Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(6): 147-149
Received: 19-09-2019
Accepted: 21-10-2019

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Assessment of nutrient management and omissions on yield of transplanted rice

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Abstract
Field experiment was conducted for 3 season's *kharif* 2012, 2013 and *rabi* 2013 on sandy clay loam soils of College Farm, College of Agriculture, Rajendranagar, Hyderabad, Telangana to evaluate nutrient management in transplanted rice through nutrient omission plot technique for yield maximization with eight treatments in randomized block design. Highest number of tillers m^{-2}(477), highest number of panicles m^{-2}(441), number of grains $panicle^{-1}$(127) and grain yield (6567 kg ha^{-1}) with highest sustainable index (0.8) was recorded with site specific nutrient management for targeted yield of 6500 kg ha^{-1} over the other treatments (RDF, N, P, K, Zn, Fe omissions and absolute control).

Keywords: Nutrient management, omissions, yield, transplanted rice

Introduction
Rice (*Oryza sativa* L.) is one of the most important staple food crop in the World. Globally rice is grown over an area of 161.83 million ha with an annual production of 717.8 million tons (IRRI, 2017) [3]. In Asia, more than two billion people are getting 60-70% of the energy requirements from rice. The increment of yield with increment of nutrient is higher (17.9 kg grain kg^{-1} nutrient applied) during green revolution period (1960-70), but there was gradual decline in the increment (6.3kg grain per kg nutrient applied) during 1991-2000 (Tandon, 2012) [9]. In irrigated conditions especially in rice, more recent analysis of yield trends in several long-term experiments in Asia and more specifically in India confirmed that rice yields are either stagnating or declining. This is mainly attributed to improper nutrient management approaches that resulted in decreased nutrient supply capacity of soil and use efficiency of the applied fertilizers (Khurana *et al.*, 2007) [5]. The decision on fertilizer use requires knowledge of the expected crop yield response to nutrient application which is a function of crop nutrient needs, supply of nutrients from indigenous sources and the short and long term fate of fertilizer applied (Doberman *et al.*, 2003) [2]. Grain yield in a particular nutrient omission plot can be used directly as intercept (Y_0) in yield–fertilizer application response curve and fertilizer needs can be estimated from the difference between target yield and intercept (ΔY) by assuming a certain amount of plant nutrient uptake per unit yield increase (Wilt and Doberman, 2002).

Material and methods
The field experiment was conducted with IR-64 rice variety at College Farm, College of Agriculture, Rajendranagar, Hyderabad during *kharif* 2012, 2013 and *rabi*, 2013-2014. The farm is geographically situated at an altitude of 542.6 m above mean sea level at17º 19' N latitude and 73º23' E longitude. It is covered under Southern Telangana agro-climatic zone of Telangana state, India. According to Troll's climatic classification, it falls under semi-arid tropics (SAT). The experimental site was clay loam in texture with pH of 7.5, organic carbon 0.45%, available nitrogen -151 kg ha^{-1}, available phosphorus – 46 $kgha^{-1}$, available potassium-315 kg ha^{-1}, available Zn - 0.79 mg kg^{-1}, available Fe – 4.36 mg kg^{-1}. The experiment consisted of 8 treatments *viz.*, T_1 - Recommended Dose of Fertilizers (RDF), T_2- Site Specific Nutrient Management (SSNM), T_3 – N omission, T_4 – P omission, T_5 – K omission, T_6 –Zn omission, T_7 – Fe omission and T_8 control laid in randomized block design with three replications. Transplanting was done with 20 cm x 15cm spacing. Fertilizers were applied as per the treatments. While under site specific nutrient management, fertilizers were calculated based on soil test prescription and equation. SSNM based nutrient requirement equations developed for transplanted rice for a targeted yield of 65qha^{-1} is given as follows.

***Kharif* 2012**
Nitrogen = 4.2 T – 0.55 soil N
= 4.2 x 65 – 0.55 x 138 (Soil test value after first season)
= 197.1 kg N ha^{-1}
Phosphorus = 2.7T – 2.67 soil P
= 2.7 x 65 -2.67x 45.6 (Soil test value after first season)
= 53.8 kg P_2O_5 ha^{-1}
Potassium = 2.22 T -0.21soil K
= 2.22 x 65 – 0.21 x 301(Soil test value after first season)
= 81.09 kg K_2O ha^{-1} –Potassium was applied to SSNM treatment

***Kharif* 2013**
Nitrogen = 4.2 T – 0.55 soil N
= 4.2 x 65 – 0.55 x 160 (Soil test value after first season)
= 185 kg N ha^{-1}
Phosphorus = 2.7T – 2.67 soil P
= 2.7 x 65 -2.67x 49.1 (Soil test value after first season)
= 44.5 kg P_2O_5 ha^{-1} – phosphorus was applied to the SSNM treatment
Potassium = 2.22 T -0.21soil K
= 2.22 x 65 – 0.21 x 324 (Soil test value after first season)
= 76.3 kg K_2O ha^{-1} –Potassium was applied to SSNM treatment

Rabi, 2013-14
Nitrogen = 3.8 T – 0.57 soil N
= 3.8 x 65 – 0.57 x 165(Soil test value after first season)
= 247 – 94.0
= 153 kg N ha^{-1}
Phosphorus =1.7 T – 2.46 soil P
= 1.7 x 65– 2.46 x 51(Soil test value after first season)
= 110.5 – 125.4
= -14.96 kg P_2O_5 ha^{-1} (P was not applied)
Potassium = 1.48 T -0.16 soil K
= 1.48 x 65– 0.16 x 329 (Soil test value after first season)
= 96.2 – 52.6
= 43.6 kg K_2O ha^{-1}

In this treatment, 197.1 kg ha^{-1} N and 81.09 kg ha^{-1} K_2O was applied along with $ZnSO_4$ and $FeSO_4$ were applied @ 20 and 30 kg ha^{-1} respectively. Likewise, during *kharif* 2013 and *rabi* 2013-14 nutrient requirement is calculated with the same regression equations based soil test values of N,P_20_5,K_20 (160, 49.1, 324 kg ha^{-1} before initiation of the experiment during *kharif* 2013 and 165, 51, 329 kg ha^{-1} during *rabi* 2013-14). Based on above equations 185, 44.5, 76.3 kg N, P_2O_5, K_2O ha^{-1} and 153, 14.96, 43.6 kg N, P_2O_5, K_2O ha^{-1} were applied during *kharif* 2013 and *rabi* 2013-14 respectively. As SSNM approach is followed for macro nutrients, uniform dose of 20 kg ha^{-1} $ZnSO_4$ and 30 kg ha^{-1} $FeSO_4$ were applied to all seasons.
The experiment was provided need based plant protection and cultural management throughout the period of crop growth. The data on number of tillers, panicles m^{-2} number of grains per panicles and grain yield at harvest were taken and statistically analyzed to present the data.

Results and Discussion
The site specific nutrient management was recorded more yield than the recommended dose of fertilizers during *kharif* 2012 and 2013 and similar effect was observed during *rabi* 2013-14. The influence of nutrient proportion estimates from targeted yield equations to improve the number of tillers was also reported by Ramesh and Chandrasekaran (2007) [6]. The recommended dose of 120:60:40 kg ha^{-1} in *kharif* and 150:60:40 kg ha^{-1} in *rabi* significantly increased the panicles to 393, 417 and 400 m^{-2} in the respective seasons. The prescription based on SSNM of 197:54:81, 185:45:76 and 154:0:44 kg ha^{-1} N, P_20_5, K_20 in these seasons activated the crop to produce 427, 453 and 443 panicles m^{-2} (Table 1). This increase was significant in *kharif* 2012 and *rabi* 2013. Ramesh and Chandrasekaran (2007) [6] recorded significant increase in dry matter content of rice fertilized with balanced nutrient dose through soil test response functions than the blanket recommended dose.The absolute control produced least number of panicles m^{-2} during *kharif* 2012, 2013 and *rabi* 2013-14 (210, 207 and 212, respectively).
Omission of N, P, K, Zn or Fe reduced the panicles consistently in the three seasons. Omission of N was most serious compared to others. Jadhav *et al*. (2014) [4] reported that the application of Zn or Fe did not influence the number of panicles m^{-2} in any one of the three seasons' studied. The unfertilized transplanted rice produced least number of grains per panicle during *kharif* 2012, 2013 and *rabi* 2013-14(80, 73 and 68, respectively). The recommended level of treatment crop produced a mean of 118, 118 and 119 grains per panicle in the respective seasons. The variable level of nutrients based on pre-test soil considerations was equally effective to produce the number of grains on par with the recommended level of fertilizers. The omission of nutrients barring N showed a variable trend in the three seasons.
Rice transplanted in the puddled condition without fertilizers recorded 3913, 2875 and 2654 kg $ha^{-1}$of grain yield during *kharif* 2012, 2013 and *rabi* 2013-14, respectively. The recommended dose of fertilizers to supply 120:60:40 kg ha^{-1} NPK in *kharif* and 150:60:40 kg ha^{-1} in *rabi* significantly increased the level of production to 6177, 6250 and 6313 kg ha^{-1} in the corresponding seasons (Table 2).
The response to omission of nutrients were indifferent. The omission of N alone drastically reduced the yield (2484 kg ha^{-1}) compared to the recommended dose of fertilizers in *kharif* 2012. But the crop suffered severe yield losses due to omission of any of the nutrient in *kharif* and *rabi* 2013. Das *et al.* (2009) [1] also recorded the sensitivity of transplanted rice to yield low by the omission of N, P or K through the fertilizers. In contrast, the investigations of Reddy (2004) [8] and Rana *et al.* (2017) [7] showed that under conditions of puddling and subsequent submergence of the field already rich in K status did not respond to the addition of K fertilizer.
The transplanted rice was more secure to seasonal and nutritional changes. The recommended dose of fertilizers recorded a sustainable yield index of 76% across 2 *kharif* seasons and 75% over 3 seasons. The site specific nutrient management was more secure. The sustainable indices assured the minimum likely production of 80% of the potential yield. The omission of any nutrient N, P, K or Zn or Fe drastically reduced this index. The omission of key nutrient N for high production reduced the sustainable index to 0.45 in transplanted rice (Table 3). This indicates that the minimum likely production of 45% of the maximum potential yield in the transplanted rice without application of N.

Conclusion
Site-specific nutrient management (SSNM) based on targeted yield approach maintained soil fertility at healthy levels by supplying all nutrients in proportion matching with crop needs which is reflected by highest grain yields over the other treatments and is recommended for maximizing grain yield of transplanted rice.

Table 1: Influence of nutrient management and omissions on tillers m^{-2} and panicles m^{-2} at harvest in transplanted rice.

Treatment	Tillers m^{-2}				Number of panicle m^{-2}			
	Kharif 2012	*Kharif* 2013	*Rabi* 2013-14	Pooled	*Kharif* 2012	*Kharif* 2013	*Rabi* 2013-14	Pooled
T1-RDF	399	431	455	428	393	417	400	403
T2-SSNM	468	476	487	477	427	455	443	441
T3-N-Omission	285	230	248	254	269	217	245	243
T4-P-Omission	353	327	378	353	352	316	305	324
T5-K-Omission	340	308	360	336	343	320	300	321
T6-Zn-Omission	362	328	372	354	391	348	348	362
T7-Fe-Omission	370	347	402	373	397	313	381	363
T8-Control	210	176	204	196	210	207	212	209
Mean	348	327	363	346	347	324	329	333
SeM±	11	8	17	8	31	15	9	20
C.D at 5%	33	25	53	24	10	44	29	33

Table 2: Influence of nutrient management and omissions on number of grains panicles $^{-1}$, grain yield (kg ha^{-1}) in transplanted rice.

Treatment	Number of grains $panicle^{-1}$				Grain yield (kg ha^{-1})			
	Kharif 2012	*Kharif* 2013	*Rabi* 2013-14	pooled	*Kharif* 2012	*Kharif* 2013	*Rabi 2013-14*	pooled
T1-RDF	118	118	108	108	6177	6260	6313	6250
T2-SSNM	125	130	126	116	6404	6544	6755	6567
T3-N-Omission	92	83	89	82	4593	3580	3125	3766
T4-P-Omission	110	114	110	108	6034	5350	5128	5504
T5-K-Omission	116	104	103	107	5900	5235	4644	5259
T6-Zn-Omission	111	107	100	109	5912	5673	5236	5607
T7-Fe-Omission	114	116	112	98	6054	5860	5436	5783
T8-Control	80	73	68	58	3913	2875	2654	3147
Mean	108	105	103	98	5623	5172	4911	5235
S.Em±	5	4	4	7	97.5	68	72	138
C.D at 5%	14	12	11	11	296	206	216	22

Table 3: Influence of nutrient management and omissions on sustainable yield index in transplanted rice

Sustainable yield index		
Treatment	**2 seasons (*Kharif* 2012 & *Kharif* 2013)**	**3 seasons (*Kharif* 2012, *Kharif* 2013 & *Rabi* 2013-14)**
T1-RDF	0.76	0.75
T2-SSNM	0.8	0.8
T3-N-Omission	0.45	0.38
T4-P-Omission	0.68	0.64
T5-K-Omission	0.66	0.6
T6-Zn-Omission	0.7	0.65
T7-Fe-Omission	0.72	0.68
T8-Control	0.34	0.29

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