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Impact of modern rice varieties in submergence prone lowlands: A case study

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ABSTRACT

Three lowland rice varieties viz. Durga, Gayatri and Sarala were introduced in the submergence prone area of Orissa state and the varieties have spread to 51 percent of the lowland area within three years in the target villages. Durga was adopted much faster than the other two varieties because of its higher submergence tolerance ability. The returns from all the three modern varieties were found to be attractive in comparison to traditional varieties and the additional income generated ha^{-1} was Rs 4736 from these varieties. The additional employment generation by the cultivation of these modern varieties was found to be 23 man days ha^{-1}. These varieties have added 825 kg of rice ha^{-1}, which has improved the household food security of poor farmers. Due to popularity of the varieties, seed exchange of 1802 kg has taken place among farmers, both within and outside the village.

Key words: *Impact assessment, rice varieties, submergence prone lowland, Orissa*

Rice is the staple food of 37 million people of Orissa state. It is grown in an area of 4.4 m ha, which accounts for more than 75% of the total area under cereals and 46% of the total cropped area in the state. Rice is mainly grown in the wet season, which accounts for 94% of the total rice area and 89% of the total rice production. Out of total 2.2 m ha of rainfed lowlands of Orissa, about 50% are submergence/flood prone. The lower reaches of these lands are largely covered by local varieties. The yield of rice in flood prone lowland conditions are low and highly variable (0 - 2.5 t ha^{-1}) due to frequent occurrence of natural calamities. It has been reported that drought and flood of various intensities occurred across geographical locations almost every year in the state (Reserve Bank of India, 1984 and Samal, 2004).

The occurrence of poverty (40%) is the highest in Orissa among all the states of India (Government of India, 2007). It has been reported that majority of poor live in the rainfed areas (Hossain, 1995) and they derive their livelihoods mainly from rainfed rice systems. Though modern varieties of rice were introduced during the late sixties in the state, the progress of adoption of these varieties as well as their yield performance was not impressive during the wet season and particularly in unfavorable lowland conditions. Therefore, under the International Fund for Agricultural Development (IFAD) supported project on 'Accelerating technology adoption to improve rural livelihoods in the rainfed eastern gangetic plains', an effort has been made to introduce new varieties into these rainfed areas, validate the technologies and accelerate the proven technologies to wider areas having similar ecosystems to improve the livelihood of the poor farmers. Technology driven farm production have the most direct impact on the rural poor (Adato *et al*, 2007). Increase in agricultural output can also directly impact the rural mass by increasing agricultural employment, which can be beneficial to small farmers and agricultural labourers. In this context, an effort has been made to assess the impact of a technology introduced through the project i.e. 'Replacement of traditional varieties with modern varieties like Durga, Gayatri and Sarala in the submergence prone lowlands'. The assessment has been made in terms of area spread, cost reduction per tonne of produce, employment generation and seed exchange.

MATERIALS AND METHODS

During 2004, a preliminary survey was made in the

coastal submergence prone areas in Orissa and three villages (Paikarapur, Bidyadharpur and Brahmanabasta) of Cuttack district were selected based on frequency of occurrence of flood / submergence, and accessibility by all weather roads. Participatory Rural Appraisal (PRA) technique was used to identify the causes of low income of farmers in the selected villages. The important reasons for low income of farmers were listed and scoring technique was used to assign scores to different ranking criteria. The ranking criteria used were percentage of farmers affected by a problem, frequency of occurrence of the problem and severity of the problem. The problems which were ranked first, second and third were, Lack of alternative income generating opportunities; Low yield of rice in rainfed flood prone lowlands; and Low yield of rice in rainfed flood prone medium lands respectively. Out of first 3 problems, the second problem was selected to tackle with, as some rice varieties with certain degree of tolerance to submergence are available. Although scientists have defined broad lowland ecosystems (shallow, intermediate, semi-deep and deep), individual farmers in such areas usually manage land distributed across local landscapes that include a diverse and dynamic range of rice environments (Fujisaka, 1990). The farmers in the study area have classified their land into three broad types i.e. upland (no standing water), medium land (water depth 0-30 cm) and lowland (water depth >30 cm). In this study, farmers' classification has been used to facilitate data collection. The occurrence of natural calamities at the target sites over ten year period was also gathered through PRA technique.

The list of farmers of each village with their land holding size was collected from the block office. The farmers were categorized into 3 types according to the land owned by them i.e. marginal (0-1 ha), small (1-2 ha) and large (>2 ha). Twenty farmers from each village were selected according to the probability proportion of each group of farmers available in a particular village. Out of the 20 farmers, 10 farmers were selected for testing of selected technologies in their field, which are designated as participating farmers and the rest 10 are designated as non-participating farmers. Thus, the total sample consisted of 60 farmers. A baseline survey was conducted during 2004 to record the varieties grown by farmers in different land types, income from rice cultivation with the help of a questionnaire. The new technology i.e. the rice varieties Durga, Gayatri and Sarala were introduced in the fields of participating farmers during 2004 wet season with improved management practices. The local check varieties Khuda, Pasakathia and Bagadachampa were grown in the adjacent plots along with the usual management practices followed by farmers. This technology was tested for three wet seasons i.e. 2004, 2005 and 2006. The inputs used by farmers, labourers employed in different operations, output obtained and price of inputs and outputs were recorded every year to compute the costs and returns. The sample farmers were again interviewed during 2007 with the help of structured schedules and questionnaires to study the spread of modern varieties and their impact on income and employment.

RESULTS AND DISCUSSION

The rainfall and the natural calamities faced by farmers during 1995 to 2004 are listed in Table 1. The normal rainfall in the area is 1424.3 mm. Out of 10 years, submergence has occurred in 7 years and drought in 4 years and flood in 3 years. The probability of occurrence of submergence in a year is 0.7. The rainfall distribution is uni-modal and > 80% of rainfall was received during June to October. The availability of land with the sample farmers are presented in (Table 2).

Rice is the dominant crop covering 89% of total available land during wet season. The major cropping sequences followed by farmers in the study area were Rice-Fallow (54%), Rice-Rice (22%), Rice-Pulses

Table 1. Rainfall and stresses observed in the study areas of Cuttack, Orissa

Year	Rainfall (mm)	Deviation from normal (mm)	Stresses
1995	1689	265	Submergence
1996	865	-559	Drought
1997	1835	411	Submergence & Flood
1998	1472	48	Submergence
1999	1881	457	Submergence & Cyclone
2000	1016	-408	Drought
2001	1814	390	Submergence & Flood
2002	1185	-239	Drought
2003	1970	546	Submergence & Flood
2004	1379	-45	Drought & Submergence

Source: Block office, Athagarh and PRA; Normal rainfall: 1424.3 mm

Table 2. Availability of different types of land with the sample farmers

Type of farmer	Land type			
	Upland	Medium land	Lowland	All land
Participating farms	22.91*(0.27)	28.70(0.34)	48.39(0.57)	100(1.18)
Non- Participating farms	21.89(0.29)	23.76(0.31)	54.35(0.72)	100(1.32)
All sample farms	22.37(0.28)	26.09(0.33)	51.54(0.64)	100(1.25)

Figures in parentheses indicate area in ha. * Percent land

(18%) and Rice-Vegetables (6%). The trend was similar when cropping pattern of participating and non-participating farmers were compared.

The coverage of modern varieties (MV) and traditional varieties (TV) of rice by land type before the project and after the project is presented in Table 3. The coverage of modern varieties has been presented in (Table 4)**.**

On an average, the percentage coverage of Durga, Gayatri and Sarala was 33%, 10% and 8%, respectively. Disaggregated by type of farmers i.e. participating and non-participating, the coverage by the participating farmers was 36, 11 and 12 percent for Durga, Gayatri and Sarala respectively. The similar figures for the non-participating farmers were 31, 9 and 5 percent, respectively. This increase is due to reduction in area coverage of major lowland varieties like Khuda, Pasakathia and Bagadachampa (Figure 1). The area under Khuda, Pasakathia and Bagadachampa had reduced by 18, 16 and 9 percent, respectively. The area reduction of other lowland varieties taken together was 8 percent. Durga has become more popular among farmers in semi-deep (0-70 cm water depth) and deep water (0-100 cm water depth) areas as the other two varieties could not withstand submergence. It was observed that Durga can tolerate submergence up to 10 days and it has good regeneration ability after the flood recedes. Therefore, this variety has become more popular than the other two varieties among farmers.

The average yield obtained from MV and TV in lowlands was 3.57 and 1.97 t ha^{-1}, respectively. On an average, the yield of modern varieties was 81 percent higher than traditional varieties. The average yield obtained from modern varieties by participating and non-participating farmers was 3.42 and 3.73 t ha^{-1}, respectively, while the corresponding yield from

Table 3. Percentage coverage of modern and traditional varieties in lowlands

Land type /Variety type	Participating farms		Non-Participating farms		All sample farms	
	Before the project	After the project	Before the project	After the project	Before the project	After the project
Lowland						
MV	0	58.75	0	44.58	0	50.85
TV	100	41.25	100	55.42	100	49.15

MV: modern varieties; TV: Traditional Varieties

Table 4. Coverage of modern rice varieties in sample farms in the submergence prone lowland

Type of farm	Durga	Gayatri	Sarala	All varieties	Total lowland
Participating farms	35.78* (0.20)	11.13 (0.06)	11.83 (0.07)	58.75 (0.33)	100 (0.57)
Non- Participating farms	30.57 (0.22)	9.36 (0.07)	4.64 (0.03)	44.58 (0.32)	100 (0.72)
All sample farms	32.88 (0.21)	10.14 (0.07)	7.83 (0.05)	50.85 (0.33)	100 (0.64)

Figures in parentheses indicate actual area in ha. * Percent land

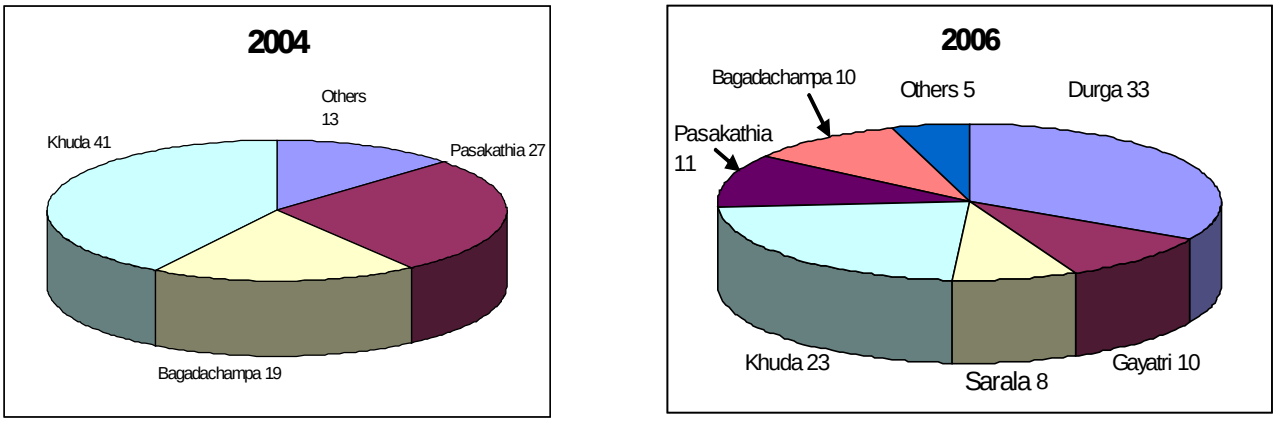

Fig. 1. Changes in variety composition after the project period in lowlands, Cuttack, Orissa

traditional varieties was 2.17 and 1.85 t ha^{-1}, respectively. Due to introduction of lowland MVs, on the average, farmers could increase their rice production by 825 kg ha^{-1}, which has increased their household food security.

The costs and returns from the three lowland varieties introduced in the project area along with their local check varieties are presented in Table 5. The cost of cultivation per ha of Durga, Gayatri and Sarala was computed to be Rs 12133, Rs 12691, and Rs 12159, respectively. These costs were more by Rs 2000, Rs 2465 and Rs 1774 over their local check varieties Khuda, Pasakathia, and Bagadachampa, respectively. The net returns ha^{-1} realized from the modern varieties i.e. Durga, Gayatri and Sarala was Rs 8318, Rs 10765 and Rs 5055 in comparison to Rs 960, Rs 2358 and Rs 729, respectively from their traditional check varieties. The additional return ha^{-1} realized from the modern varieties was Rs 9359, Rs 10874 and Rs 6100 from Durga, Gayatri and Sarala, respectively. The additional income gain ha^{-1} was Rs 9359 from Durga, Rs 10874 from Gayatri and Rs 6100 from Sarala with an aggregate income gain of Rs 9187 ha^{-1} due to the project activities. The incremental benefit–cost ratio was also attractive in all the three varieties, but highest in Durga variety (4.68), which implies that an additional rupee spent, returns an amount of Rs 4.68. The reduction in cost of production per quintal of rice was computed and it was

Table 5. Costs and returns of improved technology vs. farmer's practices in participatory trials (2004-2006)

Particulars		Durga	Gayatri	Sarala
Grain yield (t ha^{-1})	MV	3.77	4.22	3.09
	TV	1.79	2.25	1.82
Straw yield (t ha^{-1})	MV	6.67	6.09	4.97
	TV	5.00	5.09	4.72
Cost of cultivation (Rs ha^{-1})	MV	12,133	12,691	12,159
	TV	10,133	10,227	10,385
Gross returns (Rs ha^{-1})	MV	20,452	23,456	17,215
	TV	11,093	12,582	11,114
Net returns (Rs ha^{-1})	MV	8,318	10,765	5,055
	TV	960	2,358	729
Additional cost (Rs ha^{-1})		2000	2465	1774
Additional return (Rs ha^{-1})		9359	10874	6100
BC Ratio	MV	1.69	1.85	1.42
	TV	1.09	1.23	1.07
Reduction in cost per tonne of paddy (Rs)		2033	1210	1377

MV: Modern varieties; TV: Traditional varieties.

Rs 2033, Rs 1210 and Rs 1377 in Durga, Gayatri and Sarala, respectively over the local varieties.

Both participating and non-participating farmers had exchanged seeds of new varieties with 72 farmers amounting 1802 kg, both within and outside the villages (Table 6). The participating farmers have exchanged seeds with 21 farmers within the village and 25 farmers outside the village amounting 1182 kg, while the non-participating farmers have exchanged seeds with 26 farmers amounting 620 kg. Among the three varieties, Durga seed was exchanged in maximum quantity, the figures being 900 kg by participating farmers and 495 kg by non-participating farmers. The total number of farmers exchanged Durga seed was 46, which indicates the popularity of this variety over the other two.

The submergence tolerant lowland rice varieties like Durga, Gayatri and Sarala were introduced in the project area. The area coverage of modern varieties before the project and after the project was assessed through formal surveys. It was found that there was no modern variety under cultivation before the project in lowlands. After the introduction of new technology, it was estimated that the coverage of modern varieties in lowlands was 51 per cent during the end year of the project. Durga, Gayatri and Sarala, which were introduced through the project activities, covered 33, 10 and 8 per cent of the total lowland area. Durga has spread to more area because of its higher submergence tolerance ability than the other two varieties. The costs and returns analysis revealed that the new varieties were efficient over traditional varieties in terms of net returns and benefit-cost ratio. The reduction in cost of production tonne^{-1} of rice was computed to be Rs 2033, Rs 1210 and Rs 1377 for Durga, Gayatri and Sarala, respectively over their local check varieties. The additional income from the adoption of modern varieties in submergence prone lowlands was Rs 9187 per ha. The additional employment generation due to adoption of these varieties in lowlands was computed to be 23 man days per ha. On the average, these three varieties together have added 825 kg of rice per ha, which has improved the household food security of poor farmers. Therefore, extension efforts both by Government and private agencies should be intensified to spread these varieties to more submergence prone areas of the state.

Table 6. Exchange of seeds by sample farmers within and outside the villages

Variety	Participating farmers (n = 20)		Non-participating farmers (n = 12)		All sample farmers (n = 32)	
	Number of farmers	Amount (kg)	Number of farmers	Amount (kg)	Number of farmers	Amount (kg)
Within the village						
Durga	13	365	9	270	22	635
Gayatri	4	75	-	-	4	75
Sarala	4	65	4	45	8	110
Outside the village						
Durga	15	535	9	225	24	760
Gayatri	5	82	-	-	5	82
Sarala	5	60	4	80	9	140
Total						
Durga	28	900	18	495	46	1395
Gayatri	9	157	-	-	9	157
Sarala	9	125	8	125	17	250

Note: 20 participating farmers exchanged seed to other farmers out of 30 participating sample farmers and 12 non-participating farmers exchanged seed to other farmers out of 30 non-participating sample farmers.

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