Fundamental and Applied Agriculture
Vol. 4(2), pp. 823–828: 2019
doi: 10.5455/faa.19122

Agricultural Extension
ORIGINAL ARTICLE

Impact of adopting salt tolerant rice varieties in the coastal areas of Bangladesh

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ARTICLE INFORMATION

Article History
Submitted: 06 Dec 2018
Revised: 07 Mar 2019
Accepted: 10 Mar 2019
First online: 27 Mar 2019

Academic Editor
Sadika Haque

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ABSTRACT

Rice cultivation in saline prone area is very difficult. Some recently developed salt tolerant rice varieties are introduced in the coastal zone of Bangladesh. But their impact on income analysis is not done yet. The present study was designed to assess the adoption and impact on income of salt tolerant rice varieties *viz.*, Binadhan-8 and Binadhan-10 cultivation in coastal areas of Bangladesh. In total 300 farmers from six salt tolerant rice growing areas, namely Patuakhali, Cox's Bazar, Chittagang, Bagerhat, Khulna and Sathkhira districts were taken to conduct the present study. Profitability analysis was done to achieve the objectives of the study. The major findings of the study revealed that the average cost of production of salt tolerant rice variety (Binadhan-8 and Binadhan-10) was Tk 62670 ha^{-1}. Average cost of production for Binadhan-8 was Tk 61729 ha^{-1} and it was Tk 63611 ha^{-1} for Binadhan-10. Per hectare gross return of Binadhan-8 and Binadhan-10 were Tk 81934 and Tk 94786, respectively. Therefore, ha^{-1} average cost as well as gross return of Binadhan-10 was higher than that of Binadhan-8. Average ha^{-1} net return received by adopting farmers was Tk 25690 and it was higher in case of Binadhan-10 (Tk 31175) than Binadhan-8 (Tk 20205). In the study area, the average yield of Binadhan-10 (5.45 t ha^{-1}) was higher than Binadhan-8 (4.92 t ha^{-1}). The undiscounted benefit cost ratio (BCR) was 1.40 which indicates that cultivation of these varieties is profitable to the farmers when all sorts of cost were taken into consideration. Results also revealed that most of the farmers are not using the recommended technologies regarding input usage and agronomic practices. The highest area coverage of salt tolerant rice varieties (Binadhan-8 and Binadhan-10) was in Cox's Bazar district which is 3.7% of total cultivated area followed by Chittagong (2.62%), Bagerhat (2.40%), Patuakhali (2.18%) and Khulna (1.53%), respectively. In the study area, the highest income impact (27.1%) was in Sathkhira district, and it was the lowest (12.91%) in Patuakhali district.

Keywords: Salt tolerant rice varieties, adoption, benefit cost ratio, coastal area, Bangladesh

Cite this article: Haque MR, Sultana R, Rahman MH, Islam S, Hasan AK. 2019. Impact of adopting salt tolerant rice varieties in the coastal areas of Bangladesh. Fundamental and Applied Agriculture 4(2): 823–828. doi: 10.5455/faa.19122

1 Introduction

The coastal belt of Bangladesh consists of 19 districts, which cover 32% of the country and accommodate more than 35 million people (Alam et al., 2017). About 53% of the coastal areas are affected by salinity due to inundation from the sea and intrusion of sea water through rivers, estuaries, etc. in coastal areas (Haque, 2006). Bangladesh is one of the major rice producing countries of the world (Salam et al., 2011). Rice is the major crop of this highly populated (160 million people) agrarian country with an average annual production of 40 million tons, additional one million ton is imported every year (Dorosh and Rashid, 2012). The rice sector is by far the most important provider of rural employment. Presently, single, double and triple cropped areas of Bangladesh are 29%, 52% and 19%, respectively with an average cropping intensity of 191% (BBS, 2015). There is a considerably large coastal area in Bangladesh. The coastal saline areas are spread in 64 upazillas of 13 district of Bangladesh (Chowdhury et al., 2012). Rice production significantly increased over the past few years (276.84 metric tons in 2003-04 and 369.36 metric tons in 2009-10) but the number of the population also increased during this period (BBS, 2010). To meet the huge demand of food for this growing population there must be the world's annual rice production increased about 760 million tons within 2020 (Kundu and Ladha, 1995). The prospect of global warming resulting from accumulation of greenhouse gases is causing major concern, especially in connection with its potential effect on rice production (Wassmann et al., 2009). Bangladesh Institute of Nuclear Agriculture (BINA) had release two saline tolerant rice variety which are high yielding and can tolerate 10-12 dS m^{-1} salinity (BINA, 2016).

In view of the above, this study was conducted to achieve the following objectives:
(i) to estimate the profitability of salt tolerant rice variety Binadhan-8 and Binadhan-10, (ii) to know the adoption status of salt tolerant rice variety Binadhan-8 and Binadhan-10 in the coastal region, (iii) to identify the impact of these variety on farmers income, and (iv) to identify the problems and suggest some policies for salt tolerant variety cultivation.

2 Methodology

The study was conducted in six coastal areas of Bangladesh, namely Sathkhira, Patuakhali, Cox's Bazar, Chittagang, Bagerhat and Khulna during Boro season of 2015. A total of 300 farmers (50 from each district) were randomly selected by using multi stage sampling method in the study area. Data were collected from Binadhan-8 and Binadhan-10 growers through interview schedule. Collected data were edited (means data collected in local unit, was converted into standard unit), summarized, tabulated and analyzed to fulfill the objectives of the study. To determine the profitability of salt tolerant rice varieties, cost and return analysis was done using the following profit equation (Dillon and Hardaker, 1993).

$$\prod = \sum P_m Q_m - \sum (P_{xi} X_i) - TFC \qquad (1)$$

where, $\prod$ = net return (Tk ha^{-1}), P_m = per unit price of produce (Tk kg^{-1}), Q_m = quantity of the production (kg ha^{-1}), P_{xi} = per unit price of ith inputs (Tk), X_i = quantity of the ith inputs ha^{-1} (kg), TFC = total fixed cost (Tk), and $i = 1, 2, 3, \ldots, n$ (number of inputs).

Gross return Per hectare gross return was calculated by multiplying the total amount of product and byproduct by their respective per unit prices.

Net return Net return was calculated by deducting the total production cost from the total return or gross return. That is, Net return = Total return – Total production cost

Gross margin Gross margin is defined as the difference between gross return and variable costs. Generally, farmers want maximum return over variable cost of production. The argument for using the gross margin analysis is that the farmers are interested to get returns over variable cost. Gross margin was calculated on TVC basis. Per hectare gross margin was obtained by subtracting variable costs from gross return. That is, Gross margin = Gross return – Variable cost (Uddin and Fatema, 2016).

For determining the adoption level of technologies for Binadhan-8 and Binadhan-10 varieties cultivation, farmers were classified into three categories in terms of agronomic practices, time of operation, and input use. The categories were developed based on the mean index of the farmers with respect to each technology. A higher index indicates a higher level of adoption, while a lower index indicates a lower level of adoption of a technology. Technology adoption level was categorized based on mean index >100 as 'overuse', 70-100 as 'high', 50-69 as 'medium' and <50 as 'low', which was adopted by by several researchers (Islam et al., 2013; Salam et al., 2003, 2011; Miah et al., 2010; Akter et al., 2010).

Adoption index was determined by the following formula:

$$\text{AI} = \frac{T_U}{T_R} \times 100 \qquad (2)$$

where, AI = adoption index, T_U = technology used, and T_R = technology recommended.

To fulfill the objective no (iii) (see Section 1), the impact of cultivation of these varieties on farmer's income, tabular analysis (before-after) was used.

Table 1. Cost component of salt tolerant rice varieties Binadhan-8 and Binadhan-10 among the study areas

Cost component	Cost (Tk ha^{-1})		Average cost (Tk ha^{-1})
	Binadhan-8	Binadhan-10	
Human-labor	30627	32782	31705
Power tiller	6538	6900	6719
Seed	1108	1130	1119
Fertilizer	4491	5851	5171
Urea	2127	2308	2217
TSP	1797	2037	1917
MP	567	707	637
Organic manure	205	800	502
Pesticide	2840	3018	2929
Insecticide	424	651	538
Irrigation	11417	8493	9955
Interest on operating capital	4080	4321	4200
Total variable cost	55073	58330	56702
Total fixed cost	6656	5281	5968
Total cost	61729	63611	62670

Table 2. Profitability of salt tolerant rice varieties Binadhan-8and d Binadhan-10 among the study areas

	Binadhan-8	Binadhan-10	Average
Grain yield (t ha^{-1})	4.92	5.45	5.19
Unit price of grain (Tk kg^{-1})	14.9	15.66	15.28
Return from grain (Tk ha^{-1})	73291	85371	79331
Return from by-product (Tk ha^{-1})	8643	9414	9028.49
Gross return (Tk ha^{-1})	81934	94786	88360
Total variable cost (Tk ha^{-1})	55073	58330	56702
Total cost (Tk ha^{-1})	61729	63611	62670
Gross margin	26861	36456	31658
Net return (Tk ha^{-1})	20205	31175	25690
Benefit cost ratio (BCR)			
Over variable cost	1.42	1.62	1.55
Over total cost	1.33	1.49	1.4

3 Results and Discussion

From Table 1it is found that the respondent farmers in the study area are using higher inputs than the recommended level because of inappropriate knowledge of cultivating Binadhan-10 compared to Binadhan-8. The average cost of production of salt tolerant rice variety (Binadhan-8 and Binadhan-10) was Tk 62670 ha^{-1}. The highest share of the total cost was for human-labour and irrigation in cultivating both varieties. Per hectare fertilizer cost was higher in case of Binadhan-10 (Tk 5851) cultivation and it was lower in Binadhan-8 (Tk 4491) cultivation.

According to Table 2, the average net return received by adopting farmers was Tk 31650 ha^{-1}. Irrespective of the study areas the average yield of Binadhan-8 was 4.92 t ha^{-1} and net return was Tk 20205 ha^{-1} which was lower than Binadhan-10 yield, 5.45 t ha^{-1} and net return Tk 31175 ha^{-1}. The undiscounted benefit cost ratio (BCR) was 1.40 which indicates that cultivation of these variety is profitable to the farmers when all sorts of cost were taken into consideration (Table 2).

3.1 Adoption of salt tolerant varieties

Appropriate inputs use and time of operations are essential for achieving higher yield and economic benefit. Therefore, it is important to know the existing level of technology in terms of agronomic practices, time of operation, and input use. The existing level of technology employed in the production of salt tol-

Table 3. Percent of adoption of crop management technologies among the study areas

Technology †	Patuakhali (n=50)	Cox's Bazar (n=50)	Chittagang (n=50)	Bagerhat (n=50)	Satkhira (n=50)	Khulna (n=50)	All areas (N=300)	AL ‡
Ploughing, laddering								
Recom. number (2-3)	76 (38)	86 (43)	84 (42)	62 (31)	90 (45)	68 (34)	77.67 (233)	H
Below recom. (1)	24 (12)	14 (7)	16 (8)	38 (19)	10 (5)	32 (16)	22.33 (67)	
Seed sowing period								
21 Nov–21 Dec	90 (45)	92 (46)	86 (43)	82 (41)	80 (40)	88 (44)	86.60 (259)	H
No recom. period	10 (5)	8 (4)	14 (7)	18 (9)	20 (10)	12 (6)	13.66 (31)	
Number of irrigation								
Recom. number (2-3)	72 (36)	58 (29)	66 (33)	70 (35)	70 (35)	76 (38)	68.66 (206)	M
Below recommendation	16 (8)	28 (14)	26 (13)	22 (11)	24 (12)	16 (8)	14.33 (66)	
Above recommendation	12 (6)	14 (7)	8 (4)	8 (4)	6 (3)	8 (4)	12.66 (28)	
Number of weeding								
Recom. number (2)	8(4)	10 (5)	16 (8)	14 (7)	32 (16)	14 (7)	15.67 (47)	L
Below recommendation	44 (22)	62 (31)	78 (39)	56 (28)	38 (19)	64 (32)	57.00 (171)	
Above recommendation	–	–	–	–		–	–	
Provide no-weeding	48 (24)	28 (14)	6 (3)	30 (15)	30 (15)	22 (11)	27.33 (82)	
Insect-pest control								
Do not use pesticides	82 (41)	70 (35)	68 (34)	80 (40)	72 (36)	88 (44)	76.67 (230)	
Use pesticides	18 (9)	30 (15)	32 (16)	20 (10)	28 (14)	12 (6)	23.33 (70)	

† Technologies are recommended by Bangladesh Institute of Nuclear Agriculture (BINA); Figures in the parentheses indicates number of farmers responded; ‡ AL = adoption level. Adoption level was categorized for mean index >100 as overuse; 70-100 as high (H), 50-69 as medium (M), and <50 as low (L)

erant varieties and their level of adoption have been presented in Table 3 and Table 4.

From Table 3 it can be seen that on an average, 78% farmers ploughed their land 2-3 times, which is the recommended for rice cultivation. Based on the mean index, seed sowing secured the high level of adoption. About 69% farmers applied irrigation 2-3 times which was recommended.

From Table 4, it can be found that adoption level of seed rate was high among the study areas but farmers often do not follow recommendations for applying fertilizers. All the sample farmers in Patukhali district applied urea, TSP, and MoP in higher quantity compared to their recommended doses. Therefore, according to adoption index, the level of adoption for applying fertilizer is overuse. In case other districts farmer using either in excess or in small quantities of fertilizer.

Table 5 shows that the highest area coverage was in Cox's Bazar district and it was 3.70% in term of total cultivated area followed by Chittagong (2.62%), Satkhira (2.40%) and Bagerhat (2.40%), Patuakhali (2.18%), Khulna (1.53%), respectively. This figure indicates that area coverage among the coastal areas is not satisfactory. Therefore more extension program is needed to bring extra area under salt tolerant varieties cultivation.

From Table 6 it can be seen that among the study areas the highest impact percentage was in Sathkhira district (27.10% followed by Bagerhat (26.91%), Cox's Bazar (21.66%), Khulna (17.97%, Chittagong (16.91%) and Patuakhali (12.90%) district, respectively.

3.2 Problems and suggestions in cultivation of these varieties

Higher doses of fertilizers especially urea is needed. It was also found that pest and disease hampers the potential yield in the study areas. In some cases, early flowering causes yield loss. Extension personnel trained in saline soil management is inadequate. For appropriate management practices in crop production more extension and training programme is needed in the coastal community of the country.

4 Conclusions

Since the introduction of salt tolerant rice varieties has already shown profitable and farmer's annual income also has increased by cultivating of these varieties among the study areas, it should be rational to bring more unutilized saline areas under saline tolerant rice varieties cultivation like Binadhan-8 and Binadhan-10. By giving proper training to the farmer about recommended sowing and fertilizing procedure, paddy production will be increased and thus it will help to continue self-sufficiency in food grains and therefore to promote the enhanced living standard of the coastal people of Bangladesh.

Table 4. Adoption level of technology at the study areas in term of major inputs used

District		Seed		Urea		TSP		MoP	
		Bina dhan-8	Bina dhan-10	Bina dhan-8	Bina dhan-10	Bina dhan-8	Bina dhan-10	Bina dhan-8	Bina dhan-10
	R. dose †	25-30	25-30	210-220	210-220	110-115	110-115	80-100	85-100
Patuakhali	FP	28.57	31.51	214.28	357.53	128.57	131.01	119.05	107.79
	AI	95.23	105.03	97.4	162.51	111.8	113.92	119.05	107.79
	AL ‡	H	O	H	O	O	O	O	O
Cox's Bazar	FP	25.04	32.5	124.36	187.23	85.18	127.21	38.33	65.37
	AI	83.47	108.33	56.53	85.1	74.07	110.62	38.33	65.37
	AL	H	O	M	H	H	O	L	M
Chittagong	FP	22.14	24.69	134.24	122.22	98.78	92.82	35.67	41.97
	AI	73.8	82.3	61.02	55.55	85.9	80.71	35.67	41.97
	AL	H	H	M	M	H	H	L	L
Bagerhat	FP	29.41	26.86	156.87	145.61	93.14	81.4	44.12	38.6
	AI	98.03	89.53	71.3	66.19	80.99	70.78	44.12	38.6
	AL	H	H	H	M	H	H	L	L
Khulna	FP	25.27	28.05	121.13	148.37	173.61	85.36	82.47	40.69
	AI	84.23	93.5	55.059	67.45	150.96	74.26	82.47	40.69
	AL	H	H	M	M	O	H	H	L
Satkhira	FP	29.12	25.75	135.61	119.68	107.14	84.99	57.69	46.4
	AI	97.06	85.83	61.64	54.4	93.16	73.9	57.69	46.4
	AL	H	H	M	M	H	H	M	L

† Technologies are recommended by Bangladesh Institute of Nuclear Agriculture (BINA);
FP =farmers practice, AI = adoption index, and AL = adoption level; ‡ Adoption level was categorized for mean index >100 as overuse (O); 70-100 as high (H), 50-69 as medium (M), and <50 as low (L)

Table 5. District wise adoption level of Binadhan-8 and Binadhan-10 in terms of area coverage in the coastal zone

District	Total cultivated area (ha)	Area for Binadhan-8 and Binadhan-10 (ha)			% of total area
		Binadhan-8	Binadhan-10	Total	
Bagerhat	50940	475	747	1222	2.4
Khulna	50345	377	391	768	1.53
Cox's Bazar	57580	1288	840	2128	3.7
Chittagong	58570	880	654	1534	2.62
PatuaKhali	55354	630	575	1205	2.18
Satkhira	60705	705	749	1454	2.4
Total	333494	4355	3956	8311	2.49

Table 6. Impact of Binadhan-8 and Binadhan-10 varieties cultivation on farmer's income among the study areas in Boro season

District	Before (2 yrs)	After (2 yrs)	Differences	% change yr^{-1}
Bagerhat	16716.7	25715.4	8998.7	26.9
Khulna	18733.3	25467.2	6733.9	18
Cox's Bazar	19913.3	28540	8626.7	21.7
Chittagong	16100	21545.7	5445.7	16.9
Patuakhali	20900	26295.3	5395.3	12.9
Sathkhira	17855.1	27533	9677.9	27.1

Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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The Official Journal of the **Farm to Fork Foundation**
ISSN: 2518–2021 (print)
ISSN: 2415–4474 (electronic)
http://www.f2ffoundation.org/faa