INFLUENCE OF INTEGRATED USE OF FARMYARD MANURE AND INORGANIC FERTILIZERS ON YIELD AND YIELD COMPONENTS OF IRRIGATED LOWLAND RICE

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ABSTRACT

Integrated use of organic and inorganic fertilizers can improve crop productivity and sustain soil health and fertility. The present research was conducted with an objective to study the influence of application of farmyard manure in combination with three levels of chemical fertilizers [80 : 40 : 30, 120 : 60 : 45 and 160 : 80 : 60 kg N, P2O5 and K2O ha⁻¹, respectively] on yield and yield components of irrigated lowland rice. The experiment was conducted in split-plot design during the rainy season with and without farmyard manure as main plots and three inorganic

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fertilizer levels as subplots. Data on grain and straw yield, number of tillers, panicle length, filled grains per panicle, 1000-grain weight and nutrient uptake were collected. The results showed that application of farmyard manure at 10 t ha⁻¹ increased grain yield of rice by 25% compared to no farmyard manure control. Similar observations were also made on straw yield, tiller number, filled grains per panicle, and 1000-grain weight. There were significant interactions between farmyard manure and inorganic fertilizer treatments. The beneficial effects of application of farmyard manure were not enhanced at increased rates of application of inorganic fertilizers. However, the highest grain yield of rice was obtained with the application of farmyard manure at 10 t ha⁻¹ and inorganic fertilizer at 120 : 60 : 45 kg N, P₂O₅ and K₂O ha⁻¹. The increased grain yield was due mainly to increased nutrient uptake and number of tillers, filled grains per panicle and 1000-grain weight.

INTRODUCTION

Rice (Oryza sativa L.) is one of the major food crops grown in south Asia. It is mostly grown in lowlands under fully irrigated or rain-fed conditions. Organic materials particularly farmyard manure and green manures have traditionally been used by rice farmers in pre-industrial age. But with the present day high yielding cultivars, which have higher nutrient requirements, the use of inorganic fertilizers has increased considerably leading to decline in the use of organic materials.[1] The impact of increased fertilizer use on crop production has been large, but ever increasing cost of energy is an important constraint for increased use of inorganic fertilizer.[2] Use of organic matter to meet the nutrient requirement of crops would be an inevitable practice in years to come, particularly for resource poor farmers. Furthermore, ecological and environment concerns over the increased and indiscriminate use of inorganic fertilizers have made research on use of organic materials as a source of nutrients very necessary.[3,4] However, the use of organic manures alone may not be enough to meet the enormous nutrient requirements of present day high yielding cultivars. Therefore, an integrated nutrient management in which both organic manures and inorganic fertilizers are used simultaneously has been suggested as the most effective method to maintain a healthy and sustainable soil system while increasing crop productivity.[5,6] There is evidence from field research that high and sustainable yields are possible with integrated use of fertilizers and manure.[7,8] However, it is important to identify the optimum dose of chemical
fertilizer required for maintaining adequate supply of nutrients for increased yield, and reduced environmental pollution.

Farmyard manure is a heterogeneous composted organic material consisting of dung, crop residue, and/or household sweeping in various stages of decomposition.\(^9\) Farmyard manure is mostly available and produced in farms, and is an important organic resource for agricultural production in livestock-based farming systems in many countries including semi-arid regions of India.\(^9\) Thus, there is a lot of potential for use of farmyard manure in the fertilizer schedule of rice and to reduce total dependence on inorganic fertilizers. The present research was therefore conducted to study the influence of combined application of farmyard manure and different levels of inorganic fertilizer on growth, yield and yield components of irrigated lowland rice.

MATERIALS AND METHODS

A field experiment was conducted at the College farm of Acharya N G Ranga Agricultural University, Rajendranagar, Hyderabad, India (17°10'N lat., 78°28'E long. and 543 m above mean sea level). The soil at the experimental site was sandy loam with pH 7.8, 0.4% organic carbon, 220 kg available N ha\(^{-1}\), 17.3 kg available P ha\(^{-1}\), and 152 kg K ha\(^{-1}\). The irrigation water used for the experiment was of good quality devoid of any salinity.

Experimental Details

The experiment was laid out in split-plot design with three replicates and conducted during the rainy season (June–October) of 1994. The main plots (5.5 m wide and 18 m long) were treated with and without farmyard manure. Three fertilizer doses [80:40:30, 120:60:45, and 160:80:40 kg N:P\(_2\)O\(_5\):K\(_2\)O ha\(^{-1}\)] were assigned to the subplots (5.5 m wide and 5 m long).

The crop management practices were similar in all treatments except for the organic manure and fertilizer treatments. Farmyard manure (18.5% C, 1.46% N, 0.56% P, 0.5% K, 0.9% Ca, and C:N ratio of 12.7) collected from a nearby farm was incorporated into rice field one day before transplanting at 10 t ha\(^{-1}\). All the inorganic phosphorus and potassium and one-third of the inorganic N were applied as a basal dose during transplanting. The remaining two-thirds of inorganic N was applied in two equal splits at active tillering and at panicle initiation stages.

Field preparation was done by ploughing once, followed by flooding with water, and puddling three to four times. Thereafter, individual plots of equal size were prepared by bunds. Organic manure and inorganic fertilizers were uniformly
applied and incorporated at 15 cm depth to each plot as per treatment. The plots were leveled using a wooded plank. One day after the application of organic manure, rice seedlings of cultivar Tellahamsa were transplanted at a spacing of 15 × 15 cm and plots saturated with water. The water level in the field was always maintained at 15 to 20 cm until 30 days after transplanting. The field was then drained of all water for 2 d (mid-season drainage), thereafter the water level was maintained at 10 to 15 cm until a week before final harvest, when the field was allowed to dry for easy harvesting.

There was no serious incidence of pests and diseases or nutrient deficiencies. Crops were kept healthy by giving prophylactic sprays of recommended insecticides and fungicides as necessary. Fields were kept weed free by hand weeding at 20–25 d intervals.

**Data Collection and Analysis**

At maturity all the plants from net plot area (22.5 m²) were harvested and data on grain and straw yield were measured. Subsamples of plants were selected randomly and harvested to determine the number of tillers per hill, number of filled grains per panicle, and 1000-grain weight.

Subsamples of grain and straw collected at harvest were oven dried, finely ground, and analyzed for nitrogen (N), phosphorus (P), and potassium (K) content. Plant samples were analyzed for N by micro-Kjeldahl method, total P by vanadomolybdo phosphoric yellow color method using spectrophotometer, and K by digestion followed by flame photometry. The uptake of various nutrients was calculated by multiplying concentration of each nutrient and dry weights and expressed in kg ha⁻¹.

All the data were statistically analyzed by standard analysis of variance technique for a split plot design as suggested by Gomez and Gomez. Wherever treatment differences were found significant based on results of F-test, critical differences were calculated at 5% level of probability.

**RESULTS AND DISCUSSION**

There were significant effects of different fertilizer treatments on yield and yield attributes of rice (Table 1). Application of farmyard manure significantly improved number of tillers, number of filled grains, 1000-grain weight, grain yield and straw yield of rice (Table 1). Grain and straw yields of rice were significantly increased by 25% and 12%, respectively, over no farmyard manure control. Similarly the number of tillers, number of filled grains, and 1000-grain weights were increased by 12, 6, and 9%, respectively, due to application of
farmyard manure. Organic manure plays an important role in improving soil permeability to air and water and water stable aggregates. Thus application of organic materials such as farmyard manure considerably improves soil physical properties and nutrient uptake resulting in greater growth, yield and yield components.\(^{12-14}\) Application of farmyard manure at \(10 \text{ t ha}^{-1}\) contributes \(30-70 \text{ kg N ha}^{-1}\) in rice besides leaving a significant residual effect on succeeding crops.\(^{15}\) Long-term studies on rice have shown increased yield and yield components due to application of farmyard manure.\(^{7,8,16}\) These effects are largely attributed to improved soil organic matter, soil physical, chemical and microbial properties with application of farmyard manure.\(^{17}\)

There was significant influence of different inorganic fertilizer levels on grain and straw yield, tiller numbers, filled grains per panicle and 1000-grain weight of rice (Table 2). Application of \(120:60:45 \text{ kg N: P}_2\text{O}_5: \text{K}_2\text{O ha}^{-1}\) produced significantly greater grain yield (3.63 \text{ t ha}^{-1}) as compared to that obtained with lower fertilizer levels of \(80:40:30 \text{ kg N: P}_2\text{O}_5: \text{K}_2\text{O ha}^{-1}\) (3.17 \text{ t ha}^{-1}).

### Table 1. Effects of Application of Farmyard Manure on Grain Yield and Yield Components of Rice (Data Were Averaged Across Fertilizer Treatments)

<table>
<thead>
<tr>
<th>Trait</th>
<th>No Farmyard Manure</th>
<th>Farmyard Manure</th>
<th>CD (0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain yield (t ha(^{-1}))</td>
<td>3.07</td>
<td>3.84</td>
<td>0.35</td>
</tr>
<tr>
<td>Straw yield (t ha(^{-1}))</td>
<td>4.11</td>
<td>4.59</td>
<td>0.21</td>
</tr>
<tr>
<td>Number of tillers hill(^{-1})</td>
<td>12.80</td>
<td>14.30</td>
<td>1.20</td>
</tr>
<tr>
<td>Filled grains panicle(^{-1})</td>
<td>68.50</td>
<td>72.30</td>
<td>2.20</td>
</tr>
<tr>
<td>1000-grain weight (g)</td>
<td>26.83</td>
<td>29.31</td>
<td>0.62</td>
</tr>
</tbody>
</table>

### Table 2. Effects of Application of Different Fertilizers Rates on Grain Yield and Yield Components of Rice (Data Were Averaged Across Two Farmyard Manure Treatments)

<table>
<thead>
<tr>
<th>Trait</th>
<th>80 : 40 : 30</th>
<th>120 : 60 : 45</th>
<th>160 : 80 : 60</th>
<th>CD (0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain yield (t ha(^{-1}))</td>
<td>3.17</td>
<td>3.63</td>
<td>3.76</td>
<td>0.41</td>
</tr>
<tr>
<td>Straw yield (t ha(^{-1}))</td>
<td>4.05</td>
<td>4.43</td>
<td>4.53</td>
<td>0.29</td>
</tr>
<tr>
<td>Number of tillers hill(^{-1})</td>
<td>12.5</td>
<td>13.4</td>
<td>13.8</td>
<td>0.90</td>
</tr>
<tr>
<td>Filled grains panicle(^{-1})</td>
<td>65.0</td>
<td>68.0</td>
<td>73.0</td>
<td>5.80</td>
</tr>
<tr>
<td>1000-grain weight (g)</td>
<td>26.86</td>
<td>27.58</td>
<td>29.80</td>
<td>0.75</td>
</tr>
</tbody>
</table>
However, application of higher fertilizer level of 160 : 80 : 60 N : P$_2$O$_5$ : K$_2$O ha$^{-1}$ produced grain yield of 3.76 t ha$^{-1}$, which was statistically similar to that obtained with application of 120 : 60 : 45 kg N : P$_2$O$_5$ : K$_2$O ha$^{-1}$. Similar effects were also observed for straw yield, number of tillers, filled grains per panicle and 1000-grain weight (Table 2). These effects were due mainly to low available N and P in the soil.

There was significant interaction between application of organic manures and inorganic fertilizer levels for grain yield, straw yield, filled grains and 1000-grain weight. These effects are typically represented by grain yield and straw yield data in Fig. 1, which shows that application of farmyard manure in

![Figure 1. Effects of different fertilizer treatments in combination with farmyard manure (solid bars) and without farmyard manure (hatched bars) on grain (a) and straw yield (b) of rice. Vertical bars are the standard errors for comparing means.](image)
combination with 120:60:45 kg N:P₂O₅:K₂O ha⁻¹ produced an optimum grain yield when compared to other treatment combinations. Furthermore, the positive effects of farmyard manure were not enhanced with increased rate of inorganic fertilizer application. This is in agreement with other studies where combined application of organic and inorganic fertilizer increased productivity of rice.⁻¹³,¹⁸ Said studies have even shown that organic manures with an adequate amount of chemical N fertilizers could produce higher dry matter yield and high N accumulation, than those of conventional inorganic N fertilizers treatments.⁵¹²,¹⁹ A combined use of organic manures and inorganic fertilizers checks nitrogen losses, conserves soil N by forming organic-mineral complexes and thus ensures continuous N availability to rice plants and greater yields.⁶²⁰ Furthermore, research in farmers field on separate and combined application of fertilizers and farmyard manure has shown long-term yield benefits, and these effects have been attributed largely to the maintenance of soil organic matter and microbial activity.⁶²¹ Data on the uptake studies showed that application of farmyard manure increased the uptake of N, P, and K by 20, 12, and 9%, respectively (Fig. 2). There were significant interactions between organic manure and fertilizer treatment. Maximum uptake of N, P, and K was observed at a fertilizer level of 120:60:45 kg N:P₂O₅:K₂O ha⁻¹ in combination with application of farmyard manure (Fig. 2). The increase in P and K in farmyard manure application treatment could be attributed to enhanced availability of these nutrients due to improved soil structure and increased microbial activity.

Research has shown that combined application of farmyard manure and green manure could meet all the nitrogen requirement (150 kg fertilizer N ha⁻¹) of the high yielding varieties and yielded better than the application of inorganic fertilizer alone.⁶¹² Long-term effects of integrated nutrient management on productivity of rice-rice cropping system in both rainy and post-rainy seasons showed that the use of inorganic fertilizer (50%) and farmyard manure or green manure (50%) produced better yields than those obtained by application of 100% of recommended inorganic N.⁶¹² This suggests that judicious use of organic material can produce rice yield on par with that obtained with inorganic fertilizers.⁶¹⁷,⁶¹⁸,⁶²³ Thus application of organic materials have potential of not only improving crop yield, but also reducing dependence on fossil fuel based inorganic fertilizers, thereby reducing hazards caused by continuous and indiscriminate use of chemical fertilizers. Studies have also shown the beneficial effects of green manures, and blue green algae on productivity of rice.⁶²³ Therefore, research efforts should be continued to study the combined effects of different organic materials such as green manures, legumes, rice straw, compost, sewage sludge, bio-fertilizers (blue green algae and azolla) and inorganic fertilizer on the productivity of rice in lowland areas.
CONCLUSIONS

In conclusion this research has shown that application of farmyard manure at 10 t ha\(^{-1}\) increased grain yield of rice by 25%. There were significant effects of different fertilizer treatments and their interactions with organic manures.

Figure 2. Effects of different fertilizer treatments in combination with farmyard manure (solid bars) and without farmyard manure (hatched bars) on total plant N (a), P (b), and K (c) uptake of rice. Vertical bars are the standard errors for comparing means.
In general the beneficial effects of farmyard manure on yield, yield attributes, and nutrient uptake was less noticeable with increasing levels of inorganic fertilizer. An optimum yield of rice was obtained by application of 120 : 60 : 45 kg N : P₂O₅ : K₂O ha⁻¹ in combination with farmyard manure. The higher yield obtained with integrated use of farmyard manure and inorganic fertilizers were attributed to increased nutrient availability and uptake, resulting in greater number of tillers, filled grains per panicles and 1000-grain weight.

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