

Developing stand establishment of rice (*Oryza sativa*) in flood-prone lowland situations—an exploratory study under on-station and on-farm location

A. GHOSH

Division of Agronomy, Central Rice Research Institute, Cuttack, Orissa 753 006.

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ABSTRACT

A field study was conducted both under on-station location at the Central Rice Research Institute, Cuttack, in 1996 and successively under on-farm location at farmers' field in 1997. The locations were identified under rainfed lowland ecologies, characterized with aberrant micro-environment constraining the normal yield potential of rice (*Oryza sativa* L.). Generally, the ecology experiences a waterlogged situation during entire crop-growing period. Water depth fluctuated between 0 and 50 cm; thereby the situation could be identified as intermediate deep water situation. The cropping geometry constituting 4 rows continuous seeding alternated with 1 row skip (no seeding) at 15 cm × 20 cm spacing arrangement under 4 : 1 stand situation achieved the maximum grain yield, 2.46 and 2.33 tonnes/ha in 1996 and 1997, respectively, comparable with that devoid of any skip within the entire stand. Nonetheless it also identified a semi-dwarf plant type 'CR 260-77', superior to other plant types assessed under the identical situation. Therefore, the study has a great applied significance ensuring considerable relief in operational expenditure over that incurred traditionally following conventional method of stand establishment; importantly, no significant reduction in grain yield was realized herein compared with conventional method.

Key words : Stand establishment, Rice, Flood-prone lowland

Rice farming in India is predominantly rainfed. It constitutes about 40% area under lowland ecology alone. However, contribution to the national granary is not worth-mentioned due to poor and unstable productivity (Jha *et al.*, 1997). In contrast, a sharp hike in operational expenditure demoralizes farmers owning this type of fragile farming situation. This may be due to their inherent inclination to the cost-expansive conventional method of farming. Initial stand establishment seems to be the major index deserving more attention for the success of lowland rice farming. Subsequently, it also becomes imperative to ascertain sufficient panicle growth. As it is

evident that number of panicles emerged herein happens to be meagre. However, an attempt to increase its number may impair its subsequent development substantially (Sharma and Ghosh, 1998). Therefore, a major concern in this context needs appropriate internal adjustment of the cropping geometry. Even, sink capacity following a favourable temporal spacing may be enhanced ensuring substantial exploitation of resources accrued therein (Moorthy and Saha, 1998). Thus, a better understanding of the circumstances calls for developing a worth-yielding stand establishment to economize the operational expenditure appreciably.

Present study tried to explore the impact of different cropping geometry on different plant types under flood-prone lowland situation both at on-station and on-farm locations.

MATERIALS AND METHODS

A field study was conducted during wet seasons at 2 locations under on-station situation in 1996 and also under on-farm situation in 1997. On-station trial was carried out at the Institutes' experimental farm in the Central Rice Research Institute, Cuttack, to study the different cropping geometry on rice under unfavourable (water depth > 45 cm) lowland situation. Subsequently, the results achieved therein were verified through on-farm trial at the farmers' field in the village, Khentaloo, Jagatsingpur (Cuttack). Both the experimental sites was characterized with naturally occurring hydrology. Unprecedented flooding following the monsoon rains caused excess water stress during the

growing period. The experimental soil was typical rainfed lowland paddy soil having sandy clay loam in texture, characterized as aric, heplaquept. Normal practice of dry seeding was infeasible in 1996 due to unusual water stagnation in the field following heavy shower at the end of April. Instead, 45-day-old seedlings of a semi-tall (150–160 cm), long-duration (170–180 days) rice plant type, 'Panidhan' were transplanted during end of June under 10 cm stagnant water. Three types of row arrangement, viz. 1 row skip (no planting) alternated with every 2 (2:1) and 4 (4:1) rows of planting and no skip (continuous planting), were laid out under 3 types of inter-row spacing arrangement 10, 15 and 20 cm; while intra-row (hill to hill) spacing, 15 cm remained constant.

In 1997, dry seeding (dibbling) was done conveniently during the first fortnight of June at the farmers' field. Treatment combinations emerged significantly superior under the previous years' on-station trial were only taken into consideration at on-farm trial. Therefore, skipping pattern constituting 4:1 situation under spacing arrangement 15 cm × 20 cm (plant × row) was assessed on 3 different plant types. Plant types were selected depending on their variable morphophysiological attributes. Semi-dwarf (100–120 cm) type 'CR 260-77', semi-tall (150–160 cm) type 'Panidhan' and tall (> 160 cm) type 'Nalini' were directly sown @ 600 kg seed/ha within 3–5 cm deep furrows developed behind a country plough at 20 cm apart. A common dose of 40 kg N, 8.7 kg P and 16.7 kg K/ha was applied during planting in the first, while similar dose of P

at sowing followed by similar dose of N and K was applied 10 days after germination in the next year.

Treatment combinations (9 in 1996, 6 in 1997) were randomized in split-plot design considering skipping pattern as main factor and spacing arrangement/plant type's as subfactor under 3 replications.

RESULTS AND DISCUSSION

Flooding pattern vis-a-vis stand establishment

Variable water column following the occurrence of flooding brought about considerable impact on the stand establishment. In 1996, favourable micro-environment due to less water depth (10 cm) during planting appeared to be conducive to the initial stand. However, sudden rise in water level up to 50 cm at 25 days after transplanting (DAT) and subsequent relapse to similar depth further at 50 DAT adversely affected the crop stand. Instead, less water depth during rest of the growing period inspired crop development and its subsequent vigour. The detrimental effect of excess water stress adjudged with initial poor stand was substantially migrated with enhanced vigour achieved later on. Even, crops tillered adequately under relatively less water depth. In addition, gradual recession of water level during post-flowering period proved conducive, promoting panicle development appreciably. Nonetheless, early termination of flood hastened the crop maturity ensuring the harvest during mid-December. Overall flooding pattern indicates that water level raised maximum to 52 cm at 90 DAT with an usual

fluctuation between 30 and 45 cm during major part of the growing period.

In 1997, pre-monsoon shower was received soon after the dry seeding. It helped the seed germinate well promoting seedling emergence (68%) appreciably. However, water accumulated fast in the field following the advancement of the monsoon; consequently crop suffered much from excess water stress therein. Evidently, such an unusually excess water situation caused meagre stand therein. It seems to be critical depressing crop growth severely under this fragile lowland (Sharma and Reddy, 1993). Further more increase in water level consistently during grain development stage at October end–November caused substantial spikelet sterility. Grain yield declined further due to delayed harvest till January end following the late recession of water from the field.

Growth attributes

Phenomenal variation in growth and subsequent crop development under different flooded environments was discernible. Adverse impact of flooding on entire crop growth was pronounced more in 1997 causing distressed performance of crop compared with 1996. Plant height at maturity showed no significant variation due to either skipping pattern or spacing arrangement in 1996; while in 1997, 'Nalini' attained plant height 164 cm, significantly higher than that of 'CR 260-77'; this was however at par with 'Panidhan (Tables 1, 2). However, skipping pattern brought about no significant variation in plant height as evidenced also with the on-station results. Unlike plant height, stand

Table 1. Growth and yield attributes, and grain yield of rice variety 'Panidhan' as influenced by different skip-row and spacing arrangement under rainfed, lowland situation at CRRI, Cuttack, in 1996

Crop stand	Plant height at maturity (cm)	Tillers/m ²	Panicles/m ²	Panicle weight (g)	Grain yield (tonnes/ha)
<i>Skipping pattern</i>					
No skip	160	225	190	3.17	2.33
2:1 (rice : skip)	163	165	153	3.58	1.79
4:1 (rice : skip)	162	194	184	3.31	2.46
CD (P=0.05)	NS	26	9.63	0.18	0.49
<i>Spacing arrangement (plant × row)</i>					
15 cm × 10 cm	161	226	185	3.28	2.16
15 cm × 15 cm	162	198	174	3.40	2.30
15 cm × 20 cm	164	185	164	3.44	2.12
CD (P = 0.05)	NS	24	NS	NS	NS

Table 2. Growth and yield attributes, and grain yield of different rice plant types as influenced by different skip-row arrangements under rainfed, lowland situation at farmers' field in 1997

Crop stand	Plant height at maturity (cm)	Tillers/m ²	Panicles/m ²	Panicle weight (g)	Grain yield (tonnes/ha)
<i>Skipping pattern</i>					
No skip	145	180	151	2.98	2.26
4:1 (rice : skip)	150	145	144	3.35	2.33
CD (P=0.05)	NS	32	NS	0.33	NS
<i>Plant type</i>					
'CR 260-77'	122	185	164	2.74	2.60
'Panidhan'	156	157	139	2.90	1.98
'Nalini'	164	147	135	3.54	2.31
CD (P=0.05)	25	26	21	0.60	0.16

situation caused remarkable variation in tillering in both the locations. Tillering appeared to be inspired at no skip situation, 225 tillers/m², followed by 4:1 situation 194/m², ensuring significantly more tillers than 2:1 situations, 165/m² in 1996. On the other hand, crops in closer spacing with 15 cm × 10 cm tillered 226/m², significantly more than other spacings assessed therein; while crops in 2 other spacings produced comparable tillers. Similar trend in tillering

was also observed in 1997 ensuring more tiller count at no skip situation than that at 4:1 situation. As regards tillering among plant types, 'CR 260-77' tillered significantly more than other 2 types; although, 2 other types accounted comparably. It implies that elongating nature of plant types can retard tillering under excess water situation. This inverse relationship was established also in some previous studies (Sharma and Reddy,

1992). This is due to considerable diversion of reserved carbohydrate enabling faster stem elongation, particularly in tall plant types coping with the increasing water level. This carbohydrate would otherwise have the probability to be employed in tiller production reasonably (Ghosh and Sharma, 1999).

Yield attributes and grain yield

Wider spacings within the stand insisted the growth and subsequent development of panicle; while it was retarded substantially under a clumsy micro-environment arranged with closer spacing. Cropping geometry consisting 4:1 situation inspired panicle emergence comparable with that at no skip situation in both the locations, which was however, significantly more than that counted in 2:1 situation. Poor panicle emergence in 2:1 situation in 1996 was due to occurrence of restricted tillering therein. Likely observation was also visualized adopting different spacing arrangements; ascertaining comparable panicles in all spacing arrangement. Considerable variation in panicle emergence was also discernible among different plant types. Panicles in 'CR 260-77' were significantly more than 2 other types having comparable panicles. Similar trend also held true in panicle development witnessing significantly higher panicle weight in 'Nalini', followed by 'Panidhan', and 'CR 260-77'. On the other hand, crops in 2:1 situation developed panicle weight significantly more than other skipping patterns; however, it remained comparable in either of the no skip and 4:1 situation in both the locations. However, panicle weight

developed in different spacing arrangement was at par.

It was evident that despite skipping a row within the stand, no significant reduction in grain yield was realized; instead, the situation enabled the crop yielding comparably with that devoid of any skip (Wagh *et al.*, 1988; Mahapatra *et al.*, 1989). Alternate arrangement of row (s) consisting with and without seeding was also reported earlier advantageous, causing no appreciable reduction in grain yield (Manna and Rao, 1982). Moreover, considerable relief in the operational expenditure following this method was derived over that incurred in the traditional methods (Sharma and Waris, 1987). Identical yield (2.46 and 2.33 tonnes/ha) respectively at on-station and on-farm situation under 4:1 situation was attributed to the substantial growth and development of panicles. This happened to be at par, even more than that at no skip situation, grain yield 2.33 and 2.26 tonnes/ha respectively at on-station and on-farm situation. Evidently, a favourable internal adjustment providing adequate space within the plant stand seems to be essential deriving identical benefit realized either under no skip or closely spaced stands. In contrast, poor grain yield (1.79 tonnes/ha) at 2:1 situation implies that crop may not rely on such stand deriving advantages similar to that acquired in 4:1 situation. The grain yield achieved at the stand developed with either of the space arrangement was on par. Comparable grain yield achieved therein was attributed to significantly higher panicle size at the stand with 15 cm × 15 cm or 15 cm × 20 cm

spacing compensating for the apparent loss caused due to less panicle count compared with that at 15 cm × 10 cm spacing. Therefore panicle weight appears to be one of the major indices determining the final grain yield under excess water situation (Sharma and Reddy, 1991). It certainly emphasizes the need of developing panicle size which happens to have greater implication for the cause of the ultimate grain yield.

Assessment of plant types under different cropping geometry identified 'CR 260-77' significantly out yielding other plant types tested therein; while 'Nalini' achieved grain yield significantly higher than 'Panidhan'. Higher grain yield in 'CR 260-77' was owing to more panicle count.

Interaction between skipping pattern and

spacing arrangement significantly influenced the grain yield. On-station evaluation in 1996 identified the crop stand achieving grain yield 2.51 tonnes/ha under 4:1 situation at 15 cm × 15 cm spacing arrangement superior to all other combinations tested therein (Table 3). However, 2 other stands under 4:1 situation and also all stands under no skip situation gave comparable grain yield. However, grain yield declined at all spacing arrangements under 2:1 situation. Therefore, it indicates that cropping geometry 4:1 row pattern under 15 cm × 20 cm spacing arrangement may conveniently be followed, realizing benefit equivalent to even closer spacing with no skip arrangement. The grain yield of all plant types under 4:1 situation remained consistently at par with no skip situation even

Table 3. Intereaction effect of skip-row and spacing arrangement on grain yield (tonnes/ha) of rice in 1996

Spacing arrangement (A)	No skip	Skipping pattern (S)	
		2:1 (rice : skip)	4:1 (rice : skip)
15 cm × 10 cm	2.34	1.74	2.40
15 cm × 15 cm	2.46	1.94	2.51
15 cm × 20 cm	2.20	1.70	2.46
CD (P = 0.05)			
2 S means at each A	0.41		
2 A means at each S	NS		

Table 4. Interaction effect of skip-row and different rice plant types on grain yield (tonnes/ha) in 1997

Plant types (P)	Skipping pattern (S)	
	No skip	4:1 (rice : skip)
'CR 260-77'	2.65	2.55
'Panidhan'	1.85	2.10
'Nalini'	2.27	2.35
CD (P = 0.05)		
2 S means at each P	NS	
2 P means at each S	0.16	

under on-farm evaluation (Table 4). 'CR 260-77' emerged superior in all the situations of skipping pattern to all other types assessed therein.

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