RESEARCH ARTICLE

EVALUATION OF SITE-SPECIFIC NUTRIENT MANAGEMENT APPROACH IN TRANSPLANTED RICE UNDER SUB-HUMID CONDITION OF SOUTHERN RAJASTHAN

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Abstract: Site-specific nutrient management (SSNM) in a new approach that provides the proper quantity and timely supply of nutrients to the crop plants according its requirement in the existing soil and climate. With this background, a field experiment was conducted on a fixed site at Agriculture Research Station (MPUAT), Banswara, Rajasthan, during two consecutive *kharif* seasons of 2008 and 2009 to evaluate the plant based SSNM strategy for rice crop. The experiment consisted of seven treatments with the application of different category of nutrients, including control and State Fertilizer Recommendation (SFR). SSNM treatment (T_4) gave a maximum grain yield (74.00q ha^{-1}) which was recorded significantly 10, 12, 30, 55 and 58% higher compared to the Improved fertilizer recommendation (T_3), State fertilizers recommendation (T_2), SSNM-P (T_6), SSNM-N (T_5), and absolute control (T_1), respectively. The grain yield increased in T_4 could be recorded the maximum tillers (352 m^{-2}), Panicles (340 m^{-2}), grains (150.30 $panicle^{-1}$). The maximum B: C ratio (3.54) was also recorded with SSNM (T_4). The yield lower in N and P omission from SSNM treatments indicated that there is large response to added N but low response to added P due to variation in indigenous soil nutrient supply. Hence, high variability to applied N, P, K suggests the necessity of SSNM to improve the productivity of rice crop.

Keywords: Rice, SSNM, Grains yield, Nutrient

INTRODUCTION

Rice is one the most staple food of about 50% of the world's population and its area is concentrated mostly in South East Asia. Rice contributes around 45 per cent of India's total food grain production and it continues to hold the key for food sufficiency in the country. The sub-humid area of southern Rajasthan is also a major rice-growing zone during rainy season. Being the cereal crops, the nutrient requirement of rice is very high and due to imbalanced and unscientific nutrient management practice, the productivity of the crop is realized to decline with the available genetic resources. The conventional and injudicious fertilizer application practices are not only reduces nutrient use efficiency, but also causes nutrient imbalance in the soil resulting in decreased crop yield (Ladha *et al*. 2005). The productivity of rice may be increased by fine-tuning nutrient and crop management. Site-specific nutrient management (SSNM) provides a field-specific approach for dynamically applying nutrients to crops as and when needed. This approach advocates the optimal use of indigenous nutrients originating from soil, plant residues, manures, and irrigation water. Fertilizers are then applied in a timely fashion to overcome the deficit in nutrients between the total demand by rice to achieve a yield target and the supply from indigenous sources. An estimate of soil indigenous N, phosphorus (P), and K supply was obtained from omission plots situated in each field. There results from these plots were used as inputs in a model designed to estimate field-specific fertilizer requirements in the SSNM plots (Dobermann *et a*l, 2002).SSNM has been proposed an approach to tailor fertilizer application to match field-specific needs of crops to improve productivity and profitability (Buresh *et al*, 2010, Dobermann *et al*, 1996 and Wett *et al*, 1999). This could be done by utilizing available information on indigenous nutrient supplying capacity, nutrient contributions from organic manures, irrigation water, rainfall and crop residue pools and finally crop nutrient demand for targeted yield of crop. Based on these considerations, the present investigation was carried out to evaluate the SSNM approach for rice under sub-humid condition of southern Rajasthan.

Table 1. Effect of different nutrient management options on growth and yield attributes of rice (Pooled data of two years)

Treatment	Plant height (cm)	Tillers m^{-2}	Panicles m^{-2}	Grains $Panicle^{-1}$
T_1: Control (No NPK)	80.50	133.65	130.55	120.40
T_2: State fertilizers recommendation (120-60-40 kg N-P_2O_5-K_2O ha^{-1})	94.70	311.81	287.03	128.70
T_3: State fertilizers recommendation (120-60-40 kg N-P_2O_5-K_2O ha^{-1})	102.00	315.23	310.18	145.30

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T_4 : Site-specific nutrient management (SSNM) (142-37-0 & 25 kg N-P_2O_5-K_2O & $ZnSO_4$ ha^{-1})	107.00	351.23	338.55	150.30
T_5: N omission (SSNM-N) (0-37-0 & 25 kg N-P_2O_5-K_2O & $ZnSO_4$ ha^{-1})	93.25	173.05	168.07	126.20
T_6: P omission (SSNM-P) (142-0-0 & 25 kg N-P_2O_5-K_2O & $ZnSO_4$ ha^{-1})	98.70	248.55	220.50	135.60
T_7 : K omission (SSNM-K) (142-37-0 & 25 kg N-P_2O_5-K_2O & $ZnSO_4$ ha^{-1})	100.40	332.95	318.72	152.30
CD (P=0.05%)	7.60	32.60	27.60	14.20

Table 2. Effect of different nutrient management options on growth and yield attributes of rice (Pooled data of two years)

Treatment	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index	Cost of cultivation (Rs ha^{-1})	Net return (Rs ha^{-1})	B:C ratio	Agronomic efficiency (%)		
							N	P	K
T_1	31.12	46.08	40	23850	28930	1.21			
T_2	65.10	85.48	43	26478	81758	3.09	54.25	108.50	162.75
T_3	66.58	87.35	43	27438	83244	3.03	55.48	110.97	166.45
T_4	74.00	93.80	44	26975	95525	3.54	52.11	200.00	
T_5	33.22	48.17	41	25920	30222	1.17		89.78	
T_6	52.00	73.80	40	26359	61201	2.32	36.62	140.54	
T_7	73.68	92.56	44	26975	94689	3.51	61.40	199.14	
CD (P=0.05%)	3.20	3.42	1.0						

Table 3. Effect of different nutrient management options on nutrient uptake (Pooled data of two years)

Treatment	Nutrient uptake by grain (kg ha^{-1})			Nutrient uptake by straw (kg ha^{-1})			Nutrient uptake by straw (kg ha^{-1})		
	N	P	K	N	P	K	N	P	K
T_1	31.12	6.85	7.78	27.63	5.53	63.56	58.75	12.37	71.34
T_2	74.87	15.62	17.58	53.85	12.82	121.38	128.45	28.45	138.96
T_3	81.23	17.31	17.98	56.78	14.85	126.66	138.01	32.16	144.63
T_4	91.02	19.24	20.72	67.54	18.76	136.95	158.56	38.0	157.67
T_5	37.21	7.64	8.31	27.46	8.19	67.44	64.66	15.83	75.74
T_6	59.80	10.92	13.52	51.66	7.38	103.32	111.46	18.30	116.84
T_7	91.36	18.42	19.16	65.16	16.72	131.44	157.08	35.08	150.59
CD (P=0.05%)	9.20	2.60	2.80	8.55	2.80	4.60	12.47	4.20	12.81

MATERIAL AND METHOD

A field experiment was conducted on fixed site at agriculture research station (MPUAT), Banswara, Rajasthan during two consecutive *kharif* season of 2008 and 2009 to evaluate the agronomic management of seven nutrient options on growth and yield of rice. The experimental site is geographically situated at $23^0.33'$ and latitude, 74^0 27' E longitude and altitude of 220 M above Mean Sea Level. It is covered under humid southern plain agro-climatic zone of Rajasthan, which falls under sub-humid climate with dry, hot summer and mild winters. The average rainfall of the season was 862mm. The soil of experimental field is clay loam in texture, slightly alkaline in reaction with contain low in organic carbon (0.33%), low in available N(156.75 kg ha^{-1}), low in available phosphorous (17.76 kg ha^{-1}) and high available potassium (480 kg ha^{-1}). Initial soil samples were collected randomly from the experimental field, soil analysis was done by adopting standard procedures, and the SSNM recommendations were developed from soil test values and nutrient uptake requirements for the targeted yield of the crop. The experiment consisting of seven treatments was laid-out in a randomized complete block design with three replications. The treatments comprised viz. T_1- Absolute control (No NPK), T_2- State fertilizers recommendation (120-60-40 kg N-P_2O_5-K_2O ha^{-1}), T_3- Improved nutrient recommendation (120-60-40 & 25 kg N-P_2O_5-K_2O & $ZnSO_4$ ha^{-1}), T_4- Site- Specific Nutrient Management (142-37-0 & 25 kg N-P_2O_5-K_2O & $ZnSO_4$ ha^{-1}), T_5- N omission (SSNM-N), T_6- P omission (SSNM-P) and T_7- K omission (SSNM-K). The nutrient levels for T_4 to T_7 treatments were calculated based on the QUEFTS model (Janssen *et al*. 1990) taking into account organic carbon and available P and K in the soil as well as targeted yield of 5t ha^{-1} for using rice variety PRH 10. 1/3 dose of nitrogen, full dose of phosphorus, potassium and $ZnSO_4$ were applied at the time of transplanting as per the treatment in the form of urea for nitrogen, SSP for phosphorus, muriate of potash for potassium and $ZnSO_4$ for Zn. The first top dressing of N (one-third quantity) was applied at the tillering stage and second top dressing of N (one-third quantity) was applied at the panicle initiation stage. PRH-10 was transplanted during July with two seedlings per hill, with spacing of 20x10cm and harvested during the first week of November. Uniform cultural operations and plant protection measures were adopted in all the treatments. The observations on growth and yield parameters were recorded and the average of two years is reported and discussed.

RESULT AND DISCUSSION

Growth and yield attributes

Pooled data of two consecutive rainy seasons of 2008 and 2009 revealed that SSNM approach enhanced the plant height, number of effective tillers and panicles/hill and number of grains $panicle^{-1}$ (Table 1). Application of SSNM treatment (T_4) significantly increased plant height (107cm) 34, 29, and 15% over control, SSNM-N and state fertilizers recommendation, respectively. Similarity, maximum number of tillers (352 m^{-2}) and panicle (340 m^{-2}) and number of grains (150.30 $panicle^{-1}$) were recorded with the application of T_4 which significantly increased 62, 51, 29, and 11% number of tillers m^{-2} and 62,51, 35 and18 9% number of panicles m^{-2} over $T_{1,}$ $T_{5,}$ T_6 and $T_{2,}$ respectively. However, number of grains/panicle increased significantly 46, 33, 16, and 14, higher over $T_{1,}$ $T_{5,}$ T_6 and $T_{2,}$ respectively. The similar results observed by Peng *et al*,2006 those found significantly increased average ear-bearing tiller rate (12.3%) and LAI for grain-filling stage (14.1-27.6%) and improved dry matter weight to application of nitrogen through SSNM approach over farmers field practices.

Yield

Application of nutrients based on SSNM approach significantly influenced the grain and straw yields (Table 2). Maximum grain yield (74q ha^{-1}) produced with the application of SSNM (T_4) that significantly increased 58, 55, 29 and 12% higher over $T_{1,}$ $T_{5,}$ T_6 and $T_{2,}$ respectively. Similarly, straw yield gets highest (94q ha^{-1}) with the application of T_4 that was calculated significantly 51, 48, 21 and 12% superior over $T_{1,}$ $T_{5,}$ T_6 and $T_{2,}$ respectively. The highest grain yield in T_4 could be attributed to higher number of yield attributes compared to rest treatments. Similarly, higher straw yields in T_4 could be attributed to more plant height (11-34%) and number of tillers m^{-2} (10-62%) as compared to other treatments. Application of SSNM (T_4) recorded maximum harvest index (44.10%) that significantly superior to control (40.31%), SSNM-N (40.82%). SSNM-P (41.34%).The yield advantage through site-specific nutrient management (SSNM) over farmer practices and unbalance use of nutrient was reported by several workers (Timsina *et al*, 2010, Jat *et al*, 2011 and Nagegowda *et al*, 2011). The harvest index may be attributable to higher grain yield because of increased dry matter accumulation in panicle and grains (Gangaiah and Prasad, 1999) which attributed to higher number of panicles $hill^{-1}$ and grains $panicle^{-1}$.

Economics

SSNM treatment added expenditure ranging from Rs. 497 to 3125 ha^{-1} over state fertilizers' recommendation and control, respectively (Table 2). The additional expenditure generated an extra produce worth Rs.13767 and 66595 ha^{-1} to state fertilizer recommendation and control, respectively. The maximum B:C ratio (3.54) was recorded with the SSNM practice that means higher net return (Rs 70913) archived due to get higher yield and judicial application of nutrient as compared to state fertilizer recommendation and control.

Agronomic efficiency

Agronomic efficiency (AE) expressed, as kg grain/kg nutrient was grater in SSNM treatment compared to state and improved fertilizer recommendation (Table 2). Agronomic efficiency of nitrogen under SSNM treatment was recorded (52.11kg rice/kg N) that range from 36.62-55.44 kg rice/kg N. Whereas, maximum agronomy efficiency of P was recorded 200 kg rice/kg P was that range from 89.78- 200 kg rice/kg $P_2O_{5.}$ However, Potash has not applied in SSNM treatment because its availability is higher in soil. Total agronomy efficiency was recorded with

SSNM Treatment (252.11 kg rice/kg NP) which range from 162-260.54kg rice/kg N and P_2O_5. Agronomy efficiency was also increased with ZnSO4 application.

Nutrient uptake

A perusal of table 3 shows that maximum nitrogen uptake by grain, straw and grain straw was recorded in SSNM treatment which significantly superior over control, SSNM-N, SSNM-P and state fertilizers recommendation. The N uptake by grain (91.02kg ha^{-1}) in SSNM treatment increased 18, 34, 59, and 66 % over state fertilizer recommendation, SSNM-P, SSNM-N, and control treatments, respectively. Similarly, maximum N uptake (67.54 kg/ha) by straw under SSNM treatment that was also significantly 20, 23, 60 and 62 % higher over state fertilizer recommendation, SSNM-P, SSNM-N, and control, respectively. The total uptake of N by grain and straw was recorded maximum (158kg ha^{-1}) in SSNM treatment which significantly 13, 19, 29, 59 and 63% superior over $T_{3,}$ $T_{2,}$ $T_{6,}$ T_5 and $T_{1,}$ respectively. The increased nitrogen uptake by grain, straw and grain+straw might be due to the improved concurrent between plant N demand and supply by soil and amount of nitrogen application. The nitrogen application increased under SSNM approach to soil to be increased N supply to plant to get higher content and enhanced the yield. Similar, result was reported by nagegowda *et al*, 2011 those observed N uptake enhanced due to synchrony between demands of plant and supply from soil. Phosphorous uptake by plant was recorded maximum (38.00 kg ha^{-1}) under SSNM treatment that significantly increased 25, 52, 58, and 67% higher over $T_{2,}$ $T_{6,}$ $T_{5,}$ and T_1, respectively. This uptake might be correlated with yield and phosphorus application. Similar finding were reported by Debermann *et al*, 2002. Maximum potash uptake (152.52kg K ha^{-1}) was recorded with SSNM treatment which also at par with SSNM-K treatment. It was not found limiting nutrient to production due to highly available in soil and adequate supply to plant. These results shown the maximum nutrient uptakes govern by nitrogen supply from soil and fertilizer to plant because nitrogen is most limiting factor due experiment conducted on low available N in soil.

CONCLUSION

On the basis, two years data may be concluded that the site- specific nutrient management approach provides nutrients in adequate responded the plant need compared that ultimately has reflected in terms of grain yield. This also economic practice compared blanket and improves recommendations.

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