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) [9]. 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) [9]. 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 2.42 t 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°01.077 N latitude 79°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 (Subbiah 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) |
|------------------|-------------------|--------------------------|--------------------------|
| T₁ | Current RDF: (N, P, K, Zn, S & B) | 120-60-40 | 120-60-40 |
| T₂ | Soil Test based fertilizer usage: N, P, K (30% excess/less) | 120-78-40 | 120-42-28 |
| T₃ | 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 |
| T₄ | Soil Test Crop Response based Equation: Prod-II (15% Higher) + RD of Zn, S, B if deficient. | 155-203-136 | 148-30-63 |
| T₅ | New treatment for Production-I N=150%RDN if available N is <140Kg/ha else 125% RDN. P=100%RD 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 |
| T₆ | New treatment for Production-II N=200%RDN if available N is <140Kg/ha else 150% RDN. P=100%RD 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°C 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 (H₂SO₄) using kelpus 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) \(^\text{[10]}\).

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° 01.077 N latitude 79° 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\(_5\) over T\(_1\), T\(_2\) and T\(_3\) but it is at par with T\(_2\) and T\(_3\) 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\(_1\) 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 T6 over T1, T2, T3, T4 and T5 and lower straw yields 6173, 5922 and 6110 kg/ha were recorded in 2015, 2016 and in pooled mean by T3, T4 and T5 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.

| Treatments | 2015 | 2016 | Pooled |
|------------|------|------|--------|
| T1         | 6240 | 6535 | 6388   |
| T2         | 6050 | 6351 | 6201   |
| T3         | 6064 | 6283 | 6173   |
| T4         | 6220 | 6377 | 6299   |
| T5         | 6246 | 6345 | 6296   |
| T6         | 6429 | 6481 | 6455   |
| Mean       | 6208 | 6395 | 6066   |

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

*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 T6 over T1, T2, T3, T4 and T5 and lower nitrogen uptake (128 kg/ha) was recorded by T2 in 2015. Significantly, higher N-uptake was found (134 kg/ha) by T6 over T1, T2 and T3 but it is at par with T4 and T5 in 2016 and significantly higher N uptake (141 kg/ha) was recorded by T6 over T1, T2, T3, T4 and T5 and it is at par with T3 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].

Nitrogen 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 organic 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.

| Treatments | 2015 | 2016 | Pooled |
|------------|------|------|--------|
| T1         | 126  | 136  | 131   |
| T2         | 123  | 133  | 128   |
| T3         | 125  | 134  | 130   |
| T4         | 129  | 145  | 137   |
| T5         | 134  | 143  | 138   |

Table 4: Nitrogen uptake (kg/ha) of kharif rice as influenced by rescheduling of fertilizer doses.
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$_3$ over T$_1$, T$_2$, T$_3$, T$_4$, and T$_5$ and lower phosphorus uptake (17.95 kg/ha) was recorded by T$_1$ 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 non and lower phosphorus uptake (17.95 kg/ha) was recorded by T$_1$, T$_3$, and T$_5$.

| Treatments | 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   | 19.97|
| 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    | NS          | 5.26   | 3.23        | 3.23   | 3.23        | 3.23   |
| interaction| NS          | 7.44   | NS          | 4.6    | NS          | 4.6    |

*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) [20]. 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) and 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 Without *VC | With *VC Mean | 2016 Without *VC | With *VC Mean | Pooled Without *VC | With *VC Mean |
|------------|------------------|---------------|------------------|---------------|--------------------|---------------|
| T1         | 84               | 102           | 93               | 98            | 109                | 104           | 91             | 106           | 99             |
| T2         | 93               | 100           | 97               | 90            | 97                 | 93            | 92             | 99            | 95             |
| T3         | 96               | 105           | 101              | 99            | 107                | 103           | 98             | 106           | 102            |
| T4         | 92               | 107           | 100              | 97            | 106                | 102           | 95             | 107           | 101            |
| T5         | 96               | 108           | 102              | 101           | 128                | 115           | 99             | 118           | 109            |
| T6         | 103              | 116           | 110              | 115           | 120                | 117           | 109            | 118           | 114            |
| Mean       | 94               | 107           | 106              | 100           | 111                | 109           | 97             | 109           | 102            |

Factors: CD (P=0.05) SEm+

VC: Vermicompost

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

| Treatments | 2015 Without *VC | With *VC Mean | 2016 Without *VC | With *VC Mean | Pooled Without *VC | With *VC Mean |
|------------|------------------|---------------|------------------|---------------|--------------------|---------------|
| T1         | 304              | 395           | 350              | 343           | 397                | 370           | 324            | 396           | 360            |
| T2         | 335              | 396           | 366              | 314           | 408                | 361           | 325            | 402           | 366            |
| T3         | 313              | 389           | 351              | 335           | 369                | 352           | 324            | 379           | 352            |
| T4         | 373              | 415           | 394              | 383           | 411                | 397           | 378            | 413           | 396            |
| T5         | 377              | 423           | 400              | 368           | 430                | 399           | 373            | 427           | 400            |
| T6         | 407              | 426           | 416              | 401           | 455                | 428           | 404            | 441           | 422            |
| Mean       | 351              | 407           | 397              | 357           | 412                | 354           | 410            | 410           | 410            |

Factors: CD (P=0.05) SEm+

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

| Treatments | 2015 Without *VC | With *VC Mean | 2016 Without *VC | With *VC Mean | 2017 Without *VC | With *VC Mean |
|------------|------------------|---------------|------------------|---------------|------------------|---------------|
| T1         | 39.98            | 48.18         | 44.08            | 41.98         | 50.44            | 46.21         | 40.98          | 49.31         | 45.15         |
| T2         | 42.64            | 46.84         | 44.74            | 43.33         | 49.38            | 46.36         | 42.99          | 48.17         | 45.55         |
| T3         | 44.98            | 47.41         | 46.20            | 45.10         | 48.88            | 46.88         | 45.04          | 48.15         | 46.54         |

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 T6 over T1, T2 and T3 & it is at par with T4 and T5. 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 interaction effect of varying N, P and K levels along with vermicompost on copper uptake was significantly higher 57.15, 57.25 and 53.47 g/ha were recorded in 2015, 2016 and in pooled mean, respectively.

The interaction effect of varying N, P and K levels with vermicompost on potassium uptake was significant 351, 357 and 354 in 2015, 2016 and in pooled mean, respectively.

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 T6 over T1, T2 and T3 and it is at par with T4 and T5 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.
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 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.

| Treatments | Without VC | With VC | Mean | Without VC | With VC | Mean | Without VC | With VC | Mean |
|------------|------------|---------|------|------------|---------|------|------------|---------|------|
| T1         | 1507       | 1869    | 1688 | 1745       | 1882    | 1813 | 1626       | 1876    | 1666 |
| T2         | 1436       | 1769    | 1603 | 1431       | 2027    | 1729 | 1434       | 1898    | 1797 |
| T3         | 1337       | 1503    | 1420 | 1339       | 1541    | 1440 | 1338       | 1522    | 1430 |
| T4         | 1571       | 1860    | 1716 | 1625       | 2058    | 1841 | 1598       | 1959    | 1787 |
| T5         | 1697       | 1809    | 1753 | 1675       | 2041    | 1858 | 1686       | 1925    | 1800 |
| T6         | 1611       | 2093    | 1852 | 1637       | 2230    | 1934 | 1684       | 2162    | 1893 |

Mean: 1527 1817 1575 1683 1651 1880

Factors: CD (P=0.05) SEm+ CD (P=0.05) SEm+ 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 T4 and lower uptake 1204, 1298 and 1251 g/ha were found in kharif-2015, 2016 and in pooled mean, respectively by T2. 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.

| Treatments | Without VC | With VC | Mean | Without VC | With VC | Mean | Without VC | With VC | Mean |
|------------|------------|---------|------|------------|---------|------|------------|---------|------|
| T1         | 1204       | 1247    | 1226 | 1393       | 1424    | 1409 | 1299       | 1336    | 1318 |
| T2         | 1174       | 1234    | 1204 | 1198       | 1398    | 1298 | 1186       | 1316    | 1251 |
| T3         | 1137       | 1308    | 1223 | 1274       | 1485    | 1380 | 1206       | 1397    | 1302 |
| T4         | 1212       | 1419    | 1315 | 1332       | 1552    | 1442 | 1272       | 1486    | 1379 |
| T5         | 1229       | 1402    | 1316 | 1309       | 1524    | 1417 | 1269       | 1463    | 1367 |
| T6         | 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 T4, and also same benefit cost ratio (1.44) was found by T2, but net income is low (23,188/-) and lowest benefit cost ratio (0.60) was observed with T1, 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 | Without VC | With VC |
| T1         | 55480      | 70480   | 74595      | 75645   | 19115      | 5165   | 1.35       | 0.60   |
| T2         | 55860      | 70860   | 74790      | 78330   | 18930      | 717    | 1.34       | 1.1    |
| T3         | 58106      | 73106   | 72608      | 73823   | 14502      | 1434   | 1.26       | 0.60   |
| T4         | 60068      | 75068   | 79725      | 81855   | 19658      | 6788   | 1.34       | 0.63   |
| T5         | 56260      | 71260   | 79448      | 81923   | 23188      | 6313   | 1.44       | 0.63   |
| T6         | 57040      | 72040   | 82478      | 85703   | 25438      | 5488   | 1.44       | 0.65   |

Unit cost of nutrients (N-13/-, P-52/- & K-20/-), Vermicompost-5/-, ZnSO₄ = 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 @ 2 t/ha.

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