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Plant nutrient concentration in rice (*Oryza sativa*) and properties of soil as influenced by integrated nitrogen management under system of rice intensification

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Abstract
A field experiment was conducted at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India during the two consecutive rainy (*Kharif*) and winter (*Rabi*) seasons of 2015-16 and 2016-17 with rice-wheat sequence in split plot design to study the influence of integrated nitrogen management on plant nutrient concentration in rice and properties of soil under system of rice intensification. The results obtained from the two years study showed that the nitrogen content in the grain and straw remained significantly unaffected due to the various varieties of rice. Among integrated nitrogen management, the higher concentration of nitrogen in grain and straw of rice was attributed to the plots treated with 75% recommended dose of nitrogen (RDN) through urea along with 25% nitrogen through *Azolla microphylla* which was at par with the application of 75% RDN + 25% RDN through sewage sludge applied to rice crop. The results on phosphorus content in grain and straw of rice revealed the non-significant variation due to different varieties and integrated nitrogen management practices. Further, the potassium content in grain recorded higher with the rice variety 'HUR-4-3' being at par with 'HUR-105' while, the potassium content in straw was highest with 'HUR-4-3'. The integrated nitrogen management with 75% RDN and 25% N through *Azolla microphylla* exhibited the highest content of potassium in grain and straw. Moreover, different varieties and integrated nitrogen management applied to rice crop resulted statistically non-significant variation in soil properties *viz*., bulk density, particle density, water holding capacity and electrical conductivity during the course of study.

Keywords: Rice, *Azolla microphylla,* Nitrogen management, Nutrient content, Soil properties, System of rice intensification (SRI),

Introduction
Rice (*Oryza sativa* L.) holds a major share in the world's food basket. Worldwide, rice is cultivated over 161.30 million ha area having 486.30 million tonnes production and has a productivity of 4.51 tonnes ha^{-1}(USDA, 2017) [8]. In India, about 43.38 m ha area is under rice cultivation with 104.32 million tonnes production and has a productivity of 2.40 tonnes ha^{-1} (Directorate of Economics and Statistics, 2017) [2]. To meet the demand for rice and maintaining a plant and soil health we have to look for the improved package of practices and location specific technologies in the changing scenario. System of Rice Intensification (SRI) is one of them having the positive impact on the plant and soil physical, chemical and biological properties. The application of organic sources of plant nutrient along with chemical fertilizers for soil fertility improvement has been found better under SRI (Krupnik *et al.*, 2012) [6]. For better understanding this need to study in more and in detail. Hence, the present study focused to evaluate different aromatic varieties and integrated nutrient management practices under SRI regarding their effect on the plant nutrient concentration in the crop and the inclusion of organics on the soil properties.

Materials and Methods
The field experiment was conducted at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University Varanasi, India during the two consecutive rainy (*Kharif*) and winter (*Rabi*) seasons of 2015-16 and 2016-17 with rice-wheat sequence. The soil of the experimental field was sandy clay loam in texture (typic *Ustochrepts*) with *p*H 7.45. It was moderately fertile being low in organic carbon (0.32%) and available nitrogen (195 kg N ha^{-1}), but medium in available phosphorus (26.8 kg P_2O_5 ha^{-1}) and potassium (224 kg K_2O ha^{-1}). The experiment was laid out in split plot design assigning four aromatic rice varieties ('HUR-4-3', 'HUR-105', 'NDR-6093' and 'Rajendra Kasturi') in main plot, five integrated nitrogen management practices [100% recommended dose of nitrogen (RDN), 75%

RDN + 25% RDN through *Azolla microphylla*, 75% RDN + 25% RDN through NADEP compost, 75% RDN + 25% RDN through sewage sludge and 75% RDN + 25% RDN through vermicompost] made 20 treatment combinations were replicated thrice followed by the succeeding wheat (cv. 'PBW-502'). The recommended dose of nitrogen was 120 kg N ha^{-1}. Half dose of the total nitrogen (120 kg N ha^{-1}) along with the full dose of phosphorus (60 kg P_2O_5 ha^{-1}), potassium (60 kg K_2O ha^{-1}) and zinc (5.5 kg Zn ha^{-1}) as basal dose were applied just before transplanting of rice crop on puddled surface and incorporated into the top 15 cm soil manually.

Grain and straw samples were dried, processed and analyzed for their total nitrogen content by micro-Kjeldahl's, phosphorus by Vanadomolybdo phosphoric acid-yellow colour method and potassium by flame-photometer. Bulk density, particle density and water holding capacity were determined as per the procedure given by (Black *et al*., 1965)[1] while, electrical conductivity was quantified through the procedure suggested by Jackson (1973)[4]. The plant samples were dried in oven at 70°C ± 2°C till constant weight. All the plant and soil data obtained for consecutive two years were statistically analyzed using the F-test as per Gomez and Gomez (1984) [3].

Results and Discussion

Nutrient content in rice

The data pertaining to nutrient content in rice grain and straw as affected by varieties and integrated nitrogen management is presented in the Table 1. The result depicts the marked variation in the nutrient content in grain and straw due to different varieties and integrated nitrogen management applied to the rice crop. It is evident from the two years study that the nitrogen content in the grain and straw remained significantly unaffected due to the various varieties of rice. Among integrated nitrogen management, the higher concentration of nitrogen in grain (1.22% N) and straw (0.70% N) of rice was attributed to the plots treated with 75% recommended dose of nitrogen (RDN) through urea along with 25% nitrogen through *Azolla microphylla* which was at par with the application of 75% RDN + 25% RDN through sewage sludge applied to rice crop. The results on phosphorus content in grain and straw of rice revealed the non-significant variation due to different varieties and integrated nitrogen management practices. Further, the potassium content in grain (0.31% K) recorded higher with the rice variety 'HUR-4-3' being at par with 'HUR-105' while, the potassium content in straw (1.78% K) found highest with 'HUR-4-3' which proved its superiority over the other varieties. The integrated nitrogen management with 75% RDN + 25% N through *Azolla microphylla* exhibited the highest content of potassium in grain (0.31% K) and straw (1.77% K) which was significantly superior to rest of the treatment during the experimentation. Acquisition of nutrients from the soil is related to their respective availability particularly during the stage of tillering, at heading stage and between heading and maturity. Increase in nutrients supply is known to increase carbohydrate, utilization for the production of nitrogenous compounds leading to increased nitrogen content. The variable rate of nutrient content in aromatic rice varieties has been reported by Sharma *et al.* (2012) [7]. Regarding the integrated nitrogen management, the significance of integrated supply of plant nutrient sources in increasing the nutrient content in grain and straw has been reported by Yadav *et al.* (2018) [9] who concluded that the highest nitrogen, phosphorus and potassium concentration in grain and straw of *Basmati* rice was recorded when it was grown after the incorporation of *Sesbania aculeata.*

Soil properties

The data pertaining to soil properties as affected by varieties and integrated nitrogen management is presented in the Table 2. The result reveals that the soil properties *viz.*, bulk density, particle density, water holding capacity and electrical conductivity exhibited statistically non-significant variation due to different treatments during the course of study. Addition of organic matter may change the physico-chemical properties of soil but it takes relatively more time and continuous supplementation of organic sources of plant nutrients. Jagannath (2016) [5] working on rice under SRI found non-significant variation in bulk density, particle density, water holding capacity and electrical conductivity by the application of RDN (150 kg N ha^{-1}) along with BGA (12 kg ha^{-1}). The findings are in harmony with the current study.

Table 1: Effect of integrated nitrogen management on nitrogen, phosphorus and potassium content in grain and straw of rice varieties under SRI (pooled data of two years)

Treatment	Nitrogen content (%)		Phosphorus content (%)		Potassium content (%)	
	Grain	Straw	Grain	Straw	Grain	Straw
Varieties						
HUR-4-3	1.21	0.70	0.19	0.077	0.31	1.78
HUR-105	1.19	0.68	0.18	0.077	0.30	1.71
NDR-6093	1.20	0.68	0.17	0.076	0.28	1.66
Rajendra Kasturi	1.20	0.68	0.17	0.076	0.28	1.68
SEm±	0.007	0.006	0.0102	0.0005	0.005	0.015
LSD (*P*=0.05)	NS	NS	NS	NS	0.018	0.053
Integrated nitrogen management						
100% RDN (120 kg N ha^{-1})	1.19	0.67	0.17	0.076	0.28	1.67
75% RDN + 25% N through *Azolla microphylla*	1.22	0.70	0.19	0.077	0.31	1.77
75% RDN + 25% N through NADEP compost	1.19	0.68	0.18	0.077	0.29	1.68
75% RDN + 25% N through Sewage sludge	1.21	0.69	0.18	0.077	0.29	1.72
75% RDN + 25% N through Vermicompost	1.18	0.68	0.17	0.076	0.29	1.68
SEm±	0.005	0.004	0.0085	0.0004	0.004	0.014
LSD (*P*=0.05)	0.015	0.012	NS	NS	0.012	0.040

Table 2: Soil properties as influenced by integrated nitrogen management in rice varieties under SRI (pooled data of two years)

Treatment	Bulk density (kg m^{-3})		Particle density (kg m^{-3})		Water holding capacity (%)		Soil EC (dS m^{-1} at 25°C)	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Varieties								
HUR-4-3	1428	1427	2624	2623	41.69	43.22	0.16	0.14
HUR-105	1419	1418	2629	2628	41.94	43.48	0.15	0.13
NDR-6093	1422	1422	2614	2613	42.05	43.59	0.15	0.13
Rajendra Kasturi	1421	1420	2624	2623	41.81	43.34	0.15	0.13
SEm±	6.14	6.95	16.35	15.64	0.64	0.65	0.016	0.015
LSD (*P*=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Integrated nitrogen management								
100% RDN (120 kg N ha^{-1})	1428	1428	2629	2628	41.11	42.66	0.16	0.14
75% RDN + 25% N through *Azolla microphylla*	1418	1418	2594	2593	42.62	44.17	0.14	0.12
75% RDN + 25% N through NADEP compost	1428	1428	2629	2628	41.69	43.24	0.15	0.13
75% RDN + 25% N through Sewage sludge	1418	1418	2594	2593	42.47	44.02	0.15	0.13
75% RDN + 25% N through Vermicompost	1428	1428	2629	2628	41.52	43.06	0.16	0.14
SEm±	5.34	5.65	14.26	13.85	0.56	0.59	0.014	0.012
LSD (*P*=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Conclusion

It is concluded from the study that the rice variety 'HUR-4-3' and the application of 75% recommended dose of nitrogen (RDN) (90 kg N ha^{-1}) through chemical fertilizers and 25% RDN (30 kg N ha^{-1}) through *Azolla microphylla* resulted higher nutrient concentration in grain and straw of rice. Further, soil properties remained statistically unaffected due to different varieties and integrated nitrogen management applied to rice crop.

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