



Original Research Article

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## Effect of Nutrient Management Approaches and Major Nutrients on Dry Direct Seeded Rice (dry- DSR) in TBP Command Area

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The present experiment was conducted during *kharif-2016* at ARS, Dhadesugur with ten treatments and three replications. Results revealed that the significant higher grain and straw yield were recorded with nutrients applied through SSNM approach ( $7,358$  and  $10,674 \text{ kg ha}^{-1}$ , respectively) as compare to other treatments. Further, omission of major nutrients has resulted in yield loss of 56 per cent (-N), 16.5 per cent (-P) and 20 per cent (-K) compared to SSNM treatment. Application of fertilizers as per SSNM approach noticed higher nitrogen and phosphorus use efficiency (94.05 and 49.98 %, respectively) and potassium use efficiency of (220.91 %) was noticed in STL rating method.

### Introduction

Rice is a vital food to more than half of the world's population. Rice accounts for 55 per cent of total cereal production in the country. The per capita food intake in India is 2,234 calories per day of which 30 per cent comes from rice. In India, rice is grown in an area of  $43.95 \text{ m ha}$  with an annual production of about  $106.54 \text{ mt}$  and the productivity is about  $2.37 \text{ t ha}^{-1}$  (Anon., 2015). In Karnataka, rice is cultivated in command areas of Cauvery, Tungabhadra and Upper Krishna, where conventional puddling and transplanting are the major system of cultivation. The total area under rice in Karnataka is  $1.42 \text{ m ha}$  with an

annual production of  $3.5 \text{ mt}$  and the productivity to the tune of  $2.63 \text{ t ha}^{-1}$  (Anon., 2015).

The nutrient requirement of direct-seeded rice is probably lower than that of transplanted rice during early growth stages. In TBP areas are known for using imbalance dose of nutrients with higher tendency for N application. This also causes environmental damage and increase the total cost of production as heavy N use makes the rice crop more susceptible to pest and disease and thus increases cost of protection. Unbalanced fertilizer use also causes soil degradation and particularly when N fertilizer use drives the removal of P and K

that are not replenished by the addition of fertilizer nutrients. So it has been considered worthwhile to study the uptake and availability of nutrients in dry- DSR as influenced by omission of major nutrients.

## Materials and Methods

The experiment was carried out on clayey soil during *kharif*-2016 at ARS Dhadesugur to study the nutrient uptake, use efficiency and yield of DSR as influenced by different nutrient approaches. Initially the soil of experimental plot had pH of 8.23, EC of 0.51 dS m<sup>-1</sup>, organic carbon of 4.6 g kg<sup>-1</sup> and available nitrogen, phosphorus and potassium were 167, 55 and 300 kg ha<sup>-1</sup>, respectively.

The experiment was laid out in randomized block design with the ten treatments and three replications *viz.*, T<sub>1</sub>- Absolute Control, T<sub>2</sub>- SSNM approach targeted yield of 70 q ha<sup>-1</sup>, T<sub>3</sub>- Recommended Dose of Fertilizer (Urea, DAP and MoP), T<sub>4</sub>- Recommended Dose of Fertilizer (Urea: SSP: MoP), T<sub>5</sub>- Soil Test Ratings method (STL) (Urea: SSP: MoP), T<sub>6</sub>- N Omission with Recommended Dose of P and K as per STL method, T<sub>7</sub>- P Omission with Recommended Dose of N and K as per STL method, T<sub>8</sub>- K Omission with Recommended Dose of N and P as per STL method, T<sub>9</sub>- STCR method and T<sub>10</sub>-Farmer Practice. The soil samples were analyzed by adopting standard procedures (Nitrogen - Subbaiah and Assija method (1956), Phosphorus and Potassium - Jackson (1973)).

## Results and Discussion

### Grain yield and yield attributes of paddy

The present study showed that, the effect of nutrient application through targeted yield approach exerted significant influence on the grain and straw yield of dry DSR. The grain yield of dry DSR recorded was higher in

treatment receiving T<sub>2</sub>: SSNM approach (7,358 kg ha<sup>-1</sup>) and it was found on par with T<sub>9</sub>: STCR approach (7,050 kg ha<sup>-1</sup>) and followed by T<sub>5</sub>: STL (6,783 kg ha<sup>-1</sup>) and significantly lowest grain yield was recorded in absolute control (1,883 kg ha<sup>-1</sup>) (Table 1). The significantly higher straw yield was recorded in T<sub>2</sub>: SSNM (10,674 kg ha<sup>-1</sup>) followed by T<sub>9</sub>: STCR approach (10,229 kg ha<sup>-1</sup>) and the lowest was recorded in T<sub>1</sub>: Absolute control (2,782 kg ha<sup>-1</sup>). The higher grain yield can be attributed to the ability of targeted yield approaches to satisfy the nutrient demand of crop more efficiently. The higher grain yield of dry DSR was also due to better translocation of photosynthates from source to sink and higher yield attributing characters *viz.*, panicle length, number of grains per panicle, filled grains per panicle, lower number unfilled grains per panicle, and higher test weight. The results are in confirmation with the findings of Dhillon *et al.*, (2006) who reported higher grain yield (46.0 q ha<sup>-1</sup>) with the application of fertilizer based on targeted yield (45.0 q ha<sup>-1</sup>) approach when compared to farmer's practice, RDF and soil test based applications.

These results are also corroborated with the findings of Doberman *et al.*, (2000), Biradar *et al.*, (2006), Keram *et al.*, (2012), Umesh *et al.*, (2014) and Singh *et al.*, (2014). Grain yield is governed by the factors which have direct or indirect impact. The factors which have direct influence on the grain yield are the yield components *viz.*, panicle length, number of grains panicle<sup>-1</sup> (Table 1), filled grains panicle<sup>-1</sup>, unfilled grains panicle<sup>-1</sup>, grain filling per cent (Table 1) and test weight have an indirect influence on grain yield through the yield components, however all these growth components could have been promoted by more quantity of nutrients made available by the treatments to dry DSR and evidenced through higher uptake of nutrients *viz.*, nitrogen, phosphorous and potassium.

The highest number of grains per panicle was recorded in treatment with application of nutrients through SSNM approach (296) followed by STCR approach (278) and STL method (256) over absolute control (144) (Table 1). Significant difference in the number of grains per panicle of dry DSR obtained by higher amounts of nutrients supplied through targeted yield approaches as evidenced by their nutrient content and higher number of grains per panicle. Lesser number of grains per panicle was recorded in absolute control (144) and K omitted treatment (161) which might be due to the inadequate supply of plant nutrients this might be due to adequate supply of potassium fertilizer during early and panicle initiation stage which helped in proper filling of grains which resulted in higher number of plump grains and thus increased the number of grains panicle<sup>-1</sup> and reduced grain filling percentage. The improved grain filling with potassium application was due to increased photosynthetic activity which stimulated some vital biochemical processes. The present findings are in agreement with findings of Venkateshwarlu and Singh (1980). However, significantly higher 1000 seed weight of dry DSR grain (17.80 g) was recorded with SSNM approach over absolute control (12.98 g) and STCR approach (16.54 g) and it was found on par with STL method (16.29 g) and (Table 1). Higher 1000 seed weight of dry DSR was mainly attributed to higher dry matter production in plants (Table 1) which might have supplied required photosynthates to the reproductive parts more precisely to the seed. Thus, due to availability of photosynthates the seed might have developed fully and resulted in plump grains and hence recorded higher test weight. These results are in accordance with the findings of Ravi and Rao (1992) who had reported that maximum test weight, number of filled grains per panicle and yield were obtained due to application of higher potassium in two equal splits as basal and at panicle initiation stage.

### Grain yield

The present study showed that, the effect of nutrient application through targeted yield approach exerted significant influence on the grain and straw yield of dry DSR (Table 1). The grain yield of dry DSR recorded was higher in treatment receiving T<sub>2</sub>: SSNM approach (7,358 kg ha<sup>-1</sup>) and it was found on par with T<sub>9</sub>: STCR approach (7,050 kg ha<sup>-1</sup>) and followed by T<sub>5</sub>: STL (6,783 kg ha<sup>-1</sup>) and significantly lowest grain yield was recorded in absolute control (1,883 kg ha<sup>-1</sup>) (Table 1). The significantly higher straw yield was recorded in T<sub>2</sub>: SSNM (10,674 kg ha<sup>-1</sup>) followed by T<sub>9</sub>: STCR approach (10,229 kg ha<sup>-1</sup>) and the lowest was recorded in T<sub>1</sub>: Absolute control (2,782 kg ha<sup>-1</sup>). The higher grain yield can be attributed to the ability of targeted yield approaches to satisfy the nutrient demand of crop more efficiently. The higher grain yield of dry DSR was also due to better translocation of photosynthates from source to sink and higher yield attributing characters viz., panicle length, number of grains per panicle, filled grains per panicle, lower number unfilled grains per panicle, and higher test weight. The results are in confirmation with the findings of Dhillon *et al.*, (2006) who reported higher grain yield (46.0 q ha<sup>-1</sup>) with the application of fertilizer based on targeted yield (45.0 q ha<sup>-1</sup>) approach when compared to farmer's practice, RDF and soil test based applications. These results are also corroborated with the findings of Singh *et al.*, (2014).

Further, omission of major nutrients has resulted in yield loss of 52 per cent (-N), 6.5 per cent (-P) and 10 per cent (-K) respectively, compared to farmer's practice. These results are in conformity with the findings of Wang *et al.*, (2007) and Shaobing *et al.*, (2006) they reported that on average SSNM reduced N fertilizer by 32 % and increased grain yield by 5% compared with farmer's N practices in

China and other major rice-growing countries of South East Asia.

### Nutrient uptake

The effect of different nutrient management approaches on nitrogen, phosphorus, and potassium uptake by dry direct seeded rice after harvest presented in the Table 2 the results were found to be significant.

The targeted approach of SSNM significantly increased the uptake of nitrogen, phosphorus and potassium by grain and straw in dry DSR over other approaches. Significantly the highest nitrogen ( $105.44 \text{ kg ha}^{-1}$ ), phosphorus ( $28.86 \text{ kg ha}^{-1}$ ) and potassium ( $24.62 \text{ kg ha}^{-1}$ ) content in grain as well as highest N ( $129.45 \text{ kg ha}^{-1}$ ), P ( $8.85 \text{ kg ha}^{-1}$ ) and K ( $118.80 \text{ kg ha}^{-1}$ ) content in straw were recorded in SSNM

and followed by STCR targeted approach and STL (Table 1). It might be due to application of balanced fertilization based on target yield resulting in higher total NPK & S uptake.

The higher nutrient uptake is well reflected in terms of higher grain and straw yield of dry DSR (Table 2). Obviously this could be due to application of nitrogen in four splits, potash in two splits and along with required phosphatic fertilizers; this might be the reason for higher uptake of nutrients by the rice crop. The results are in line with the different research workers viz., Sharma and Mittra (1989) reported that uptake of N, P and K increased significantly with increasing N levels. Further, Mukopadhyaya and Majumdar (2010) conducted field experiments for evaluating the impact of soil test-based fertilization on rainfed rice.

**Table.1** Grain yield and yield parameters as influenced major nutrients in dry-DSR at harvest

Treatments	Panicle Length (cm)	No. of grains panicle <sup>-1</sup>			Grain filling %	Test Weight (g)	Grain Yield (kg ha <sup>-1</sup> )	Straw Yield (kg ha <sup>-1</sup> )
		Filled	Unfilled	Total				
T <sub>1</sub>	21.37	93	51	144	64.51	12.98	1883	2782
T <sub>2</sub>	24.16	280	16	296	94.59	17.80	7358	10674
T <sub>3</sub>	22.02	229	25	254	90.30	16.02	6603	9579
T <sub>4</sub>	23.17	226	25	251	89.92	15.12	6533	9486
T <sub>5</sub>	23.78	235	21	256	91.73	16.29	6783	9842
T <sub>6</sub>	23.36	160	24	184	86.95	13.91	3200	4634
T <sub>7</sub>	23.26	183	21	204	89.70	15.11	6173	8968
T <sub>8</sub>	24.16	115	47	161	71.05	15.58	5967	8673
T <sub>9</sub>	23.99	258	20	278	92.69	16.54	7050	10229
T <sub>10</sub>	23.29	205	40	245	83.63	16.07	6500	9428
S. Em. $\pm$	0.50	3.68	1.30	3.33	0.68	0.37	158	254
CD@5%	1.49	10.74	3.80	9.72	1.98	1.09	460	742

**Table.2** Uptake of nutrients as influenced by major nutrients in dry-DSR after harvest

Treatment	Nitrogen			Phosphorus			Potassium		
	(kg ha <sup>-1</sup> )								
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T <sub>1</sub>	16.81	12.65	41.47	6.99	2.75	9.74	5.78	23.18	28.95
T <sub>2</sub>	105.44	129.45	220.17	28.86	8.85	37.22	24.62	118.80	139.41
T <sub>3</sub>	70.61	68.96	132.31	21.85	7.47	29.32	21.59	95.53	117.13
T <sub>4</sub>	72.29	75.19	142.73	22.67	8.48	31.16	21.93	99.72	126.09
T <sub>5</sub>	84.56	92.55	173.74	26.15	8.02	34.18	20.61	91.38	116.00
T <sub>6</sub>	31.20	32.08	77.80	12.03	4.79	16.82	10.20	49.05	59.25
T <sub>7</sub>	62.22	81.37	139.70	18.27	6.33	24.60	19.55	96.32	115.87
T <sub>8</sub>	72.68	93.44	158.83	20.83	7.57	28.40	13.63	81.23	94.86
T <sub>9</sub>	95.91	105.80	205.01	26.63	8.52	35.15	23.90	104.15	123.62
T <sub>10</sub>	75.27	92.24	136.86	22.65	8.37	31.51	22.09	92.78	114.87
S. Em. $\pm$	3.94	7.81	7.94	1.48	0.87	1.92	1.07	6.75	7.14
CD@5%	11.49	22.81	23.17	4.31	2.54	5.62	3.11	19.71	20.83

**Table.3** Nutrient use efficiency as influenced by major nutrients in dry-DSR after harvest

Nutrient use efficiency %			
Treatments	Nitrogen	Phosphorus	Potassium
T <sub>1</sub>	0.00	0.00	0.00
T <sub>2</sub>	94.05	49.98	59.21
T <sub>3</sub>	60.56	26.11	117.56
T <sub>4</sub>	67.51	28.56	129.51
T <sub>5</sub>	75.58	39.11	220.91
T <sub>6</sub>	0.00	11.33	60.59
T <sub>7</sub>	79.86	0.00	173.83
T <sub>8</sub>	67.06	29.86	0.00
T <sub>9</sub>	84.74	24.67	78.89
T <sub>10</sub>	39.58	13.44	67.12
Mean	56.89	22.30	90.76

**Table.4** Soil physico-chemical properties as influenced by various treatments after the harvest of dry-DSR

Treatments	Avail. N (kg ha <sup>-1</sup> )	Avail. P <sub>2</sub> O <sub>5</sub> (kg ha <sup>-1</sup> )	Avail. K <sub>2</sub> O (kg ha <sup>-1</sup> )
T <sub>1</sub>	115.20	34.27	191.03
T <sub>2</sub>	133.59	47.48	253.12
T <sub>3</sub>	128.58	47.23	239.23
T <sub>4</sub>	133.59	46.20	221.54
T <sub>5</sub>	104.74	47.48	248.08
T <sub>6</sub>	86.76	37.22	210.26
T <sub>7</sub>	129.62	37.54	247.89
T <sub>8</sub>	128.99	38.89	225.19
T <sub>9</sub>	132.55	65.45	247.59
T <sub>10</sub>	165.58	44.28	263.31
S. Em. $\pm$	1.55	0.58	3.58
CD@5%	0.27	0.45	0.20

**Table.5** Cost of cultivation, Net returns, B: C ratio as influenced major nutrients in dry-DSR

Treatment	Cost of cultivation (₹ ha <sup>-1</sup> )	Gross returns (₹ ha <sup>-1</sup> )	Net returns (₹ ha <sup>-1</sup> )	B:C ratio
<b>T1</b>	27400	40620	13220	1.5
<b>T2</b>	42867	158431	115564	3.7
<b>T3</b>	42152	142176	100024	3.4
<b>T4</b>	43234	140681	97447	3.3
<b>T5</b>	42629	146054	103425	3.4
<b>T6</b>	40197	68887	28690	1.7
<b>T7</b>	38328	132935	94607	3.5
<b>T8</b>	41633	128492	86859	3.1
<b>T9</b>	45025	151795	106770	3.4
<b>T10</b>	48714	139949	91235	2.9
<b>S. Em.±</b>	-	-	3418	0.1
<b>CD@5%</b>	-	-	9977	0.2

### Nutrient use efficiency

The data pertaining to nutrient use efficiency of nitrogen, phosphorus and potassium after harvest of dry direct seeded rice as influenced by different nutrient management approaches were presented in Table 3.

Nutrient use efficiency is the ratio of difference between the nutrient uptake by a crop in fertilized plot and nutrient uptake by a crop in control plot to the amount of nutrient applied. Hence, the nutrient use efficiency depends on nutrient uptake by crop in control and fertilized plot and the amount of nutrient supplied to the respective plots. The higher nitrogen use efficiency (94.05 %) was recorded in SSNM approach followed by the application of fertilizers through STCR approach (84.74%). Whereas, lowest nitrogen use efficiency (39.58 %) was observed in farmer practice. The higher use efficiency of phosphorus (49.98 %) was observed with SSNM approach followed by treatment receiving soil test rating method (39.11%). Lowest phosphorus use efficiency (11.33 %) was observed in N omitted treatment. The higher potassium use efficiency of (220.91 %)

was obtained with soil test rating method followed by the P omitted treatment (173.83%) as compared to rest of other treatments and lowest potassium use efficiency (59.21 %) was noticed (Table 3). The results are in conformity with the findings of Ferguson *et al.*, (2002) reported that recovery efficiency of fertilizer N (REN) in rice increased significantly with SSNM. On an average REN increased by about 29 per cent high with SSNM compared to farmer's fertilizer practice. Abdulrahaman *et al.*, (2002) reported that application of nutrients through SSNM approach increased fertilizer use efficiency of N by (12 to 36 %), P (8 to 13%) and K (>100%) and average rice yield in the SSNM (5.6 to 6.4 t ha<sup>-1</sup>) over farmer's practice. SSNM supported to increase the nutrient use efficiency of N, P and K. The "Agronomic Efficiency" and "Recovery Efficiency" of NPK of SSNM plot were higher than those of Farmer's practice as reported by Khuong *et al.*, (2007).

### Available N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O in soil

The available nutrients in soil differed significantly with different nutrient

management approaches at the end of cropping season. The balance of N and P were highest with farmer practice (165.58, 47.48 and 263.31 kg N, P and K ha<sup>-1</sup>, respectively) whereas treatment receiving SSNM approach (133.59, 47.48 and 253.12 kg N, P and K ha<sup>-1</sup>, respectively) resulted in higher balance of K, N and P (Table 4). It could be due to enhanced nutrient pool at elevated fertility level which might have contributed to higher residual nutrient status of soil by retaining part of external applied nutrients in soil. Similar opinion of elevated fertility levels increased the available nutrient status of the soil after harvest of crop by several researchers. This might be due to release of nutrients from organic matter intern increases 'N' in soil was more with SSNM treatments. It was also in accordance with Ramachandrapappa *et al.*, (2014) reported that the soil available nitrogen and potassium is low and phosphorus is medium in SSNM for a targeted finger millet yield of 4000 kg ha<sup>-1</sup> with the application of 155:45:203 kg N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O ha<sup>-1</sup>.

### **Economics of dry DSR as influenced by different nutrient management approaches**

Economics of any treatment is the deciding factor in many situation to judge its applicability in the field condition to recommend farming community to obtain better return with minimum investment in cultivation.

The cost of cultivation of dry DSR was higher (₹48,714ha<sup>-1</sup>) with farmers practice fertilization due to higher quantity of fertilizers application rates as compared to other treatments. SSNM approach registered cost of cultivation (₹42,867 ha<sup>-1</sup>) and these results are confirmation with findings of Wang *et al.*, (2001) reported that the site-specific nutrient management led to reduction of the average fertilizer cost by \$15 ha<sup>-1</sup> crop<sup>-1</sup>

and an increase in GRF by \$ 88 ha<sup>-1</sup> crop<sup>-1</sup> compared with Farmer's practice.

Among the different treatments, the highest gross returns, net returns and BC ratio (₹1,58,431 ha<sup>-1</sup>, ₹ 1,15,564 ha<sup>-1</sup> and 3.7, respectively) were recorded with SSNM approach followed by STCR approach (₹1,51,795 ha<sup>-1</sup>, ₹ 10,6,770 ha<sup>-1</sup> and 3.4, respectively) and STL method (₹1,46,054 ha<sup>-1</sup>, ₹1,03,425 ha<sup>-1</sup> and 3.4, respectively) as compared to farmer practice (₹1,39,949 ha<sup>-1</sup>, ₹91,235 ha<sup>-1</sup> and 2.9, respectively) (Table 5) and rest of the other treatments. This is mainly due to higher grain and straw yield obtained with least investment in fertilizer brought lower cost of cultivation leads more gross returns, net returns and finally BC ratio.

These results corroborated the findings of Dhillon *et al.*, (2006) noticed the superiority of the target yield concept over the other practices as it gave higher yields and optimal economic returns. Pampolina *et al.*, (2007) evaluated the economic benefits of SSNM in farmer's fields. The results showed that the net annual benefit due to use of SSNM was US \$ 34 ha<sup>-1</sup> per year in Vietnam, 106 US \$ ha per year in the Philippines, and US \$ 168 ha<sup>-1</sup> year in India. The increased benefit with SSNM was attributed to increased yield rather than reduced costs of inputs. Abdulrahman *et al.*, (2002) the yields with SSNM were close to the yield goal and 16 per cent greater than the farmer's practice. The fertilizer cost was about US \$ 40 ha<sup>-1</sup> in both SSNM and FFP but the profitability (gross return over fertilizer cost) increased by US \$130 with SSNM due to increase in yield. Lowest gross returns, net returns and BC ratio (₹40,620 ha<sup>-1</sup>, ₹13,220 ha<sup>-1</sup> and 1.5, respectively) were obtained with absolute control. This is due to lower grain yield and without application of chemical fertilizer. The results are in close proximity with the findings of Wang *et al.*, (2005) and Milapchand *et al.*, (2006).

Among the different nutrient management approaches, the SSNM approach produced significantly higher panicle length, maximum number of grains panicle<sup>-1</sup>, filled grains panicle<sup>-1</sup> and test weight, were recorded significantly higher (24.16 cm, 296, 280 and 17.8 g, respectively) with nutrients applied through SSNM approach as compared to absolute control, RDF and STL. However, it was on par with STCR and STL method. Total uptake (grain and straw) of nutrients was significantly higher with treatment receiving SSNM approach as compared to other treatments. However, it was on par with STCR approach and STL method. Further, omission of major nutrients has resulted in yield loss of 56 per cent (-N), 16.5 per cent (-P) and 20 per cent (-K) compared to SSNM treatment. Application of fertilizers as per SSNM approach noticed higher nitrogen and phosphorus use efficiency. However higher potassium use efficiency of was noticed in STL rating method. Among the different treatments, the highest gross returns, net returns and BC ratio ( $\text{₹ } 1,58,431 \text{ ha}^{-1}$ ,  $\text{₹ } 1,15,564 \text{ ha}^{-1}$  and 3.7, respectively) were recorded with SSNM approach followed by STCR approach and STL method.

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