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Water use efficiency and yield performances of rice varieties in direct sown rainfed uplands

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ABSTRACT

Eight improved short duration rice cultivars (83-90 days) viz. Anjali, RR166-645, RR348-6, RR361-1, RR51-1, RR165-1160, Vandana were evaluated with local popular variety Chali for their water use efficiency in rainfed upland during the wet seasons of 2001 to 2003. Rice varieties showed limited but significant yield potential ranging from 1.89 to2.75 t ha^{-1}. Among the varieties, Vandana, Anjali, RR 165-1160 and RR 166-645 yielded more than average (2.28 t ha^{-1}). Total water uptake was more in improved rice varieties (520-607 mm) and higher water use efficiency (4.35 - 5.22 kg ha^{-1} mm^{-1}) was noted in Vandana, Anjali and RR 165-1160. Vandana variety had more vigorous root growth and low root density was noted in RR51-1. Significant positive correlation was observed only for effective tillers (0.661) with yield.*

Key words: *Water use efficiency, yield performances, rice varieties, direct sown rainfed uplands*

Rainfed rice faces periodic drought in unbunded and bunded uplands of Red and Laterite Zone of West Bengal. Districts like Purulia. Bankura, Birbhum and Midnapur (W) come under this zone. Farmers of Purulia occasionally grow traditional rice, ground nut and black gram in rolling uplands where soils are gravely sand with the depth of 0 - 7.5 cm, rill and sheet erosion are common. Majority (15-20%) of unbunded uplands remain fallow due to less soil depths, erratic rainfall and uncertainty in production due to moisture stress. Transplanting of rice is a common practice in bunded upland which suffers due to shortage of water during midterm cease of monsoon. The occurrence of drought at various growth stages affects the crop growth and yield (Chauhan *et al*. 1996). There is a dearth of good drought tolerant varieties in this zone. So, efforts have been made to study the performances of different rice varieties under in rolling uplands of red and laterite soils of Purulia district in West Bengal.

On-farm trials were conducted in the village Ashanboni of Purulia district during the wet season of 2001 to 2003. Seven improved varieties of 83-90 days duration viz. Anjali, RR166-645, RR348-6, RR361-1, RR51-1, RR-165-1160 and Vandana were tested in randomized block design with local popular variety Chali as check. The soils of experimental fields were gravely sand in texture with bulk density 1.65 g cc^{-1}. Water retained at 0.3 and 15 bar were 0.211 and 0.067 m^3 respectively. Root zone (0-30 cm) storage capacity was 43.2 mm. Rice varieties were direct sown on 3rd week of June with a row spacing of 20 cm having a plot size of 50 m^2. A fertilizer dose of 40:20:20: kg N, P_2O_5 and K_2O ha^{-1}. Pre-emergence chemical weed control measure was taken with Pretilachlor 50% EC at 2.5 ml litre^{-1}. Observations on soil moisture status, biometrical and yield characters were recorded at different stages.

Improved rice varieties were dwarf to semi dwarf in plant stature with mean hight 107.7 cm (Table 1). Local popular variety 'Chali' attained the maximum plant height of 139 cm, whereas, RR 51-1 recorded the minimum (84 cm). The number of ear bearing tillers ranged from 219 m^{-2} in Vandana to 188 m^{-2} in Chali which might be attributed to periodic soil moisture stress (Rammoorthy *et al*., 1998) along with poor nutrient status of laterite soil (Singh and Modgal, 2005). Tiller mortality was high in Anjali (64%) followed by RR 348-6 and it was less (37%) in Chali.

Improved rice varieties showed limited but significant yield ranging from 1.89 to 2.75 t ha^{-1}. Four

Table 3. Rooting pattern of some rice varieties in rolling uplands

Variety	Rootingdepth(cm)	Rooting characteristics*			Remark
		Length (cm)	No	Density (cm cm^{-3})	
Vandana	0-10	120	15	1.41	Thick and stout root with profuse ramification
	10-20	15	6	0.21	
RR-166-645	0-10	45	16	0.62	Thick root with less fibrous
	10-20	13	4	0.18	
RR-51-1	0-10	34	9	0.47	Thick root with less fibrous
	10-20	18	6	0.25	
Chali	0-10	60	14	0.83	Thin but stout root with profuse ramification
	10-20	19	7	0.26	

*Core method (core volume 72.1 cm^3)

varieties viz. Vandana, Anjali, RR 165-1160 and RR 166-645 yielded more than average (2.28tha^{-1}). Similar poor yield performances of dry land varieties have been reported by Sinha *et al*, 1991. Lilley and Fukai, 1994b; Vijay Lakshmi and Nagarajan, 1994. Correlation co-efficient studies for different combinations of agronomic traits of drought tolerant rice varieties revealed that effective tillers (0.661*), panicle weight (0.488), grain number (0.320) exhibited positive correlation with yield. Panicle weight had a strong positive association with panicle length (0.784**), filled grain number (0.885**) but had a negative correlation with chaffiness (-0.536) and 1000-grain weight.

Improved rice cultivars showed wide variation in water use efficiency ranging from 3.41 to 5.22 kg ha^{-1} mm^{-1} (Table 2). Total water uptake was more in improved varieties and the higher water use efficiency was noted in Vandana, Anjali and RR 165-1160 due to their better root distribution characteristics in unbunded uplands of laterite soil (Table 3). In case of Vandana variety, roots were thick and much ramified and relative root distribution was more (88.8%) in upper layer (0-10cm) with a higher root density (1.41 cm cm^{-3}). Low root density was noted in cv. RR-51-1 (0.47). Local popular variety Chali possessed thin but stout root with profuse ramification with the relative root density of 0.83 cm cm^{-3}.

In unbunded rainfed rice ecosystem Vandana, Anjali , RR 166-645 and RR165-1160 performed well in red and laterite soils of West Bengal under soil water stress caused by midterm ceasation of monsoon rain. These varieties showed higher water use efficiency.

Table 2. Crop growth. yield and water use efficiency (WUE) of rainfed direct sown rice cultivars in rolling upland (pooled mean of two years).

Variety	Plant height (cm)	Ear bearing tillers (No.m^{-2})	Tiller mortality (%)	Panicle weight (g)	Filled grains $panicle^{-1}$	Grain yield (q ha^{-1})	Water used (mm)	WUE (kg ha^{-1} mm^{-1}
Anjali (89 days)	108.1	192.0	64.0	1.9	82.2	2.68	564	4.75
RR166-645 (90)	105.0	212.0	53.2	1.7	68.4	2.36	520	4.35
RR348-6 (88)	90.1	170.4	63.2	1.9	84.8	2.14	570	3.75
RR361-1 (88)	100.3	186.1	58.9	1.6	77.8	2.24	550	4.07
RR51-1 (87)	83.5	186.0	47.3	0.9	56.2	2.15	580	3.70
RR165-1160 (90)	107.4	205.4	67.3	2.3	117.4	2.55	607	4.20
Vandana (87)	128.0	219.0	43.3	2.7	103.7	2.75	527	5.22
Chali (83)	139.0	188.0	36.8	2.1	98.8	1.89	554	3.41
Mean (88)	107.7	191.1	59.5	1.9	82.4	2.28	543	4.19
CD (P=0.05)	17.14	11.91	7.50	0.48	17.6	0.27	29.1	0.36

Table 1. Association of characters with yield and yield attributes

Associations	Linear relationship (Y = a +b)	r-value
Yield vs effective tillers	-0.043 + 0.012	0.661*
vs plant height	2.202 + 1.326	0.081
vs panicle weight	0.488 + 0.273	0.488
vs grain number	1.931 + 0.048	0.320
Panicle weight vs panicle length	14.363 + 4.840	0.784**
vs grain number	23.77 + 33.05	0.885**
vs chaff number	22.10 – 2.865	- 0.215
vs 1000 grain weight	30.00 – 1.424	- 0.536

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