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Assessment of yield and quality attributes of rice cultivars under rainfed upland situation

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ABSTRACT

Grain yield ability and grain quality traits of 22 varieties were studied at Central Rainfed Upland Rice Research Station, Hazaribag. It was observed that the varieties Vandana, Kalyani 2 and Anjali proved their stability and superiority to the check variety Heera resulting in 97.5, 97.0 and 95.0 % higher yields respectively. The grain yield was 5.8 % more in the bunded upland than in the unbunded upland plots. With regard to physico-chemical characteristics, the mean head rice recovery (56.8 %) and the kernel test weight (40.8%) were recorded under unbunded upland. Kernel length after cooking, volume expansion ratio and elongation ratio (10 mm, 3.7, 1.5) were estimated. Among twenty two upland rice varieties, six varieties namely Kalinga III, Kalyani 2, Heera, VL 221, RR 366-8 and RR 363-36 were comparable and satisfied the minimum acceptable standard of grain quality traits.

Key words: *Short duration, bunded upland, drought tolerant, crop lodging, yield index*

Eastern India comprising the states of Orissa, West Bengal, Bihar, Assam, Jharkhand, Chhattisgarh and eastern Uttar Pradesh occupies nearly 5.2 m ha under upland rice i.e. about 75% of the total upland area of the crop. Since productivity of upland rice is only 0.8 t ha^{-1} it is highly essential to improve the productivity of rainfed rice to improve the overall food production of the country in general and improve the economy of the poor rainfed upland farmers in particular (Roy, 2002). The rainfed topo-sequence land types including upland, medium and low land are all broadly sub-divided into two: unbunded (undulating) and bunded uplands. The unbunded uplands are characterised as aerobic and well drained fields very often sloppy, with no or little surface water accumulation, low water holding capacity. Therefore, the present investigation was undertaken to evaluate and compare the grain yield ability and grain quality traits of short duration, popular rice varieties and advanced breeding lines under rainfed upland situations.

MATERIALS AND METHODS

The influence of management practices in respect to growth, yield and yield components of the rice varieties were studied. Twelve local popular varieties and 10 advanced breeding lines were grown in the experimental farm of Central Rainfed Upland Rice Research Station, Hazaribag adopting a randomized block design with three replications. Each sub-plot size was (5 m x 0.8 m) square meter. Seeds of the varieties (10 g m^{-2}) were direct seeded in the field in three lines 20 cm apart during the 2nd week of July when the land was dry and soil was in good tilth. A recommended fertilizer dose of NPK 40: 30: 20 kg ha^{-1} was followed. Full dose of phosphorus and potassium was uniformly applied to all the plots as basal dressing at the rate of 30 kg P_2O_5 as single super phosphate and 20 kg K_2O per hectare as muriate of potash respectively. The three splits of urea-N were applied with an amount of 10, 20 and 10 kg ha^{-1} at 10, 30 and 50 days after sowing the seeds.

For controlling weeds, crop was manually weeded twice at 25 and 45 days after sowing. The mature crop was harvested during the month of October. One central line from each variety from each replication was selected and the plant growth and yield components such as plant height, crop duration (days) and grain yield were recorded. The grains and straw were dried under the sun and subsequent yields were recorded at 14 and 10% moisture content, respectively. The samples were threshed, cleaned and weighed. After

four months of ageing, the dried rough rice was hulled and milled to 5-6 per cent polish. The physical and chemical quality characteristics of kernels were determined for head rice recovery, kernel colour, 1000-kernel weight, kernel length, kernel breadth, length/ breadth (L/B) ratio, alkali digestion value, kernel length after cooking, volume expansion ratio, water uptake and linear kernel elongation ratio using an average of ten randomly selected kernels following the standard methods (Ghosh et al. 1971; Little et al.1958; Beachell and Stansel 1963; Azeez *et al.*1966).

RESULTS AND DISCUSSION

Maintenance of soil moisture at field capacity is essential but difficult to achieve. In the bunded upland ecosystem, where the moisture and fertility were slightly better than the unbunded uplands, rice variety Kalyani 2 recorded maximum grain yield (2.82 t ha^{-1}) being 154% higher than the check (Heera). This was followed by the variety Vandana with a yield of 2.72 t ha^{-1} being 145% and Anjali with a yield of 2.67 t ha^{-1} being 140% higher over the check (Table 1). Besides this, some rice cultivars namely RR 347-2 (2.59 t h^{-1}), Brown gora (2.55 t ha^{-1}) and Sathi 34-36 (2.42 t ha^{-1}) proved promising. This data revealed the significant varietal differences in the grain yields. Moreover, the varieties/ advanced breeding lines that showed good field performance were RR 433-2 (2.49 t ha^{-1}), RR 286-2 (2.36 t ha^{-1}), RR 347-2 (2.32 t ha^{-1}), Kalinga III (2.29 t ha^{-1}), Vandana (2.25 t $ha^{-1)}$ and Anjali (2.25 t ha^{-1}) under

Table 1. Yield performance (t ha^{-1}) of very early and early duration rice cultivars under unbunded and bunded uplands

Variety/ Genotype	Plant stature	Crop duration (days)	Unbunded upland			Bunded upland			Overall mean	Yield index
			Grain yield (t ha^{-1})	Yield index	B : C	Grain yield (t ha^{-1})	Yield index	B : C		
Brown gora	D	82-86	1.69	113	0.414	2.55	229	0.621	2.12	171
Kalinga III	SD	86-87	2.29	153	0.575	2.04	184	0.505	2.16	108.5
Vandana	D	92-98	2.25	150	0.552	2.72	245	0.667	2.48	197.5
Anjali	D	93-100	2.25	150	0.598	2.67	240	0.655	2.46	195
Kalyani 2	D	82-82	2.1	140	0.517	2.82	254	0.644	2.46	197
Heera	D	79-82	1.5	100	0.368	1.11	100	0.264	1.31	100
Barani deep	D	106-107	2.01	134	0.494	1.95	176	0.471	1.98	150
N 22	D	82-93	1.95	130	0.41	1.89	170	0.4	1.92	150
VL 221	SD	82-86	1.87	125	0.46	1.77	159	0.437	1.82	142
GR 5	D	92-95	2.25	150	0.552	2.34	211	0.575	2.29	180
Sathi 34-36	SD	92-96	2.17	145	0.529	2.42	218	0.586	2.29	181.5
RR 347-2	D	82-96	2.32	155	0.575	2.59	233	0.632	2.45	194
RR 410-5-1-B-1-B-B-2	SD	82-82	1.92	128	0.471	1.57	141	0.379	1.74	134.5
RR 410-82-1-B-2-B	SD	82-97	2.07	138	0.505	1.74	157	0.425	1.9	147.5
RR 366-4	SD	88-95	2.12	141	0.787	2.42	218	0.892	2.27	179.5
RR 366-7	SD	86-95	1.69	113	0.63	2.02	182	0.752	1.85	147.5
RR 366-8	SD	92-100	1.99	133	0.735	2.32	209	0.857	2.15	171
RR 363-36	SD	82-87	1.99	133	0.735	1.74	157	0.647	1.86	145
RR 385-249	SD	98-98	2.25	150	0.564	2.34	211	0.587	2.29	180.5
RR 383-22	SD	92-97	1.74	116	0.37	2.02	182	0.45	1.88	149
RR 286-2	D	87-97	2.36	157	0.575	2.1	189	0.517	2.23	173
RR 433-2	D	92-100	2.49	166	0.575	2.72	204	0.552	2.6	185
Mean		88-94	2	137	0.545	2.17	194	0.568	2.11	165.4
CD (P=0.05)			16.6			17.7				

Paddy sale price: Coarse @ Rs.400q^{-1}, Medium @ Rs.450q^{-1}, Fine @ Rs.460q^{-1}, Superfine @ Rs.470q^{-1}, Scented @ Rs.700q^{-1}, Paddy straw @ Rs.55q^{-1}; Very early duration (below 100 days); Early duration (below 120 days); Medium duration (upto 140 days); Late duration (beyond 140 days)

unbunded uplands. Thus the rice varieties Vandana, Kalyani 2 and Anjali proved their stability and superiority giving 97.5%, 97.0% and 95.0% higher yields respectively over the check.

Based on the mean values of the total plot yields, the grain yield increased by 5.8% in the bunded upland over the unbunded upland plots. Crop duration ranged from 79 to 107 days for the varieties. The varieties in the bunded upland showed a crop duration 7 days longer than the unbunded upland rice.

The quality analysis (Table 2 and 3) indicated that the mean head rice recovery percentage was more under unbunded (56.8 %) than the bunded (54.7%) upland situations. The highest head rice recovery was in RR 410-82-1-B-2-B (59.6%) followed by RR 366-4 (59.6%). All other varieties had higher head rice recovery than the minimum acceptable standards (40%). The variety Brown gora (brown), Sathi 34-36 (red), RR 366-4 (red), RR 366-7 (red), RR 366-8 (red) had coloured kernels whereas all other varieties had white coloured kernels. The test kernel weight ranged from 14.4 to 30.4 g in the varieties. The rice RR366-8 had the highest kernel weight (30.4 g) under the unbunded upland. Grain size, shape and appearance are important physical quality features that determine the market value of rice. The extra long kernel length was found in Heera (7.1 mm), RR 366-4 (9.0 mm), RR 366-7 (8.3 mm), RR 366-8 (9.3 mm), RR 363-36 (8.0 mm) and RR 385-249 (7.3 mm) under bunded upland. The kernel length/breadth (L/B) ratio ranged from 1.88 to 3.57 and rice RR 347-2 showed the minimum L/B ratio of 1.88 to 1.90. The alkali digestion values ranged from 3.0 to 4.3 indicating their low to intermediate amylose content in the varieties. Water uptake value (ml) ranged from 240 to 444 in the varieties tested.

Table 2. Physical and chemical grain quality characteristics of rice under unbunded rainfed uplands

Variety/Genotype	Head rice recovery (%)	Kernel colour	1000-kernel weight (g)	Kernel length (mm)	L/B ratio	Alkali digestion value	Kernel length after cooking (mm)	Volume expansion ratio	Water uptake (ml/100 g)	Elongation ratio
Brown gora	55.3	Brown	20.8	6.3	2.1	3.3, 3.3	9.2	3.3	260.0	1.5
Kalinga III	56.0	White	17.6	6.0	2.3	3.2, 3.2	9.0	4.0	320.0	1.5
Vandana	55.3	White	17.6	6.0	2.3	3.3, 3.2	8.5	4.0	320.0	1.4
Anjali	56.0	White	20.8	6.0	2.2	3.3, 3.0	8.0	4.4	348.0	1.3
Kalyani 2	56.1	White	24.0	6.7	2.9	3.1, 3.1	10.4	5.1	404.0	1.6
Heera	56.5	White	20.8	6.7	2.5	3.6, 3.3	10.2	4.6	368.0	1.5
Barani deep	55.1	White	24.0	6.3	2.4	4.0, 4.0	7.4	3.0	240.0	1.2
N 22	55.1	White	16.0	6.0	2.3	3.3, 3.3	8.6	4.6	444.0	1.4
VL 221	55.1	White	20.8	6.0	2.3	3.1, 3.1	10.4	5.0	400.0	1.6
GR 5	59.1	White	22.4	6.0	2.3	3.2, 3.2	9.2	4.6	368.0	1.5
Sathi 34-36	55.3	Red	17.6	6.7	2.3	3.6, 3.6	9.4	3.0	240.0	1.4
RR 347-2	59.5	White	20.8	6.3	1.9	4.3, 3.6	8.1	3.0	240.0	1.3
RR 410-5-1-B-1-B-B-2	56.3	White	25.6	7.0	2.3	3.0, 3.0	7.8	3.6	288.0	1.1
RR 410-82-1-B-2-B	59.6	White	17.6	7.3	2.8	3.0, 3.0	9.0	4.0	320.0	1.2
RR 366-4	59.6	Red	25.6	8.0	2.7	3.0, 3.0	8.5	4.3	340.0	1.1
RR 366-7	59.1	Red	27.2	7.3	3.1	3.0, 3.0	9.2	3.3	260.0	1.2
RR 366-8	55.3	Red	30.4	8.0	3.0	3.0, 3.0	9.5	3.8	301.0	1.2
RR 363-36	55.3	White	19.2	7.3	3.1	3.1, 3.1	11.0	3.4	280.0	1.5
RR 385-249	58.3	White	24.0	7.7	3.3	3.0, 3.0	8.4	3.0	240.0	1.1
RR 383-22	58.1	White	17.6	6.0	2.7	3.0, 3.0	7.4	3.0	240.0	1.2
RR 286-2	55.4	White	20.8	6.3	2.4	3.0, 3.0	8.4	3.0	240.0	1.4
RR 433-2	59.1	White	19.2	6.7	2.5	3.1, 3.1	9.5	3.8	301.0	1.4
Mean	56.8		20.5	6.7	2.5	3.2, 3.2	8.9	3.8	304.0	1.4

Table 3. Physical and chemical grain quality characteristics of rice under bunded rainfed uplands

Variety/Genotype	Head rice recovery (%)	Kernel colour	1000-kernel weight (g)	Kernel length (mm)	L/B ratio	Alkali digestion value	Kernel length after cooking (mm)	Volume expansion ratio	Water uptake (ml/100 g)	Elongation ratio
Brown gora	55.5	Brown	22.4	6.4	2.5	3.3, 3.3	9.8	3.5	280.0	1.5
Kalinga III	51.5	White	16.0	7.0	3.0	3.2, 3.2	10.5	3.5	280.0	1.5
Vandana	51.5	White	20.8	6.8	2.7	3.3, 3.3	9.5	3.3	284.0	1.4
Anjali	52.0	White	20.8	6.8	2.3	3.1, 3.0	9.3	3.3	264.0	1.4
Kalyani 2	52.1	White	25,60	7.0	2.3	3.1, 3.1	10.7	3.5	280.0	1.5
Heera	51.3	White	14.4	7.1	2.4	3.3, 3.3	10.6	3.5	280.0	1.5
Barani deep	51.2	White	24.0	6.6	2.6	3.7, 3.7	7.8	3.5	280.0	1.2
N 22	51.7	White	16.0	5.5	2.2	3.0, 3.0	9.0	3.2	256.0	1.6
VL 221	51.2	White	17.6	6.5	2.6	3.1, 3.0	10.7	3.5	280.0	1.5
GR 5	55.4	White	22.4	6.8	2.7	3.2, 3.2	9.7	3.0	240.0	1.4
Sathi 34-36	53.3	Red	25.6	6.9	2.7	3.3. 3.5	9.6	3.0	240.0	1.4
RR 347-2	56.3	White	20.8	6.3	1.9	4.0, 3.8	8.2	3.0	240.0	1.3
RR 410 –5-1-B-1-B-B-2	52.3	White	22.4	7.0	2.6	3.0, 3.0	7.9	3.5	280.0	1.1
RR 410-82-1-B-2-B	55.1	White	16.0	6.7	2.5	3.0, 3.0	9.5	3.0	240.0	1.4
RR 366-4	54.5	Red	22.4	9.0	3.4	3.0, 3.0	9.4	3.5	280.0	1.0
RR 366-7	57.5	Red	28.8	8.3	3.6	3.0, 3.0	9.7	3.0	240.0	1.2
RR 366-8	54.5	Red	25.6	9.3	3.5	3.0, 3.0	10.0	3.0	240.0	1.1
RR 363-36	58.8	White	17.6	8.0	3.4	3.1, 3.2	12.0	3.3	280.0	1.5
RR 385-249	57.4	White	20.8	7.3	2.4	3.0, 3.0	8.8	2.8	204.0	1.2
RR383-22	59.3	White	14.4	5.7	2.1	3.0, 3.0	7.7	2.8	204.0	1.4
RR 286-2	52.3	White	16.0	6.7	2.5	3.0, 3.0	8.8	2.8	204.0	1.3
RR 433-2	57.2	White	20.8	7.0	2.3	3.0, 3.0	9.8	3.0	240.0	1.4
Mean	54.7		20.5	7.0	2.7	3.2, 3.1	9.4	3.2	251.0	1.4

Highest water uptake value was recorded in N 22 (444) followed by Kalyani 2 (404). The kernel length after cooking, volume expansion ratio, elongation ratio and aroma in the test varieties matched the minimum acceptable standards (10 mm, 3.7, 1.5 and mild scent respectively) according to the methods as documented by Mishra *et al.* (1996). It revealed that the tested varieties viz., Kalinga III, Kalyani 2, Heera, VL 221, RR 366-8 and RR 363-36 grown under bunded uplands satisfied the minimum acceptable standards and can be recommended for use by the consumers.

Maximum benefit cost ratio (B: C) of 0.89 was recorded for RR 366-4, followed by RR 366-8 (B: C 0.85) and RR 366-7 (B: C 0.75) in the bunded uplands. Higher B: C ratio of varieties RR 366-4 (B: C 0.78), RR 366-8 (B: C 0.73) and RR 363-36 (B: C 0.73) were found in the unbunded uplands. The higher cost of cultivation was attributed to manual cultivation resulting in negatives returns. Variety Heera, a local check registered the lowest B: C ratio of 0.26 in the experimental fields. Therefore, it can be concluded that the popular rice varieties/advanced breeding lines are suitable because of higher grain yield, good quality grains and better returns can be accrued by cultivating them under bunded uplands.

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