Practice	Rice - Mustard
T3 - General Recommended Dose	Rice - Winter Maize
T4 - Y1 without IPNS	
T5 - Y2 without IPNS	
T6 - Y3 without IPNS	
T7 - Y1 with IPNS @ compost 5 t ha^{-1}	
T8 - Y2 with IPNS @ compost 5 t ha^{-1}	
T9- Y3 with IPNS @ compost 5 t ha^{-1}	

Table 3: Treatment Details

Fertilizers	Rice – Wheat	Rice – Mustard	Rice – Winter Maize
T1 – Control plot	0	0	0
T2 – Farmers Practice	96:57:33	96:57:33	96:57:33
T3 – GRD	120:60:40	120:60:40	120:60:40
T4 – Y1 without IPNS	84:40:47	106:45:48	95:38:32
T5 – Y2 without IPNS	98:53:58	129:41:60	107:43:45
T6 – Y3 without IPNS	132:58:65	146:50:66	114:50:51
T7 – Y1 with IPNS @ compost 5 t ha^{-1}	69:38:50	77:37:51	90:38:34
T8 – Y2 with IPNS @ compost 5 t ha^{-1}	74:45:56	100:48:60	130:38:41
T9 – Y3 with IPNS @ compost 5 t ha^{-1}	123:43:64	126:49:69	128:46:47

Note: N: P_2O_5: K_2O (kg/ha) Fertilizer Source: Nitrogen (Urea), Phosphorus (SSP) and Potash (MOP)

Table 4: Effect of long-term application of organics and inorganics on various parameters of yield and yield attributing characteristics in rice crop under rice based cropping System in calcareous soil of Bihar.

Management practices	Gran yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological yield (q ha^{-1})	Plant Height (in cm)	No of Tillers / m^2	No. of grapins/ Panicle	No. of chaffy grapins/ Panicle	Test Weight/ 1000 grains
Control plot	2.02	2.91	4.93	92.6	189	115	21	26.42
Farmers Practice	3.62	5.13	8.58	99.1	280	154	16	27.02
GRD	3.91	5.52	9.30	103.6	305	167	13	27.53
Y1 without IPNS	3.41	4.83	8.41	96.1	267	149	17	27.00
Y2 without IPNS	3.90	5.52	9.03	103.1	299	167	14	27.25
Y3 without IPNS	4.30	6.08	9.30	109.1	307	171	10	27.81
Y1 with IPNS @ compost 5 t ha^{-1}	3.65	5.14	9.90	100.9	320	182	15	27.64
Y2 with IPNS @ compost 5 t ha^{-1}	4.03	5.65	10.22	106.1	327	189	12	27.90
Y3 with IPNS @ compost 5 t ha^{-1}	4.43	6.20	10.58	111.7	333	196	8	28.01
Cropping systems								
Rice-wheat	3.68	5.19	8.72	101.9	285	160	14	27.15
Rice-Mustard	3.68	5.20	9.07	102.3	297	169	14	27.43
Rice-Winter Maize	3.73	5.27	8.95	103.3	294	168	13	27.62
S.Em. (±)								
Management practices	0.15	0.14	0.21	3.09	6.64	6.07	0.39	0.87
Cropping systems	0.07	0.11	0.16	1.70	5.49	2.70	0.32	0.37
Interaction M X C	0.23	0.29	0.45	5.19	15.00	8.98	0.87	1.26
CD (0.05)								
Management practices	0.47	0.42	0.62	9.35	20.07	18.35	1.18	NS
Cropping systems	NS	NS	NS	NS	NS	NS	NS	NS
Interaction M X C	NS	NS	NS	NS	NS	NS	NS	NS

Table 5 : Effect of long-term application of organics and inorganics on Nutrients uptake (kg/ha) in rice crop under Rice based Cropping System in calcareous soil of Bihar

Management practices	Nitrogen ($kg\ ha^{-1}$)		Phosphorus ($kg\ ha^{-1}$)		Pottasium ($kg\ ha^{-1}$)		Sulphur ($kg\ ha^{-1}$)	
	Straw	**Grain**	**Straw**	**Grain**	**Straw**	**Grain**	**Straw**	**Grain**
Control plot	3.97	10.38	3.63	10.38	31.86	3.63	0.60	0.32
Farmers Practice	11.68	23.61	7.34	23.61	70.80	7.34	1.35	0.69
GRD	15.93	31.20	8.75	31.20	86.36	8.75	1.69	0.89
Y1 without IPNS	10.55	21.03	6.52	21.03	62.83	6.52	1.25	0.63
Y2 without IPNS	15.16	30.60	8.62	30.60	85.98	8.62	1.61	0.84
Y3 without IPNS	18.13	36.10	10.35	36.10	106.04	10.35	1.95	1.04
Y1 with IPNS @ compost 5 t ha^{-1}	17.53	35.61	7.64	35.61	74.10	7.64	2.11	1.01
Y2 with IPNS @ compost 5 t ha^{-1}	20.51	40.68	9.41	40.68	94.27	9.41	2.50	1.35
Y3 with IPNS @ compost 5 t ha^{-1}	24.01	46.64	11.44	46.64	116.80	11.44	2.94	1.87
Cropping systems								
Rice-wheat	14.44	29.05	8.04	29.05	79.28	8.04	1.68	0.86
Rice-Mustard	15.72	31.79	8.1	31.79	80.38	8.1	1.82	0.93
Rice-Winter Maize	15.67	31.11	8.43	31.11	83.36	8.43	1.84	1.09
S.Em. (±)								
Management practices	0.7	1.47	0.39	1.47	2.72	0.39	0.05	0.05
Cropping systems	0.34	0.6	0.151	0.6	1.7	0.15	0.04	0.02
Interaction M X C	1.07	2.04	0.53	2.04	4.94	0.53	0.1	0.08
CD (0.05)								
Management practices	2.026	4.45	1.18	4.45	8.21	1.18	0.15	0.15
Cropping systems	0.98	1.65	NS	1.65	NS	NS	0.1	0.07
Interaction M X C	NS	NS	NS	NS	NS	NS	NS	0.22

References

Ahmed, S., Basumatary, A., Das, K.N., and Medhi, B.K. (2015). Targeted yield-based fertilizer prescriptions for autumn rice (Oryza sativa L.) in inceptisols of Assam, India. *Indian Journal of Agricultural Research,* **49**(5), 437-441.

Ashwini, M., Sridhar, C. J., Mamathashree, C. M. and Shruthi, T. M. (2016). Influence of enriched FYM and fertilizer levels on yield and economics of aerobic rice (*Oryza sativa* L.). *Journal of Pure and Applied Microbiology,* **10(1):** 565-572.

Bagavathi Ammal, U., Sankar, R., Coumaravel, K., & Dey, P. (2022). STCR-A Tool for Fertilizer Recommendation for Rice–Rice Cropping Sequence in UT of Puducherry. In *Transforming Coastal Zone for Sustainable Food and Income Security: Proceedings of the International Symposium of ISCAR on Coastal Agriculture, March 16–19, 2021* (pp. 815-825). Cham: Springer International Publishing.

Bandyopadhyay, P.K., Saha, S., Mani, P.K. and Mandal, B. (2010). Effect of organic inputs on aggregate associated organic carbon concentration under long-term rice-wheat cropping system. *Geoderma*, **154**, 379-386.

Dotaniya, M. L. (2013). Impact of crop residue management practices on yield and nutrient uptake in rice-wheat system. *Current Advances in Agricultural Sciences (An International Journal,* **5(2)**: 269-271.

Gautam, A., Singh, V., & Aulakh, G. S. (2020). Effect of various sowing technologies of wheat cultivation under rice-wheat cropping system in the western plain zone of punjab. *Multilogic in Science*, ***9***(32), 459-461.

Gourav, Sankhyan, N. K., Sharma, R. P. and Sharma, G. D. (2018). Vertical distribution of Sulfur fractions in a continuously fertilized acid Alfisol under maize–wheat cropping system. *Communications in Soil Science and Plant Analysis,* **49(8)**: 923-933.

Jackson, M. L. (1973). Soil Chemical Analysis.Prentice Hall of India. Pvt. Ltd. New Delhi.

Jackson, W. A., Flesher, D. and Hageman, R.H. (1978). Nitrate uptake by dark-grown corn seedlings: some characteristics of apparent induction. *Plant Physiology,* **51(1)**: 120-127.

Jha, A. K., Kewat, M. L., Upadhyay, V. B. and Vishwakarma, S. K. (2011). Effect of tillage and sowing methods on productivity, economics and energetics of rice (*Oryza sativa*)-wheat (*Triticum aestivam*) cropping system. *Indian Journal of Agronomy* **56(1)**: 35-40.

Kakraliya, S.K., Jat, R.D., Kumar, S., Choudhary, K.K., Prakash, J. and Singh, L.K. (2017). Integrated Nutrient Management for Improving, Fertilizer Use Efficiency, Soil Biodiversity and Productivity of Wheat in Irrigated Rice Wheat Cropping System in Indo-Gangatic Plains of India. *International Journal of Current Microbiology and Applied Sciences*, **6**(3), 152-163.

Khan, A. M., Ram, D., Wani, J. A., Saxena, A., Mir, S. A., & Bhat, N. A. (2020). Depth wise distribution of available nutrients of soils of Langate block of district Kupwara of Kashmir valley. *IJCS 8*(**4**): 3579-3583.

Kumar, V. and Prasad, R.K. (2008). Integrated effect of mineral fertilizers and green manure on crop yield and nutrient availability under rice-wheat cropping system in Calciorthents. *J. Indian Soc. Soil Sci.,* **56(2):** 209-214.

Kumar, V., Pandey, A. K., Prasad, R. K., & Prasad, B. (2011). Long-term influence of organic and inorganic sulphur and fertility levels on yields, distribution and build-up of sulphur under rice-wheat cropping system in

Calciorthents. *Journal of the Indian Society of Soil Science*, **59**(3), 278-282.

Lv, M., Li, Z., Che, Y., Han, F. X. and Liu, M. (2011). Soil organic C, nutrients, microbial biomass, and grain yield of rice (*Oryza sativa* L.) after 18 years of fertilizer application to an infertile paddy soil. *Biology and Fertility of Soils,* **47(7)**: 777-783.

Mahajan, G.R., Pandey, R.N., Datta, S.C., Kumar, D., Sahoo, R.N. and Prasad, R. (2013). Soil Test Based Fertilizer Recommendation of Nitrogen, Phosphorus and Sulphur in Wheat (*Triticum aestivum* L.) in an Alluvial Soil. *International Journal of Agriculture, Environment and Biotechnology*, 6(2), 271-281.

Pandey, A. K., Kumar, V. and Prasad, J. (2016). Effect of continuous cropping and fertilization on sulphur fractions and their contribution to sulphur uptake under rice-wheat system in calciorthents. *Journal of the Indian Society of Soil Science,* **64(2)**, 163-168

Panse, V. G. and Sukhatme, P. V. (1985). Statistical method for agricultural workers ICAR, New Delhi. pp. 152-160.

Rao, A., Singh, N.B. and Pandey, D. (2019). Impact of Organic and Inorganic Source of Nutrients on Growth and Yield of Basmati Rice under SRI. *International Journal of Current Microbiology and Applied Sciences*, **8**(12), 2319-7706.

Sheoran, P., Kumar, A., Sharma, R., Barman, A., Parjapat, K., Singh, R. K., ... & Singh, R. K. (2021). Managing sodic soils for better productivity and farmers' income by integrating use of salt tolerant rice varieties and matching agronomic practices. *Field Crops Research*, **270**, 108192

Singh, V., and Pandey, M. (2006). Effect of integrated nutrient management on yield of and nutrient uptake by onion and on soil fertility. *Journal of the Indian Society of Soil Science,* **54(3)**: 365-367.

Singh, G., Singh, S. and Singh, S.S. (2013). Integrated Nutrient Management in Rice and Wheat crop in Rice-Wheat Cropping System in Lowlands. *Annals of Plant and Soil Research*, **15**(1), 1-4.