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Evaluation of different crop establishment techniques and nitrogen levels on the performance of growth, phenology and yield of *Kharif* season rice (*Oryza sativa* L.)

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Abstract
A field experiment was conducted at Agronomy Research farm, College of Agriculture, N.D. University of Agriculture and technology, Kumarganj, Faizabad, U.P. during *kharif* season of 2016 to find out the best crop establishment technique and the optimum nitrogen dose for rice. During the experiment, common packages of practices were followed time to time and periodically are observations were recorded on growth and yield for evaluate the treatment effects. The results obtained during the study revealed that grain yield of the different establishment techniques were in the order, SRI (52.14 q ha^{-1}) being at par to transplanting (45.43 q ha^{-1}) while lowest yield obtained under direct seeding method (36.82 q ha^{-1}). The highest plant height (86.14 cm), number of effective tillers (464.40 m^{-2}), leaf area index (4.19), dry matter accumulation (1027.5 g), days taken to 50 % flowering (81.20) and maturity (135.51) and B:C ratio (M_2N_4 - 1:2.10) were recorded in SRI technique except initial plant population which was under direct seeding. Based on the results obtained, it can be concluded that in areas where labour is available and cheap, SRI technique is a better establishment method of rice because it produces more yield and gross monetary economic return than other methods.

Keywords: SRI, direct seeding, transplanting, nitrogen and yield

Introduction
Rice (*Oryza sativa* L, 2n = 24) is the principal food for more than 50% people and contributes about one-fifth to the total calories consumption of the world (Singh *et al*., 2012), belongs to the family Poaceae (Gramineae). Predictions indicate that world's rice production should increase from its present level of 520 million tons to 880 million tons in the year 2025 to meet the rice demand of the ever-increasing human population. Rice, being a staple food crop of India plays a vital role in food security system. It serves as major staple food for half of the world, considered as 'strategic' commodity in both developed and developing countries. Nearly half of the humanity is mainly grown and consumed in Asian. The method of establishment in rice largely affects the initial stand and uniformity. There are different methods of establishment *viz*., direct seeding, transplanting and SRI are adopted for the cultivation of rice. Among these methods, transplanting method most commonly used in different areas while direct seeding method is used in the areas where less water is available and frequent irrigation at proper interval is generally given to avoid yield loss. While SRI cultivation is visualized as a water saving system of cultivation. It is reported that the rice yields obtained in this method is more to the yields obtained under conventional system with 50% less water. Transplanting is the most popular method of lowland rice establishment in irrigated areas. Although, transplanting in rice is considered as best for higher productivity of crop, it is not much profitable due higher labour wages and problem of unavailability of labour during the peak period of operation. Some alternatives such as SRI and direct sowing of sprouted seeds under puddle condition must be explored to overcome these problems.
In recent years, the direct seeding method has been promoted as a replacement for transplanting to address this problem of labor scarcity and high water demand. The labor requirement of direct seeding is only about 34% that of transplanted rice (Ho Nai-Kin *et al*., 2002).
Direct seeding of rice is becoming a popular alternative to transplanting system as it reduces

labour requirement, cost of cultivation, shortens the duration of crop and provide comparable grain yield with transplanting (Sharma *et al.*, 2005) [12]. Muhammad Aamir Iqbal (2014) [8] observed that direct seeded rice result showed better growth and productivity due to the better utilization of environmental as well as soil resource base and found that this close planting pattern also suppresses the weed infestation which is the most notorious factor for reducing the quality and yield of rice.

The System of Rice Intensification (SRI) is a recent breakthrough in rice production technology. Rice is mainly grown by transplanting of seedling in puddle soil. It is reported that the rice yields obtained in this method is more to the yields obtained under conventional system and it require 50% less water. This is the most important feature, since the water table depletion has become a global phenomenon, which is sending alarming signals to rice growing countries.

The yield performance of lowland rice varieties depends on the methods of crop establishment. Published results are, however, inconsistent and yield of SRI method is generally believed to be higher than that of transplanted rice and dry-seeded rice. Chandrapala (2010) [1] reported that higher yield attributes and biological yield were observed with SRI establishment method when compared with direct sowing and transplanting method during wet season. Senthil (2015) reported that the crop establishment techniques, SRI machine planting significantly influenced the growth and yield characters and was on par with SRI square planting. The maximum plant height, number of tillers hills^{-1}, dry matter production, number of panicles m^{-2}, number of grains panicle^{-1}, panicle length, grain yield, straw yield, gross return, net return and benefit cost ratio were recorded higher under SRI machine planting during *Kharif* and *Rabi*. The lowest grain yield, straw yield, gross return, net return and B-C ratio were recorded under wet seeding during both *Kharif* and *Rabi*.

Nitrogen (N) is one of the most yield limiting nutrients for annual crops around the world and its efficient use is important for economic sustainability of cropping systems. In rice production, efficient use of N fertilizer is a critical factor in achieving high and stable yield, while minimizing negative effects to the environment (Tylaran *et al.* 2009) [19]. An adequate supply of nitrogen to the crop plants during their early growth period is very important for the initiation of leaves and florets primordia. Clearly, crop performance also depends on the way applied N fertilizers are managed in the field. This paper reports the results of a one-season study that was conducted to evaluate the crop establishment technique and nitrogen levels on the performance of rice.

Materials and Methods

A field experiment on ‘‘Evaluation of different crop establishment techniques and nitrogen levels on the performance of growth, phenology and yield attributes of kharif season rice (*Oryza sativa* L.)" was conducted during kharif 2016 at Agronomy Research Farm, Narendra Deva University of Agricultural and Technology, Kumarganj, Faizabad (U.P.). The experimental site was silt-loam in texture and slightly alkaline in reaction (8.10 pH), low in organic carbon (0.43%) and available nitrogen (160 kg ha^{-1}), medium in available phosphorus (16.5 kg ha^{-1}) and potassium (260 kg ha^{-1}). The experiment was laid out in split-plot design with three crop establishment techniques as main plot treatments *viz*., Conventional transplanting (M_1), SRI (M_2) and Direct seeding (M_3) and five nitrogen levels as sub-plot treatments *viz*., Control (N_0), 40 kg N ha^{-1} (N_1), 80 kg N ha^{-1} (N_2) and 120 (N_3) and 160 kg N ha^{-1} (N_4) and replicated thrice. The recommended dose of nitrogen as per recommendation, 60 kg P_2O_5 and 40 kg K_2O ha^{-1} was applied through urea, single super phosphate and murate of potash, respectively. Entire P_2O_5 and K_2O was applied basally to all the treatments duly taking into consideration of the phosphorus and potassium content of the organic manure. Nitrogen was applied as per the treatments in 3 split doses of 50% basal and 25% each at active tillering and panicle initiation stages, respectively.

Results and Discussion

(A) Growth parameters

1) Initial plant population (m-^{2}): Initial plant population was significantly influenced by various techniques of crop establishment at 20 DAS/ DAT of crop growth. The highest IPP was obtained by direct seeding (136.87), due to the fact that direct seeding method required more seed rate than other methods as well as spacing is also lower than other methods, leading to greater initial plant population. Increasing level of nitrogen did not affect of the initial plant population taken at 20 DAS/ DAT due to same atmospheric condition. This was because the germination totally depends on moisture and varietal germinability (Kumar, 1985) [5].

2) Plant height (cm): Plant height was significantly affected by at 5 per cent probability level by different crop establishment techniques and nitrogen levels. Maximum plant height was recorded under SRI (86.14 cm) being at par with conventional transplanting (81.10) while lowest plant height obtained under direct seeding (75.95 cm). Tallest plants in SRI method might be due to the fact that, the plant gets sufficient space above the ground (shoot) and bellow the ground (root) to grow well as the increased light transmission in the canopy and easier cultural operation was carried out in the field, leading to the greater plant height (Shrirame *et al.*, 2000) [13]. Maximum plant height (89.26 cm) was recorded under 160 kg N ha^{-1} at all the crop growth stages, which was mainly due to enhanced availability of nitrogen which enhanced more leaf area resulting in higher photo assimilates and thereby resulted in more dry matter accumulation. The effect of nitrogen in the improvement of plant height can be explained by the fact that nitrogen is the main growth promoter element and helps for more synthesis of food resulting into greater cell division and cell enlargement (Meena *et al*., 2003) [7].

3) Effective tillers (cm): Number of effective tillers was influenced significantly by different crop establishment techniques and levels of nitrogen. The SRI recorded significantly highest effective panicle (464.40 m^{-2}) on par with conventional transplanting (419.72 m^{-2}) while lowest under direct seeding (380.17 m^{-2}). This was probably due to proper utilization of all the available and terrestrial growth resources which may be better translocation of photosynthetic from source to sink which may result higher yield attributes under SRI. Similar results have also been reported by Pandey Nissanka and Bandara (2004) [9]. The number of tillers (431.30m^{-2}) was significantly highest under treatment (N_4) 160 kg N ha^{-1} being at par to 120 & 80 kg N ha^{-1} while lowest under control. The increasing number of tillers with increasing levels of nitrogen may be attributed to the fact that nitrogen seems to have played a vital role in the formation of new tissues which are dependent on the protoplasmic structure, cell division and cell elongation. Similar results have also been reported by Pandey *et al*. (2001) [10] and Meena *et al*. (2003) [7].

4) Leaf area index (LAI): The different techniques of crop establishment and nitrogen levels had significant effect on leaf area index. At 90 DAS/ DAT maximum leaf area index (4.19) was recorded under SRI being at par with conventional transplanting method (4.02) while lowest LAI under direct seeding method (3.54). In SRI, this may be due to increased rate of light absorption, high photosynthetic activities and increased absorption of nutrients from the soil. At 90 DAS/ DAT maximum leaf area index was obtained under 160 kg N ha^{-1} (N_4) being at par with 120 kg N ha^{-1} (N_3) while lowest LAI was recorded with control (0 kg N ha^{-1}). It was possibly due to the poor plant height, less number of leaves, low rate of light absorption, low photosynthetic activities and low absorption of nutrients from the soil.

5) Dry matter (g m^{-2}): Dry matter was influenced significantly by different crop establishment techniques and nitrogen levels. The SRI method recorded significantly higher dry matter production (1027.50 g m^{-2}) being at par with conventional transplanting (984.46 g m^{-2}) while lowest dry matter under direct seeding (803.09 g m^{-2}). Crop dry matter is directly proportion to total biological yield. This might be due to higher collective contribution of various growth characters like plant height, number of shoot, leaf area index and yield of vegetative part. Similar findings were reported by Singh and Seth (1979) [15], Singh and Mishra (1980) [14]. 160 kg N ha^{-1} (N_4) produced significantly higher dry matter (1453.46 g m^{-2}) being at par with 120 kg N ha^{-1} (N_3) while lowest dry matter under control (N_0). This was due to more assimilation and utilization of available nitrogen by the growing plants during the entire grand growth period. Similar results were reported by earlier workers Meena *et al*. (2003) [7].

(B) Phenological attributes

1) Days taken to 50 % flowering: Various techniques of crop establishment and nitrogen levels had significant effect on days taken to 50% panicle emergence. The highest days (81.2) were taken to 50% panicle emergence under SRI (M_2) and lowest days (76.34) were taken under direct seeding method (M_3). Gill *et al.* (2014) also observed that direct seeded rice reduced time by shorten crop duration by 7–10 days than transplanted rice. The maximum days (84.11) were taken to 50% panicle emergence under 160 kg N ha^{-1} (N_4) and minimum days (70.18) were taken under control (N_0). Increasing nitrogen levels increased the days taken to 50 % panicle emergence and maturity of crop. This might be due to more amount of nitrogen, which prolonged the vegetative phase of crop.

2) Days taken to maturity: Different techniques of crop establishment and nitrogen levels had significant effect on days taken to maturity. The highest days (135.51) were taken to maturity under SRI (M2) and lowest days (130.10) were taken under direct seeding method (M3). Various nitrogen levels had significant effect on days taken to maturity. The maximum days (138.85) were taken to maturity under 160 kg N ha^{-1} (N_4) and minimum days (123.08) were taken under control (N_0). Increasing nitrogen levels increased the days taken to maturity of crop. This might be due to more amount of nitrogen, which prolonged the vegetative phase of crop.

(C) Yield

i) Grain yield (q ha^{-1}): Grain yield is the most important parameter used for the evaluation and the effectiveness of any treatment because grain production is the ultimate objective of experiment in cereal crops. Maximum grain yield (52.14 q ha^{-1}) was recorded with SRI method (M_2) while the grain yield was lowest with direct seeding method (36.82 q ha^{-1}). Higher yield under SRI method was due to better crop growth and development resulting in to higher value of yield attributes which had direct bearing on the grain yield. Higher number of panicle per unit area, panicle size and filled grains percentage in case of SRI method as compared to other method of crop establishment might be responsible for superiority of this treatment over other in respect of grain yield. Similar results have been reported by Krishna *et al*. (2008). Grain yield was affected significantly due to different levels of nitrogen. The grain yield was obtained higher (51.25 q ha^{-1}) under N4 treatment (160 kg N ha^{-1}) while the lower grain yield (36.42 q ha^{-1}) was obtained under control. This may be due to adequate nitrogen availability which contributed to increase dry matter accumulation. Productivity of a crop is collectively determined by vigour of the vegetative growth, development as well as yield attributes which is the result of better translocation of photosynthates from source of leaves and stem to the grains. Similar results have been reported by Rao and Rao (2014) and Krishna *et al.* (2008).

ii) Straw yield (q ha^{-1}): Different crop establishment techniques and nitrogen levels had significantly affect the straw yield of crop. Higher straw yield was recorded under SRI method of crop establishment, probably due to greater dry matter production per unit area, caused by better nutrient absorption from the soil, and the increased rate of metabolic processes, higher light absorption and photosynthetic activity with more number of leaves (Yadhav and Singh, 2006) [18]. The lowest yield was recorded under direct seeding method due to lesser of effective tillers m^{-2} for available growth resources on account of heavy weed infestation. Higher straw yield was recorded under 160 kg N ha^{-1} while lowest straw yield under control. This may be probably due to higher density of tiller and increased rate of dry matter production. Similar findings were reported by Kumar and Singh (1998) [6].

Table 1: Growth, Phenology and yield parameters (*Oryza sativa* L.) as affected by different crop establishment techniques and different nitrogen levels.

Treatments	IPP at 20 DAS/DAT	Plant Height (cm)	Effective tillers (m^{-2})	Leaf area index	Dry matter (g m^{-2})	Phenological attributes (Days taken to)		Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest Index (%)
						50% flowering	Maturity			
Main plot- Methods of establishment										
Conventional transplanting	100	81.10	419.72	4.02	984.46	78.66	132.35	45.43	54.72	45.36
SRI	16.0	86.14	464.40	4.19	1027.5	81.20	135.51	52.14	61.42	45.91
Direct seeding	136.87	75.95	380.17	3.54	803.09	76.34	130.10	36.82	47.71	43.55
S. Em. ±	3.71	1.30	10.41	0.09	18.72	---	---	0.24	0.12	---
C. D. at 5 %	14.55	4.48	34.21	0.37	73.57	---	---	0.95	0.48	---
F- Test	Sig.	Sig.	Sig.	Sig.	Sig.	---	---	Sig.	Sig.	---

Sub plot- Nitrogen levels										
$N_0 – 0$	83.10	75.23	414.02	3.28	771.92	70.18	123.08	36.42	46.24	34.30
$N_1 – 40$	83.67	79.97	418.96	3.94	926.30	77.22	129.32	42..23	52.78	42.10
$N_2 – 80$	84.76	82.36	422.27	4.24	1003.5	80.30	133.45	45.58	54.29	45.16
N_3 -120	85.30	85.55	424.58	4.47	1050.7	82.58	137.37	47.65	56.32	45.83
N_4- 160	85.78	89.26	431.30	4.55	1071.1	84.11	138.50	51.25	60.23	45.97
S. Em. ±	0.83	1.2	3.52	0.08	21.98	---	---	0.21	0.22	---
C. D. at 5 %	2.47	3.58	10.98	0.29	64.98	---	---	0.61	0.64	---
F- Test	NS					---	---	Sig.	Sig.	---

Note:
- Days taken to 50 % flowering and maturity does not require statistical analysis.
- HI always having non – significant effect except different varieties.

(D) Harvest Index (%): Harvest index is the function of grain yield to the total biological yield (grain + straw). Harvest index influenced significantly due to different techniques of crop establishment and nitrogen levels. The higher harvest index was recorded under SRI method (45.91 %), due to higher grain yield of rice per unit biological yield, led higher harvest index while lowest with direct seeding. Similar findings have also been reported by Stoop (2005) [17] and Hussain *et al*. (2003) [3]. Harvest index also influenced significantly due to different nitrogen levels. The higher harvest index was recorded with 160 kg N ha^{-1} (45.97 %), due to higher grain yield of rice per unit biological yield, led higher harvest index.

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