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Evaluate the effect of SSNM on yield and yield attributing parameters 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 "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 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 obtained in this study showed that the T2-SSNM based on nutrient expert performed significantly better than the other treatments for yield attributing characters viz. number of tillers 400, number of panicle 350, panicle length 24.30 cm, filled grain per panicle 145, test weight of 1000 seeds of rice 28.8gm, grain yield 50.2q ha^{-1} and straw yield 82.8q ha^{-1} and lowest was found under control treatments at harvest stage of rice. SSNM Treatment based on nutrient expert (NE) recommendations proved superiority over applied different treatments on yield involved balance removal as required by rice as well sustaining soil available nutrient status.

Keywords: Rice, Nitrogen, Leaf Color chart, site specific nutrient management

Introduction
Rice (*Oryza sativa* L.) is cultivated in more than 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. In India, rice occupies an area of 42 million hectare with production of 103.04 million tonnes with an average productivity of 2137 kg per hectare, 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} (Department 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.

Nutrient management is a major component of a soil and crop management system. Knowing the required nutrients for all stages of growth and understanding the soil's ability to supply those needed nutrients is critical to profitable crop production. Site specific nutrient management is applying those concepts to areas within a field that are known to require different management from the field average. Site specific management includes practices that have been previously associated with maximum economic yield management, best management practices as well as general agronomic principles. SSNM aims at dynamic field-specific management of N, P, and K fertilizer to optimize the balance between supply and demand of nutrients. SSNM, a decision support system provides – before planting – a pattern for splitting an estimated total N fertilizer requirement among pre-set application times (Dobermann, and Witt 2003) [2]. 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.

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 developing location specific fertilizer guidelines without data from field trials. 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].

Methods & Materials

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 "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 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 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 treatment means were compared using least significant differences at 5% level of significance (Gomez and Gomez 1984) [3].

Results & Discussion

Number of total tillers m^{-2}

Tillering is an important agronomic trait for grain yield, but the emergence and development of tillers are greatly influenced by factors such as nitrogen supply, solar radiation and temperature (Murata and Matsushima, 1975). The data on number of tillers m-2 at as influenced by SSNM treatments have been presented in Table 1 and also illustrated graphically through Fig. 1. The number of tillers m-2 differed significantly with different SSNM treatments. Among the applied treatments T2- SSNM (Nutrient expert) recorded significantly higher number of tillers (400 m-2) followed by T_3-SSNM LCC based treatment (383 m-2) and T_1- RDF based nutrient management practices compared to other SSNM treatments and lowest number of tillers (217 m-2) occurred in the treatment devoid of fertilizer application (control-T_7). 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.. Similar results have been reported by Nath *et al.* (2012) [8] who observed that SSNM as nutrient expert increased the total number of tillers as well as grain yield of transplanted rice.

Number of panicle (m^{-2})

The data on panicle length of rice as influenced by different SSNM treatments have been shown in Table 1. It is evident from the data that number of panicles per meter square was significantly influenced by the applied different SSNM treatments. The highest number of panicle per meter2 (350) was recorded under the treatment T_2- SSNM based on Nutrient expert followed by T_3-SSNM based on LCC (333), T_4 –SSNM-N treatment (317) and T_1- RDF (300) the lowest number of panicles per meter square (267) was found under T_7-Control ($N_{0,}$ P_0,K_0) treatment. Similar results have also been reported by Nath *et al.* (2012) [8] observed all applied nutrients were best performances which increase the growth and numbers of panicle hill^{-1}, numbers of grains panicle^{-1}. The results are in conformity with the findings of Laharia *et al.* (2015) obtained more number of productive tillers hill^{-1} under the SSNM nutrient expert treatment as the important yield attributing characters.

Panicle length (cm)

The data pertaining to panicle length (cm) of rice are presented in Table 1. The maximum panicle length of 24.30 cm was recorded in T_2 - SSNM based on Nutrient expert which stood on par with those recorded under T_1- RDF (23 cm) and T5-SSNM-P (23) treatments while proved significantly better compared to all other treatments. The lowest panicle length of 21.3 cm was measured under the treatment T_7 - control. Similar results were also reported by Feng *et al.* (2007) and Sridhara (2008).

Filled grains panicle^{-1}

Data on filled grains/panicle as influenced by different SSNM treatments are summarized in Table 1. It is obvious from the data that number of filled grains per panicle of rice did not influenced significantly due to fertilizer application. However, treatment T_2 - SSNM based on nutrient expert recorded the higher number of filled grains (145/panicle) followed by T_5-SSNM- P treatment (142/panicle) and T_3- SSNM based on LCC (139/panicle) and lowest number of filled grains (123 panicle^{-1}) was recorded under T_8- Farmer practices. Feng *et al.* (2007) were also reported on filled grains per panicle may be due to genotypes than nutrient management.

Test weight of Rice (1000 grain weight in g)

The data on test weight of rice as influenced by different SSNM treatments have been presented in Table 1. It is quite clear from the data that test weight of rice grain varied from 27.2 to 28.8 g based on the treatments. The 1000-grain weight of rice remained unaffected due to fertilizer application. However, treatment SSNM based on Nutrient expert (T_2) resulted in heavier test weight of 28.8 g followed by T_1 -RDF (28.6) and T_3 -SSNM based on LCC (28.7) as compared to T_7 -Control (27.2 gm) treatment. In contrast to these findings, Biradar *et al.* (2006) [1] found that SSNM resulted in significantly higher test weight over FP (Farmer's Practice) and RDF (Recommended Dose of Fertilizer) in rice crop.

Grain yield of rice (q ha^{-1})

The data pertaining to grain yield of rice grown as influenced by different SSNM treatments is presented in Table 2. It is evident from the data that grain yields of rice varied significantly due to various SSNM treatments. Application of fertilizer enhanced the yield of rice significantly compared to the unfertilized crop. The highest grain yield of rice (50.2 q ha^{-1}) was recorded in T2- SSNM (NE) being significantly superior over control (T7), FFP (T8), RDF (T1), SSNM-N (T4), SSNM (T6) but remained at par with the grain yield obtained under SSNM (T3) and SSNM-P(T5) treatments. Grain yield advantage with treatment T1 was higher over other SSNM treatments. Treatment omitting either N,P or K resulted in a marked yield loss, indicating the significance of replenishment of these nutrients for achieving high yield targets. Compared with SSNM (NE), yield reductions were 6.6, 2.9 5.0 q/ha in –N, -P and –K plots, respectively. Although, treatments receiving recommended doses of fertilizers (T1) had higher yield than farmer's practice (T8), the best SSNM schedule based on NE out-yielded all other treatments. The positive effect of SSNM on rice yield was the cumulative increase measured in different yield-contributing characters.

These results are in conformity with findings of other researchers (Kabir *et al*. 2011) [4], Biradar *et al.* (2006) [1] and Maheshwari *et al., (*2007). Singh *et al.* (2000) [11] compared SSNM in rice and wheat with farmer's fertilizer practice and found that average increase in rice and wheat yield was achieved by SSNM as nutrient expert. Wang *et al*. (2001) [13] found that the performance of SSNM has consistently improved grain yield by about 10-15 per cent compared to the farmers' fertilizer practice. The yield levels of 7.5 t ha^{-1}or more seem achievable and sustainable through introduction of SSNM. Mishra *et al.* (2003) [6] conducted experiment on SSMM in hybrid rice revealed that the highest grain yield of 9.7 t $ha^{-1}$was obtained with 150:60:120 N P2O5K2O kg ha^{-1} with 6 kg Zn $ha^{-1}$and 7 kg Mn ha^{-1}. The rice yields in SSMM plots ranged between 6.8 to 7.1 t ha^{-1} which were 0.7 to 0.8 t ha^{-1}greater than state recommendation (SR) and 0.2 to 0.3 t ha^{-1}greater than common farmers practice (FP). Biradar *et al.* (2006) [1] conducted an experiment with nutrient application on the basis of SSNM principles resulted in significantly higher grain yield over FP The yield increases under SSNM shows the promise for yield improvement can be achieved through SSNM approach. The average yield increase due to SSNM over RDF was 35 per cent and was 50 per cent over FP. Similar result reported by Mishra *et al*. (2007) [7] have also reported in grain and straw yield of rice.

Straw yield (q ha^{-1})

The data on straw yield of rice as influenced by different SSNM treatments are given in Table 2. The results showed that application of nutrients based on SSNM approach significantly influenced the straw yield of rice compared to FP and RDF. The highest straw yield of 82.8 q ha^{-1} was obtained in T2 -SSNM based on nutrient expert, which was significantly superior over all other treatments except with T_3--SSNM-LCC (78.3 q ha^{-1}) and T_5- SSNM –P (77.5 q ha^{-1}) treatments which remained on par with each other. Omission of N, P and K reduced the straw yield of rice significantly over SSNM based on NE and LCC approaches. The unfertilized control plots (T_7) recorded the lowest straw yield (56.1q ha^{-1}) being significantly lower than those produced with other fertilizer treatments. Mishra *et al*. (2007) [7] and Islam *et al.* (2012) [8] have also reported same results with applied different nutrient management system.

Table 1: Yield contributing characters of rice as influenced by different SSNM treatments.

Treatment	Number of tillers/m^2	No. of panicle /m^2	Panicle length (cm)	Filled grain/ panicle	Test weight (gm)
T1 RDF	333	300	23.00	127	28.6
T2 SSNM (NE)	400	350	24.30	145	28.8
T3 SSNM (LCC)	383	333	22.70	139	28.7
T4 SSNM –N	333	317	22.30	127	28.1
T5 SSNM-P	300	283	23.00	142	28.6
T6 SSNM-K	317	300	22.00	127	28.2
T7 (C)	217	201	21.30	121	27.2
T8 FFP	350	300	22.70	123	28.2
CD (P=0.05%)	62.28	59.27	1.34	NS	NS

Table 2: Grain and straw yield (q ha^{-1}) of rice as influenced by different SSNM treatments

Treatment	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
T1 RDF	45.6	73.8
T2 SSNM (NE)	50.2	82.8
T3 SSNM (LCC)	48.7	78.8
T4 SSNM –N	43.6	69.3
T5 SSNM-P	47.3	77.5
T6 SSNM-K	45.2	73.6
T7 (C)	35.1	56.1
T8 FFP	44.4	70.5
CD (P=0.05%)	3.58	5.73

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