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Effect of site specific nutrient management on uptake and nutreint use efficiency of rice in vertisol

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Abstract
A field experiment was carried out during the *kharif* season (June–October) of 2016 at the Research Farm of the Indira Gandhi Agricultural University, Raipur (C.G.), India to study the "Effect of site specific nutrient management on uptake of nutrient of rice in vertisol". The experiment was laid out in a Randomized block design with three replications and eight treatments namely i.e. RDF (100:60:40:5 NPK and Zn kg ha^{-1}), SSNM based on nutrient expert (120:60:60:5, NPK & Zn kg ha^{-1}), SSNM based on leaf color chart (60:60:60:5, NPK & Zn kg ha^{-1}, rest 50% N based on LCC), SSNM-N, SSNM-P, SSNM-K, Control (N_0, P_0, K_0) and Farmer Fertilizer Practices (N_{80}, P_{40}, K_0).The results was revealed that the highest nutrients uptake- nitrogen 114.3 kg ha^{-1}, Total phosphorus 21.5 kg ha^{-1} and 185.9 kg ha^{-1} potassium was recorded under treatment T_2 SSNM based (NE) similarly total uptake of Zn were reported 338 g ha^{-1} under T_3-SSNM (LCC) and was also reported that nutrient use efficiency of rice (cv. Rajeshwari) recorded for nitrogen 40.4%, phosphorus 21.2% P, potassium 138 % under treatment T_2 based on SSNM (NE).Overall concluded that treatment based on nutrient expert (NE) recommendations proved superiority over applied different treatments on yield, nutrients uptake (N,P,K & Zn) involved balance removal as required by rice as well sustaining soil available nutrient status.

Keywords: Leaf color chart (LCC), site specific nutrient management, uptake, nutrient use efficiency

Introduction
Rice (*Oryza sativa* L.) is cultivated in morethan hundred countries and undoubtedly a dominant staple food of world and 91 per cent of the world's area and production of rice grown and consumed in Asia (Dobermann and Witt, 2003) [2]. Rice is grown in a wide range of climatic conditions *viz.*, temperature ranging from 17 to 33 °C, rainfall 100 to 5100 mm with an altitude of 2600 meters from mean sea level. Demand for rice is growing every year and it is estimated that by 2025 AD the requirement would be 140 million tonnes.

On a global scale, rice provides 21 per cent of per capita energy and 5-7 per cent of per capita protein for humans (Maclean *et al.*, 2002). The warm and moist climatic conditions in much of Asia are very well suited to rice production. In Asia, more than two billion people are getting 60-70 per cent of their energy requirement from rice and its derived products**.** Area under rice in the world is 161.4 million hectare with a production of 678.7 million tonnes and average productivity of 4204 kg ha^{-1} (Anon, 2011). According to Doberman and Witt (2003) [2] it will be necessary for rice yields in Asia to increase by 25 per cent from 2010 to 2020.

In India, rice occupies an area of 42 million hectare with production of 103.04 million tonnes with an average productivity of 2137 kg ha^{-1} (Ministry of Agriculture & Farmer Welfare, 2015), which is half of the global average. In Chhattisgarh, rice occupies an area 3.7 million ha with production of 7.65 million tonnes with an average productivity of 1322 kg ha^{-1} (Directorate of Agriculture, Raipur, 2015-16). Demand for rice is growing every year and it is estimated that by 2025 AD the requirement would be 140 million tonnes. To sustain present food self-sufficiency and to meet future food requirements, India has to increase its rice productivity by 3 per cent per annum.

Material and methods
SSNM aims at dynamic field-specific management of N, P, and K fertilizer to optimize the balance between supply and demand of nutrients. The plants need for N, P, or K fertilizer are determined from the gap between the supply of a nutrient from indigenous sources,

as measured with a nutrient omission plot, and the demand of the rice crop for that nutrient, as estimated from the total nutrient required by the crop to achieve a yield target for average climatic conditions. SSNM, a decision support system provides – before planting – a pattern for splitting an estimated total N fertilizer requirement among pre-set application times (Witt and Dobermann, 2004). Fertilizer P and K recommendations with SSNM are based on the indigenous supply of these nutrients from soil, organic materials, and irrigation water considering nutrient removal with grain and straw. Needs for micronutrients such as zinc and sulphur are based on local recommendations.

Nutrient Expert (NE) is as a computer-based decision support tool having nutrient decision support software that uses the principles of site-specific nutrient management (SSNM) and enables to develop fertilizer recommendations tailored to a specific field or growing environment. The parameters needed in SSNM are usually measured in nutrient omission trials. With NE, parameters can be estimated using proxy information, which allows to develop location specific fertilizer guidelines without data from field trials (International Plant Nutrition Institute, 2017). The optimum use of N can be achieved by matching N supply with crop demand. A simple and quick method for estimating plant N demand is LCC i.e. leaf is easy to use and an inexpensive diagnostic tool for monitoring the relative greenness of a rice leaf as an indicator for the plant N status and can be used as an alternative to chlorophyll meter. Use of LCC for N management has consistently increased grain yield and profit in comparison to the farmers' fertilizer practice in Bangladesh. (Sen *et al.*, 2011) [10].

A field experiment was carried out during the *kharif* season (June–October) of 2016 at the Research Farm of the Indira Gandhi Agricultural University, Raipur (C.G.), to "Evaluate the effect of SSNM on yield and yield attributing parameters of rice in vertisol". The experiment was laid out in a Randomized block design (RBD) with three replications and eight treatments namely i.e. RDF (100:60:40:5 NPK and Zn kg ha-1), SSNM based on nutrient expert (120:60:60:5, NPK & Zn kg ha^{-1}), SSNM based on leaf color chart (60:60:60:5, NPK & Zn kg ha^{-1}, rest 50% N based on LCC), SSNM-N, SSNM-P, SSNM-K, Control (N0, P0, K0) and Farmer Fertilizer Practices (N80, P40, K0). The soil (black soil) was clay loam in texture with alkaline pH (7.3.). It was non saline (EC 0.23 dS m^{-1}) and high in organic carbon content (0.51%). The soil was low in available nitrogen (180 kg ha^{-1}) (Subbiah and Asija 1956), high in available phosphorus (14.35 kg P_2O_5 ha^{-1}) (Olsen *et al.*, 1954) and high in available potassium (387 kg K_2O ha^{-1}). Available zinc content (1.0 mg kg^{-1}) was above the critical level (0.7 mg kg^{-1}). The treatmentmeans were compared using least significant differences at 5% level of significance (Gomez and Gomez 1984) [3].

Result and Discussion

Data pertaining to total nitrogen uptake by rice as influenced by different SSNM treatments are presented in Table 1. Results revealed that application of major nutrients + Zn based on NE recorded higher uptake of nitrogen (80.92 kg ha^{-1}) followed by T_3- SSNM LCC (70.62 kg ha^{-1}), T_1- RDF (68.85 kg ha^{-1}) and minimum N uptake was observed in T_7 control (43.38 kg ha^{-1}) and T_3 was significantly at par. The increase uptake might be due to the improved synchrony between plant N demand and supply from soil and fertilizer. Total phosphorus uptake by rice as influenced by different SSNM treatments are presented in Table 1 & Fig 1. Results revealed that T_2 SSNM based on Nutrient expert (T_2) recorded higher uptake of phosphorus (21.5 kg ha^{-1}) followed by T_3- SSNM LCC (19.7 kg ha^{-1}), T_1- RDF (17.1 kg ha^{-1}) and lowest total P uptake by rice was observed in T_7 control (8.7 kg ha^{-1}) i.e. without fertilizer nutrients and T_3 was significantly at par. Total potassium uptake by rice as influenced by different SSNM approaches are presented in Table 1 & Fig 1. Results revealed that application of major nutrients + Zn based on NE recorded higher uptake of potassium (185.9 kg ha^{-1}) followed by T_3- SSNM LCC (180.8 kg ha^{-1}), T_1- RDF (161.3 kg ha^{-1}) significantly different over T_7 control plots (105.7 kg ha^{-1}) having lowest K uptake and T_3 was significantly at par. Higher uptake of K with application of Potassium by rice has been observed by Bhuiyan *et al.*, 1986). Total Zinc uptake by rice as influenced by different SSNM treatments are presented in Table 1 & Fig 1. Results revealed that the treatment T_3- SSNM LCC (180.8 kg ha^{-1}) recorded higher uptake of Zinc (338.0 g ha^{-1}) and followed by T_2 SSNM treatment by nutrient expert (322.5 g ha-^{1}) followed by T_5- (T2-P) 287.8 g ha^{-1}, T_6- (T_2-K) 278.6 g ha^{-1} and minimum Zn uptake was observed in T_7 control (171.2 g ha^{-1}) and T_2 was significantly at par. Supply of all the nutrients including Zn increased the availability of Zn in soil resulting in higher grain and straw yields causing higher Zn uptake (Mukhi and Shukla, 1991).

Nitrogen use efficiency was found higher in treatment T_2 SSNM based on Nutrient expert (40.41%) followed by the treatment T_1-RDF (32.56%) T_3- SSNM LCC based treatment (30.4%),), T8- FFP (24.83%), T_6-SSNM-K (21.59%), and minimum was found in T5- SSNM-P (20.38%) with the difference was significant. Prasad *et al.* (1994) have also reported similar trends in nutrient use efficiency of rice. The phosphorus use efficiency was found higher in treatment T_2 SSNM based on Nutrient expert (21.29%) followed by the treatment T_3- SSNM LCC based treatment (18.34%), T_1-RDF (14.01%) T8- FFP (14.40%), T_6-SSNM-K (12.82%) and minimum was found T4- SSNM –N (5.41%). Abdul rachman *et al.* (2002) stated that compared to farmers practice, SSNM was characterized by increased in fertilizer efficiency of P and K use efficiency was found higher in T_1-RDF (106.23%) treatments followed by T_2-SSNM based on nutrient expert (133.62%) followed by T_3 -SSNM based on LCC (125.09%), T_5-SSNM-P (84.42%) and minimum was found under the T4-SSNM –N treatment (56.87%). Nutrient use efficiency was greater with the SSNM approach as reported by Olk *et al.* (1999); Dobermann *et al.* (2000); Khuong *et al.* (2007); Khurana *et al.* (2007) and Johnston *et al.* (2009).

Table 1: Total uptake of nitrogen, phosphorus, potassium (kg ha^{-1}) and Zn (g ha^{-1}) by rice as influenced by different SSNM treatments

Treatment	Total nutrient uptake (kg ha^{-1})			
	N	P	K	Zn (g ha^{-1})
T1 RDF	98.37	17.13	161.32	253.97
T2 SSNM (NE)	114.31	21.50	185.93	322.47
T3 SSNM (LCC)	102.41	19.73	180.81	338.00
T4 SSNM –N	87.16	11.97	139.88	230.44
T5 SSNM-P	90.27	15.02	156.41	287.80
T6 SSNM-K	91.72	16.42	157.88	278.67
T7 (C)	65.82	8.72	105.76	171.27
T8 FFP	85.68	14.49	150.77	250.70
CD (P=0.05%)	8.37	2.43	22.85	34.46

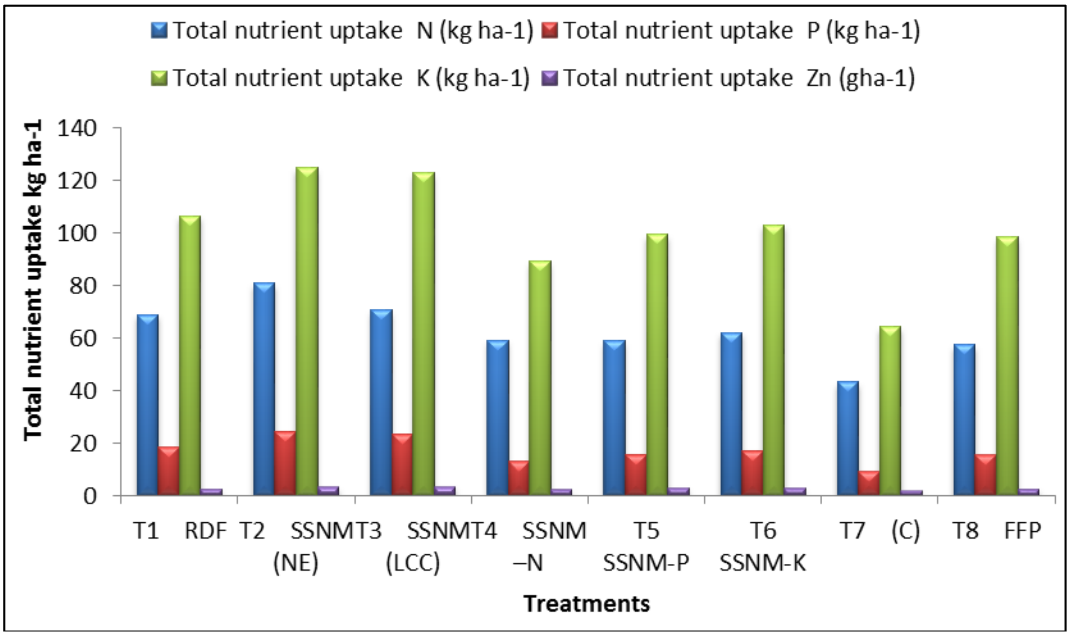

Fig 1: Total nutrient uptake of N, P, K and Zn in rice as influenced by different SSNM treatment

Table 2: The use efficiency of N, P, K (%) of rice as influenced by applied SSNM treatments

Treatment	Nitrogen use efficiency (%)	Phosphorus use efficiency (%)	Potassium use Efficiency (%)
T1 RDF	32.56	14.01	133.62
T2 SSNM (NE)	40.41	21.29	138.92
T3 SSNM (LCC)	30.49	18.34	125.09
T4 SSNM –N	-	5.41	56.87
T5 SSNM-P	20.38	-	84.42
T6 SSNM-K	21.59	12.82	-
T7 (C)	-	-	-
T8 FFP	24.83	14.4	-

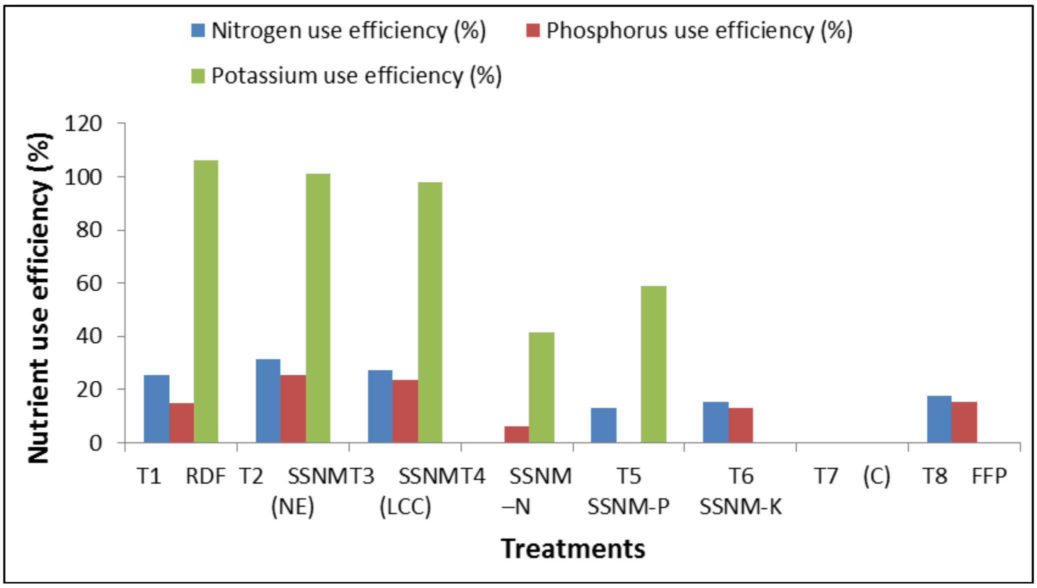

Fig 2: Nutrient use efficiency of N, P & K (%) by rice as influenced by different SSNM treatments

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