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Rescheduling of fertilizer doses in kharif rice for Central Telangana

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Abstract
A field experiment was conducted at Rice block in RARS Warangal, during kharif-2015 and 2016 to study the rescheduling of fertilizer doses in Rice for Central Telangana. The results revealed that the significantly higher grain yield and non-significantly higher straw yields (5561 and 6354 kg/ha, respectively) were recorded by the application of nitrogen, phosphorus and potassium 150%-100%-100% (180-60-40 kg/ha) recommended dose over the others. Significantly maximum N, P, K, Zn, Cu, Fe and Mn uptake 141kg/ha, 19.49kg/ha, 113kg/ha, 417g/ha, 55.61g/ha, 1893g/ha and 1412g/ha, respectively were recorded, by the application of nitrogen, phosphorus and potassium 150%-100%-100% (180-60-40 kg/ha) recommended dose, respectively over the others. The highest benefit cost ratio (1.44) and net income (25,438/-) was recorded by the application of nitrogen, phosphorus and potassium 150%-100%-100% (180-60-40 kg/ha) recommended dose over the others. Lowest benefit cost ratio (0.60) was observed with the application of current recommended dose of fertilizers along with vermicompost application @ 2t/ha.

Keywords: rescheduling, fertilizer doses, kharif rice, telangana

1. Introduction

Fertilizer application is one of the efficient means of increasing agricultural profitability. The fertilizer prices have gone up and hence their use in required amounts depends much upon the purchasing ability of the farmers. At the same time a balanced fertilization has to be considered for maintaining soil health for sustainable use because indiscriminate and imbalanced use of fertilizers has already distorted soil fertility and deteriorated soil health in India (Santhi *et al.* 2011) [1]. Accordingly, much attention is given to the integrated use of organic and mineral nutrition for meeting the economic needs of farmers as well as for sustainability in terms of productivity and soil fertility. Soil test based fertilizer recommendation result in efficient fertilizer use and maintenance of soil fertility. Several approaches have been used for fertilizer recommendation based on chemical soil test so as to attain maximum yield per unit of fertilizer use. Among the various approaches, the targeted yield approach (Ramamoorthy *et al.* 1967) [2] had received wide acceptability and popularity in India. Targeted yield concept is based on quantitative idea of the fertilizer needs based on yield and nutritional requirement of the crop, per cent contribution of soil available nutrient and that of the applied fertilizer. This method not only estimates soil test based fertilizer dose but also the level of yield the farmer can achieve with that particular dose. Targeted yield approach also provides scientific basis for balanced fertilization not only between the nutrients from the external sources but also from the internal sources.

Degradation of soil health has also been reported due to long-term imbalanced use of fertilizer nutrients. Although, overall nutrient use (N: P_2O_5:K_2O) of 4:2:1 is considered ideal for Indian soils, the present use ratio of 6.8:2.8:1 is far off the mark. This imbalance of nutrient use has resulted in wide gap between crop removal and fertilizer application. Long-term experiments, in India have in general showed that P and K status in soils at all centres has gone down when only N was applied. Declining soil fertility and mismanagement of plant nutrients have made this task more difficult. Balanced NPK fertilization has received considerable attention in India (Gosh *et al.* 2004; Hegde *et al.* 2004 and Prasad *et al.* 2004) [3-5]. Soil testing helps the farmers to use fertilizers according to needs of crop. In the intensive agriculture system integrated fertilizer recommendation is an urgent need since, it balance soil and applied nutrients from inorganic as well as organic sources to balance nutrition of crops and maintenance of soil health.

Assessment of the nutrient requirements of the different crops for desired yield levels from a cropping sequence is an important step in developing fertilizer management practices. Soil fertility and productivity changes over time and this change is towards negative direction because of intensive cropping with modern varieties, improper and imbalance use of fertilizers and manures and also declining soil organic matter to a considerable extent. Again crops grown in different cropping patterns and cropping zones responded differently to fertilizer nutrients. A crop production system with high yield targets cannot be sustained unless balanced nutrient inputs are supplied to soil against nutrient removal by crops (Bhuiyan *et al.* 1991) [6]. Mineral fertilizer inputs are the crucial factors to the overall nutrient balance in intensive cropping system (Islam and Haq 1998) [7]. Soils and fertilizer management is very complex and dynamic in nature. Fertilizer recommendation for crops in a cropping pattern needs change after a certain period of time. With the advancement of technology and with a progress of fertility and fertilizer management research in the country, there has been a continuous need for updating the fertilizer recommendation guide. The application of fertilizer in proper amounts must be done to boost up agricultural production to an economically desirable level (Panaullah *et al.* 1998) [8].

Rice is the most important staple food for more than half of the world's population. In Asia, more than two billion people are getting 60-70 percent of their energy requirement from rice and its derived products, a major source of dietary protein for most people in tropical Asia (Juliano 1993) [9]. In India rice (*Oryza sativa*) is the staple food crop for more than two thirds of the population. The slogan "RICE is life" is most appropriate for India as this crop plays a vital role in our national food security and is a means of livelihood for millions of rural households. In India, it is grown on an area of 44.10m ha with a production of 106.70 m t with a productivity of 2.42t ha^{-1}. In Telangana state, rice is also the principal food crop cultivated throughout the state. The crop is cultivated in an area of about 2.01m ha with an annual production of 6.62 m t and productivity of 3.29 t ha^{-1} (Statistical year book 2015) [10]. The continuous cultivation of high yielding varieties of rice and indiscriminate use of fertilizers leads to imbalance in nutrient status of soils. Under present conditions fertilizer recommendations developed decades back were not meet the requirement of rice crop to get the optimum yields. Hence, there is need to work out the performance of rice under rescheduling of fertilizer doses in kharif for Central Telangana Zone. Therefore, the present study was carried out to determine an economically optimal dose of fertilizer nutrients at which rice gave maximum paddy yield.

2. Materials and Methods

The field experiment was conducted during kharif-2015 and 2016 at Rice block in RARS Warangal, located at 18^0 01.077 N latitude 79^0 36.197 E longitudes and an altitude of 259 m above mean sea level to study the rescheduling of fertilizer doses in Rice for Central Telangana. A composite soil sample was collected from 0-20 cm depth during the study years, processed and analysed in laboratory for pH and Electrical Conductivity(EC) (1:2 soil : water suspension), by pH and Ec meters, respectively (Jackson 1973) [10], Organic Carbon percentage (OC) was estimated by rapid titration method (Walkley and Black method 1934) [12], available nitrogen was estimated by alkaline permanganate method (Subbaiah and Asija 1956) [13], available phosphorus by Olsens method (Olsen *et al.* 1954) [14], available potassium by ammonium acetate extraction method (Jackson 1973) [10], available Zinc, Copper, Iron and Manganese were extracted with DTPA and estimated using AAS as described by Lindsay and Norvell (1978) [15]. Boron was extracted by hot water and measured colorimetrically using Azomethine-H (Berger and Trough 1939) [16].The experiment was laid out in factorial randomized block design with 6 treatments in two sets one set without vermicompost and another set with vermicompost application @ 2t/ha replicated in three times. The details of treatments were depicted in table -1.

Table 1: Treatment wise details and N, P, K levels arrived in two seasons

Treatment Number	Treatment details	Kharif-2015 (N,P,K kg/ha)	Kharif-2016 (N,P,K kg/ha)
T_1	Current RDF: (N, P, K, Zn, S & B)	120-60-40	120-60-40
T_2	Soil Test based fertilizer usage: N, P, K (30% excess/less) Zn, S, B if deficient full recommended dose	120-78-40	120-42-28
T_3	Soil Test Crop Response based Equation: Prod-I (current highest in dist/Zone) + RD of Zn, S, B if deficient.	102-172-114	97-30-42
T_4	Soil Test Crop Response based Equation: Prod-II (15% Higher) + RD of Zn, S, B if deficient.	155-203-136	148-30-63
T_5	New treatment for Production-I N=150%RDN if available N is <140Kg/ha else 125% RDN. P= 100%RDP if available P is high, else 125%. K=100%RDK if available K is medium and high other wises 125%RDK, Zn =125% if def. Else 25%RD Zn, S=125%RD sulphur if def. Else 25% RD Sulphur. B=125%RD Boron if def. Else 25% RD Boron.	150-75-40	150-60-40
T_6	New treatment for Production-II N=200%RDN if available N is <140Kg/ha else 150% RDN. P=100%RDP if available P is high, else 150%. K=100%RDK if available K is medium and high other wises 125%RDK, Zn =125% if def. Else 25%RD Zn, S=125%RD sulphur if def. Else 25% RD Sulphur. B=125%RD Boron if def. Else 25% RD Boron.	180-90-40	180-60-40

*RDF= Recommended dose of fertilizers *RD= Recommended dose

Rice (RNR-15048) was sown during second week of July, transplanted in second week of August by adopting 15x15cm spacing with three seedlings per hill and fertilizers applied as per the treatments protocol. The crop cultural practices were carried out according to the standard practices in the rice fields and harvested at 125 days after sowing. The grain and straw samples were collected at harvest, oven dried at 70^0C processed and analysed for total content of N, P, K, Zn, Cu, Fe and Mn following standard procedures. The nitrogen content in grain and straw was determined after digesting the samples with single acid (H_2SO_4) using kelplus nitrogen analyser. The P, K, Zn, Cu, Fe and Mn in grain and straw were determined after digesting the samples with di-acid (nitric and perchloric acid 9:3 ratio). The phosphorus was determined by ammonium molybdate method and potassium was determined by using flame photometer method. Zn, Cu, Fe and Mn were determined using Atomic Absorption Spectrophotometer (AAS) (Jackson 1973) [10].

The economics were also calculated on the basis of cost of cultivation, gross return, net return and benefit cost ratios. The cost of cultivation for each treatment was calculated by summing all the variable cost items in the production process. Similarly gross returns were calculated based on prevailing market price of the produce. The net returns were obtained after deducting the cost of cultivation from gross returns. Thus, the benefit cost analysis was obtained by dividing total returns from a unit with total cost of a unit.

3. Results and Discussion

The field experiment was conducted at Rice block in RARS Warangal, located at 18^0 01.077 N latitude 79^0 36.197 E longitude and an altitude of 259 m above mean sea level during kharif-2015 and 2016 to study the rescheduling of fertilizer doses in Rice for Central Telangana Zone (CTZ). The soil was clay in texture, moderately alkaline in reaction (pH - 8.15), non saline in nature (EC - 0.44 dSm^{-1}), higher in organic carbon content (OC- 0.88%), medium in available nitrogen (339 kg/ha), higher in available phosphorus (68 kg/ha), lower in available potassium (235 kg/ha) and sufficiently available Zn, Cu, Fe and Mn 0.66, 1.38, 11.48 and 3.56 mg/kg, respectively.

3.1 Grain yield

The results presented in table-1 indicated that, by the application of varying N, P and K levels arrived by different concepts of fertilizers application without vermicompost and with vermicompost to the kharif rice and observed that the overall grain yield was significantly influenced by varying N, P and K levels in kharif 2015 and in pooled mean, but non-significantly influenced in kharif 2016. However, significantly higher grain yield (5492 kg/ha) was recorded by T_6 over T_1, T_2 and T_3 but it is at par with T_4 and T_5 in kharif 2015. In kharif 2016 non-significantly higher grain yield (5629 kg/ha) was recorded by T_6 over T_1, T_2, T_3, T_4 and T_5 and lower grain yield (5079 kg/ha) was recorded by T_3 and in pooled mean significantly higher grain yield (5561 kg/ha) was recorded by T_6 over T_1 and T_3 but it is at par with T_2, T_4 and T_5. However, overall grain yield was maximum at 180 kg N ha^{-1} which was significantly superior over low level 120 kg N ha^{-1}.The increase in growth might be due to enhanced cell division and cell elongation induced by abundant nitrogen supply with increase in nitrogen levels, favouring enlargement and better development of panicle resulting in more number of total grains $panicle^{-1}$ and keep leaves green even at the time of maturity. Hence, the contribution of carbohydrates from photosynthetic activity resulting in efficient translocation of food material into the sink (grain) thereby increased number of filled grains $panicle^{-1}$. These results were in accordance with the findings of Prasada Rao *et al.* (2013) [17].

The significant increase in grain and straw yields of rice with increase in N rates was accompanied by significant increase in total N, P and K uptake. This increase in total N, P and K uptake can be attributed to higher grain and straw yields. Cong *et al.* (2009) [18] also observed that total N and P uptake was related to grain and straw yields of rice. The increased yields of rice from the application of FYM and fertilizer N was accompanied by significant increase in total uptake of N, P and K.

Overall effect of vermicompost application @ 2t/ha along with varying N, P and K levels on grain yield was non-significant in kharif 2015, 2016 and in pooled mean. However, overall higher grain yields 5245, 5362, 5304 kg/ha were recorded by the application of varying N, P and K levels along with vermicompost over N, P and K alone 5003, 5301 & 5152 kg/ha, in kharif-2015, 2016 and in pooled mean, respectively. With application of a single chemical fertilizer, dry matter accumulation and nutrient uptake in rice were mainly concentrated at the tillering and booting stages, but were mainly concentrated from the heading to maturity stage in response to combined application of chemical and organic fertilizers, which could increase the number of panicles per unit area and the number of grains per panicle (Guindo *et al.* 1994; Yang *et al.* 2004; Yang *et al.* 2010) [19, 20, 21]. Improvement in yield due to combined application of inorganic fertilizer and organic manure might be attributed to controlled release of nutrients in the soil through mineralization of organic manure which might have facilitated better crop growth (Saha *et al.* 2008) [22]. The results showed that combined application of organic and inorganic fertilizers promoted the transfer of nutrients to the grains and improved rice yields. The present study showed that vermicompost application in combination with varying N, P and K levels promoted the uptake and utilization of nitrogen, phosphorus and potassium by rice plants.

The interaction effect of varying N, P and K levels along with vermicompost on grain yield was non-significant in both the years and in pooled mean.

Table 2: Grain yield of kharif rice as influenced by rescheduling of fertilizer doses.

Treatments	2015			2016			Pooled		
	Without *VC	**With *VC**	**Mean**	**Without *VC**	**With *VC**	**Mean**	**Without *VC**	**With *VC**	**Mean**
T_1	4633	4800	4717	5246	5286	5266	4940	5043	4992
T_2	4867	5300	5083	5105	5144	5125	4986	5222	5104
T_3	4700	4733	4717	5048	5110	5079	4874	4922	4898
T_4	5133	5400	5267	5380	5414	5397	5257	5407	5332
T_5	5433	5500	5467	5460	5523	5492	5447	5512	5480
T_6	5250	5733	5492	5564	5694	5629	5407	5714	5561
Mean	5003	5244		5301	5362		5152	5303	
Factors	CD (P=0.05)	SEm±		CD (P=0.05)	SEm±		CD (P=0.05)	SEm±	
N, P, K levels	528	180		NS	213		437	149	
Vermicompost	NS	104		NS	123		NS	86	
Interaction	NS	255		NS	302		NS	211	

*VC: Vermicompost

3.2 Straw yield

The results presented in table-2 indicated that, the application of varying levels of N, P and K arrived by different concepts of fertilizers application without vermicompost and with vermicompost to the kharif rice and observed that the overall straw yield was non-significantly influenced by varying N, P and K levels in 2015, 2016 and in pooled mean. However, higher straw yields 6455, 6252 and 6354 kg/ha were recorded in 2015, 2016 and in pooled mean, respectively by T_6 over T_1, T_2, T_3, T_4 and T_5 and lower straw yields 6173, 5922 and 6110 kg/ha were recorded in 2015, 2016 and in pooled mean by T_3, T_4 and T_4, respectively. The dry matter production at all growth stages and harvest index were maximum at 180 kg N ha^{-1} over low level of 120 kg N ha^{-1}. These results were in accordance with the findings of Prasada Rao *et al*. (2013) [16].

Though the overall effect of vermicompost along with varying N, P and K levels on straw yield was non-significant but recorded higher straw yields 6395, 6174 and 6285 kg/ha over N, P and K alone 6208, 6066 and 6137 kg/ha in 2015, 2016 and in pooled mean, respectively. These results were in accordance with the findings of Prasada Rao *et al*. (2013) [16].

The interaction effect of varying N, P and K levels with vermicompost on straw yield was non-significant in both the years and in pooled mean.

Table 3: Straw yield of kharif rice as influenced by rescheduling of fertilizer doses.

Treatments	2015			2016			Pooled		
	Without *VC	With *VC	Mean	Without *VC	With *VC	Mean	Without *VC	With *VC	Mean
T_1	6240	6535	6388	6118	6184	6151	6179	6360	6270
T_2	6050	6351	6201	6150	6214	6182	6100	6283	6192
T_3	6064	6283	6173	6064	6112	6088	6064	6198	6131
T_4	6220	6377	6299	5887	5956	5922	6054	6167	6110
T_5	6246	6345	6296	6113	6138	6126	6180	6242	6211
T_6	6429	6481	6455	6062	6441	6252	6246	6461	6354
Mean	6208	6395		6066	6174		6137	6285	
Factors	CD (P=0.05)	SEm±		CD (P=0.05)	SEm±		CD (P=0.05)	SEm±	
N, P, K levels	NS	268		NS	244		NS	176	
Vermicompost	NS	155		NS	141		NS	101	
Interaction	NS	379		NS	345		NS	248	

*VC: Vermicompost

3.3 Nitrogen uptake

Nitrogen uptake by kharif rice was non-significantly influenced in 2015, significantly influenced in 2016 and in pooled mean by varying N, P and K levels. However, higher N uptake (147 kg/ha) was recorded by T_6 over T_1, T_2, T_3, T_4 and T_5 and lower nitrogen uptake (128 kg/ha) was recorded by T_2 in 2015. Significantly, higher N-uptake was found (134 kg/ha) by T_6 over T_1, T_2 and T_3 but it is at par with T_4 and T_5 in 2016 and significantly higher N uptake (141 kg/ha) was recorded by T_6 over T_1, T_2, T_3 and T_4 and it is at par with T_5 in pooled mean.

N uptake increased with increase in the level of nitrogen application up to 180 kg ha^{-1} over low level of 120 kg N ha^{-1}. The increase in nitrogen uptake at higher levels may be ascribed to the fact that the plant absorbed nitrogen proportionately as the pool of available nitrogen improved in soil by the addition of higher amount of nitrogen. These results were in accordance with the findings of Prasada Rao *et al*. (2013) [16].

Nnitrogen uptake in kharif rice was significantly influenced by vermicompost application along with varying N, P, and K levels in both the seasons and in pooled mean. However, significantly higher N uptake 141,127 and 134 kg/ha were recorded in 2015, 2016 and in pooled mean, respectively by the application of vermicompost along with varying N, P and K levels over N, P and K alone 129, 119 and 124 kg/ha in 2015, 2016 and in pooled mean, respectively. The increase of N uptake in rice with the application of FYM and N might be due to increase in N availability in the soil, and increased in yield.

Rice variety KMP101 was treated with both organic and inorganic manure. The field and experimental studies were conducted, before applying organic and inorganic manures. The values obtained for available nitrogen, phosphorous and potassium were 360 kg/ha, 12 kg/ha and 166 kg/ha respectively. After treatment and harvest there was a gradual increase in available nitrogen, phosphorus and potassium ranging between 335-415, 14-23 and 173-235 kg/ha respectively among the treatments. Applying 15 t of vermicompost/ha and 10 t of vermicompost/ha and recommended dose of fertilizer showed a greater availability of nitrogen and phosphorus. It is revealed that after addition of organics into the soil year-wise, the soil became more stable. Also, the biological activity increased in the soil and was influenced to maintain the available nitrogen in the soil. Therefore, it is evident that vermicompost significantly increases the availability of available nutrients (Shwetha and Narayana 2014) [23].

The interaction effect of varying N, P and K levels with vermicompost on N-uptake was non-significant in both the years and in pooled mean.

Table 4: Nitrogen uptake (kg/ha) of kharif rice as influenced by rescheduling of fertilizer doses.

Treatments	2015			2016			Pooled		
	Without *VC	With *VC	Mean	Without *VC	With *VC	Mean	Without *VC	With *VC	Mean
T_1	126	136	131	119	125	122	123	131	127
T_2	123	133	128	112	123	118	118	128	123
T_3	125	134	130	110	114	112	118	124	121
T_4	129	145	137	122	129	126	126	137	132
T_5	134	143	138	124	129	127	129	136	133

T_6	138	155	147	127	142	134	133	149	141
Mean	129	141		119	127		124	134	
Factors	CD (P=0.05)	SEm±		CD (P=0.05)	SEm±		CD (P=0.05)	SEm±	
N, P, K levels	NS	5.26		9	3.23		9	3	
Vermicompost	9	3.03		5	1.9		5	2	
interaction	NS	7.44		NS	4.6		NS	4	

*VC: Vermicompost

3.4 Phosphorus uptake

Effect of varying N, P and K levels on phosphorus uptake in kharif rice was non-significant in 2015, significant in 2016 and in pooled mean. However, higher phosphorus uptake (19.84 kg/ha) was recorded by T_6 over T_1, T_2, T_3, T_4 and T_5 and lower phosphorus uptake (17.95 kg/ha) was recorded by T_3 in 2015, significantly higher phosphorus uptake was found (19.83 and 19.84 kg/ha) by T_6 over T_2, T_3 and T_4 and it is at par with T_1 and T_5 in 2016 and in pooled mean, respectively.

The increase in P uptake by rice with the application of P might be due to increase in P availability in the soil, and increased in yield.

Overall effect of vermicompost along with varying N, P and K levels on phosphorus uptake in kharif rice was significant in both the seasons and in pooled mean. However, significantly higher phosphorus uptake 19.62, 19.05 and 19.34 kg/ha were recorded in 2015, 2016 and in pooled mean, respectively by the application of vermicompost @ 2t/ha along with varying N, P and K levels over N, P and K alone 18.10, 16.99 and 17.55 in 2015, 2016 and in pooled mean, respectively.

Increase in P uptake of rice by vermicompost application might be due to organic acids produced during decomposition are capable of releasing the phosphorus associated with clay minerals. Besides this, organic manures form complexes with iron, aluminium ions and hydrous oxide thereby preventing its fixation as inorganic complexes (Sri Ranjitha 2011) [24].

The solubilizing action of organic acids produced during decomposition of organic manures or green manure might have increased the release of native P, stimulated microbial growth in soil, and favoured root growth which had finally led to increased P uptake by rice. Dwivedi *et al.* (2007) [25] also recorded higher P uptake due to combined application of inorganic fertilizers with organic manure (FYM) under soybean-wheat cropping sequence in a Vertisol.

The interaction effect N, P, K levels with vermicompost on P-uptake was non-significant in both the years and in pooled mean.

Table 5: Phosphorus uptake (kg/ha) of kharif rice as influenced by rescheduling of fertilizer doses.

Treatments	**2015**			**2016**			**Pooled**		
	Without *VC	**With *VC**	**Mean**	**Without *VC**	**With *VC**	**Mean**	**Without *VC**	**With *VC**	**Mean**
T_1	18.00	19.83	18.92	18.13	19.91	19.02	18.07	19.87	18.97
T_2	17.28	19.37	18.32	17.43	18.65	18.04	17.36	19.01	18.18
T_3	17.48	18.41	17.95	14.21	17.16	15.68	15.85	17.79	16.82
T_4	17.94	20.38	19.16	14.42	18.63	16.53	16.18	19.51	17.85
T_5	18.57	19.34	18.96	18.54	19.49	19.02	18.56	19.42	18.99
T_6	19.29	20.39	19.84	19.19	20.47	19.83	19.24	20.43	19.84
Mean	18.10	19.62		16.99	19.05		17.55	19.34	
Factors	CD (P=0.05)	SEm±		CD (P=0.05)	SEm±		CD (P=0.05)	SEm±	
N,P,K levels	NS	0.79		1.67	0.57		1.17	0.40	
Vermicompost	1.34	0.46		0.96	0.33		0.7	0.23	
interaction	NS	1.12		NS	0.80		NS	0.60	

*VC: Vermicompost

3.5 Potassium uptake

Effect of varying N, P and K levels on potassium uptake in kharif rice was non-significant in 2015, significant in 2016 and in pooled mean. However, higher potassium uptake (110 kg/ha) was recorded by T_6 over T_1, T_2, T_3, T_4 and T_5 and lower potassium uptake (93 kg/ha) was recorded by T_1 in 2015, 2016 and in pooled mean significantly higher potassium uptake was found (117 and 114 kg/ha, respectively) by T_6 over T_1, T_2, T_3 and T_4 and it is at par with T_5.

The increase in K uptake by rice with the application of K might be due to increase in K availability in the soil, and increased in yield.

Effect of vermicompost application along with varying N, P and K levels on potassium uptake in kharif rice was significant in both the seasons and in pooled mean. However, significantly higher potassium uptake 107, 111 and 109 kg/ha were recorded in 2015, 2016 and in pooled mean, respectively by the application of vermicompost along with varying N, P and K levels over N, P and K alone 94, 100 and 97 kg/ha in 2015, 2016 and in pooled mean, respectively. The higher uptake of K by the addition of organics might be due to the solubilizing effect besides the decomposition of K minerals (Balaji Naik *et al.* 2011) [26]. The increased uptake of K by rice may be ascribed to the release of K from the K- bearing minerals by complexing agents and organic acids produced during decomposition of organic resources. Similar results were also observed by Mohapatra *et al.* (2008) [27] in rice-potato cropping system.

The interaction effect of N, P and K levels with vermicompost on potassium uptake was non-significant in both the years and in pooled mean.

The uptake of N, P and K were highest with the supply of nitrogen at 180 kg/ha which was significantly superior to other nitrogen levels.

The total potassium accumulation in the rice plants showed a trend to increase with increasing nitrogen application level at different growth stages. The total potassium accumulation in all nitrogen application treatments showed a significant difference. These results indicated that combined application of organic and inorganic fertilizers increased potassium uptake in rice under the nitrogen application level of 180 kg

N/ha (Guindo *et al.* 1994; Yang *et al.* 2004; Yang *et al.* 2010) [18, 19, 20].

Majumdar *et al.* (2007) [28] also observed significant increase in total N, P and K uptake in rice when FYM was applied in conjunction with fertilizer N.

Table 6: Potassium uptake (kg/ha) of kharif rice as influenced by rescheduling of fertilizer doses

Treatments	2015			2016			Pooled		
	Without *VC	With *VC	Mean	Without *VC	With *VC	Mean	Without *VC	With *VC	Mean
T_1	84	102	93	98	109	104	91	106	99
T_2	93	100	97	90	97	93	92	99	95
T_3	96	105	101	99	107	103	98	106	102
T_4	92	107	100	97	106	102	95	107	101
T_5	96	108	102	101	128	115	99	118	109
T_6	103	116	110	115	120	117	109	118	114
Mean	94	107		100	111		97	109	
Factors	CD (P=0.05)	SEm±		CD (P=0.05)	SEm±		CD (P=0.05)	SEm±	
N,P,K levels	NS	3.63		11	3.72		11	3.68	
Vermicompost	6	2.10		6	2.15		6	2.13	
Interaction	NS	5.13		NS	5.26		NS	5.20	

VC: Vermicompost

3.6 Zinc uptake

Zinc (Zn) uptake in kharif rice was significantly influenced by varying N, P and K levels in 2015, 2016 and in pooled mean. However, significantly higher zinc uptake 416, 428 and 422 g/ha were recorded in 2015, 2016 and in pooled mean, respectively by T_6 over T_1, T_2 and T_3 & it is at par with T_4 and T_5.

Zinc uptake in kharif rice was significantly influenced by the application of vermicompost along with varying N, P and K levels in both the seasons and in pooled mean. However, significantly higher zinc uptake 407, 412 and 410 g/ha were recorded in 2015, 2016 and in pooled mean, respectively by the application of vermicompost along with varying N, P and K levels over N, P and K alone 351, 357 and 354 in 2015, 2016 and in pooled mean, respectively.

The increase in Zn uptake by rice with the application of FYM and Zn might be due to increase in Zn availability in the soil, and increased in yield

The interaction effect of varying N, P and K levels with vermicompost on potassium uptake was non-significant in both the years and in pooled mean.

Table 7: Zinc uptake (g/ha) of kharif rice as influenced by rescheduling of fertilizer doses.

Treatments	2015			2016			Pooled		
	Without *VC	With *VC	Mean	Without *VC	With *VC	Mean	Without *VC	With *VC	Mean
T_1	304	395	350	343	397	370	324	396	360
T_2	335	396	366	314	408	361	325	402	366
T_3	313	389	351	335	369	352	324	379	352
T_4	373	415	394	383	411	397	378	413	396
T_5	377	423	400	368	430	399	373	427	400
T_6	407	426	416	401	455	428	404	441	422
Mean	351	407		357	412		354	410	
Factors	CD (P=0.05)	SEm±		CD (P=0.05)	SEm±		CD (P=0.05)	SEm±	
N,P&K levels	42	14		32	11		37	13	
Vermicompost	25	8		18	6		22	7	
Interaction	NS	20		NS	15		NS	17	

3.7 Copper uptake: Overall copper (Cu) uptake in kharif rice was significantly influenced by varying N, P and K levels in 2015, 2016 and in pooled mean (Table-7). However, significantly higher copper uptake 57.15, 57.25 and 53.47 g/ha were recorded in 2015, 2016 and in pooled mean, respectively by T_6 over T_1, T_2 and T_3 and it is at par with T_4 and T_5 treatments.

Copper uptake in kharif rice was significantly influenced by the application of vermicompost along with varying N, P and K levels in both the seasons and in pooled mean. However, significantly higher copper uptake 53.82, 54.19 and 54.09 g/ha were recorded in 2015, 2016 and in pooled mean, respectively by the application of vermicompost along with varying N, P and K levels over N, P and K alone 45.58, 45.80 and 45.69 g/ha in 2015, 2016 and in pooled mean, respectively.

The interaction effect of varying N, P and K levels along with vermicompost on copper uptake was non-significant in both the years and in pooled mean.

Table 8: Copper uptake (g/ha) of kharif rice as influenced by rescheduling of fertilizer doses.

Treatments	2015			2016			2017		
	Without *VC	With *VC	Mean	Without *VC	With *VC	Mean	Without *VC	With *VC	Mean
T_1	39.98	48.18	44.08	41.98	50.44	46.21	40.98	49.31	45.15
T_2	42.64	46.84	44.74	43.33	49.38	46.36	42.99	48.17	45.55
T_3	44.98	47.41	46.20	45.10	48.88	46.88	45.04	48.15	46.54

T_4	50.42	54.30	52.36	48.76	51.04	50.00	49.59	52.67	51.18
T_5	49.75	57.59	53.67	50.65	55.88	53.26	50.20	56.74	53.47
T_6	45.70	68.59	57.15	44.96	69.53	57.25	45.33	69.06	57.20
Mean	45.58	53.82		45.80	54.19		45.69	54.01	
Factors	CD (P=0.05)	SEm±		CD (P=0.05)	SEm±		CD (P=0.05)	SEm±	
N,P&K levels	8.57	2.92		NS	2.89		7.43	2.91	
Vermicompost	4.95	1.69		4.9	1.67		4.92	1.68	
Interaction	NS	4.13		NS	4.09		NS	4.11	

3.8 Iron Uptake: influence of varying N, P and K levels on iron uptake in rice was significant in kharif-2015, 2016 and in pooled mean (Table-8). However, significantly higher iron uptake 1852, 1934 and 1893 g/ha were recorded by T_6 over T_3 and at par with rest of the treatments in both the years and in pooled mean.

Iron uptake in kharif rice was significantly influenced by vermicompost application along with varying N, P and K levels in both the years and in pooled mean. However, significantly higher iron uptake 1817,1963 and 1890 g/ha were recorded in 2015, 2016 and in pooled mean, respectively by the application of vermicompost along with varying N, P and K levels over N, P and K alone 1527,1575 and 1551 in 2015, 2016 and in pooled mean, respectively.

The interaction effect of N, P and K levels with vermicompost on iron (Fe) uptake was non-significant

Table 9: Iron uptake (g/ha) of kharif rice as influenced by rescheduling of fertilizer doses.

Treatments	2015			2016			Pooled		
	Without *VC	With *VC	Mean	Without *VC	With *VC	Mean	Without *VC	With *VC	Mean
T_1	1507	1869	1688	1745	1882	1813	1626	1876	1666
T_2	1436	1769	1603	1431	2027	1729	1434	1898	1797
T_3	1337	1503	1420	1339	1541	1440	1338	1522	1430
T_4	1571	1860	1716	1625	2058	1841	1598	1959	1787
T_5	1697	1809	1753	1675	2041	1858	1686	1925	1800
T_6	1611	2093	1852	1637	2230	1934	1684	2162	1893
Mean	1527	1817		1575	1963		1551	1880	
Factors	CD (P=0.05)	SEm±		CD (P=0.05)	SEm (P=0.05)		CD (P=0.05)	SEm±	
N, P, K levels	257	88		289	98		273	93	
Vermicompost	148	51		167	57		158	54	
interaction	NS	124		NS	139		NS	132	

3.9 Manganese uptake

Manganese uptake in kharif rice was non-significantly influenced by varying N, P and K levels in both the years and in pooled mean. (Table-9). However, higher manganese uptake 1406, 1448 and 1427 g/ha were recorded in kharif-2015, 2016 and in pooled mean, respectively by T_6 and lower uptake 1204, 1298 and 1251g/ha were found in kharif-2015, 2016 and in pooled mean, respectively by T_2.

Manganese (Mn) uptake in kharif rice was significantly influenced by vermicompost application along with varying N, P and K levels in both the years and in pooled mean. However, significantly higher manganese uptake 1342, 1483 and 1413 g/ha were recorded in 2015, 2016 and in pooled mean, respectively by the application of vermicompost along with varying N, P and K levels over N, P and K alone 1221, 1315 and 1268 in 2015, 2016 and in pooled mean, respectively.

The interaction effect of N, P and K levels with vermicompost on manganese (Mn) uptake in kharif rice was non-significant.

The higher nutrient uptake with organic manure might be attributed to solubilization of native nutrients, chelation of complex intermediate organic molecules produced during decomposition of added organic manures, their mobilization and accumulation of different nutrients in different plant parts. The results are in agreement with the findings of Mohapatra *et al*. (2008) [26].

Table 10: Manganese uptake (g/ha) of kharif rice as influenced by rescheduling of fertilizer doses.

Treatments	2015			2016			2017		
	Without *VC	With *VC	Mean	Without *VC	With *VC	Mean	Without *VC	With *VC	Mean
T_1	1204	1247	1226	1393	1424	1409	1299	1336	1318
T_2	1174	1234	1204	1198	1398	1298	1186	1316	1251
T_3	1137	1308	1223	1274	1485	1380	1206	1397	1302
T_4	1212	1419	1315	1332	1552	1442	1272	1486	1379
T_5	1229	1402	1316	1309	1524	1417	1269	1463	1367
T_6	1371	1441	1406	1382	1513	1448	1377	1477	1427
Mean	1221	1342		1315	1483		1268	1413	
Factors	CD	SE(m)		CD	SE(m)		CD	SE(m)	
N,P,K levels	NS	60		NS	66		NS	63	
Vermicompost	101	34		113	38		107	36	
interaction	NS	84		NS	94		NS	89	

4. Economics of applied inputs to rice crop

Due to application of varied N, P, K levels arrived by different concepts of fertilizer application alone and in combination with Vermicompost @ 2t/ha uniformly (Table-10). The benefit cost ratio ranged from 0.60 to 1.44 and net income ranged from 717/- to 25,438/- rupees per hectare. The highest benefit cost ratio (1.44) and net income (25,438/-) was recorded by T_6 and also same benefit cost ratio (1.44) was found by T_5 but net income is low (23,188/-) and lowest benefit cost ratio (0.60) was observed with T_1 with vermicompost. Though the grain, straw yields and gross income recorded higher by the application of vermicompost along with varying N, P and K levels the net income and benefit cost ratios were low due to higher cost of vermicompost.

Table 11: Economics of applied inputs to rice crop

Treatments	Cost of cultivation (Rs/ha)		Gross income (Rs/ha)		Net income (Rs/ha)		B:C ratio	
	Without VC	With VC	Without VC	With VC	Without VC	With VC	Without VC	With VC
T_1	55480	70480	74595	75645	19115	5165	1.35	0.60
T_2	55860	70860	74790	78330	18930	717	1.34	1.1
T_3	58106	73106	72608	73823	14502	1434	1.26	0.60
T_4	60068	75068	79725	81855	19658	6788	1.34	0.63
T_5	56260	71260	79448	81923	23188	6313	1.44	0.63
T_6	57040	72040	82478	85703	25438	5488	1.44	0.65

Unit cost of nutrients (N-13/-, P-52/- & K-20/-), Vermicompost-5/-, $ZnSO_4$ = 30/-per kg

Conclusion

It may be concluded that the higher grain, straw yields, uptake of nutrients, highest benefit cost ratio (1.44) and net income (25,438/-) was recorded by the application of 180-60-40 kg N, P and K/ha alone and Lowest benefit cost ratio (0.60) was observed with the application of current RDF (100-60-40 kg N, P and K/ha) along with vermicompost application @ 2t/ha.

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