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# Partial factor productivity of nitrogen, nitrogen uptake and Soil health as influenced by different establishment methods, varieties and nitrogen levels in rice under late sown conditions in Telangana state

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**Abstract**
A field experiment was carried out during *kharif*, 2017 on clay loam soil at Regional Agricultural Research Station, Polasa, Jagtial. The experiment was laid out in a split plot design with three replications and twelve treatments with three main plots *viz.*, $M_1$: Sowing of nursery (July 20$^{th}$) and transplanting of seedlings at 25 DAS (August 16$^{th}$), $M_2$: Direct seeding by Broadcasting on August 16$^{th}$, $M_3$: Direct seeding by Drum seeder on August 16$^{th}$ and four subplots *viz.*, $S_1$: RNR-15048 with 100% Recommended N (120 kg ha$^{-1}$), $S_2$: RNR-15048 with 150% Recommended N, $S_3$: JGL-18047 with 100% Recommended N and $S_4$: JGL-18047 with 150% Recommended N. Grain and straw yield was significantly higher in drum seeding over broadcasting which was again significantly superior over transplanting method. JGL-18047 recorded significantly higher grain and straw yield at both levels of nitrogen over RNR-15048. The physico-chemical properties and post-harvest nutrient status of soil were not significantly influenced by establishment methods, nitrogen levels and varieties. Nitrogen uptake and partial factor productivity of nitrogen was significantly higher in drum seeding over other methods. While among both varieties with nitrogen levels, JGL-18047 recorded significantly higher uptake at both levels of nitrogen over RNR-15048.

**Keywords:** Crop establishment, direct seeding, transplanting, broadcasting, partial factor productivity

## Introduction
In India rice is cultivated in an area of 44.10 M ha, with a production and productivity of 104.3 MT and 2.38 t ha$^{-1}$, respectively (Directorate of Economics and Statistics, GOI, 2015-16). Rice yields are highly variable due to aberrations in weather like late onset of monsoon, heavy continuous rains, intermittent dry spell and heavy rains at the time of harvesting, etc. Time of sowing is the most important factor in influencing the crop yield. Delay in planting generally results in yield reduction which cannot be compensated by any other means (Shah and Bhurer, 2005) [14]. Another reason for low profitability of rice cultivation is increased cost of cultivation. Traditional method of rice cultivation involves seedbed preparation, nursery raising, care of seedlings in nursery, uprooting of seedlings and transplanting operations which is usually done by hired labour, and is becoming increasingly difficult due to massive migration of labour. The event of delayed release of water from the canal, invariably causes delay in farm operations. This situation is forcing the farmers to deviate from normal date of sowing to delayed sowing. The late planted crop has low productivity per plant due to restricted vegetative growth.

To tackle all these problems direct seeding of rice has been found most appropriate alternative to transplanting. Direct seeding of rice avoids nursery maintenance, transplanting and crop also matures 7-12 days earlier than transplanted rice (Gill, 2008) [4] thus reduces the overall water demand for rice culture and also saves the time, input requirements, labour and energy. Nitrogen is one of the most important nutritional elements contributing for higher productivity of cereal crops and a major factor that limits agricultural yields (Balasubramanian *et al.*, 2000) [2]. Nitrogen absorbed by rice during the vegetative growth stages contributes in growth during reproduction and grain-filling through translocation. The application of nitrogen fertilizer either in excess or less than optimum rate affects both yield and quality of rice to remarkable

extent, hence proper management of crop nutrition is of immense importance (Manzoor *et al.*, 2006) [9]. Recommendation of best establishment method and nitrogen requirement for recently released high yielding medium duration varieties under late sown conditions is necessary in order to achieve optimum yields. Therefore an attempt has been made to evaluate the effect of crop establishment methods, varieties and nitrogen levels on partial factor productivity of nitrogen, nitrogen uptake and soil health in rice under late sown conditions of Telangana state.

**Materials and Methods**

Field experiment was carried out during *kharif*, 2017 at Regional Agricultural Research Station, Polasa, Jagtial which is geographically situated at an altitude of 243.4 m above mean sea level on 18º49'40" N latitude and 78º56'45" E longitude in the Northern Telangana Zone of Telangana State. A rainfall of 254.2 mm was received in 17 rainy days during the entire crop growth period. The experimental soil was clay loam texture with slightly alkaline pH (8.2), EC (0.20 d $Sm^{-1}$) and low in OC (0.40 %). The soil was medium in available N (441 kg $ha^{-1}$), high in available P (43.1 kg $ha^{-1}$) and K (380 kg $ha^{-1}$). The cultivars RNR-15048 and JGL-18047 were used in the experiment. The experiment was laid out in a split plot design with three replications and twelve treatments with three main plots *viz.*, $M_1$: Sowing of nursery (July 20$^{th}$) and transplanting of seedlings at 25 DAS (August 16$^{th}$), $M_2$: Direct seeding by Broadcasting on August 16$^{th}$ and $M_3$: Direct seeding by Drum seeder on August 16$^{th}$, and four subplots *viz.*, $S_1$: RNR-15048 with 100% Recommended N, $S_2$: RNR-15048 with 150% Recommended N, $S_3$: JGL-18047 with 100% Recommended N and $S_4$: JGL-18047 with 150% Recommended N.

In case of conventional transplanting method ($M_1$), nursery was raised by broadcasting the seeds @ 50 kg $ha^{-1}$. Transplanting was done using twenty five day old seedlings. Seedlings were uprooted and transplanted @ 2-3 seedlings $hill^{-1}$ about 2-3 cm deep in soil at 15 x 15 cm spacing manually. In direct seeding by broadcasting method ($M_2$), the seeds @ 37.5 kg $ha^{-1}$ were broadcasted into the puddled field manually. In direct seeding by drum seeder ($M_3$), the seeds @ 37.5 kg $ha^{-1}$ were sown into the puddled field by using a manually operated drum seeder consisting of drums made of fibre with a spacing of 20 cm between the rows and 8 cm between the plants of the rows. The drums were filled with the seed upto three fourth of their capacity. About 3-4 seeds can be placed in a hill with the help of the drum seeder at all row spacing. In all the planting methods, the seeds were soaked in water, drained and incubated for 24 hours before sowing.

For control of weeds, pretilachlor @ 1250 ml in 50 kg of sand $ha^{-1}$ was applied. The left over weeds are removed by hand weeding was done at 15 days interval. Irrigation was applied as per requirement to the plots. It was withheld 15 days before harvesting of the crop. A fertilizer dose of 60 kg $ha^{-1}$ $P_2O_5$ was applied to all the plots as basal dose in the form single super phosphate and 40 kg $ha^{-1}$ $K_2O$ was applied in two equal splits *viz.*, as basal at the time of transplanting/sowing and panicle initiation stage in the form of muriate of potash, respectively. Nitrogen (120 and 180 kg $ha^{-1}$) was applied in the form of urea as per the treatments. It was applied in three equal splits *viz.*, as basal at the time of transplanting/sowing, 30 DAS (maximum tillering) and panicle initiation stage. Zinc was applied in the form of $ZnSO_4$ as foliar spray @ 2g $lt^{-1}$ to the plots at 20 DAS. Carbofuran 3G @ 25 kg $ha^{-1}$ were applied at 30 DAS. Other plant protection measures were taken up as and when required.

The crop was harvested manually with the help of sickles. After harvesting the crop in each net plot of all treatments, threshing, cleaning and drying of the grain was done and weight of the grain and straw of each treatment was recorded and expressed as kg $ha^{-1}$.

Soil Analysis was carried out by collecting the soil samples before planting and after harvest of the crop and analyzed for soil reaction (pH), electrical conductivity, organic carbon, available nitrogen, available phosphorus and available potassium. The soil reaction was estimated by digital pH meter (Jackson, 1973) [6], electrical conductivity by digital conductivity bridge method (Jackson, 1973) [6], organic carbon by Walkley and Black's modified method (Jackson, 1967) [5]. The available nitrogen was estimated by alkaline potassium permanganate method (Subbaiah and Asija, 1956), available phosphorus by Olsen's method (Olsen's *et al*., 1954) [11] and available potassium by flame photometry (Muhr *et al*., 1963) [10].

For nitrogen uptake plant samples at 30, 60 DAS/DAT and harvest were taken. Nitrogen content was estimated by micro kjeldhal method. The nitrogen uptake in kg $ha^{-1}$ was worked out by multiplying N content with the corresponding dry matter yield and expressed as N uptake in kg $ha^{-1}$. N Uptake (kg $ha^{-1}$) = [N concentration (%) x Dry matter production (kg $ha^{-1}$)]/ 100

**Fig 1:** Transplanting of seedlings in the main field

**Fig 2:** Sowing with drum seeder

**Fig 3:** Broadcasting of seeds in mainfield


**Fig 4:** General view of the experimental field

## Results and discussion

### Partial factor productivity of nitrogen

Significantly higher partial factor productivity of N was observed in direct seeding by drum seeder (M3) over the other two establishment methods (Table 1). It was followed by direct seeding by broadcasting method (M2) which was again significantly superior over conventional transplanting method (M1). The higher partial factor productivity of N in both the direct seeding methods was due to higher grain yield obtained than in transplanting method for the same amount of nitrogen fertilizer applied.

Significantly higher partial factor productivity of nitrogen was obtained in JGL-18047 with 100% nitrogen (S3) over RNR-15048 with 100% nitrogen (S1) and JGL-18047 with 150% nitrogen (S4). The least was observed in RNR-15048 with 150% nitrogen (S2) over other subplots. The lower partial factor productivity of nitrogen was due to greater amount of nitrogen applied coupled with lower grain yield indicating that further increase in nitrogen level over 120 kg ha$^{-1}$ had no effect on crop response to fertilizer. These results are in line with the findings of Mahajan *et al.* (2010) [8] and Rao *et al.* (2014) [13].

**Table 1:** Partial factor productivity of nitrogen as influenced by different establishment methods and varieties at different levels of nitrogen in rice

| Treatment | Partial factor productivity of nitrogen |
|---|---|
| **Main plots: Establishment methods** | |
| $M_1$ | 27.0 |
| $M_2$ | 31.5 |
| $M_3$ | 34.1 |
| SEm± | 0.6 |
| CD (P = 0.05) | 2.5 |
| **Sub Plots: Varieties at different levels of nitrogen** | |
| $S_1$ | 33.1 |
| $S_2$ | 22.3 |
| $S_3$ | 40.1 |
| $S_4$ | 27.9 |
| SEm± | 1.0 |
| CD (P = 0.05) | 3.0 |
| **Interaction** | |
| S at same level of M | |
| SEm± | 1.7 |
| CD (P = 0.05) | NS |
| M at same or different level of S | |
| SEm± | 1.6 |
| CD (P = 0.05) | NS |

**Main plots**

$M_1$: Sowing of nursery (July 20th) and transplanting of seedlings at 25 DAS (Aug 16th)

$M_2$: Direct seeding by Broadcasting on August 16th

$M_3$: Direct seeding by Drum seeder on August 16th

**Sub plots**

$S_1$: RNR-15048 with 100% Recommended N

$S_2$: RNR-15048 with 150% Recommended N

$S_3$: JGL-18047 with 100% Recommended N

$S_4$: JGL-18047 with 150% Recommended N

### Nitrogen Uptake (kg ha$^{-1}$)

The perusal of mean data at 30 and 60 DAS/DAT revealed that the nitrogen uptake was superior in conventional transplanting method (M1) compared to direct seeding by broadcasting (M2) and drum seeder method (M3) which were at par with each other (Table 2). However, at harvest the uptake of nitrogen by grain and straw were significantly higher in direct seeding by drum seeder (M3) over other two establishment methods. It was followed by direct seeding by broadcasting (M2) which was again superior to conventional transplanting method (M1). Significantly higher nitrogen uptake in direct seeding method might be due to the greater and healthy root growth, which increased availability and efficient absorption of nutrients from the soil and transport of nutrients from root to shoot and grains. The results are in consonance with that of Singh and Singh (2010) [15] and Kaur and Singh (2015) [7].

Among the varieties at different nitrogen levels, the uptake of nitrogen was not significantly influenced at 30 DAS/DAT. But, at 60 DAS/DAT and harvest, JGL 18047 with 150% recommended nitrogen (S4) recorded significantly higher nitrogen uptake over RNR-15048 with both levels of nitrogen (S1 and S2) and was at par with JGL 18047 with 100 % recommended nitrogen (S3).

**Table 2:** Nitrogen uptake (kg ha$^{-1}$) of rice as influenced by different establishment methods and varieties at different levels of nitrogen

| Treatment | 30 DAS/DAT | 60 DAS/DAT | Harvest | | |
|---|---|---|---|---|---|
| | | | Grain | Straw | Total |
| **Main plots: Establishment methods** | | | | | |
| $M_1$ | 17.0 | 55.8 | 38.2 | 34.8 | 73.0 |
| $M_2$ | 11.3 | 34.2 | 44.3 | 40.3 | 84.6 |
| $M_3$ | 11.2 | 37.2 | 48.5 | 43.4 | 91.9 |
| SEm± | 0.4 | 1.3 | 1.0 | 0.7 | 1.7 |
| CD (P = 0.05) | 1.7 | 5.2 | 3.9 | 2.9 | 6.9 |
| **Sub Plots: Varieties at different levels of nitrogen** | | | | | |
| $S_1$ | 12.9 | 38.3 | 38.9 | 35.9 | 74.9 |
| $S_2$ | 13.2 | 40.5 | 39.3 | 36.1 | 75.4 |
| $S_3$ | 13.1 | 44.8 | 47.2 | 42.2 | 89.4 |
| $S_4$ | 13.4 | 46.0 | 49.3 | 43.8 | 93.1 |
| SEm± | 0.4 | 1.2 | 1.5 | 1.1 | 2.6 |
| CD (P = 0.05) | NS | 3.6 | 4.4 | 3.4 | 7.7 |
| **Interaction** | | | | | |
| S at same level of M | | | | | |
| SEm± | 0.7 | 2.1 | 2.5 | 1.9 | 4.5 |
| CD (P = 0.05) | NS | NS | NS | NS | NS |
| M at same or different level of S | | | | | |
| SEm± | 0.7 | 2.2 | 2.4 | 1.8 | 4.3 |
| CD (P = 0.05) | NS | NS | NS | NS | NS |

**Main plots**
$M_1$: Sowing of nursery (July 20$^{th}$) and transplanting of seedlings at 25 DAS (Aug 16$^{th}$)
$M_2$: Direct seeding by Broadcasting on August 16$^{th}$
$M_3$: Direct seeding by Drum seeder on August 16$^{th}$

**Sub plots**
$S_1$: RNR-15048 with 100% Recommended N
$S_2$: RNR-15048 with 150% Recommended N
$S_3$: JGL-18047 with 100% Recommended N
$S_4$: JGL-18047 with 150% Recommended N

**Soil health**
The soil samples collected from the plots of different treatments after the harvest of rice crop revealed that the post-harvest nutrient status of soil i.e., pH, EC, OC (Table 3), available nitrogen, phosphorus and potassium (Table 4) were not significantly influenced by the different establishment methods, varieties at different levels of nitrogen and their interaction. These results are in line with Dinesh *et al*. (2009) [3] and Prathiksha *et al.* (2017) [12].

**Table 3:** Initial and final soil pH, EC and OC of rice as influenced by different establishment methods and varieties at different levels of nitrogen

| Treatment | pH | EC (dSm $^{-1}$) | OC (%) |
|---|---|---|---|
| **Main plots: Establishment methods** | | | |
| $M_1$ | 7.8 | 0.30 | 0.43 |
| $M_2$ | 7.9 | 0.36 | 0.46 |
| $M_3$ | 7.9 | 0.30 | 0.45 |
| SEm± | 0.1 | 0.02 | 0.01 |
| CD (P = 0.05) | NS | NS | NS |
| **Sub Plots: Varieties at different levels of nitrogen** | | | |
| $S_1$ | 7.8 | 0.34 | 0.44 |
| $S_2$ | 7.9 | 0.36 | 0.45 |
| $S_3$ | 7.9 | 0.34 | 0.46 |
| $S_4$ | 7.9 | 0.30 | 0.44 |
| SEm± | 0.1 | 0.01 | 0.01 |
| CD (P = 0.05) | NS | NS | NS |
| **Interaction** | | | |
| S at same level of M | | | |
| SEm± | 0.1 | 0.02 | 0.02 |
| CD (P = 0.05) | NS | NS | NS |
| M at same or different level of S | | | |
| SEm± | 0.1 | 0.03 | 0.02 |
| CD (P = 0.05) | NS | NS | NS |
| Initial | 8.2 | 0.20 | 0.40 |

**Main plots**
$M_1$: Sowing of nursery (July 20$^{th}$) and transplanting of seedlings at 25 DAS (Aug 16$^{th}$)
$M_2$: Direct seeding by Broadcasting on August 16$^{th}$
$M_3$: Direct seeding by Drum seeder on August 16$^{th}$

**Sub plots**
$S_1$: RNR-15048 with 100% Recommended N
$S_2$: RNR-15048 with 150% Recommended N
$S_3$: JGL-18047 with 100% Recommended N

**Table 4:** Initial and final available soil N, P and K (kg ha$^{-1}$) of rice as influenced by different establishment methods and varieties at different levels of nitrogen

| Treatment | N | P | K |
|---|---|---|---|
| **Main plots: Establishment methods** | | | |
| $M_1$ | 393 | 44.0 | 348 |
| $M_2$ | 399 | 41.8 | 334 |
| $M_3$ | 402 | 42.1 | 355 |
| SEm± | 9.7 | 1.0 | 8.9 |
| CD (P = 0.05) | NS | NS | NS |
| **Sub Plots: Varieties at different levels of nitrogen** | | | |
| $S_1$ | 402 | 42.3 | 342 |
| $S_2$ | 405 | 42.1 | 340 |
| $S_3$ | 389 | 42.5 | 360 |
| $S_4$ | 397 | 43.6 | 340 |
| SEm± | 8.4 | 0.9 | 11.6 |
| CD (P = 0.05) | NS | NS | NS |
| **Interactions** | | | |
| S at same level of M | | | |
| SEm± | 14.6 | 1.6 | 20.2 |
| CD (P = 0.05) | NS | NS | NS |
| M at same or different level of S | | | |
| SEm± | 15.9 | 1.8 | 19.6 |
| CD (P = 0.05) | NS | NS | NS |
| Initial | 441 | 43.1 | 380 |

**Main plots**

$M_1$: Sowing of nursery (July 20$^{th}$) and transplanting of seedlings at 25 DAS (Aug 16$^{th}$)

$M_2$: Direct seeding by Broadcasting on August 16$^{th}$

$M_3$: Direct seeding by Drum seeder on August 16$^{th}$.

**Sub plots**

$S_1$: RNR-15048 with 100% Recommended N

$S_2$: RNR-15048 with 150% Recommended N

$S_3$: JGL-18047 with 100% Recommended N

$S_4$: JGL-18047 with 150% Recommended N

**Yield**

Direct seeding by drum seeder has recorded significantly higher grain and straw yield over direct seeding of sprouted seeds on puddled soil by broadcasting which was again significantly superior over conventional transplanting method. With respect to varieties at different levels of nitrogen, JGL-18047 recorded significantly higher grain and straw yield over RNR-15048 with both the levels of nitrogen. The harvest index was not significantly influenced by either crop establishment methods or varieties at different levels of nitrogen (Table 5).

**Table 5:** Yield of rice as influenced by different establishment methods and varieties at different levels of nitrogen

| Treatment | Grain yield (kg ha$^{-1}$) | Straw yield (kg ha$^{-1}$) | Harvest index (%) |
|---|---|---|---|
| **Main plots: Establishment methods** | | | |
| $M_1$ | 3901 | 5066 | 44.0 |
| $M_2$ | 4520 | 5863 | 43.9 |
| $M_3$ | 4949 | 6307 | 44.3 |
| SEm± | 103.1 | 107.9 | 0.7 |
| CD (P = 0.05) | 404.9 | 423.7 | NS |
| **Sub Plots: Varieties at different levels of nitrogen** | | | |
| $S_1$ | 3975 | 5139 | 43.6 |
| $S_2$ | 4010 | 5157 | 43.7 |
| $S_3$ | 4815 | 6228 | 44.4 |
| $S_4$ | 5027 | 6458 | 44.5 |
| SEm± | 152.1 | 162.3 | 0.3 |
| CD (P = 0.05) | 451.9 | 482.3 | NS |
| **Interaction** | | | |
| S at same level of M | | | |
| SEm± | 263.4 | 281.3 | 0.8 |
| CD (P = 0.05) | NS | NS | NS |
| M at same or different level of S | | | |
| SEm± | 250.4 | 266.3 | 0.8 |
| CD (P = 0.05) | NS | NS | NS |

**Main plots**

$M_1$: Sowing of nursery (July 20$^{th}$) and transplanting of seedlings at 25 DAS (Aug 16$^{th}$)

$M_2$: Direct seeding by Broadcasting on August 16$^{th}$

$M_3$: Direct seeding by Drum seeder on August 16$^{th}$

**Sub plots**

$S_1$: RNR-15048 with 100% Recommended N

$S_2$: RNR-15048 with 150% Recommended N

$S_3$: JGL-18047 with 100% Recommended N

$S_4$: JGL-18047 with 150% Recommended N

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