



Influence of Tillage Practices and Nitrogen Sources on Nitrogen Availability and Uptake of Rice

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Authors' contributions

This work was carried out in collaboration among all authors. Author PN designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors BV, MS, PRKP and KJ managed the analysis of the study. All authors read and approved the final manuscript.

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ABSTRACT

Aim: Evaluation of tillage practices and nitrogen sources on nitrogen availability in soil and nitrogen uptake of rice

Study design: The experiment was laid out in strip-plot design with different tillage practices in horizontal strip and different nitrogen sources in vertical strip and was replicated thrice.

Place and duration of study: The field experiment was conducted during the *kharif* season of 2019 and 2020 at the Agricultural College Farm, Bapatla, ANGRAU, Lam, Guntur, Andhra Pradesh.

Methodology: The experiment was performed with twenty treatments in strip-plot design. The horizontal strip comprised four different tillage practices and vertical strip with five different nitrogen sources. Rice variety "BPT-5204" was taken as the test variety. Observations of the crop and soil during the experimentation were recorded at regular intervals. The significance of the treatment impact was examined by the test.

Results: Among tillage practices, higher nitrogen uptake by rice grain (85.30 and 86.96 Kg ha⁻¹) and straw (41.21 and 41.91 Kg ha⁻¹) during 2019-20 and 2020-21, respectively was recorded in conventional tillage (T₄) which was found statistically on a par with dry seeding on puddled soil (T₁) (81.15 and 82.79 Kg ha⁻¹, 38.59 and 39.20 Kg ha⁻¹ during 2019-20 and 2020-21, respectively) and significantly superior over reduced tillage (T₂) and minimum tillage (T₃). Among nitrogen source, application of 50% STBN through fertilizer + 50% N through cured poultry manure (N₅) registered the highest uptake of nitrogen in grain and straw (85.38 and 87.02 Kg ha⁻¹, 42.09 and 42.76 Kg ha⁻¹ during 2019-20 and 2020-21, respectively) and it was found significantly on a par with 75% STBN through fertilizer + 25% N through cured poultry manure (N₄) and significantly superior over 50% STBN through fertilizer + 50% N through FYM (N₃), 75% STBN through fertilizer + 25% N through FYM (N₂), and 100% STBN through fertilizer (N₁) treatment.

Keywords: Tillage; nitrogen; poultry manure; FYM and rice.

1. INTRODUCTION

Rice is the staple food crop in India and Asia. It is mostly grown under submerged soil conditions and requires more water compared with other crops. Asia's irrigated rice fields consume more than 40% of the world's freshwater that is used for agriculture. By 2025, approximately two million hectares of irrigated dry season rice and 13 million hectares of wet-season rice will experience water scarcity Tuong and Bouman (2003).

Tillage practice is the most important factors affecting soil properties and crop yield. Among the crop production factors, tillage contributes up to 20% and affects the sustainable use of soil resources through its influence on soil properties. Reducing tillage positively influences several aspects of the soil whereas excessive and unnecessary tillage operations give rise to opposite phenomena that are harmful to soil. Conventional tillage practices cause change in soil structure by modifying soil bulk density and soil moisture content. In addition, repeated disturbance by conventional tillage raise to a finer and loose-setting soil structure and adversely affects the performance of succeeding upland crops. Conventional tillage is labor, water, and energy-intensive and is becoming less profitable as these resources are becoming increasingly scarce. These factors demand a major shift from puddled transplanting to direct seeding of rice (Ashwini et al., 2016) Therefore, currently there is a significant interest and emphasis on the shift from conventional tillage to conservation and no-tillage methods for the purpose of controlling all these complications.

In contrast, organic fertilizers such as Poultry manures and FYM are little used as a source of nutrients in rice crops. Therefore, the use of

poultry manure in rice fields as an organic fertilizer is a strategy that enables, at the same time, a correct form of disposal of these residues and a fertilization method capable of improving the physical, chemical and biological characteristics of the soil [1].

Fertilization using poultry manure and FYM should consider the crop's requirements and the manure's speed of decomposition and nutrient release, as well as its nutrient concentration. Therefore, one of the main obstacles to the use of organic manures in rice production is crop nutrition, mainly N supply to the production system. In rice crop, organic manures must be incorporated into dry soil approximately one month before soil puddling and rice sowing, to enable the mineralization process and to prevent the formation of organic acids during the anaerobic decomposition of organic material. Applying poultry manure to rice plants at their developmental stages has negative practical implications and causes environmental pollution [2]. In flooded soils, information about nutrient release from organic manure to the soil are scarce. However, understanding the dynamics of nutrient release following poultry manure and FYM application to waterlogged soils is necessary to establish the adequate quantities to achieve high yield and decrease environmental impacts to soil and water.

Therefore, it is necessary to evaluate if the use of poultry manure and FYM provides N in an available form and in adequate amounts to increase rice crop productivity, and also if, after a long time of continuous use of these organic manures in rice fields, there is an increase in soil fertility when compared with other rice fields treated only with chemical fertilizers [3]. The objective of this work was to evaluate changes in the soil available nitrogen and nitrogen uptake of

rice crop after the addition of these organic manures during two consecutive years.

2. MATERIALS AND METHODS

The field experiment was conducted during *kharif* season of 2019 and 2020 at the Agricultural College Farm, Bapatla. The soil of the experimental site was a sandy clay loam (sand 42.50%, silt 18.21% and clay 39.29%) with a bulk density of 1.22 g/cc having pH 7.9, EC 0.56 dsm^{-1} , low in organic carbon (0.5%), available nitrogen (250 kg ha^{-1}), medium in phosphorus (39 kg ha^{-1}) and high potassium (440 kg ha^{-1}). Rice variety "BPT-5204" Samba Mahsuri was taken as the test variety with 140-150 days growth duration. Samba Mahsuri is popular among farmers of Andhra Pradesh and is widely grown because of its good quality and marketability. The experiment was laid out in strip-plot design with crop establishment methods in horizontal strip and nitrogen management in vertical strip with three replications. The main plot comprised four different crop establishment methods *viz.* Dry seeding on puddled soil (T_1), Reduced tillage (T_2), Minimum tillage (T_3) and Conventional tillage (T_4); as horizontal strip treatments. Five nitrogen management treatments to rice *viz.* 100% STBN through fertilizer (N_1), 75% STBN through fertilizer + 25% N through FYM (N_2), 50% STBN through fertilizer + 50% N through FYM (N_3), 75% STBN through fertilizer + 25% N through Cured poultry manure (N_4) and 50% STBN through fertilizer + 50% N through Cured poultry manure (N_5) as vertical strip treatments.

3. RESULTS AND DISCUSSION

3.1 Nitrogen Content (%) and Uptake (Kg Ha^{-1}) in Rice

The data pertaining to nitrogen content and uptake in grain and straw were significantly influenced by tillage practices and nitrogen source treatments during 2019 and 2020 Table.1. Tillage practices did not have effect on nitrogen content in rice grain during 2019-20. Higher nitrogen content in rice grain recorded in conventional tillage (T_4) which was significantly superior to other treatments except dry seeding on puddled soil (T_1) during 2020-21. Significantly higher nitrogen uptake in grain and straw of rice were recorded with T_4 treatment, which was on par with T_1 treatment and was found significantly superior to reduced tillage and minimum tillage. Significantly the lowest nitrogen uptake was

reported in minimum tillage. More dry matter production in terms of grain and straw might be due to better control of weeds in conventional tillage and dry seeding on puddled soil treatments which may have facilitated more availability of nutrients to the crop compared to the reduced tillage and minimum tillage, which in turn accumulated and assimilated more nitrogen. Similar results were observed by Ali et al., [4], Sridhara et al. [5] and Alam et al., [6].

Among the various nitrogen sources, during 2019-20 and 2020-21 where both organic and inorganic sources applied, it was noticed with that nitrogen uptake in grain and straw were significantly higher in N_5 treatment, which was at par with N_4 treatment and significantly superior to other FYM treatments and inorganic fertilizer alone treatment. Significantly lower nitrogen uptake was recorded in N_1 treatment. Higher nitrogen content and uptake in both grain and straw might have facilitated higher uptake due to increased drymatter accumulation in those treatments which received higher doses of nitrogen fertilization. Higher drymatter accumulation coupled with higher nitrogen concentration in grain increased nitrogen uptake. Addition of organic manures might have released organic acids due to organic decomposition and reduced the soil pH and improved nutrient availability. Goel and Verma [7], Mankotia et al. [8] and Gill et al. [9] also expressed similar views.

Higher N-uptake in treatments where FYM and Poultry manure followed by 50 per cent of the inorganic nitrogen might be due to more grain yield. Nitrogen availability and better translocation of available nitrogen ultimately resulted into more grain yield and higher nitrogen concentration in grains. Uptake of nitrogen increased because it was utilized for metabolism of various substances required for the growth of plants resulting produced more dry matter. Pandey et al. [10] and P. K. Gill and C. S. Aulakh [11] reported that integration of organic fertilizer with reduced dose of recommended nitrogen significantly increased the N-uptake in rice.

3.2 Available Nitrogen in Soil (kg ha^{-1})

Data pertaining to available nitrogen in soil measured at different growth stages of crop *viz.*, at 30, 60, 90 DAS/DAT and at harvest as affected by tillage practices and nitrogen sources are presented in Table 2.

Table 1. Nitrogen content (%) and uptake (kg ha⁻¹) of rice as influenced by Tillage practices and Nitrogen sources during *kharif*, 2019 and 2020

| Treatments | Nitrogen content (%) and uptake (kg ha ⁻¹) | | | | | | | | | | | |
|--|--|---------------|---------------|--------------|--------------|--------------|---------------|---------------|---------------|--------------|--------------|--------------|
| | 2019-20 | | | | | | 2020- 21 | | | | | |
| | Grain content | Straw content | Total content | Grain uptake | Straw uptake | Total uptake | Grain content | Straw content | Total content | Grain uptake | Straw uptake | Total uptake |
| Tillage practices | | | | | | | | | | | | |
| T ₁ - Dry seeding on puddled soil | 1.39 | 0.49 | 1.72 | 81.15 | 38.59 | 119.7 | 1.42 | 0.50 | 1.74 | 82.79 | 39.20 | 122.0 |
| T ₂ - Reduced tillage | 1.32 | 0.42 | 1.60 | 65.52 | 28.43 | 93.95 | 1.36 | 0.46 | 1.66 | 67.37 | 29.06 | 96.43 |
| T ₃ - Minimum tillage | 1.36 | 0.39 | 1.63 | 57.55 | 23.37 | 80.91 | 1.37 | 0.38 | 1.62 | 59.71 | 24.03 | 83.74 |
| T ₄ -Conventional tillage | 1.47 | 0.51 | 1.81 | 85.30 | 41.21 | 126.5 | 1.48 | 0.52 | 1.83 | 86.96 | 41.91 | 128.8 |
| S.Em± | 0.03 | 0.02 | 0.04 | 1.59 | 0.50 | 1.47 | 0.03 | 0.01 | 0.03 | 1.67 | 0.47 | 1.57 |
| CD (p = 0.05) | NS | 0.06 | NS | 5.52 | 1.72 | 5.07 | NS | 0.04 | NS | 5.77 | 1.64 | 5.45 |
| CV (%) | 9.63 | 16.03 | 9.99 | 8.53 | 5.87 | 5.39 | 8.64 | 9.39 | 7.36 | 8.70 | 5.46 | 5.66 |
| Nitrogen sources | | | | | | | | | | | | |
| N ₁ - 100% STBN | 1.15 | 0.33 | 1.36 | 54.79 | 18.72 | 73.51 | 1.19 | 0.31 | 1.39 | 56.75 | 19.28 | 76.02 |
| N ₂ -75% STBN + 25% FYM | 1.39 | 0.45 | 1.69 | 68.37 | 30.17 | 98.54 | 1.41 | 0.47 | 1.72 | 70.25 | 30.85 | 101.0 |
| N ₃ -50% STBN + 50% FYM | 1.43 | 0.48 | 1.75 | 71.91 | 34.44 | 106.3 | 1.45 | 0.49 | 1.77 | 73.66 | 35.11 | 108.7 |
| N ₄ -75% STBN + 25% PM | 1.47 | 0.50 | 1.80 | 81.44 | 39.07 | 120.5 | 1.48 | 0.53 | 1.84 | 83.36 | 39.76 | 123.1 |
| N ₅ -50% STBN + 50% PM | 1.50 | 0.52 | 1.85 | 85.38 | 42.09 | 127.4 | 1.52 | 0.52 | 1.85 | 87.02 | 42.76 | 129.7 |
| S.Em± | 0.07 | 0.01 | 0.08 | 3.83 | 1.06 | 4.49 | 0.07 | 0.02 | 0.08 | 4.04 | 1.27 | 4.94 |
| CD (p = 0.05) | 0.22 | 0.05 | 0.27 | 12.48 | 3.44 | 14.65 | 0.21 | 0.06 | 0.25 | 13.18 | 4.15 | 16.12 |
| CV (%) | 16.89 | 11.01 | 17.27 | 18.31 | 11.12 | 14.78 | 16.17 | 13.94 | 15.81 | 18.87 | 13.14 | 15.90 |

Table 2. Available Nitrogen (kg ha⁻¹) in soil as influenced by rice Tillage practices and Nitrogen sources during *kharif*, 2019 and 2020

| Treatments | Available Nitrogen (kg ha ⁻¹) | | | | | | | |
|--|---|---------------|------------|------------|---------------|---------------|------------|------------|
| | 2019-20 | | | | 2020-21 | | | |
| | 30 DAS/DAT | 60 DAS/DAT | 90 DAS/DAT | At harvest | 30 DAS/DAT | 60 DAS/DAT | 90 DAS/DAT | At harvest |
| Tillage practices | | | | | | | | |
| T ₁ - Dry seeding on puddled soil | 314.9 | 279.9 | 251.6 | 248.5 | 318.1 | 285.7 | 260.3 | 253.2 |
| T ₂ - Reduced tillage | 256.4 | 242.1 | 225.6 | 199.2 | 262.8 | 249.8 | 227.6 | 203.0 |
| T ₃ - Minimum tillage | 238.3 | 228.6 | 204.3 | 173.0 | 243.9 | 235.3 | 214.5 | 171.3 |
| T ₄ -Conventional tillage | 329.8 | 297.1 | 266.4 | 262.6 | 331.8 | 303.1 | 270.1 | 264.1 |
| S.Em± | 5.75 | 6.01 | 10.31 | 7.07 | 6.73 | 5.37 | 4.73 | 6.88 |
| CD (p = 0.05) | 19.90 | 24.81 | 22.67 | 34.47 | 23.29 | 18.57 | 16.39 | 33.82 |
| CV (%) | 7.82 | 8.98 | 16.84 | 11.86 | 9.03 | 7.82 | 7.68 | 11.44 |
| Nitrogen sources | | | | | | | | |
| N ₁ - 100% STBN | 212.2 | 206.0 | 199.2 | 176.2 | 219.4 | 210.7 | 198.6 | 167.0 |
| N ₂ -75% STBN + 25% FYM | 264.9 | 252.5 | 222.0 | 196.2 | 265.5 | 253.1 | 224.9 | 208.5 |
| N ₃ -50% STBN + 50% FYM | 284.9 | 279.2 | 232.7 | 221.2 | 290.1 | 264.8 | 239.9 | 235.3 |
| N ₄ -75% STBN + 25% PM | 318.7 | 290.3 | 251.7 | 248.1 | 321.2 | 294.9 | 257.5 | 252.4 |
| N ₅ -50% STBN + 50% PM | 343.6 | 303.2 | 271.4 | 265.3 | 347.0 | 308.2 | 273.3 | 270.3 |
| S.Em± | 15.57 | 7.07 | 6.46 | 7.01 | 12.93 | 9.80 | 7.49 | 12.11 |
| CD (p = 0.05) | 50.77 | 33.05 | 21.08 | 32.86 | 42.17 | 31.96 | 24.43 | 29.48 |
| CV (%) | 18.93 | 9.43 | 9.45 | 10.52 | 15.52 | 12.76 | 10.86 | 18.00 |

From the data, it is clear that availability of nutrients decreases with increases duration of crop in each system of tillage methods. The maximum available nitrogen was recorded with conventional tillage followed by dry seeding on puddle soil. However, these two treatments were significantly on a par with each other. It was also observed that T₂ and T₃ treatments were on a par with each other during both the years. It might be due to do pulverization of soil under conventional tillage might have facilitated the penetration of roots, improved soil aeration, apart from effective weed control and increased nutrient uptake which ultimately increased available nitrogen. Available nitrogen was the lowest with minimum tillage at every stage of crop and it was due to improper land leveling is the serious cause for losses in water resulting in lower availability of nutrients. These results were in accordance with Parihar [3], Mohanty et al. [12] and Singh et al. (2005).

Availability of nitrogen was significantly higher with 50% STBN through fertilizer with 50% N through cured poultry manure treatment than the other nitrogen treatments during all the stages of crop and it was on a par with 50% STBN through fertilizer with 50% N through cured poultry manure treatment. N₃ and N₂ treatments were on a par with one another. Significantly the lowest available nitrogen was recorded with application 100% STBN through fertilizer (N₁). This is might be due to higher nitrogen content and narrow C:N ratio coupled with succulent nature and rapid decomposition under puddled soil condition. The increase in availability of nitrogen might be due to combined application organic and inorganic fertilizers as reported by Rakesh Sahu et al (2009) and Singh et al. [13].

4. CONCLUSION

The study may be concluded that conventional tillage and dry seeding on puddled soil recorded numerically higher nitrogen content and uptake in grain and straw of rice and also higher availability of nitrogen in soil under these treatments during both successive years. Among nitrogen sources, poultry manure and FYM along with inorganic nitrogen application led to higher nitrogen content in rice grain and straw; uptake of nitrogen, by rice grain and straw; and total uptake over recommended dose of chemical fertilizer alone. This shows the importance of poultry manure and FYM in conjunction with fertilizer in improving the nutrient use efficiency

of nitrogen, which would further lead to higher rice yields.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Mcgrath S, Maguire RO, Tracy BF, Fike JH. Improving soil nutrition with poultry litter application in lowinput forage systems. *Agronomy Journal*. 2010;102:48-54.
DOI: <https://doi.org/10.2134/agronj2009.0198>
2. Nishikawa T, Li K, Inamura T. Nitrogen uptake by the rice plant and changes in the soil chemical properties in the paddy rice field during yearly application of anaerobically-digested manure for seven years. *Plant Production Science*. 2014;17:237244.
DOI: <https://doi.org/10.1626/pp.s.17.23>
3. Parihar SS. Physico-chemical properties of soil and grain yield of rice (*Oryzasativa*) as influenced by organic and inorganic sources of nutrients. *Annals of Agricultural Research, New Series*. 2004;25(3):408-411.
4. Ali QM, Akhlaq Ahmed, Mubarik Ahmed, Muhammad Anwar Arain, Abbas. Establishment of planting methods for growth and yield of paddy (*Oryzasativa*L.) under agro-ecological conditions of district Shikarpur. *American Eurasian Journal of Agricultural and Environmental Science*. 2013;13(11):1503-1508
5. Sridhara CJ, Ramachandrappa BK, Kumarswamy AS, Gurumurthy KT. Effect of genotypes, planting geometry and methods of establishment on root traits and yield of aerobic rice. *Karnataka Journal of Agricultural Sciences*. 2011;24(2):129-132.
6. Md. Khairul Alam, Md. Monirul Islam, Nazmus Salahin, Mirza Hasanuzzaman. Effect of tillage practices on soil properties and crop productivity in wheat-mungbean-rice cropping system under subtropical climatic conditions. *The Scientific World Journal*. 2014;437283:15.
Available:<http://dx.doi.org/10.1155/2014/437283>.
7. Goel AC, Verma KS. Comparative study of direct seeding and transplanting of rice.

- Indian Journal of Agricultural Research. 2000;34(3):194-196.
8. Mankotia BS, Sekhar J, Negi SC. Effect of crop establishment techniques on productivity of rice-wheat cropping system. *Oryza*. 2009;46(3):205-208.
 9. Gill MS, Kumar, Kumar P. Growth and yield of rice (*Oryzasativa*) cultivars under various methods and times of sowing. *Indian Journal of Agronomy*. 2006;51(2):123-127.
 10. Pandey D, Chitale S, Thakur DS. Nutrient uptake and physico-chemical properties of soil influenced by organic and inorganic packages in Rice. *Curr. Agri. Res. J*. 2015;3:80-84.
 11. Gill PK1* Aulakh CS. Effect of integrated nitrogen management on NPK uptake in basmati rice (*Oryza sativa L.*). *Journal of Applied and Natural Science*. 2018;10(1):258–261.
 12. Mohanty TR, Roul PK, Maity SK, Nayak A. Productivity and profitability of greengram as influenced by rice crop establishment and nutrient management practices in rice-greengram cropping system. *Journal of Crop and Weed*. 2015;11(1):92-97.
 13. Shivaji Singh SP, Singh MP, Neupane RK Meena. Effect of NPK levels, BGA and FYM on growth and yield of rice (*Oryza sativa L.*) *Environment and Ecology*. 2013;32(1A):301-330.

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