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Yield maximization and identification of limiting nutrients based on crop response and site-specific nutrient management in Inceptisol

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Abstract
An pot experiment was conducted at experimental research station Rajmohani Devi College of Agriculture and Research Station, Ambikapur during Kharif season, 2018 to study Site-specific nutrient management using nutrient omission technique in two major soil types of Koriya district of Chhattisgarh''. The objectives of the experiment were to identify the yield-limiting nutrients using the missing element technique with rice as a test crop and to demonstrate the identified limiting nutrients on farmer's field with the wheat crop to observe the yield difference with those of farmer's practice. A total of 11 treatments were tested with rice (MTU-1010) as a test crop, laid out in CRD with three replications. Grain and straw yields of rice were significantly reduced with the omission of N, P, and S in Inceptisol soil comparison to the treatment receiving all the nutrients (SSNM).The yield reduction is found to be more than 54% in the case of N, 33% in the case of P, and 15.39% in S case of Inceptisols during Kharif in rice crop. These limiting nutrients were tested on farmer's fields with wheat crop during Rabi season, 2018-19 where bulk soil samples were collected for pot culture study. The limiting nutrients were corrected with optimum doses (SSNM) as N -120, P_2O_5-80, K_2O-50 and S-30 kg/ha along with Zn @ 5 kg/ha. Wheat grain yields recorded with SSNM dose were 34% higher than that with FPD.

Keywords: SSNM, identification of yield limiting nutrients, nutrient omission technique, inceptisol, nutrient management in inceptisol of district Koriya Chhattisgarh

Introduction
SSNM is a plant-based approach enabling the farmer to apply fertilizer in an optimum amount matching the need for rice crop in a particular field of a particular season. SSNM method centers on determining fertilizer rate based on soil indigenous nutrient supply, crop yield and crop nutrient uptake (Doberman *et al.*, 2002) [1]. Site-specific nutrient management (SSNM) for rice as developed in Asia is a plant-based approach for 'feeding' rice with nutrients as and when needed (IRRI, 2006) [2]. The bright side of the SSNM approach is that it does not specifically aim to either reduce or increase fertilizer use. Instead, of that, it focuses on to apply nutrients at optimal rates and times in order to achieve higher yield and high efficiency of nutrient use by rice, which leads to the high cash value of the harvest per unit of fertilizer invested. SSNM technique even fully utilizes the existing nutrients. N could be applied as per need of the plant at a particular time, P and K applied based on their need determined through omission technique. Site-specific nutrient management also provides strategies for effective management of major secondary and micronutrients by analyzing yield parameters in pot culture with the specific omission of nutrient and by establishing a relation with plant growth with specific nutrients and by providing farmers with an optimum recommendation based on their soil by providing their crop with the right amount of essential nutrients. Fertilizing soils to bring all the deficient elements at high levels to provide sufficient ionic activity in soil solution for crop uptake is one of the most important considerations to achieve the highest crop yield.

Materials and Methods
The study of Pot based experiment on nutrient omission trials conducted at Rajmohani Devi College of Agriculture, Ambikapur on two illustrative soil types of Koriya district. Soil collected from Barbaspur village of block Manendragarh which shows characterized behavior

with Inceptisol and Alfisol. The study area is north-eastern District of Chhattisgarh state Koriya lies between 23°85'40.28 to 23°26'32.29 northern latitude and between 81°66 to 82°23 eastern longitudes. To study Crop response based assessment of limiting nutrients using site-specific nutrient management for yield maximization in Inceptisols a pot experiment was conducted in the greenhouse of Rajmohini Devi College of Agriculture and Research Station Ambikapur. The experiment was conducted in *Kharif* season 2018 using representative soil of Koriya district and rice variety MTU-1010 as crop. For this purpose, surface soil sample was collected in bulk from the farmers field in Barbaspur village,block-Manendragarh, District-Koriya. The objectives of the study were to identify the specific nutrients which limit the crop yield through rice -response using nutrient omission technique in *Kharif* season, and to demonstrate the optimum use of identified limiting nutrients and it's comparison with farmer's fertilizer practice taking wheat GW-273 as test crop in Rabi season. The pot culture established in three replication and eleven treatments with each soil type in 25 Kg pots. Three to four, twenty days old seedling of MTU 1010 per hill were transplanted in the pot which is maintained at 3cm water until harvesting. The eleven treatments constituted of application of all nutrients applied at optimum level and called as SSNM dose/All nutrients applied, omission of each nutrient from SSNM dose using nutrient omission technique to identify the limiting nutrients which are depicted in Table 1. SSNM dose for Inceptisol was N-120, P2O5- 80, K2O-50, S-30 kg/ha, and Zn- 5 Kg/ha. The nutrients were applied by different sources of nutrients, which are represented in Table 2. Different observations regarding soil and plant were taken after collection of samples, crushing and sieving them and after going through proper digestion were recorded.

Table 1: Nutrient Treatments

Treatment No.	***Inceptisol***	***Alfisol***
Treatment 1	All (N, P, K, S, Ca, Mg, Cu, Zn, B, Mo)	All (N, P, K, S, Fe, Mn, Cu, Zn, B, Mo)
Treatment 2	All – N	All – N
Treatment 3	All – P	All – P
Treatment 4	All – K	All – K
Treatment 5	All – S	All – S
Treatment 6	All – Ca	All – Fe
Treatment 7	All – Mg	All – Mn
Treatment 8	All – Cu	All – Cu
Treatment 9	All – Zn	All – Zn
Treatment 10	All – B	All – B
Treatment 11	All – Mo	All – Mo

Table 2: Nutrient Sources

Nutrient	Source of nutrient	Application Rate (kg/ha)	Amount of fertilizers (gm) to be added per pot (20 kg of soil
			Inceptisols
N	Urea	150 Kg N/ha	2.82 gm/pot
P	TSP	(100 kg P_2O_5/ha)	1.92 gm/pot
K	MOP	(100 kg K_2O/ha)	1.48 gm/pot
S	Bentonite Sulphur	45	0.44 gm/pot
Ca	$CaCl_2$. $2H_2O$	110	2.72 gm/pot
Mg	MgO	50	0.8 gm/pot
Fe	$FeCl_2$	20	-----nil----------
Mn	$MnCl_2$	15	-----nil----------
Cu	$CuCl_2.2\ H_2O$	7.5	0.16 gm/pot
Zn	$ZnCl_2$	7.5	0.127 gm/pot
B	H_3BO_3(Boric acid)	3	0.15gm/pot
Mo	$H_2Mo_4.2H_2O$	0.75	0.01 gm/pot

Results and Discussion

The effects of omission were significant in the reduction of grain and straw yield with different nutrient omission treatment and yields are influenced with fertilizer application (Boling *et al*., 2004) [3] as shown in (Table 1).The mean grain yield were significantly affected, highest grain yield received zinc omitted which is similar to SSNM treatment which received all the treatment (111.75 g/pot) significantly higher compared to all the treatment, zinc omitted treatment shown similar yield (111.96 g/pot) due to antagonist relationship between Zn x P (Zhang *et al*, 2017) [4], Omission of N reduced the grain yield by 54.23%, P omission caused a yield reduction of 33.34% while sulfur omission reduces the yield by 15.39%. The percent reduction in rice yields under different nutrients omitted pots were in the order of N> P>S>Mg>K>Ca>Mo>B. Most critical yield-limiting nutrient in Inceptisols of district Koriya was found to be N, P and S, in which sulfur is found to be the most deficient secondary nutrient in Indian soils in a range of low to medium due to intensive use of sulfur-free fertilizers (Biswas *et al*, 2004) [6]. The mean total N, P and K uptake (Fig. 2) by rice were significantly affected by the application of different treatments. Highest N uptake (1.94 g/pot) was observed in SSNM treatment followed by (1.87g/pot) in B omitted due to the negative effect of Boron on nitrogen concentration (Miley *et al*., 1907). Average P uptake by rice was significantly affected with different treatments application, highest phosphorous uptake were recorded in SSNM dose (0.48 g/pot) followed by Zn omitted (0.47 g/pot) due to antagonistic relation with phosphorous and by calcium omitted treatment(0.44 g/pot) due to major fixation of phosphorus with increased concentration of Ca. Mean Ca uptake (Fig.3) was highest in SSNM dose (1.09 g/pot) and least in nitrogen omitted (0.50 g/pot) treatment due to a decrease in nitrate content in soil reduces the Ca uptake and translocation in plants (Barta, L.A, 1977) [8]. Mean Mg uptake was highest in

SSNM (0.65 g/pot) followed by Zn-omitted treatment (0.62 g/pot) due to suppression effect. Mean S uptake was highest for SSNM (0.33 g/pot) and lowest in N-omitted pot (0.14g/pot).

Table 3: Grain and straw yields (g/pot) of rice (MTU-1010) in relation to different treatment Inceptisols

S.no	Treatment	Grain Yield	Straw Yield
1	SSNM	111.75	128.52
2	SSNM -N	51.14	58.81
3	SSNM -P	74.49	85.67
4	SSNM -K	107.38	123.49
5	SSNM -Ca	107.95	124.15
6	SSNM -Mg	106.20	122.13
7	SSNM -S	94.55	108.73
8	SSNM -Cu	108.03	124.24
9	SSNM -Zn	111.96	128.75
10	SSNM -B	110.87	127.50
11	SSNM -Mo	109.63	126.08

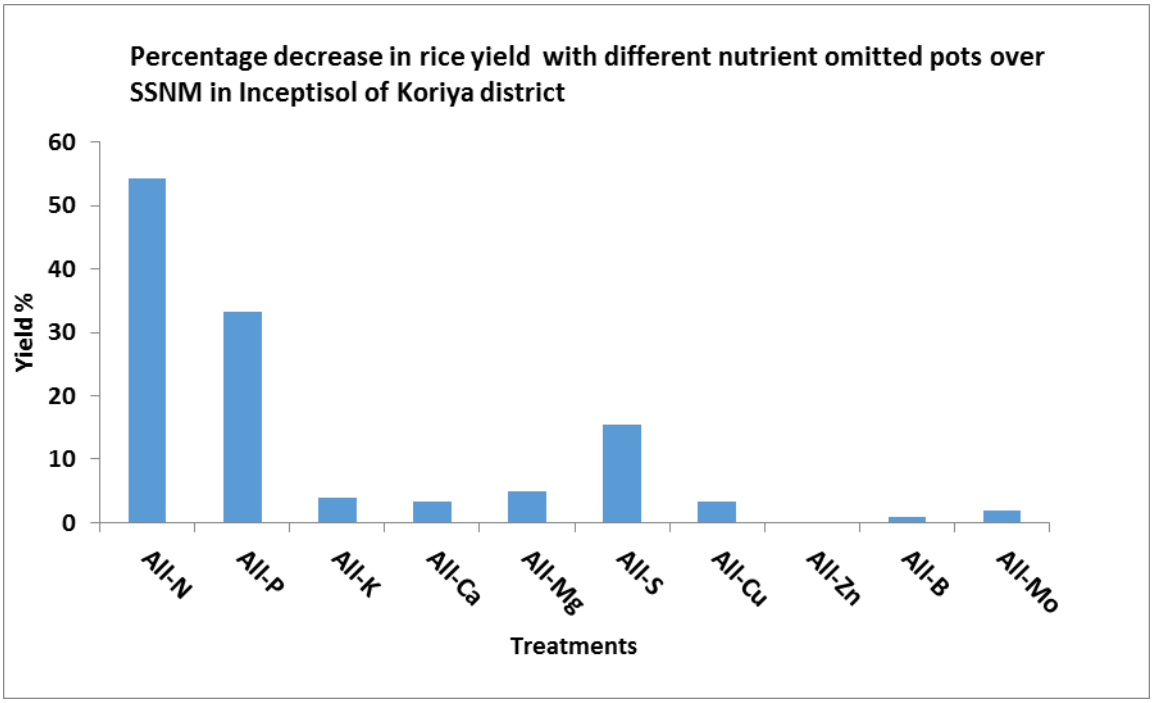

Fig 1: Percentage decrease in rice yield and different nutrient omitted pots over SSNM in Inceptisols of Koriya district

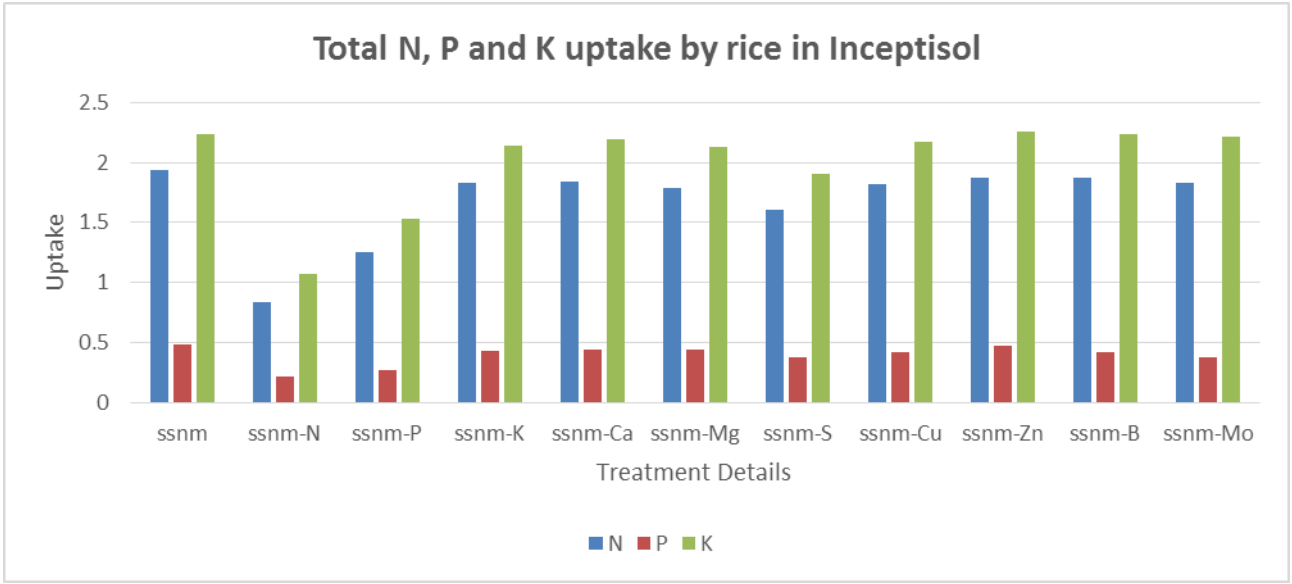

Fig 2: Total N, P and K uptake (g/pot) by rice in Inceptisols

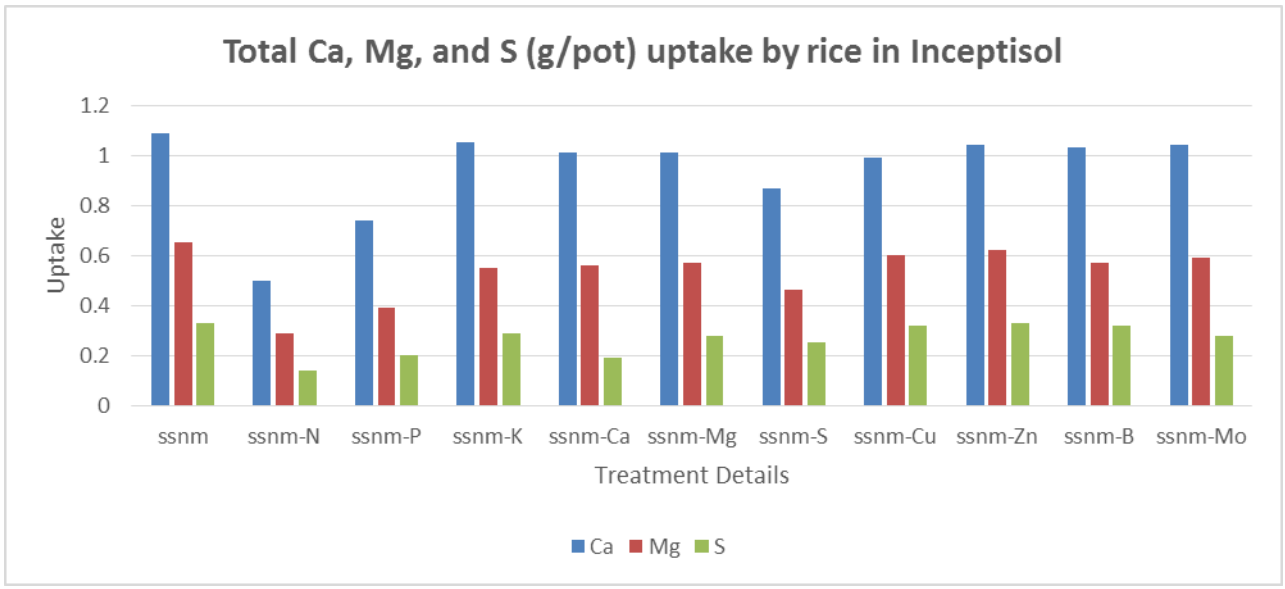

Fig 3: Total Ca, Mg and S uptake (g/pot) by rice in Inceptisol

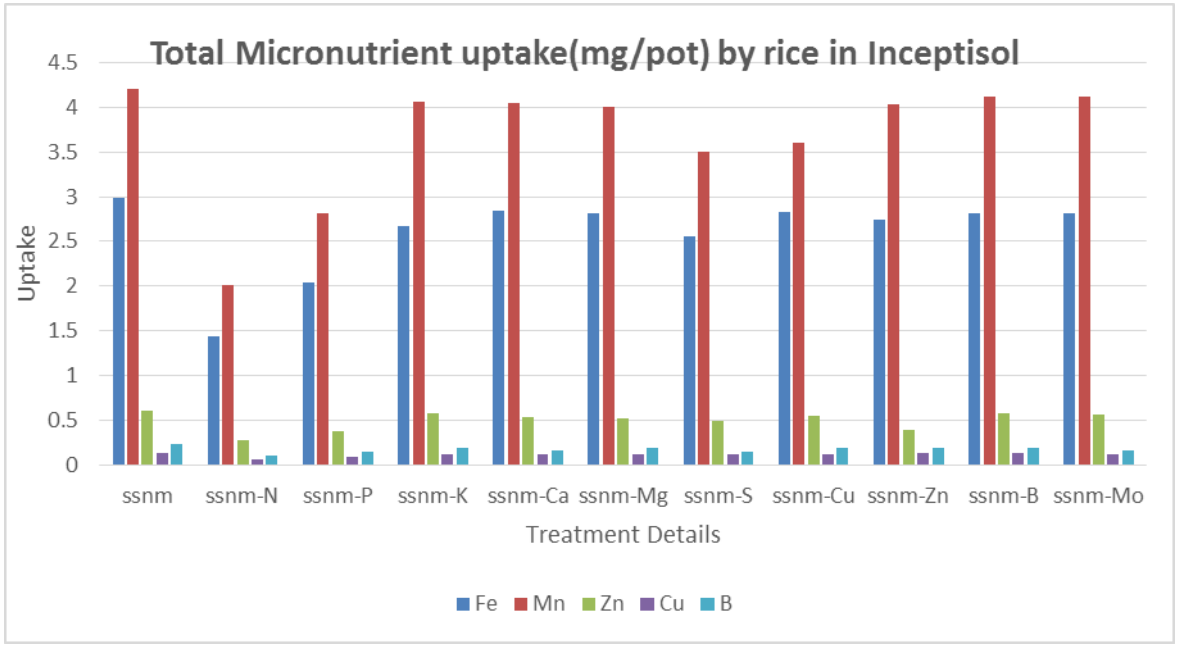

Fig 4: Total Micronutrient (Fe, Mn, Zn, Cu and B) uptake by rice in Inceptisol

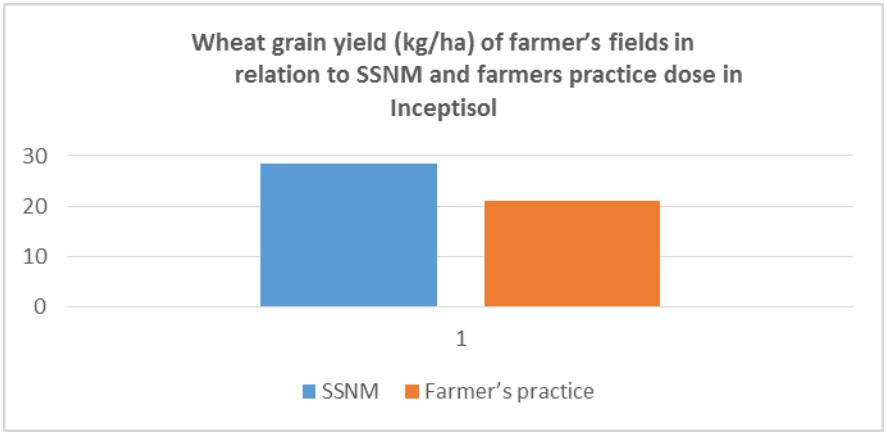

Fig 5: Wheat grain yield (kg/ha) of farmer's fields in relation to SSNM and farmers practice dose in Inceptisol

Micronutrient uptake (Fig.4) was significantly affected by different treatments. Mean Fe (2.99mg/pot), Mn (4.20mg/pot), Zn (0.61mg/pot), Cu (0.13mg/pot) and B (0.23mg/pot) were highest in SSNM treatment. Fe uptake significantly reduced by N-omission (1.44mg/pot) followed by P-omitted (2.04 mg/pot), Ca omitted pot has similar uptake (2.85 mg/pot) similar to SSNM due antagonized Fe, Ca and P relation (Adriano *et al*., 1907). Mean Boron uptake in Zn

omitted pot (0.18 mg/pot) resulting in accumulation of boron is reported (Singh *et al*., 1990) [10]. Mean Mn, Zn and Cu uptake were least in N-omitted followed by P omitted and then by S omitted pot.

Based on the performance of rice crop during *Kharif* season, the nutrients identified as limiting nutrients in *Inceptisol*, nitrogen, phosphorus, and sulfur, were traced. These nutrients were applied as per the following doses which are known as SSNM dose (as used in rice crop) and tested with wheat crop (GW-273). The SSNM doses for *Inceptisols* were as N - 120, P_2O_5 -80, K_2O - 50, S - 30, and Zn – 5 kg/ha. The farmer's fertilizer doses were applied at the rate of 80:50:40 (N: P_2O_5: K_2O) kg/ha. SSNM dose increased the yield upto 34% (Fig.5) compared to farmer practice dose, suggesting addition of sulfur or sulfur based fertilizer and Zinc fertilizer to soils of inceptisol of the region.

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