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# Effects of integrated nutrient management with mulching on rice (*Oryza sativa*)-based cropping systems in rainfed eastern plateau area*

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An integrated nutrient management system (INMS) may play a vital role in sustaining both the soil health and crop production on long-term basis (Singh *et al.* 2004). The INMS primarily relates to combined application of different sources of plant nutrients (organic and inorganic) for sustainable crop production without degrading the natural resource base, the soil and that too, on long term basis. Application of farmyard manure to improve the organic carbon and thereby the total nitrogen content of the soil. The beneficial effects of farmyard manure alone or in combination with fertilizers have also been observed by Kumar *et al.* (2000). Mulching involves covering the soil surface to conserve moisture, control weeds, and increase the populations of beneficial microflora thereby augmenting the crop yield. Crop residue mulches are also effective in conserving moisture, increasing yield and reducing erosion. It also increases the soil-water storage in the root zone.

The present study was, therefore, conducted to see the direct and residual effect of locally available farmyard manure in combination with N fertilizer on rice (*Oryza sativa* L.)-based cropping system.

The experiments were carried out at the agricultural experimental farm of the Institute situated in the eastern plateau region of India (humid sub-tropical zone) during the year 2003–04 and 2004–05 under rainfed condition. The soil was sandy-loam having *p*H 5.8–6.5, low in organic C (0.46%), 171.2 kg/ha available N ($KMnO_4$ – N), 22.8 kg/ha P ($NH_4F$ – P) and 181 kg/ha K ($NH_4OAc$ – K) per kg soil. The study consisted of 32 treatment combinations in split-plot (sub-sub) design having 3 replications.

Four organic and inorganic fertilizer levels, such as $F_0$ (control, no organic or inorganic fertilizers), $F_1$ (12 tonnes/ha farmyard manure), $F_2$ (60 kg N/ha + 30 kg P/ha + 30 kg K/ha in the form of urea, single supersphosphate and muriate of potash respectively) and $F_3$ (12 tonnes/ha farmyard manure + 30 kg N/ha in the form of urea), were allotted to the main plots during the wet season rice crop. 'MW 10' rice of 95–105 days of duration was sown on 4 July 2003 and 2 July 2004 at 20 cm apart, directly under each treatment. After harvesting rice, the plots were ploughed to give a fine seedbed without disturbing the layout, each main plot was divided into 2 subplots with 2 levels of mulch, $M_0$ (no mulch) and $M_1$ (rice straw mulch @ 10 tonnes/ha). The mulching materials were applied after sowing the winter-season crops. Again each subplot was further divided into 4 sub-subplots (3 m × 4 m) where 4 different winter crops, viz 'B 9' Indian mustard [(*Brassica juncea* (L.) Czernj and Cosson] ($W_1$), 'BR 25' lentil (*Lens culinaris* Medikus.) ($W_2$), 'BR 32' barley (*Hordeum vulgare* sensu lato.) ($W_3$) and 'B 67' linseed (*Linum usitatissimum* L.) ($W_4$) were randomly allotted.

The winter crops were sown on 12 November 2003 and 18 November 2004 and were fertilized with 30 kg/ha each of N, P and K irrespective of winter crops. Barley was sown at a spacing of 20 cm, whereas 30 cm × 10 cm was maintained for other winter crops. Experiment was carried out under rainfed condition. In both the years fixed plot technique (repeated on same plot) was followed and each plot was thus treated with the same treatment. In winter crops, soil moisture was determined at 5 different depths (0–20, 20–40, 40–60, 60–80 and 80–100 cm) with 15-day intervals in all the plots from sowing to harvest by gravimetric method. The total amount of water used by the crops and the water-use efficiency were calculated from soil moisture depletion data. At harvest, grain and straw/dry stalk samples of rice and winter crops were analysed for N, P and K content and uptake of the crop was calculated. Further soil samples were taken from 0–20 cm soil depth after each harvest and analysed in duplicate for organic C and available N by the wet digestion (Jackson 1967) and alkaline $KMnO_4$ (Subbiah and Asija 1956) methods respectively.

The grain yield of rice was significantly increased with the application of manure and fertilizers separately and their combinations in both the years. The highest grain yield were recorded under $F_2$ treatment which were 47.77 and 40.80% higher than the yield recorded under control treatment ($F_0$) in 2003 and 2004 respectively (Table 1). However, with the

*Short note

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Table 1 Grain yield of rice, grain yield of winter crops, rice equivalent yield, consumptive use of water and water use efficiency of the crops as affected by the integrated nutrient management practices with or without mulching and winter crops

| Treatment | Grain yield of rice (tonnes/ha) | Grain yield of winter crops (t/ha) | | | | Rice equivalent yield (tonnes/ha) | Consumptive use of water (mm) | Water use efficiency (kg/mm/ha) |
|---|---|---|---|---|---|---|---|---|
| | | Indian mustard | Lentil | Barley | Linseed | | | |
| $F_0$ (control) | 1.28 | 0.52 | 0.80 | 1.20 | 0.89 | 2.98 | 262.305 | 3.24 |
| $F_1$ 12 tonnes FYM/ha | 1.90 | 0.73 | 1.10 | 1.60 | 1.11 | 4.19 | 249.535 | 4.53 |
| $F_2$ (60.30.30 kg NPK/ha) | 2.28 | 0.55 | 0.90 | 1.37 | 1.05 | 4.24 | 257.43 | 3.75 |
| (12 tonnes FYM+30 kg N/ha) | 1.98 | 0.82 | 1.30 | 1.97 | 1.33 | 4.68 | 250.15 | 5.40 |
| SE (±) | 0.156 | 0.081 | 0.087 | 0.093 | 0.066 | 0.152 | 3.525 | 0.821 |
| CD ($P$=0.05) | 0.339 | 0.176 | 0.189 | 0.203 | 0.144 | 0.331 | 7.681 | 1.787 |
| $M_0$ (no mulch) | | 0.63 | 0.95 | 1.39 | 1.01 | 3.87 | 255.96 | 3.87 |
| $M_1$ (rice stra mulch 10 tonnes/ha) | | 0.69 | 1.10 | 1.68 | 1.18 | 4.18 | 253.75 | 4.57 |
| SE (±) | | 0.032 | 0.031 | 0.051 | 0.027 | 0.031 | 3.452 | 0.671 |
| CD ($P$=0.05) | | 0.068 | 0.066 | 0.108 | 0.057 | 0.066 | 7.318 | 1.423 |
| Indian mustard | | | | | | 3.84 | 225.965 | 2.90 |
| Lentil | | | | | | 4.84 | 268.665 | 3.80 |
| Barley | | | | | | 2.70 | 266.14 | 5.76 |
| Linseed | | | | | | 4.73 | 258.65 | 4.22 |
| SE (±) | | | | | | 0.045 | 4.610 | 0.078 |
| CD ($P$=0.05) | | | | | | 0.089 | 9.165 | 0.155 |

$F_0$, (Control, no organic or inorganic fertilizers); $F_1$ (12 tonnes/ha farmyard manure), $F_2$ (60 kg N/ha + 30 kg P/ha + 30 kg K/ha in the form of urea, single super phosphate and muriate of potash, respectively) and $F_3$ (12 t/ha farmyard manure + 30 kg N/ha in the form of Urea): $M_0$ (no mulch) and $M_1$ (rice straw mulch @ 10 t/ha): $W_1$ {Indian mustard (*Brassica juncea* L.)}, $W_2$ {lentil (*Lens culinaris* Medikus.)}, $W_3$ {barley (*Hordeum vulgare* sensu lato.)} and W4 {linseed (*Linum usitatissimum* L.)}

Table 2 Effect of organic manure, fertilizer and mulching on soil organic carbon, available N and N uptake by rice based cropping systems.

| Treatment | Soil organic C (%) | | Available N (mg/kg soil) | | N uptake (kg/ha) | |
|---|---|---|---|---|---|---|
| | 2003–04 | 2004–05 | 2003–04 | 2004–05 | 2003–04 | 2004–05 |
| *Manure and fertilizers (F)* | | | | | | |
| $F_0$ | 0.434 | 0.406 | 96.5 | 93.4 | 43.36 | 45.32 |
| $F_1$ | 0.506 | 0.539 | 131.6 | 141.3 | 67.87 | 68.36 |
| $F_2$ | 0.457 | 0.478 | 112.4 | 118.2 | 68.62 | 68.82 |
| $F_3$ | 0.558 | 0.578 | 140.3 | 145.8 | 77.17 | 72.28 |
| SE (±) | 0.007 | 0.014 | 3.85 | 4.43 | 2.03 | 2.10 |
| CD ($P$=0.05) | 0.018 | 0.034 | 9.43 | 10.83 | 4.97 | 5.14 |
| *Mulching (M)* | | | | | | |
| $M_0$ | 0.470 | 0.493 | 110.3 | 108.7 | 61.71 | 60.20 |
| $M_1$ | 0.507 | 0.527 | 130.2 | 140.6 | 66.77 | 67.19 |
| SE (±) | 0.008 | 0.014 | 2.248 | 2.860 | 0.81 | 0.70 |
| CD ($P$=0.05) | 0.186 | 0.033 | 5.185 | 6.59 | 1.87 | 1.61 |
| *Winter crops (W)* | | | | | | |
| $W_1$ | 0.493 | 0.502 | 117.6 | 119.3 | 55.20 | 55.19 |
| $W_2$ | 0.550 | 0.564 | 148.3 | 152.9 | 85.42 | 86.93 |
| $W_3$ | 0.439 | 0.476 | 82.2 | 102.9 | 54.96 | 52.36 |
| $W_4$ | 0.472 | 0.501 | 132.8 | 123.6 | 61.39 | 60.31 |
| SE (±) | 0.041 | 0.015 | 4.21 | 3.76 | 0.90 | 1.09 |
| CD ($P$=0.05) | 0.028 | 0.030 | 8.52 | 7.61 | 1.81 | 2.20 |

$F_0$, Control, no organic or inorganic fertilizers; $F_1$, 12 tonnes/ha farmyard manure; $F_2$, 60 kg N/ha + 30 kg P/ha + 30 kg K/ha and $F_3$, 12 tonnes/ha farmyard manure + 30 kg N/ha; $M_0$, no mulch and $M_1$, rice straw mulch @ 10 tonnes/ha; $W_1$, Indian mustard; $W_2$, lentil, $W_3$; barley and $W_4$, linseed

chemical fertilizers and manure combination treatment ($F_3$) a depression of grain yield of rice was observed compared to that of $F_2$ treatment. Significant increase in grain yield with application of chemical fertilizers ($F_2$) compared to $F_3$, $F_1$

and $F_0$ was probably due to better and quick availability of plant nutrients through their carriers.

Application of farmyard manure at 12 tonnes/ha ($F_1$) had shown significantly higher grain yield than that of absolute control ($F_0$). This is quite obvious due to addition of NPK through farmyard manure. Organic manure (farmyard manure) influences favourably plant growth and yield is thus increased as a direct or indirect consequence.

The winter crops raised under $F_3$ (12 tonnes/ha farmyard manure + 30 kg N/ha) treatment gave the maximum grain yield in both the years (Table 1). The yield increase of winter crops under $F_3$ (12 tonnes/ha farmyard manure + 30 kg N/ ha) and $F_1$ (12 tonnes/ha farmyard manure) treatments may be attributed to greater availability of residual nutrients through farmyard manure (Kumar *et al.* 2000, Shah and Ahmad 2006) and increased efficiency of applied P or the native soil P due to solubilizing effect of organic acid produced during decomposition.

Mulching with 10 tonnes/ha rice straw significantly increased the grain or seed yield of winter crops compared to no mulching. Ground cover through mulch reduces soil water evaporation and ensures that a high proportion of the soil water is used as transpiration.

The application of manure, fertilizers and their combinations along with mulching had significant effect on consumptive use of winter crops (Table 1). Application of manure decreased the total water use of the winter crops than that obtained under control ($F_0$) and $N_{60}P_{30}K_{30}$ ($F_2$) treatments. Mulching also decreased the water use of winter crops in both the years and this may be due to decrease in the evaporation loss from the soil surface. The water-use efficiency of winter crops was also varied among the winter crops (Table 2). Among the manure and fertilizers treatments, the maximum water-use efficiency (5.20 and 5.59 kg/mm/ha) was registered under $F_3$. Mulching also increased the water-use efficiency of winter crops, leading to higher utilization of water per unit economic yield.

The data on soil-moisture depletion indicated that the extraction of soil moisture was gradually less with increase in soil depth in all the crops. This may be due their shallow rooting characteristic. The $F_3$ treatment restricted the soil-moisture extraction except for Indian mustard, indicating improvement in the physico-chemical properties of the soil through decrease in bulk density and increase in porosity. However, $F_1$ treatment behaved similarly in Indian mustard and barley. Mulching also restricted soil-moisture depletion by decreasing the evaporation rate from the soil surface.

The rice-equivalent yield (Table 1) indicated that among the 4 rice based systems rice–lentil gave the maximum rice-equivalent yield followed by rice–linseed. The lowest rice equivalent was recorded under rice–barley system in both the years.

Application of manure, fertilizers and their combinations to rainy season rice depicted significant response in respect of rice equivalent yield of different rice-based systems. The systems treated with $F_3$ gave higher rice equivalent yield. Mulching also gave maximum rice equivalent yields of different rice-based systems in both the years.

There was an increase in uptake of N under $F_3$ treatment by the system (Table 2) probably due to higher biomass production. It might be due to higher dry matter production and that mineralized N from organic sources could contribute considerably towards the nutritional requirements of the crop. Nitrogen uptake under rice–lentil was the highest in both the years, followed by rice–linseed sequence. Maintenance of soil reserve of total N by leguminous crop may be attributed to the increase in N uptake due to inclusion of lentil in the system.

Application of organic and N fertilizer to rice led to varying amounts of organic carbon and available N in the soil after harvest of winter crops (Table 2). The data (Table 3) revealed that the maximum soil organic carbon was recorded under rice–lentil sequence, followed by rice-mustard. Rice–barley recorded the lowest soil organic carbon values. Among the different manure and fertilizers treatments, $F_3$ manifested the highest soil organic carbon value that was 29.16 and 29.69% more than that of $F_0$ treatment in 2003–04 and 2004–05 respectively. Mulching also increased the soil organic carbon values over no mulching.

Increase in organic carbon (%) content and nutrient percentage of the soil due to farmyard manure application were reported by Gami *et at.* 2001. Arya *et al.* (2000) observed that combined use of inorganic fertilizer with organic manure maintains higher crop productivity and simultaneously improves the fertility status of the soil.

## SUMMARY

The effect of different combinations of organic manure and inorganic fertilizer along with mulching and non-mulching on crop performance and soil fertility was studied in rice-based cropping system on medium land of sub-humid, rainfed eastern plateau area in Giridih, Jharkhand, during 2003–05. Application of inorganic fertilizers (60 kg N, 30 kg P and 30 kg K/ha) to rainy season rice increased grain yield. Winter crops grown in sequence on plots receiving 12 tonnes farmyard manure + 30 kg N/ha in rice during rainy season showed significantly higher productivity of the system. Mulching @ 10 tonnes/ha rice straw also resulted in significantly higher yield of winter season crops. Incorporation of manure in integrated nutrient management also increased the water use efficiency of winter crops.

The organic C content of the soil after the harvest of winter crops, particularly legume increased significantly after 12 tonnes farmyard manure + 30 kg N through fertilizer application in rainy season rice. There was more available N in the soil after the same treatment. Thus it emerges that for higher production, it is preferable to apply 60 kg N + 30 kg P

+ 30 kg K/ha in the form of chemical fertilizers during *kharif* rice and inclusion of either linseed or lentil as follow up winter crops with recommended doses of fertilizers.

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