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Rice Hybrids and High Yielding Varieties for Augmenting Public Distribution System Demand in Andaman and Nicobar Islands, India

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A B S T R A C T

Increases in rice grain yield depend on introduction of potential cultivars including hybrids into Andaman and Nicobar islands that with small acreage (5340 ha) won't merit developing hybrids locally. The objective of this study was to evaluate newly released hybrids and high yielding varieties of rice elsewhere in the country and identify promising ones for augmenting the huge production shortages in the islands. Twenty rice cultivars (17 hybrids and 3 high yielding varieties) were field evaluated using randomised complete block design with two replicates at Port Blair, Andaman & Nicobar Islands during kharif season of 2017. Results revealed that five hybrids (28P09, NK-16520, 27P36, KPH-272 and PAN-2423) and two varieties (NDR-359 and Gontra Bidhan-3) have 14-26% higher grain yields than local check variety 'CARI Dhan-6' (3.1 t/ha). Based on 10 and 20% increase in yield as criteria for release of a variety and hybrid in the country, NDR-359 (21%) and Gontra Bidhan-3 (23%) varieties and 28P09 hybrid (26%) merits are introduction. From economics point of view, Gontra Bidhan-3 (250%) followed by NDR-359 (217%) and 28P09 hybrid (214%) with 227% higher net income than local check (Rs. 9121) proved their merit. This study provided evidence to suggest that new cultivars introduction could augment the rice production shortages in the islands to some extent.

Introduction

Rice (*Oryza sativa* L.) is the most important staple crop of Andaman & Nicobar Islands grown under rain fed lowlands during *kharif* season on 5340 ha with a production 16845 t (DOES, 2018) and this production is far behind the local requirements. This is evident from the fact that during 2016-17, 12594 t rice was produced in islands, while 22, 821 t of rice (6,737 t wheat) were shipped from mainland and supplied though public distribution system (PDS) indicating a demand of 42152 t of cereals (DOES, 2017). The transhipment of food grains from mainland to Islands and from there to fair price shops located in each village by Food Corporation of India (FCI) is a herculean task and involves huge cost and human effort. All India transit losses of rice in India were estimated as 0.38% in 2017-18 (DFPD, 2019), though separate estimates are unavailable for Islands; the losses will be many times higher (5 times) due to multi-mode of transport (road, train, ship) and 3-4 transhipments. Food grain sourced from mainland ports, have to travel a minimum of 1200 km by ocean to reach capital that emits huge carbon dioxide gas and is thus pollutive to environment. So any attempt to enhance the local rice production aids in reducing the transhipment losses and associated economic and environmental costs. Little scope exists for horizontal growth (area expansion) as cultivated area in islands has declined from the peak 50000 ha to the current 40500 ha. This brings us to the vertical expansion (productivity enhancement) option. In this direction, hybrids with 15-20% yield advantage (1 t/ha) were exploited (FAO, 2004). India started its hybrid rice efforts in 1989 and released its first hybrid (APRRH-1) in 1994 and by 2017, 97 hybrids were released (6 hybrids in 2017 alone) in the country (DRD, 2018). Accordingly, hybrid rice area has increased to 0.5 m ha in 1999 to the current over 3 m ha of area (7% of rice acreage) in 2016 (Raja, 2016). This still far behind the 25% target set by Government of India for 2015 (TET, 2012). Hybrid rice produced in the country often finds its place in public distribution system.

This vertical expansion approach is apt for islands, as there was 55.5% area loss in rice between 2000 (12000 ha) and 2017 on account of tsunami and also due to low productivity and thus profits of rice cultivation. Thus hybrid rice cultivation was taken since 2015 in the Islands on a small scale through testing of promising and released hybrids under All India Coordinated Rice Improvement Project (AICRIP) system for offsetting the losses in acreage and also to augment local supplies for PDS. In this context, field investigation was made during 2017 to assess the yield gain from newly released hybrids supplied under Multi Location Testing (MLT) trail to support the public distribution system.

Materials and Methods

Experimental location

A field study was made during *kharif* season - 2017 (July- November) at Bloomsdale farm, ICAR-Central Island Agricultural Research Institute, Port Blair, Andaman & Nicobar Islands situated at 11^0 38’ 06” N latitude and 92^0 39’ 15’’ E longitude at an altitude of 14 m above mean sea level with tropical humid climate.

Treatments

Twenty (20) rice cultivars (15 newly released hybrids; 2 hybrid and 3 variety checks) belonging to mid early (13) and medium duration (7) maturity group formed the treatments of the study. These treatments were evaluated in Randomized Complete Block Design (RCBD) with two replicates per treatment (Table 1).

Experimental soil characteristics

Soil samples were collected from experimental field on 15^{th} June, 2017 from 0-20 cm depth, were oven dried to constant moisture and composite soil analysis was carried out as per Jackson (1973). Analysis of the experimental sandy loam soil indicated its slightly acidic (6.27 pH) and non saline (ECe:1 dS/m) nature. It contained 248, 10.9 and 124 kg/ha of available nitrogen (N), phosphorus (P) and potassium (K).

Field and crop management

The experimental field was prepared by puddling thrice with power tiller followed by its manual levelling. A plot size of $15m^2$ was used per treatment. Thirty day old nursery grown rice seedlings were transplanted in main field on 1^{st} July, 2017. The crop was grown under rain fed conditions with protective irrigation to maintain standing water (3-5 cm) throughout life cycle and thus faced no moisture stress during its life cycle. Pre-emergence application of pendimethalin 38.7% CS @ 0.75 kg a.i/ha immediately after transplanting followed by two manual weedings (25 and 45 days after transplanting, DAT) have effectively taken care of the weed menace. The crop has received uniformly 100-60-60 kg N-P_2O_5-K_2O/ha of fertilizer through prilled urea, single super phosphate and muriate of potash. Entire phosphorus and potassium fertilizers were applied in last puddling while nitrogen was top dressed in 3 equal splits on 5, 27 and 47 DAT. Two days prior to second and third N top dressing, manual weeding was done. Field was dewatered prior to N top dressing and re-watered after 48 hours. Need based plant protection measures were given to the crop against sucking insect pests and foliar diseases. The rice crop was harvested for grain on 15th January during both the years.

Growth and yield data recording

Plant height at harvest (cm) from base to the tip of plant, days to fifty flowering and days to maturity (physiological) were recorded treatment wise. Yield attributes (number of panicles/m^2, number of grains/panicle and test weight in g) from ten randomly selected plants were recorded at harvest. The plot wise biomass was harvested at physiological maturity and allowed to dry in the field for two days and weight (kg/plot) was recorded.

A representative biomass sample (1 kg) was taken treatment wise; grain was separated and dried in oven to 10 and 14% moisture, respectively. Grain was threshed manually and yield was recorded. Biological yield and grain yield of plot were adjusted based on the factor arrived with oven dried sample. From plot yields, per ha yields were estimated. Per day productivity (kg/ha-day) were worked out as ratio of grain yield (kg) to crop duration for maturity (days).

Economics

In the calculation of economics, input prices as per market, output prices based on minimum support price of paddy (Rs. 15,500/tonne) and assumed straw price (Rs. 2,000/tonne) were used. Benefit Cost Ratio (BCR) was worked out as ratio of gross income (net income + cost of cultivation) to the cost of cultivation. A cost of cultivation (Rs/ha) of 51,836 and 55631 was used for rice variety and hybrid (DOES, 2018).

Statistical analysis

The analysis of variance was done in RBD and significance of treatment differences was compared by critical difference at 5% level of significance (P=0.05) and statistical interpretation of treatments was done as per Gomez and Gomez (1984).

Results and Discussion

Weather during study period

Weather data during the experiment period was highly congenial for rain fed transplanted rice cultivation (Figure 1). A rain fall of 2063.3 mm was received in 82 rainy days. A mean maximum and minimum temperature of 30.6 and 25 ^{O}C was recorded at the nearest weather station of Indian Meteorological Department (IMD), at Port Blair. Crop required irrigations during October and November months to maintain 3-5 cm standing water. Effective plant protection measures along with recommended fertilizer inputs have excluded the biotic and abiotc stresses of rice crop cultivation and thus the differences in performance recorded was solely ascribed to treatments only i.e. cultivars (hybrid/ variety).

Growth and yields attributes

Growth and yield attributes of rice were greatly influenced by cultivars and was given in Table 1. Plant height (cm), the major parameter of rice crop growth has a mean value of 126.7 cm at harvest. Among the cultivars, BS-158 hybrid (114.5 cm) along with local check variety (CARI-Dhan-6) has produced the shortest plants (115.3 cm). PAN-2423 hybrid has the tallest plants (134.5 cm) and 28P09 has closest values (132.6 cm).

Rice crop on an average has produced 242 panicle/m^2 with 117 grains/ panicle and grains have a test weight of 23.05 g. Significantly higher number of panicles/m^2 (287), grains/panicle (137) were recorded with 28P09 hybrid, however test weight was highest in NDR-359 (26.03 g). Panicle/m^2 and grains/ panicle were least in 27P22 and Gontra Bidhan-3. Test weight (g) values ranged from the lowest of 17.51 (NPH-8899) followed by 28P09 hybrid. Lower test weight indicates its finer grain character.

Yield and harvest index

The data on grain, biological yield and harvest index was presented in Table 2. Grain yield (t/ha) data of 20 cultivars reveals that 28P09 hybrid has the highest grain yields (3.91 t/ha) while HRI1-183 has the least (2.90). When compared with local check variety 'CARI Dhan-6' (3.10 t/ha), five hybrids (28P09, NK-16520, 27P36, KPH-272 and PAN-2423) and two national check varieties (NDR-359 and Gontra Bidhan-3) have significantly higher grain yields. The yield superiority ranged from lowest of 0.45 (PAN-2423) to the highest of 0.81 t/ha (28P09) that in per cent (%) terms came to 14- 26%. Remaining rice hybrids (12) have at par grain yield as that of the local check. Superior performance of 28P09 hybrid was ascribed to its higher number of panicles, grains/ panicle, and for higher number of panicles and test weight in Gontra Bidhan-3 and NDR-359 varieties. HRI1-183 and NPH-8899 fared poorly for grain yield owing to its low panicle numbers and super fine grain (17.51 g test weight) respectively. Biological yields followed the trend of grain yields as they accounted for 34.8 of total biomass yield and it ranged from 8.39-11.37 t/ha with a mean value of 9.7 t/ha. Higher growth (plant height) and yield attributes together have contributed higher biomass yield and high grain yielding cultivars are high biomass producers too. Harvest index values ranged from 33.1 (BS-158) - 37.0 (NDR-359) and differed significantly among cultivars. The harvest index values at the current location are 4-5% lower than the normal as at the experimental site, there were bird damage that have eaten grains uniformly. As per Forest law, they can't be controlled as comes under protected category. This applies to grain yield also. A significant increase in rice grain yield with introduction of hybrids over indigenous varieties (58.1%) and high yielding varieties (6.8%) in Jharkhand state (Aravind Kumar *et al.*, 2016) corroborates our results. The increases are of lesser magnitude than above as we have used improved local variety as standard. Similar differences among hybrids for harvest index values were reported by Gangaiah and Prasad Babu (2012).

Crop duration and per day productivity

The cultivars belonging to mid early and mid group of maturity differed significantly for days to 50% flowering and also for maturity. Rice crop on an average took 97.7 days to reach 50% flowering stage and form there reached dough stage in 27 days. Quickest 50% flowering (83 days) and maturity (108 days) was observed by local variety check CARI Dhan-6 while Sahyadri-5 hybrid took the longest time for the same (108). Accordingly, maturity period also varied for the same cultivars from the lowest of 112 days to the highest of 139 days.

Rice cultivars tested have a mean per day productivity of 27 kg/ha-day. It was highest in Gontra Bidhan-3 (32.38) and closely followed by PAN-2423 (31.68). BS-129G and KPH-272 hybrids which also have a per day productivity > 30 kg/ha-day. NPH-8899 has the least per productivity (23.85) that was closely followed by Sahyadri-5 (24.16). High yields and shorted duration of crop together have resulted in high per day productivity and the converse is the reason for low per day productivity.

Economics

Economics (Rs/ha) of rain fed transplanted rice cultivation (Table 2) in islands revealed that hybrids have Rs. 4,395/ha higher cost of cultivation than a variety (Rs. 51236). The extra cost of cultivation in hybrid rice was due to high seed cost (Rs 250 kg) as compared to a variety (Rs. 30/kg) and in this study same seed rate (20 kg/ha) was used in raising seedling in nursery and their transplanting in main field. Rice cultivation is profitable as evident from the mean net returns (Rs. 10382).

Table.1 Growth and yield attributes of rice as influenced by its hybrids and varieties in the islands

Hybrid / Variety	Plant height (cm) at harvest	DFF	Days to maturity	Panicles/ m^2	Grains /panicle	Test weight (g)
PAN-2423 (ME)	134.5	89	112	234	128	22.18
NPH-8899 (M)	131.1	101	131	275	135	17.51
GK-5022 (ME)	122.4	96	123	249	110	23.54
KPH-467 (ME)	129.2	99	129	258	108	23.85
HRI1-183 (ME)	122.0	92	117	215	118	23.52
KPH-272 (ME)	130.7	95	120	245	120	23.10
HRI-180 (ME)	127.4	99	125	231	115	23.26
PAC-8744 (M)	125.1	101	131	236	121	21.57
27P22 (ME)	126.3	95	120	212	118	24.15
27P36 (ME)	127.1	103	132	243	120	22.41
28P09 (ME)	132.6	107	137	287	137	19.33
Sahyadri-5 (M)	131.4	108	139	226	114	23.78
BS-158 (ME)	114.5	94	121	225	110	24.10
NK-16520 (M)	123.7	101	129	256	118	21.97
BS-129G (ME)	123.0	90	115	248	120	22.71
US-312 (ME)**	132.6	98	120	231	115	23.16
HRI-174 (M)*	131.1	104	132	225	118	24.58
CARI Dhan 6 (M)*	115.3	83	108	224	107	25.07
Gontra Bidhan-3 (ME)*	128.3	92	118	260	106	25.13
NDR-359 (M)*	125.8	105	133	257	103	26.03
SEm±	3.49	2.0	-	5.1	2.2	0.530
CD (P=0.05)	10.3	5.9	-	13.2	5.7	1.565

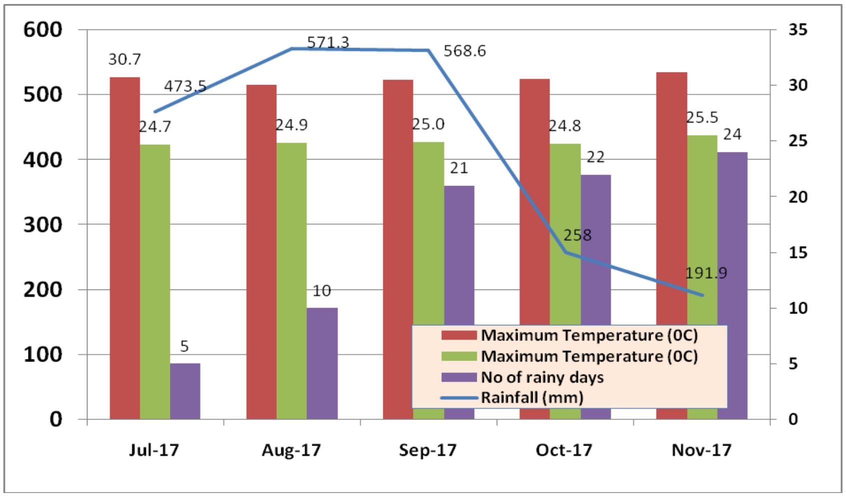
M= Medium; ME: Mid Early; * Variety check, ** hybrid check

Table.2 Yield, harvest index and economics of rice as influenced by its hybrids and varieties in the islands

Hybrid / Variety	Yield (t/ha)		Harvest index	Economics (Rs/ha)			Benefit Cost Ratio
	Grain	Biomass		Cost of cultivation	Gross returns	Net returns	
PAN-2423 (ME)	3.55	10.10	35.1	55630	68057	12426	1.22
NPH-8899 (M)	3.13	8.88	35.2	55630	59943	4312	1.08
GK-5022 (ME)	3.33	9.56	34.8	55630	64016	8385	1.15
KPH-467 (ME)	3.36	9.45	35.5	55630	64213	8582	1.15
HRI1-183 (ME)	2.90	8.39	34.5	55630	55865	234	1.00
KPH-272 (ME)	3.63	10.60	34.2	55630	70136	14505	1.26
HRI-180 (ME)	3.26	9.05	36.0	55630	62083	6452	1.12
PAC-8744 (M)	3.35	9.60	34.9	55630	64461	8830	1.16
27P22 (ME)	3.13	9.25	33.8	55630	60679	5048	1.09
27P36 (ME)	3.60	10.46	34.4	55630	69492	13861	1.25
28P09 (ME)	3.91	11.17	35.0	55630	75128	19497	1.35
Sahyadri-5 (M)	3.36	10.15	33.1	55630	65623	9992	1.18
BS-158 (ME)	3.13	9.16	34.1	55630	60516	4885	1.09
NK-16520 (M)	3.68	10.38	35.4	55630	70375	14744	1.27
BS-129G (ME)	3.45	10.09	34.2	55630	66789	11158	1.20
US-312 (ME)**	3.10	8.88	34.9	55630	59615	3984	1.07
HRI-174 (M)*	3.39	9.79	34.6	55630	65322	9691	1.17
CARI Dhan 6 (M)*	3.10	9.25	33.5	51240	60357	9121	1.18
Gontra Bidhan-3 (ME)*	3.82	10.92	35.0	51240	73418	22182	1.43
NDR-359 (M)*	3.76	8.94	37.0	51240	70990	19754	1.39
SEm±	0.127	0.254	0.76	-	-	897	-
CD (P=0.05)	0.375	0.750	1.97	-	-	2325	-

M= Medium; ME: Mid Early; * Variety check, ** hybrid check

Fig.1 Rainfall (mm/month), number of rainy days /month, maximum and minimum temperature (°C) during experiment period



Gontra Bidhan-3 mid early variety stood at the top for net income (Rs. 22182) followed by medium duration variety NDR-359 (Rs. 19754) and 28P09 hybrid (Rs.19489). Other high yielding hybrids (NK-16520, 27P36, PAN-2423 KPH-272) too have significantly higher net income (12426- 14744) than local check variety, CARI Dhan-6 (Rs. 9121). Gontra Bidhan-3 being a variety has Rs. 4395/ha lower cost of cultivation than the hybrid and thus has higher net income though has slightly lower grain yields (0.09 t/ha) than highest yielding 28P09 hybrid. Benefit cost ratio (BCR) following the net income was highest in Gontra bidhan-3 (1.43) and all the above high yielding cultivars have (1.22-1.39) higher BCR than the local check (1.18). BCR was least in US-312 hybrid. Similar differences among rice cultivars for net profits were reported by Shukla *et al.,* (2015).

From the field investigation it can be concluded that new hybrids and varieties have the potential to enhance the rice productivity in the Islands by 14 - 26%. Based on 10 and 20% increase in yield as criteria for release of a variety and hybrid, NDR-359 (21%) and Gontra Bidhan-3 (23%) varieties and 28P09 hybrid (26%) merits introduction. These 3 cultivars with a mean yield advantage 23.5% (728.7 kg/ha) over local check (3.1 t/ha), when adopted on 50% of cultivated area, could add 1945 t of additional production i.e. 8.5% PDS rice brought from mainland in 2016-17. These production increases in islands could contribute to the reductions in carbon foot print associated with its shipping from mainland.

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