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Exploring seedling vigour for post-flood stand establishment of rice–*(Oryza sativa)* under flood-prone waterlogged deepwater condition*

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Post-flood rice (*Oryza sativa* L.) cultivation has enormous potentiality to the global rice production; however, the productivity is still hovering between 1.20 and 1.50 tonnes/ha only (Peng and Bouman 2007). Enhancing productivity requires viable agro- technology wherein stand establishment appears to be the key determinant. Unlike conventional seedlings succumbing to this adverse condition, robust seedling is expected to tide over the conditions improving stands for a better yield. Adequate literatures, particularly concerning to the seedling vigour that could boost rice productivity, are not available (Ghosh 2006). Thus, a field experiment was conducted with three specific objectives to identify promising rice varieties, to improve seedling vigour and to develop post-flood agro-management practices achieving higher productivity of rice under flood-prone waterlogged condition.

Field study was conducted at the Institute, Cuttack (20°30/ N, 86° E;22 m MSL) during wet seasons in 2006 and 2007 studying four different maturity duration varieties, 'Naveen' (120 days), 'Padmini' (140 days), 'Gayatri' (160 days) and 'Durga'(180 days). The daily minimum and maximum temperature ranged from 16 to 25° C and 27 to 37°C, respectively across the year. The relative humidity and pan evaporation ranged from 90 to 95% and 21 to 39 mm, respectively across the year. Seedlings were raised both under improved and usual management. Improved management included preparation of ridge bed applying 0.5 kg farmyard manure (0.63, 0.09 and 0.46% - N, P and K at 50% moisture) and 1 kg rice hull ash (8% silicon)/m^2. Seed rate was 25% less than that (50 kg/ha) in conventional nursery. Seed stock was purified screening with salt solution of 1.06 specific gravity. Pre-germinated seeds were drill sown at 10 cm row interval and covered with farmyard manure mixed soil (1:1, volume basis). After 12 days of emergence, 50% of the recommended N dose (60 kg/ha) was applied in the nursery. Roots of uprooted seedling (30-days-old) were dipped overnight into a slurry of soil and single super phosphate (10:1 ratio). Transplanting commenced on third week of September at a receding water depth of 15 to 25 cm. Stands with robust seedling received no basal N; while 50% N was applied in conventional stands, followed by two equal split applications at tillering and panicle-initiation stage in both the stands. P and K each at 30 kg/ha was applied during planting.

The experiment was laid out in a split-plot design arranging variety in main and seedling in sub-plot with four replications. Root volume was measured following the water displacement methods (Archimedes's principle). Plant N content was estimated following micro-Kjeldahl method using H_3BO_3 indicator solution with bromocresol green and methyl red mixed indicator in 40% NAOH media titrating against 0.02N H_2SO_4. Silicon content was estimated through digestion using acid mixture of HNO_3,H_2SO_4 and $HCLO_4$ and filtering using Whatman No.44 paper and drying the paper and sample residues at 80°C. Data were analyzed using 'CropStat' statistical package and the treatment means were compared in least significant difference (LSD) tests at $P<0.05$ level of significance.

Improved nursery management ensured greater seedling vigour than that with conventional methods. Averaged over the season, root and stem of these seedlings were 62–65% and 73–75% longer than those of conventional seedlings (Table 1). Their volume and biomass also significantly improved accounting for 55–57% increase in root volume, 61–64% increase in stem biomass and 84–86% increase in root biomass. Application of rice hull ash resulted in 22–23.5% more silicon content compared with conventional seedling (Prakash and Eto 2003). Seedling vigour improved initial stand establishment encouraging crop growth substantially.

Recession of accumulated water followed different pattern

*Short note

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Table 1 Quality parameters of quality seedling and conventionally raised rice seedlings (mean of 25 seedlings ± SD)

Quality parameter	Quality seedling	Conventional seedling
Crude silica content (%)	9.0	7.38
Root growth parameter		
Length (cm)	10.00±0.32	6.35±0.20
Biomass (g/plant)	0.26±0.02	0.14±0.02
Volume (cc/plant)	0.64±0.08	0.41±0.06
Stem growth parameter		
Length	40.00±2.70	22.75±4.2
Biomass (g/plant)	1.57±0.12	0.96±0.08

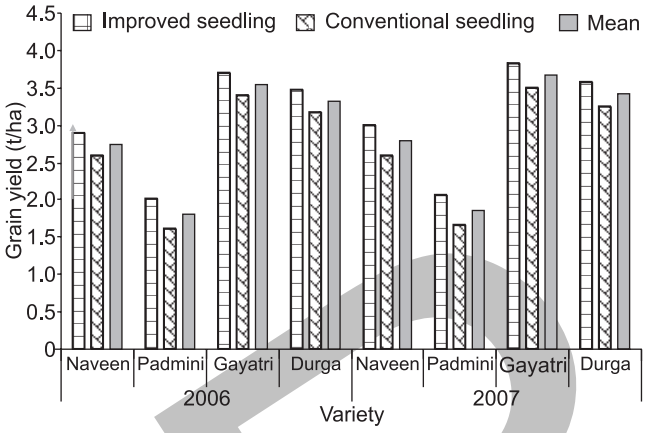

Fig 1 Effect of seedling quality on grain yield of rice varieties under post flood conditions

	2006	2007
SE_m ± for same variety or different seedling quality	0.05	0.06
CD (*P*=0.5) for same variety or different seedling quality	0.17	0.21
SE_m ± for different variety or same seedling quality	0.06	0.07
CD (*P*=0.5) for different variety or same seedling quality	0.20	0.23

across the year. In 2006, water depth of 25 cm started receding since September first week followed by a sudden increase to 15 cm during October third to fourth week with complete recession during December second week. In 2007, water depth of 15 cm started receding since September first week with complete recession during November third week. Shorter height and thin culms of conventional seedlings caused partial mortality of the stand. This was pronounced more in first year at a greater initial water depth of 25 cm than that (15 cm) in second year. Improved seedlings on account of greater vigour thrived well over excess water stress. This seedling was able to withstand initial trauma caused following their uprooting and transplanting at waterlogged condition. 'Gayatri' and 'Durga' varieties established better under this condition attributing their better capability of establishment under such adverse conditions.

Delayed planting suppressed overall crop growth in all varieties; even though, it was consistently better in stands with robust seedling. 'Durga' attained significantly longer stature, followed by 'Padmini'. Crops established with robust seedling witnessed better panicle growth accounting for 15–18% and 6–8% more number and weight than the conventional seedlings. 'Naveen' and 'Padmini' gave more secondary and tertiary tillers ascribed with poor panicle growth.

Maturity duration and seedling type greatly impacted growth and yield parameters. Long duration variety 'Gayatri' gave significantly higher grain yield while established with improved seedlings, accounting for 82–85,25–27 and 4–6% more than the 'Padmini', 'Naveen' and 'Durga' respectively over the season. Stands with robust seedling also produced significantly more straw in 'Gayatri' followed by 'Durga'. Interaction of variety with seedling type resulted in 10–12% more grain yield compared with conventional seedlings with a range of 9–25% across the varieties (Fig 1) (Prakash *et al.* 2007). Although improved seedlings boosted the productivity of all varieties (3.02–3.11 tonnes/ha) compared that (2.68–2.75 tonnes/ha) with conventional seedlings, their interaction revealed that magnitude of yield enhancement was not

Table 2 Influence of seedling quality on growth, grain yield and N uptake of promising rice varieties under post-flood condition (pooled data of 2006 and 2007)

	Plant height at harvest (cm)	Panicles (m^2)	Panicle weight (g)	Grain yield (tonnes/ha)	Straw yield (tonnes/ha)	N uptake (kg/ha)
Seedling quality						
Quality seedling	107	207	3.04	3.07	5.30	67.8
Conventional seedling	96	178	2.83	2.72	4.63	54.2
SE_m ±	2.1	4.3	0.06	0.06	0.15	1.30
CD (*P*=0.05)	7	14	0.14	0.20	0.48	3.96
Variety						
'Naveen'	94	207	2.17	2.78	4.78	60.4
'Padmini'	107	166	1.77	1.82	3.22	53.0
'Gayatri'	86	228	3.66	3.58	6.32	66.2
'Durga'	130	255	3.10	3.35	6.8	65.0
S E_m ±	3.2	2.0	0.29	0.07	0.17	1.12
CD (*P*= 0.05)	9	7	0.87	0.20	0.52	3.82

identical in all cases. Improved seedlings attributed relatively higher yield benefit to 'Padmini'(24.5–25.2%), followed by 'Naveen' (13.5–14.0%), 'Durga'(10.0–10.5%) and 'Gayatri'(8–10%) over the conventional seedling. It implies medium maturity duration variety, 'Padmini' and 'Naveen' more sensitive to seedling vigour; while long maturity duration variety, 'Gayatri' and 'Durga' showed greater flexibility to seedling quality.

Seedling quality impacted greatly the N utilization in different stands. It was significantly more (24.5–26.0%) in stands established with robust seedlings compared with conventional seedlings (Table 2). Significant variation also occurred across the varieties accounting for higher uptake in 'Gayatri', 26.0–28.0, 10.0–12.0 and 3.5–4.0% more than that of 'Padmini', 'Naveen' and 'Durga' respectively. This was attributed to the different maturity duration of the variety determining differential biomass production.

Therefore, our field study indicated post-flood planting of longer maturity duration variety 'Gayatri' and 'Durga', however the response of medium maturity duration variety, 'Padmini' and 'Naveen' to robust seedling would be pronounced better than those of long duration variety.

SUMMARY

A field experiment was conducted during wet season in 2006 and 2007 to study the relative advantages of better quality seedlings of four different maturity duration rice varieties planted under post-flood waterlogged condition. Nursery seedlings raised with improved agro-technique resulted in better seedling vigour accounting for 22–23.5% more silica than that in conventional seedling. These robust seedlings attributed relatively higher yield benefit of 'Padmini'(24.5–25.2%), followed by 'Naveen' (13.5–14.0%), 'Durga'(10.0–10.5%) and 'Gayatri'(8–10%) compared that with the conventional seedling. Long duration variety 'Gayatri' and 'Durga' gave significantly higher yield with either of seedling types than medium duration variety. Crops established with robust seedlings also recorded 24.5–26.0% more N uptake than that with conventional seedlings. Therefore, the study could suggest post-flood planting of medium duration variety with robust seedlings and long duration variety with normal or robust seedling.

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