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Effect of nitrogen levels on yield and nutrient uptake of *kharif* rice (*Oryza sativa* L.) under different establishment methods

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ABSTRACT

A research experiment was conducted on rice during kharif-2015,2016 and 2017 at Regional Agricultural Research Station, Warangal (Telangana) under different establishment methods (machine transplanting, conventional transplanting, drum seeding and broadcasting) with three nitrogen levels (120,160 and 200 kg ha^{-1}) to evaluate suitable establishment method to ensure timely planting with optimum age of seedlings with matching quantity of nitrogen requirement to rice crop to enhance grain production. The results indicated that machine transplanting found significantly higher grain yield(5345 kg ha^{-1}), straw yield(6305 kg ha^{-1}) and total N, P, K uptake of 121, 21.91, 104 kg ha^{-1}, respectively over other establishment methods. Among different nitrogen levels 160 kg N ha^{-1} recorded significantly higher grain yield (4838 kg ha^{-1}), straw yield(6109 kg ha^{-1}) and total N, P, K uptake of 121, 20.09, 98 kg ha^{-1}, respectively over 120 and 200 kg N ha^{-1}. The grain yield, straw yield, total N, P, K and micronutrients uptake (Zn, Cu, Fe and Mn) were found higher by machine transplanting combined with 160 kg N ha^{-1} over rest of establishment methods with nitrogen levels. The net income (Rs.64, 587) as well as B:C ratio (3.1:1) was maximum with machine transplanting closely followed by broadcasting (1:3.0).

***Keywords*:** Establishment methods, grain yield, nitrogen levels and nutrients uptake

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). 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 in an area of 44.1m ha with a production of 106.70 million t. with a productivity of 2.42 t ha^{-1}. In Telangana, rice is also the principal food crop cultivated throughout the state. The crop is cultivated in an area of about 1.91m ha with an annual production of 6.26 mt. and productivity of 3.19 t ha^{-1} (Statistical year book, 2018). In all rice growing areas there is an acute shortage of human labour and high wage rate during transplanting period due to diversion of labour to non agricultural sectors. In the context of acute labour shortage, the traditional method of manual transplanting becomes rather difficult to ensure timely planting with optimum age of seedlings, resulting in delay of transplanting, reduced yield and lesser profit. To overcome these difficulties in manual transplanting it can be substituted by direct seeding with drum seeder, broadcasting and machine transplanting and assuming that the nitrogen is the major nutrient limiting the higher yield potential of rice cultivars under these systems. Hence, precise N application based on crop need helps in improving the yield and reduces the N losses. Under different establishment methods the optimum nitrogen requirement of rice can be achieved by applying matching quantity of nitrogen dose to the crop.

MATERIALS AND METHODS

A research experiment was conducted during *kharif*-2015, 2016 and 2017 at the Regional Agricultural Research Station, Warangal, located at 18^0 01.077' N latitude 79^0 36.197' E longitudes and an altitude of 259 m above mean sea level to study the effect of nitrogen levels on yield and nutrients uptake of rice under different establishment methods. A composite soil sample was collected from 0-20 cm depth during the study, processed and analysed for pH, electrical conductivity (EC), organic carbon (OC), available nitrogen, phosphorus, potassium, zinc, copper, iron and manganese by following standard procedures. The experiment was laid out in split-plot design with 12 treatments replicated three times.

Rice (RNR-15048) was sown during third week of July, transplanted in third week of August in conventional transplanting, for machine transplanting nursery sowing

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was done in first week of August and for drum seeding and broadcasting seed soaked for 24 hours and incubated for 24 hours earlier to sowing. All the four systems (machine transplanting, manual transplanting, drum seeding and broad casting) transplanted in main field in third week of August. The crop was maintained weed free, pest free and harvested at 125 days after sowing. The grain and straw samples were collected at harvest, oven dried at 70^0C, processed and analysed for content of N, P, K, Zn, Cu, Fe and Mn by following standard procedures.

RESULTS AND DISCUSSION

The experimental soil was clayey 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^{-1}), higher in available phosphorus (68 kg ha^{-1}), medium in available potassium (235 kg ha^{-1}) and available Zn, Cu, Fe and Mn were 0.66, 1.38, 11.48 and 3.56 mg kg^{-1}, respectively.

Machine transplanting recorded significantly higher grain yields i.e. 5721, 5741, 4573 and 5345 kg ha^{-1}, over other establishment methods in *kharif*-2015, 2016, 2017 and in pooled analysis, respectively (Table 1). Early transplanting and sufficient space in machine transplanting leads to development of large and functional root system helps in optimum utilization of resources (Land, water, energy and nutrients) which leads better vegetative growth, dry matter accumulation and effective partitioning to the panicles which resulted in more number of panicles m^{-2} and grains per panicle had direct bearing on production of higher grain yield of rice per unit area over other establishment methods. The increase in grain yield of rice in machine transplanting was also reported by Revathi *et al.* (2016). Among different nitrogen levels 160 kg N ha^{-1} recorded significantly higher grain yield i.e.5175, 5184, 4190 and 4850 kg ha^{-1} than 120 kg N ha^{-1} (4984, 4793, 3459 and 4412 kg ha^{-1}), though at par with 200 kg N ha^{-1} in *kharif*-2015, 2016, 2017 and in pooled analysis, respectively. Higher grain yield with higher nitrogen level might be due to increased nitrogen availability in soil leads to more absorption by the plant which is responsible for profused tillering, higher growth rate, higher values of growth parameters like number of panicles m^{-2}, total number of

Table 1: Grain and straw yield of *kharif* rice as influenced by N- levels under different establishment methods

Treatments	Grain yield (kg ha^{-1})				Straw yield (kg ha^{-1})			
	2015	2016	2017	Pooled	2015	2016	2017	Pooled
Establishment methods								
Machine transplanting	5721	5741	4573	5345	6454	6072	6388	6305
Manual transplanting	5301	5324	4026	4884	6189	5987	5451	5876
Drum seeding	4768	4505	3901	4391	5516	5203	5276	5332
Broad casting	4557	4363	3072	3998	5334	5777	5058	5390
SEm (±)	**23**	**58**	**153**	**51**	**73**	**127**	**231**	**108**
LSD (0.05)	**78**	**198**	**529**	**176**	**253**	**438**	**797**	**373**
Nitrogen levels (kg ha^{-1})								
120	4984	4793	3459	4412	5527	5355	4971	5284
160	5175	5184	4190	4850	5920	5741	5674	5778
200	5101	4973	4031	4702	6174	6184	5985	6114
SEm (±)	**50**	**29**	**63**	**30**	**41**	**83**	**118**	**52**
LSD (0.05)	**151**	**88**	**189**	**91**	**124**	**250**	**355**	**155**
Interactions								
Nitrogen levels under same establishment methods								
SEm (±)	**39**	**100**	**266**	**88**	**127**	**220**	**400**	**187**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Establishment methods under same nitrogen levels								
SEm (±)	**85**	**75**	**185**	**71**	**100**	**186**	**301**	**137**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 2: Total nitrogen and phosphorus uptake by *kharif* rice as influenced by different nitrogen levels under different establishment methods

Treatments	Nitrogen uptake (kg ha^{-1})				Phosphorus uptake (kg ha^{-1})			
	2015	2016	2017	Pooled	2015	2016	2017	Pooled
Establishment methods								
Machine transplanting	134	118	111	121	21.40	22.84	19.07	21.10
Manual transplanting	132	113	88	111	20.64	21.93	17.76	20.11
Drum seeding	116	112	88	105	18.65	18.13	16.21	17.66
Broad casting	112	102	74	97	16.50	17.87	13.08	15.81
SEm (±)	**3.5**	**1.8**	**4.0**	**3.0**	**0.80**	**0.36**	**0.99**	**0.32**
LSD (0.05)	**12.0**	**6.0**	**14.0**	**9.0**	**2.75**	**1.25**	**3.40**	**1.10**
Nitrogen levels (kg ha^{-1})								
120	106	98	77	94	18.56	19.08	15.39	17.67
160	142	122	99	121	20.11	20.94	18.48	19.84
200	122	114	95	111	19.23	20.56	15.72	18.50
SEm (±)	**1.8**	**1.3**	**3.2**	**2.0**	**0.53**	**0.27**	**0.73**	**0.33**
LSD (0.05)	**5.0**	**4.0**	**10.0**	**5.0**	**NS**	**0.71**	**2.20**	**0.98**
Interactions								
Nitrogen levels under same establishment methods								
SEm (±)	**6.0**	**3.0**	**6.9**	**5.0**	**1.38**	**0.63**	**1.71**	**0.55**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Establishment methods under same nitrogen levels								
SEm (±)	**4.5**	**2.8**	**6.6**	**4.0**	**1.20**	**0.53**	**1.55**	**0.62**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

filled grains panicle^{-1}, test weight and dry matter accumulation etc. which might have resulted in higher capture of solar energy and hence led to enhanced values of yield attributing characters that ultimately resulted in higher grain yield. Similar trend of grain yields with 160kg N ha^{-1} were also reported by Ghansham *et al.* (2015) and Pramanik *et al.* (2013). Increase in yield attributes was associated with better nutrition, plant growth and increased nutrient uptake (Kumar and Rao, 1992; Thakur, 1993).

The grain yield was not significantly influenced by interaction effect between establishment methods and nitrogen levels.

Significantly higher straw yields of 6454, 6072, 6388 and 6305 kg ha^{-1}, were recorded in *kharif*-2015, 2016, 2017 and in pooled analysis, respectively by the machine transplanting over other establishment methods (Table 1). Higher straw yield with machine transplanting might be due to higher values of growth parameters like number of tillers, panicles and dry matter accumulation etc. which might have resulted in higher capture of solar energy and hence led to enhanced values of yield attributing characters that ultimately resulted in higher straw yield. Higher grain yields recorded with machine transplanting was also reported by Sathish *et al.* (2016). Among different nitrogen levels, 200 kg N ha^{-1} found significantly higher straw yield of 6174, 6184, 5985 and 6114 kg ha^{-1} in *kharif*-2015, 2016, 2017 and in pooled analysis, respectively over 120 and 160 kg N ha^{-1}. More dry matter accumulation at 200 kg N ha^{-1} might be due to increased nitrogen availability in soil leads to more absorption of nitrogen by plants responsible for profused tillering and higher growth rate. Higher straw yields with 200 kg N ha^{-1} was also reported by Ghansham *et al.* (2015) and Pramanik *et al.* (2013).

Straw yield was not significantly influenced by interaction effect between establishment methods and nitrogen levels.

Machine transplanting gave significantly higher total nitrogen uptake i.e.134, 118, 111 and 121 kg ha^{-1} in *kharif*-2015, 2016, 2017 and in pooled analysis, respectively over other establishment methods (Table 2). The uptake of nutrient is a product of dry matter accumulation and nutrient concentration. The higher total nitrogen uptake by machine transplanting might be attributed to higher grain and straw yield thus have removed more nitrogen compared to remains this was in conformity with Revathi *et al.* (2016) and Sathish

Table 3: Total potassium uptake (kg ha^{-1}) by *kharif* rice as influenced by different nitrogen levels under different establishment methods

Treatments	2015	2016	2017	Pooled
Establishment methods				
Machine transplanting	98	83	130	103
Manual transplanting	89	81	114	95
Drum seeding	78	71	105	85
Broad casting	78	74	97	83
SEm (±)	**2.6**	**3.2**	**5.0**	**2.6**
LSD (0.05)	**9.0**	**11.1**	**18.0**	**9.0**
Nitrogen levels (kg ha^{-1})				
120	81	72	100	84
160	90	83	121	98
200	87	77	114	93
SEm (±)	**2.6**	**1.7**	**3.0**	**1.4**
LSD (0.05)	**6.5**	**5.1**	**8.0**	**4.0**
Interactions				
Nitrogen levels under same establishment methods				
SEm (±)	**4.5**	**5.6**	**9.0**	**4.6**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**
Establishment methods under same nitrogen levels				
SEm (±)	**5.0**	**4.3**	**7.0**	**3.5**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**

et al. (2016). Application of 160 kg N ha^{-1} shown significantly higher nitrogen uptake of 142, 122, 99 and 121 kg ha^{-1} in *kharif* 2015, 2016, 2017 and in pooled analysis, respectively over 120 and 200 kg N ha^{-1}. The higher nitrogen uptake with application of 160 kg N ha^{-1} by rice might be attributed to higher grain, straw and total (Grains + Straw) yield and nitrogen content. These results were supported by Revathi *et al.* (2016) and in contrast to the findings of Payman *et al.* (2015) where maximum total nitrogen uptake was recorded by the 200 kg N ha^{-1} followed by 160 kg N ha^{-1}.

The total nitrogen uptake was not significantly influenced by interaction effect between establishment methods and nitrogen levels.

Significantly higher total phosphorus uptake of 21.40, 22.84, 19.07 and 21.10 kg ha^{-1} were recorded by machine transplanting in *kharif*-2015, 2016, 2017 and in pooled analysis, respectively over drum seeding and broadcasting and it was at par with manual transplanting method (Table 2). The uptake of nutrient is a product of dry matter accumulation and nutrient concentration. The higher total phosphorus uptake by machine transplanting might be attributed to higher grain and straw yield thus have removed more phosphorus compared to remains. The similar trend of higher phosphorus uptake in machine transplanting was observed by Revathi *et al.* (2016) and Sathish *et al.* (2016). Among different nitrogen levels, application of 160 kg N ha^{-1} recorded non significantly higher P-uptake (20.11 kg ha^{-1}) over the 120 and 200 kg N ha^{-1} in *kharif*-2015 and significantly higher P-uptake of 20.94, 18.48 and 19.84 kg ha^{-1} were found in 2016, 2017 and in pooled analysis, respectively over the 120 kg N ha^{-1} and it is at par with 200 kg N ha^{-1}. The higher phosphorus uptake with application of 160 kg N ha^{-1} may have directly related to the higher grain and straw yield. Similar results were also reported by Payman *et al.* (2015).

The total phosphorus uptake was not significantly influenced by interaction effect between establishment methods and nitrogen levels.

Non significantly higher total Zn uptake of 660, 650, 229 and 513 g ha^{-1}, were recorded by machine transplanting and lower Zn uptake of 586, 614, 208 and 469 g ha^{-1} were recorded by broad casting in *kharif*-2015, 2016, 2017 and in pooled analysis, respectively(Table 4). Similarly, non significantly higher total Zn uptake of 644, 650, 235 and 510 g ha^{-1} were found by the application of 160 kg N ha^{-1} and lower total Zn uptake of 618, 614, 213 and 482 g ha^{-1} were found by the application of 120 kg N ha^{-1} in *kharif*-2015, 2016, 2017 and in pooled analysis, respectively.

Table 4: Total zinc and copper uptake by *kharif* rice as influenced by different nitrogen levels under different establishment methods

Treatments	Total Zn uptake(g ha^{-1})				Total Cu uptake(g ha^{-1})			
	2015	2016	2017	Pooled	2015	2016	2017	Pooled
Establishment methods								
Machine transplanting	660	650	229	513	198	193	57	149
Manual transplanting	648	649	226	508	190	184	46	140
Drum seeding	626	616	224	489	188	181	55	141
Broad casting	586	614	208	469	186	178	49	138
SEm (±)	**16**	**20**	**20**	**11**	**4.42**	**4.89**	**2.4**	**3.0**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Nitrogen levels (kg ha^{-1})								
120	618	614	213	482	184	178	48	137
160	644	650	235	510	197	190	57	148
200	628	632	218	493	190	184	50	141
SEm (±)	**9.0**	**11.0**	**9.0**	**7.0**	**2.57**	**2.70**	**1.60**	**2.00**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Interactions								
Nitrogen levels under same establishment methods								
SEm (±)	**28**	**35**	**34**	**20**	**7.65**	**8.48**	**4.13**	**5.00**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Establishment methods under same nitrogen levels								
SEm (±)	**22**	**27**	**25**	**16**	**6.09**	**6.59**	**3.60**	**4.00**
LSD (0.05)	**NS**	NS	NS	NS	**NS**	**NS**	**NS**	**NS**

The total Zn uptake was not significantly influenced by interaction effect between establishment methods and nitrogen levels.

Machine transplanting recorded non significantly higher total Cu uptake of 198, 193, 57 and 149 g ha^{-1} and lower Cu uptake of 186, 178, 49 and 138 g ha^{-1} were recorded by broad casting in *kharif*-2015, 2016, 2017 and in pooled analysis, respectively (Table 4). Non significantly higher total copper uptake of 197, 190, 56 and 148 g ha^{-1} were recorded by the application of 160 kg N ha^{-1} and lower total Cu uptake of 184, 178, 48 and 137 g ha^{-1} were found by the application of 120 kg N ha^{-1} in *kharif*-2015, 2016, 2017 and in pooled analysis, respectively.

The total Cu uptake was not significantly influenced by interaction effect between establishment methods and nitrogen levels.

Non significantly higher total iron uptake of 1901, 1975, 1601 and 1826 g ha^{-1} were found by machine transplanting and lower iron uptake of 1629, 1683, 1349 and 1554 g ha^{-1} were recorded by broad casting in *kharif*-2015, 2016, 2017 and in pooled analysis, respectively (Table 5). Application of 160 kg N ha^{-1} found higher total iron uptake of 1882, 1892, 1547 and 1773 g ha^{-1} and lower iron uptake of 1737, 1766, 1415 and 1639 g ha^{-1} were recorded by 120 kg N ha^{-1} in *kharif*-2015, 2016, 2017 and in pooled analysis, respectively.

The total iron uptake was not significantly influenced by interaction effect between establishment methods and nitrogen levels.

Among different establishment methods machine transplanting found non significantly higher total Mn uptake of 2044, 2027, 1467 and 1846 g ha^{-1} and lower uptake of 1607, 1696, 1096 and 1466 g ha^{-1} were recorded by broad casting in *kharif*-2015, 2016, 2017 and in pooled analysis, respectively(Table 5). Among different nitrogen levels non significantly higher total Mn uptake of 1883, 1899, 1311 and 1697 g ha^{-1} were found by the application of 160 kg N ha^{-1} and lower Mn uptake of 1715, 1803, 1214 and 1577 g ha^{-1} by 120 kg N ha^{-1} in *kharif*-2015, 2016, 2017 and in pooled analysis, respectively.

The total Mn uptake was not significantly influenced by interaction effect between establishment methods and nitrogen levels.

Table 5: Total iron and manganese uptake by *kharif* rice as influenced by different nitrogen levels under different establishment methods

Treatments	Total iron uptake(g ha^{-1})				Total manganese uptake(g ha^{-1})			
	2015	2016	2017	Pooled	2015	2016	2017	Pooled
Establishment methods								
Machine transplanting	1901	1975	1601	1826	2044	2027	1467	1846
Manual transplanting	1787	1932	1446	1722	1827	1944	1301	1691
Drum seeding	1845	1734	1482	1687	1682	1785	1159	1542
Broad casting	1629	1683	1349	1554	1607	1696	1096	1466
SEm (±)	**21**	**70**	**111**	**50**	**28**	**53**	**125**	**32**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Nitrogen levels (kg ha^{-1})								
120	1737	1766	1415	1639	1715	1803	1214	1577
160	1882	1892	1547	1774	1883	1899	1311	1698
200	1753	1836	1448	1679	1773	1888	1243	1635
SEm (±)	**24**	**48**	**103**	**40**	**23**	**28**	**74**	**23**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Interactions								
Nitrogen levels under same establishment methods								
SEm (±)	**36**	**121**	**191**	**86**	**49**	**92**	**217**	**56**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Establishment methods under same nitrogen levels								
SEm (±)	**45**	**105**	**201**	**82**	**47**	**70**	**174**	**49**
LSD (0.05)	**NS**	NS	NS	NS	**NS**	**NS**	**NS**	**NS**

The uptake of nutrient is a product of dry matter accumulation and nutrient concentration. The higher total Zn, Cu, Fe and Mn uptake by machine transplanting and application of 160 kg N ha^{-1} might be attributed to higher grain and straw yield thus have removed more Zn, Cu, Fe and Mn compared to remains.

Lowest cost of cultivation (Rs.26,450) was recorded with broad casting closely higher (Rs.26,950) was recorded with drum seeding. The cost of cultivation is high in conventional as well as machine transplanting due to nursery raising and more involvement of human labour. The net income (Rs.64,587) as well as return per rupee invested (1:3.1) is maximum with machine transplanting closely followed by broadcasting (1:30). The higher yield recorded with machine transplanting was the main reason for higher benefit cost ratio though the cost of cultivation was little bit higher than the drum seeding and broadcasting (Table 6).

It can be concluded from the pooled results that the different establishment methods experienced in puddle rice machine transplanting proved to be best with 9.40% higher grain yield and 7.30% higher in straw yield and higher total N, P, K and micronutrients (Zn, Cu, Fe and Mn) uptake over manual transplanting. In medium available nitrogen soils enhancing nitrogen from 120 to 160 kg ha^{-1} significantly improved grain, straw yields

Table 6 : Effect of different establishment methods and nitrogen levels on economics of rice (Pooled)

Establishment methods (A)	Grain Yield (kg ha^{-1})	Cost of cultivation (Rs.ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs.ha^{-1})	Benefit: Cost ratio
MT	6305	29988	94575	64587	3.1:1
CT	5876	32338	88140	55802	2.7:1
DS	5332	26950	79980	53030	2.9:1
BC	5390	26450	80850	54400	3.0:1

MT: Machine Transplanting, CT: Conventional Transplanting, DS: Drum Seeding, BC: Broad Casting

and total N, P, K uptake and non significantly higher higher micronutrients (Zn, Cu, Fe and Mn) uptake were observed. The results indicated that increasing of nitrogen is required (160 kg ha^{-1}) than the present recommendation (120 kg ha^{-1}) in machine transplanting for Central Telangana Zone of Telangana state.

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