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Assessment of high yielding varieties of rice (*Oryza sativa*) for integrated rice-fish-horticulture farming system under lowland ecosystem of north eastern India

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Abstract

Field trials were conducted during 3 years from 2010-12 to assess the performance of high yielding varieties of rice for rice-fish-horticulture farming system under lowland rice ecosystem at Regional Rainfed Lowland Rice Research Station, Gerua, Asom. Among the rice varieties, Swarna performed better when water level was low during tillering stage. The new submergence tolerant variety Swarna sub-1 was not superior to Swarna when mean water depth remained below 40 cm. Ranjit, the popular high yielding variety for shallow lowland performed consistently better under rice-fish system. Performance of tall and lodging susceptible varieties like Jalpriya and Mahsuri were inferior to semi-dwarf high yielding varieties under shallow low land situation. Rice variety Swarna recorded highest B: C ratio of 1.83 followed by Ranjit (1.82) and Swarna *Sub*1 (1.75).

Key words: High yielding varieties, integrated rice-fish-horticulture farming, lLowland rice ecosystem, rice, yield.

Rice is grown in about 44 M ha in India of which 40% area are rainfed lowlands mostly located in the Eastern in India. The productivity of this mega ecosystem is very low (1.0 to 1.5 t/ha) because of monoculture of rice (Sinhababu *et al*., 2003). Among the farming system options available for rainfed lowland ecologies, rice-fish farming system is one of the best economically viable and acceptable choice considering the resources, food habits and socio-economic cultures in India in general and eastern and north-eastern India in particular (Sarangi *et al*., 2004). Rice-fish farming with high water and land productivity and employment opportunities can ensure food, nutrition and livelihood security for the farming communities, particularly the largest group of small and marginal farmers (Mahapatra *et al*., 2007). Rice-fish farming under either capture systems or culture systems is a low cost sustainable practice to obtain high value protein food and minerals (Saikia and Das, 2008). At the farm level, rice-fish integration reduces use of chemical fertilizers (Young *et al*., 2006), pesticides and herbicides (Salehi and Monen Nia, 2006) in the field. The reduction in costs of agricultural chemicals increase economics of farmers and also accrues their additional income from fish sale and higher rice yields (Mohanty *et al*., 2002). Such savings and additional income enhanced the net income from rice-fish farming system than the monoculture of rice. Also, the integrated production system can optimize resource use through the complementary utilization of land and water. In recent past, paddy-cum-fish cultivation has received a great attention from the government while focusing on sustainable rural development, food security and poverty alleviation (Singh *et al*., 2011).

The hydrological characteristics of the watershed where rice farming is traditionally practiced was found suitable for rice-fish farming .Only minor modifications in terms of construction of dykes, digging of refuge ponds/ ditch for shelter of fish are required. Keeping in view the requirements of both the components, an adoptable and eco-friendly rice-fish farming system technology was developed for rainfed lowland semi-deep areas (Sinhababu et al., 2003; Rautaray *et al*., 2005; Satapathy *et al*., 2013). Rice is the major component in this system as it occupies 60-65% of the transformed farm area and water depth remains high (20-70 cm) in the main rice field during rainy season, selection of suitable high yielding, non-lodging and water stagnation tolerant variety is needed for enhancing productivity and profitability of the systems. Keeping above facts in view, the present study was carried out to assess the suitability of some promising high yielding varieties of rice during *kharif* season for integrated rice-fish farming system in rainfed lowland rice ecosystem.

Materials and Methods

Field experiments were carried out during *kharif* seasons of 2010-12 at the main field of integrated rice-fish-horticulture farming system model site (0.5 ha) developed at Regional Rainfed Lowland Rice Research Station, Gerua, Asom (280° 14' 59'' N latitude, 91° 33' 44'' E longitudes, 49 m altitude). The site comes under sub-tropical monsoon type climate with annual average rainfall 1,500 mm. The experimental soil is high in organic carbon (1.1%) and medium in available N (295 kg/ha), P (22 kg/ha) and K (306 kg/ha). The field design of the system included wide dykes all around, a pond refuge connected to side trenches (micro-watershed-cum-pond refuge) and one guarded outlet. Rice was the major component occupying 60% of the total area followed by horticulture and agro-forestry component on pond dykes (23%).The pond refuge (30 m × 12 m × 2 m) was constructed at the lower end (down slope) of the field occupying 7.2% area. The two trenches of 2.5m width occupying 10% of the total area were constructed adjacent to the dykes along the longitudinal side of the field and those connected to the pond refuge at lower end. The dugout soil from the pond refuge and side trenches was used for construction of wide dykes all around with bottom and top width of 4 m and 2 m, respectively. The average height of the dyke was 1 m, which was 0.4 m higher than the usual maximum water level in the field.

Five high yielding varieties of rice *viz*., Ranjit, Sabita, Pooja, Jalpriya and Mahasuri during 2010 and Ranjit, Sabita, Pooja, Swarna and Swarna*Sub*1 in 2011 while Ranjit, Swarna and SwarnaSub1 in 2012 were evaluated in randomized block design. Double transplanting (locally known as Ballan) method of stand establishment was followed to cope with the high water level (more than 20 cm) at the time of transplanting. Rice seedlings were raised in primary nursery in May end in all three years of experiment. Seedlings at the age of 28 days from primary nursery were uprooted and closely transplanted (10cm × 10 cm) in bunches of 4 to 5 seedlings per hill in the secondary nursery. The clones from secondary nursery were uprooted at 28 days and transplanted in the main field with 2 to 3 clones per hill at a spacing of 20cm × 15 cm during 3rdweek of July. During 2010, farm yard manures @ 5 t/ha were applied at the time of puddling and no chemical fertilizer was applied to the crop. However during 2011 and 2012 water soluble fertilizer 19:19:19 of N: P: K @1% with a spray volume of 500 litres was applied as foliar spray at maximum tillering and panicle initiation stage of the crop. In all the three years, fingerlings of Catla, Rohu and Mrigal (composite fish culture) were released in 30:30:40 ratio after transplanting of rice at a stocking density of 6,000 fingerlings per hectare. Weeding operation was not needed in main rice field because of negligible weed population due to presence of high water level during initial two months. Lime @ 500 kg/ha were applied to pond refuge in monthly split doses (125 kg/ha). Need based insect pest management was done using neem based pesticides. The crop received 451, 340.5 and 457.3 mm of rainfall during the crop growthperiod in the first, second and third year of the experimentation, respectively.

Water levels at main rice field were recorded at periodical intervals and no drainage work was done in all three years of experiment. Weed population and density were recorded at 30 days after planting every year. One square meter area was selected at random for recording panicle bearing tillers and expressed in number per m^2. Number of filled grains in ten panicles was counted and means were expressed as filled grains per panicle. One thousand grains were weighed at 14% moisture and expressed in terms of test weight. Grain moisture content was measured by using a moisture meter and was adjusted to 14% moisture content. The grain yieldwas recorded from net plots after discarding the border area and was expressed in t/ha. The collected data on various parameters were compiled and statistically analyzed to calculate critical difference for the significant parameters (Gomez and Gomez, 1984). Economic values of seed and straw yield were estimated based on the prevailing minimum support prices by Government of India.

Results and Discussion

Water level in main rice field

Water level in main rice field at the time of transplanting was 15 cm or more in all the three years of the experiment (Fig. 1). Double transplanting helps in producing healthy and taller seedlings that can easily overcome the adverse impact of high water level at the time of transplanting (Rautaray, 2007, Ashem *et al.*, 2010). Maximum water level of 45 cm and 40 cm recorded in September, 2010 and September, 2011, respectively. In 2012, maximum water level of 35 cm was recorded in later part of August. At the time of maturity of rice, water level came down to saturation. The situation was useful in successfully raising *utera* crop of lentil, field pea and lathyrus with the residual soil moisture.

Weeds

The presence of high water level at the early stage of the crop growth helped in suppressing the weed population naturally in the main rice field of the system. However, some of the semi aquatic weeds like *Otellia alisoides* L., *Schoenoplectus articulates* L., *Monochoria avaginalis* (Bern F) Palla, *Marsilea quadrifolia* L., *Pistia stratiotes* L., *Ipomoea aquatic* (Forsk) Stapf, *Nymphae apubescens* L., *Brachiaria mutica* (Forsk) Stapf and *Ludwigia adscendens* L. were recorded in trenches and other non-cropped areas.

Plant height

Plant height was highest in Variety Jalpriya (177.4 cm) but lodging at grain filling stage resulted in poor grain filling and reduced grain yield. The variety Sabita recorded a plant height of 170.1 cm but comparatively, it was less susceptible to lodging. Varieties Ranjit, Swarna and Swarna*Sub*1 had intermediate plant height. This plant height was ideal under shallow lowland condition. Intermediate height, semi-tall and tall plant types are desired to overcome

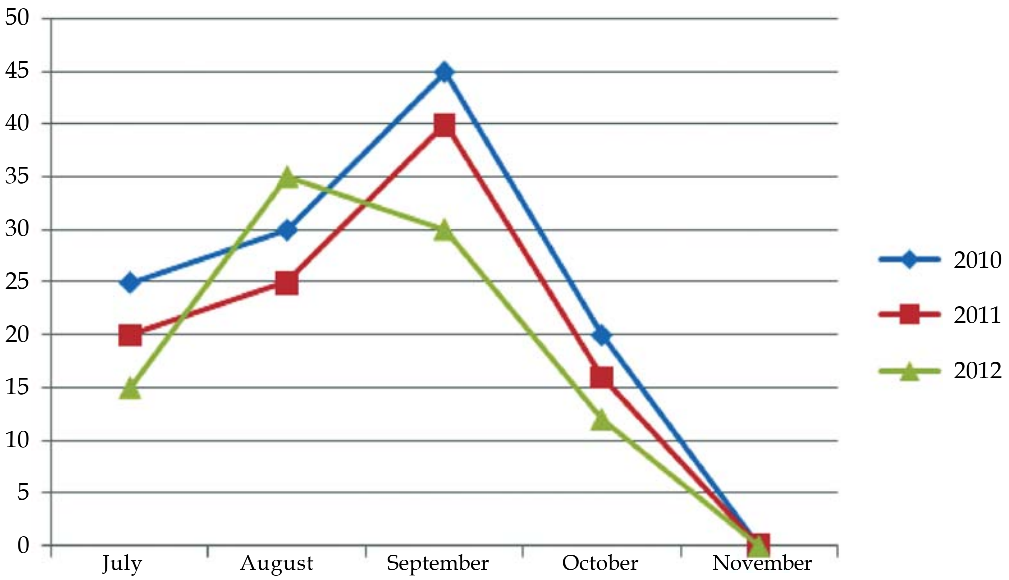

Fig. 1. Water depth (cm) in rice field in different months during study period

sudden rise in water level in rice-fish system under rainfed medium deepwater lowlands (Sinhababu *et al*., 2003).

Days to 50% flowering

Among the photo insensitive varieties tested, Pooja recorded 50% flowering at 151 days (Table 1). This was followed by Ranjit (144 days), Mahasuri (140 days), Swarna*Sub*1 (134 days) and Swarna (133 days). The photo-sensitive varieties flowered in the last week of October. Usefulness of photoperiod sensitive rice varieties under lowland situation is known (Ahamad, 1979). In photoperiod in-sensitive varieties, days to 50% flowering were prolonged for 10-15 days under rice-fish system due to double transplanting method.Such difference was not observed for photoperiod in-sensitive varieties.

Yield and yield attributes

In the year 2011, highest grain yield (5.26 t/ha) was recorded with rice variety Swarna (Table 2) and similar yield with SwarnaSub1 (4.97 t/ha). However, in the year 2012, Swarna out yielded Swarna*sub*-1.This might be due to presence of high water depth for a prolonged period till September in the year 2011 favouring the performance of Swarna *sub*-1. In the year 2011, Swarna (5.26 t/ha) recorded significantly higher yield than Ranjit (4.93 t/ha). However, in 2012, Ranjit (5.93 t/ha) and Swarna(5.73 t/ha) recorded similar yield. The higher grain yield with Swarna in the year 2011 might be due to lower water depth of 25 cm during August coinciding with the tillering stage of rice crop. Jalpriya (3.72 t/ha) and Mahasuri (4.12 t/ha) were tested in the year 2010 and these varieties recorded poor grain yield as compared to Ranjit (5.18 t/ha). This wasdue to poor grain filling percentage after lodging at flowering stage of these two varieties. The rice variety Sabita recorded highest average panicle weight of 3.4 g and test weight of 35.6 g, but grain yield was lower compared to Ranjit in year 2011 due to lesser number of panicles per unit area (184.2/m^2). Variety Pooja recorded lower grain yield compared to Ranjit in both the years due to poor number of filled grains per panicle (98) in spite of high number of panicle per unit area (302.7).

Economics

Rice variety Swarna recorded the maximum net return (Rs. 26073) followed by Ranjit (Rs.

Table 1. Growth and yield parameters of rice varieties under rice-fish-horticulture farming system(mean of 3 years)

Varieties	Plant height (cm)	Days to 50% flowering	Effective tillers m^2	Grains /panicle	Test weight (g)	Lodging behavior
Ranjit	132.2	144	242.3	141.6	20.2	Non lodging
Sabita	170.1	151	184.2	117.8	35.6	Lodging at maturity
Pooja	111.9	151	302.7	98.0	21.1	Non lodging
Jalpriya	177.4	150	251.0	110.0	22.4	Susceptible to lodging
Mahasuri	141.6	140	264.0	125.0	16.1	Susceptible to lodging
Swarna	112.8	133	260.0	141.8	20.0	Non lodging
Swarna*Sub 1*	112.1	134	254.7	139.4	19.6	Non lodging
CD(P=0.05)	8.30	2.57	13.17	9.36	0.97	-

Table 2. Grain yield and Economics of rice varieties under rice-fish-horticulture system

Varieties	Grain yield (t/ha)				Net returns (Rs.)				B:C ratio			
	2010	2011	2012	Mean	2010	2011	2012	Mean	2010	2011	2012	Mean
Ranjit	5.18	4.93	5.93	5.35	22,957	23,115	28,146	24,739	1.84	1.76	1.87	1.82
Sabita	4.80	4.39	-	4.60	13,978	15,795	-	14,887	1.51	1.52	-	1.52
Pooja	4.23	4.25	-	4.24	12,625	8,865	-	10,745	1.46	1.30	-	1.38
Jalpriya	3.72	-	-	3.72	3,965	-	-	3,965	1.14	-	-	1.14
Mahasuri	4.12	-	-	4.12	13,109	-	-	13,109	1.18	-	-	1.18
Swarna	-	5.26	5.73	5.50	-	26,470	25676	26,073	-	1.86	1.80	1.83
Swarna*Sub 1*	-	4.97	5.47	5.22	-	22,135	23450	22,793	-	1.78	1.71	1.75
CD (P=0.05)	0.56	0.30	0.22	-	-	-	-	-	-	-	-	-

24739) and SwarnaSub1 (Rs. 22793). Low net return with Jalpriya (Rs. 3965) and Pooja (Rs. 10745) was due to poor grain yield. Highest benefit: cost ratio (1.83) was registered with Swarna closely followed by Ranjit (1.82) and Swarna*Sub*1 (1.75). Lowest B:C ratio of 1.14 with the variety Jalpriya was due to poor yield and lower market price.

The study revealed that rice variety Swarna performed better when water level was low during tillering stage. The new submergence tolerant variety *Swarna sub-1*was not superior to existing Swarna when mean water depth remained below 40 cm. Ranjit, the popular high yielding variety for shallow lowland performed consistently better under rice-fish system.

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