The Pharma Innovation Journal 2018; 7(4): 904-907

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2018; 7(4): 904-907

www.thepharmajournal.com
Received: 11-02-2018
Accepted: 15-03-2018

K Dileep
College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneshwar, Odisha, India

S Pasupalak
College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneshwar, Odisha, India

A Baliarsingh
College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneshwar, Odisha, India

Correspondence
K Dileep
College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneshwar, Odisha, India

Effect of establishment methods and sowing time on growth and yield of rice varieties (*Oryza sativa* L.)

K Dileep, S Pasupalak and A Baliarsingh

Abstract
A study was conducted to evaluate the effect of establishment methods and microclimate on growth and yield of rice varieties (*Oryza sativa* L.) was carried out during kharif season 2016 at the research farm of College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar. It was laid out in a Split-Split Plot design, replicated thrice with three establishment methods (M1- Direct Seeding, M2-Unpuddled transplanting, and M3-Puddled transplanting) as main plot treatments, two dates of sowing (D1-17th June and D2-26th June) as sub plots and two varieties (V1-Naveen and V2-Pooja) as Sub-Sub plot treatments. The leaf area index (LAI) increased progressively upto panicle initiation stage there after decreased gradually and influenced by different rice establishment methods, dates of sowing and the rice cultivars. All the yield attributing characters i.e. number of panicles m^{-2}, number of grains $panicle^{-1}$and 1000 grain weight were more in plants planted after puddling than the unpuddled transplanting and direct seeding. The treatment also produced maximum grain yield (3879 kg ha-1) with HI value of (61.52).

Keywords: Establishment methods, sowing time, variety, growth parameter and yield

1. Introduction
Rice is the staple food of over half the world's population and a vital nutritional source for rural poor of most of the countries in the world providing 20% of their dietary energy. The demand of rice as staple food for about 3 billion people is expected to increase further with increase in population. In India it occupies an area of 43.13 m ha producing 104.5 mt with an average productivity 2.39 t ha-1. Odisha occupies an area of 4.17 m ha producing 8.29 mt with an average productivity of 1.98 t ha^{-1}. (Directorate of Economics & Statistics, DAC &FW, 2014-15) [4].
Transplanting in puddled soil is the most dominant and traditional method of rice establishment in irrigated low land. Puddling, the typical pre planting management practice, is done to reduce water infiltration and to maintain the standing water in the field, which also helps in weed management and facilitates easier transplanting (Sharma and De data, 1986).
Under the context of looming water, labour scarcity and deteriorated soil structure due to puddling, there is an urgent need to replace conventional transplanting method of rice with non-puddled transplanting (NPTR) or direct seeding (DSR). DSR saves water and labour (by avoiding puddling of soil, nursery management and planting operation), shortens crop duration by 7 to 10 days and can produce as much grain yield as that of transplanted crop with only 34% of the total labour requirement it saves 29% of the total cost of the transplanted crops (Ho and Romil,2000).
A study was conducted to evaluate the effect of establishment methods and sowing time on growth and yield of rice varieties (*Oryza sativa* L.) was carried out during kharif season 2015 and 16 at the research farm of College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar.

2. Materials and Methods
The field experiment was conducted during Kharif season of 2015 and 2016 to find out the growth, development and yield of two rice cultivars (Naveen and Pooja) under two dates of Sowing(19th June and 26th June) as three establishment methods (Direct seeding, unpuddled transplanting, puddled transplanting).
The experiment was laid out in a Split-Split plot Deign with establishment methods in main plots, dates of sowing and sub plot varieties as sub-sub plot treatment. The experimental plot was provided with irrigation channels as shown in the layout plan and the individual plots were demarcated with bunds.

There were 12 treatment combinations consisting of three establishment methods viz., M1- Line sowing (direct seeded); M2- Transplanting (unpuddled); M3-Transplanting (puddled), two dates of sowing viz., D1– 17th June and D2 – 26th June and two rice varieties (V1- Naveen, V2 - Pooja) and three Replication (R1, R2, R3).

3. Results and Discussion

3. Growth Parameters

3.1 Plant height

The rice establishment methods, sowing time and rice genotypes influenced the plant height (Table 1) at all the growth stages. At maturity stage tallest plants were noticed in puddled transplanted crops (113.4 cm) and shortest in direct seeded (95.1 cm) crop in all the crop growth stages. *cv.* Naveen (103.2 cm) was tallest throughout the growth stages of crops than rice *cv.* Pooja (95.3 cm). Crop sown on D1 was shorter (100.0 cm) than sown on D2 (103.5 cm). Interaction effects were not significant. Similar results were obtained by Aslam *et al.* (2008) [1] and Birhane *et al.* (2013) [3], that conventionally transplanted crop were taller than direct seeded plants.

3.2 Number of leaves per square meter

The total number of green leaves per square meter increased up to panicle initiation stage and after there decreased gradually up to maturity in all the treatments imposed on rice plants (Table. 1). Significant differences in total leaves per square meter were noticed in different planting methods, dates of planting and rice genotypes, but interaction effects were not significant. The maximum number of total leaves per square meter was observed in puddled transplanted crop (2120) and minimum in direct seeded (1548) paddy crops. In unpuddled transplanted number of leaves were 1753 per square meter. At panicle initiation stage early planted (17th June) crops registered more number of green leaves (1868) than late planting on 26th June (1745). The rice cultivar Pooja (1897) was leafy with more number of leaves per square meter than Naveen (1716).

3.3 Leaf Area Index (LAI)

It was influenced significantly by different rice establishment methods, dates of sowing and the rice genotypes but interaction effects were not significant. (Table 1) Among the three different planting methods maximum leaf area index (LAI) occurred in puddled transplanted rice plants (2.83) followed by unpuddled (2.19) and direct seeded (1.93) ones. Baloach *et al*. (2006) also reported similarly. Higher LAI values noticed in cv. Pooja (2.70) than cv. Naveen (1.93). Crop planted on D1 had more LAI (2.42) than D2 (2.22). Interaction effects were not significant.

3.4 Number of Tillers per square meter

The total number of tillers per square meter was influenced significantly by different rice establishment methods, date of showing and rice genotypes at all the growths stages (Table. 1). The maximum number of tillers was observed in puddled rice (431) as compared to unpuddled (358) and direct seeding (334) at all the crop growth stages. Similarly the early planted crop (17th June) recorded more number of tillers (383) than that with later planting crop (366).The rice cv. Pooja produced more number of tillers (430) in comparison with cv. Naveen (318). The results are in close conformity with Birhane (2013) [3], who also found highly significant difference in number of effective tiller plant^{-1} due to variety, method of planting and their interaction.

3.5 Total dry matter per square meter

The total dry matter production per square meter varied significantly in both the rice genotypes under different methods of rice establishment and dates of sowing (Table 1). The maximum dry matter accumulation was in puddled transplanted paddy (2200.5 g) and minimum in direct seeded paddy (1886.6 g), throughout the crop growth stages. Among the rice genotypes the cv. Pooja produced relatively produced higher dry matter (2282.1 g) than cv. Naveen (1767.3 g) in both the dates of planting and the early planted crop (2060.2 g) registered higher dry matter production than with later planting on 26th June (1989.3 g). Interaction effect was not significant. The increase in dry matter upto maturity also reported by AICRPAM, 1997.

Table 1: Growth of rice varieties affected by different establishment methods, sowing time and varieties

Treatments	Plant height (cm)	No. of leaves per m^2	No. of Tillers per m^2	Total dry matter (g) per m^2	LAI
Management					
M1	95.1	1191	321	1886.6	0.690
M2	100.2	1311	343	1987.1	1.000
M3	113.4	1442	417	2200.5	1.128
SEm+	1.3	32.1	7.05	27.5	0.021
CD (0.05)	4.9	101.2	22.2	86.6	0.065
CV	11.0	11.4	10.7	14.7	12.64
Date of sowing					
D1	100.0	1342	372	2060.2	0.989
D2	103.5	1286	349	1989.3	0.889
SEm+	0.2	26.2	5.7	22.4	0.021
CD (0.05)	2.7	82.6	18.1	70.7	0.065
Variety					
V1	103.2	1226	302	1767.3	1.1147
V2	95.3	1403	419	2282.1	0.7640
SEm+	1.3	18.5	5.06	22.3	0.025
CD (0.05)	6.0	57.2	15.6	68.8	0.077
CV	11.3	12.9	10.9	14.6	11.305

4. Yield and Yield Parameters

4.1 Number of Panicles per square meter

Total number of panicle per square meter differed significantly among different rice establishment methods and dates of sowing and rice cultivars (Table 2). The maximum number of panicles (366) were noticed in puddled transplanted paddy which was higher than in unpuddled transplanted (351) and direct seeded paddy (328). Early sown crop registered more number of panicles (355) than the crop planted on 26th June (342). Cultivar Pooja produced more number of panicles (408) than cultivar Naveen (289). Baloch *et al*. (2006) observed similarly in that planting methods had pronounced effect on number of panicles with more panicles (363.2 and 425.8 m^{-2}) under transplanting during both the years of experimentation. Back *et al*. (1998) [2] also observed that panicle and spikelet numbers m^2 were greater with early sowing.

4.2 Number of filled grains per panicle

There was no significant variation among different planting methods (Table 2). However, dates of sowing and the rice genotypes influenced filled grain number. Early planting produced more number of filled grain (99) per panicle than late planting (88). Pooja has more grains per panicle (100) than Naveen (86). Yuan Ji Chao *et al*. (2004) [8] reported that, sowing date of rice not only had effects on the grain filling parameters, but also on the difference of grain filling parameters between the two cultivars and between superior and inferior spikelets.

4.3 Test weight (1000 grain weight)

The data on 1000 grain weight of two rice genotypes as influenced by various planting methods and dates of sowing are presented in the Table 2. It clearly indicated that heavier grains (23.1 g/1000 grain) were recorded from puddled transplanted rice which was superior to other two planting methods. Among two dates of planting higher test weight was obtained in early planting than to the late planting. The grain weight was higher in cv. Pooja (23.6 g/1000 grains) than that in cv. Naveen (21.5 g/1000grain).). Interaction effects were not significant.

4.4 Grain yield (kg/ha)

The grain yield of rice is a function of total number of panicles, number of grains per panicle and the grain weight, which was significantly influenced by the planting methods, dates of sowing and the rice cultivars (Table 2). The transplanted puddled rice registered maximum grain yield of 3879 kg/ha, which was almost 11.5 % more than unpuddled transplanted rice (3432 kg/ha) and 30.05 % more than from direct seeded rice (2713 kg/ha). The early sown crop (27th June) produced maximum grain yield (3612kg/ha) than the crop sown on 26th June (3471 kg/ha). The highest grain yield was obtained from cv. Pooja (4280 kg/ha), which was almost 3.0 % higher than that from cv. Naveen (2802 kg/ha). Interaction effects were not significant. The superiority of early planting was also reported earlier by Mukesh *et al*, (2013) [6].

4.5 Straw yield (kg/ha)

Like grain yield the straw yield was also significantly influenced by the different rice establishment methods, planting dates and genotype (Table 2). The maximum straw yield (3714 kg/ha) was recorded from paddy crop transplanted after puddling than from unpuddled transplanted (3465 kg/ha) and direct seeded rice (3267 kg/ha). The crop planted on (17th June) registered more straw yield (3550kg/ha) than the crop planted on 26th June (3414 kg/ha). The rice cv. Pooja produce almost 9% higher straw yield (3646 kg/ha) than cv. Naveen (3318 kg/ha).

4.6 Harvest Index (%)

The harvest index was influenced significantly by different planting methods dates of sowing rice genotypes (Table 2). The maximum harvest index value (61.5%) observed in puddled transplanting method than unpuddled transplanted (51.09%) and direct seeded rice (44.09%). Early sown crop has less harvest index value (49.7%) than the crop planted on 26th June (54.6%). Among the tested rice genotypes cv. Naveen registered less harvest index value (50.1%) as than cv. Pooja (54.3%). Hossain *et al*. (1998) [5] and Salahuddin *et al*. (2009) [7] concluded that high harvest index was mainly due to higher grain yield which was achieved through better performance in most of the yield, attributing traits. Similar was observed in the present study.

Table 2: Yield and Yield parameters of rice varieties affected by different establishment methods and sowing time

Treatments	No. of Panicles per m^2	No. of filled grains per m^2	Test weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest Index (%)
Management						
M1	328	86	22.0	2713	3267	44.09
M2	351	94	22.5	3432	3465	51.09
M3	366	99	23.1	3879	3714	61.52
SEm+	4.1	2.9	0.1	35.92	50.63	1.638
CD (0.05)	12.9	NS	0.4	113.17	159.52	5.162
CV	12.0	11.1	12.2	10.51	5.04	10.866
Date of sowing						
D1	355	99	22.7	3612	3550	49.77
D2	342	87	22.3	3471	3414	54.69
SEm+	4.1	2.9	0.1	29.33	41.34	1.338
CD (0.05)	12.9	NS	0.4	92.41	130.25	4.215
Variety						
V1	289	86	21.5	2802	3318	50.11
V2	408	100	23.6	4280	3646	54.35
SEm+	3.4	2.5	0.0	30.10	36.23	0.710
CD (0.05)	10.5	7.	0.2	92.73	111.63	2.188
CV	4.1	11.5	11.7	13.61	10.41	10.768

5. Conclusion

Among three rice establishment methods, puddled transplanted crops produced tallest plants (113 cm), maximum number of total leaves m^{-2} (2120), maximum number of tillers m^{-2} (431), maximum dry matter accumulation m^{-2} (2200.57 g), maximum number of panicle m^{-2} (366), maximum number of filled grains per panicle (99), maximum test weight (23.10g/1000grain), maximum grain yield (3879 kg/ha), maximum straw yield (3714 kg/ha) and maximum harvest index value (61.52%). Thus all crop growth parameters, and yield parameters were more in puddled and transplanted method of planting than unpuddled transplanted and direct seeded methods. Based on the above findings it was concluded that in the condition of *Kharif*, 2016, puddled transplanted rice crop gave higher yield than unpuddled transplanted and direct seeded methods. Early planting of rice in first fortnight of June gave better yield than late plantings. Pooja was dwarfer, which is a desirable character as it less prone to lodging and also gave higher yield than *cv*. Naveen. Hence, concluded that variety "Pooja" planted on 17th June under puddled transplanted produced higher grain yield of 4280 kg/ha due to better response to the growing period weather.

6. Acknowledgement

My deep gratitude and respect to Hon'ble Vice Chancellor, OUAT, Bhubaneswar and the Agrometerolgist, AICRPAM, Department of Agricultural Meteorology, OUAT, Bhubaneswar for guiding in research work.

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