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ECONOMIC FEASIBILITY OF BAMBOO SUBSURFACE DRAINAGE IN COASTAL SALINE SOILS OF BANGLADESH

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ABSTRACT

A field experiment was conducted in a saline soil consecutively for two years using the bamboo subsurface drainage (at a depth of 0.75 m with spacing of 10.0 m) and the non-drainage conditions. The field was subjected to irrigation with three different grades of brackish water using a semi-salt tolerant cultivar of rice (cv. Purbachi) to foresee its economic feasibility. The results indicated that the difference in yield between the subsurface drainage and the non-drained plots was substantially high. The two years' average grain yields were 2.88, 2.28 and 1.36 t ha^{-1} with respect to low (EC 0.7 dSm^{-1}), medium (EC 2.5 dSm^{-1}) and high (5.0 dSm^{-1}) brackish water irrigation in the non-drained field, while in contrast the yields with the same treatments were 4.46, 3.31 and 2.83 t ha^{-1} from the subsurface drained plots. The total cost of the subsurface drainage (including annual interest) was Tk. 2645 ha^{-1} for the first year which increased to Tk. 2932 ha^{-1} in the following year. The average net income from the non-drained field was Tk. 8467, Tk. 3983 and Tk. 3376 ha^{-1}, respectively with low, medium and high brackish water irrigation, while it was Tk. 17338, Tk. 9076 and Tk. 5858 ha^{-1}, respectively, with low, medium and high brackish water irrigation from the bamboo subsurface drained field. The average extra net income from the subsurface drained field over that of the non-drained field was Tk. 9062, Tk. 5284 and Tk. 2478 ha^{-1} with respect to the three grades of the brackish irrigation water. The average benefit : cost ratios were 1.65, 1.30 and -0.7 when provided with low, medium and high brackish water irrigation in the non-drained plots, while in contrast they were 2.1,1.6 and 1.4 for the drained plots. So, it was inferred that the subsurface drainage was the key to the extra net income through increase in crop yield by the potential utilization of the coastal saline soil by using the low cost locally available bamboo.

In Bangladesh the impaired plant growth vis-a-vis the low yield in the saline soils, due to the prevalence of the excess salts, is quite conceivable. There are about 2.83 m ha of the saline soils in Bangladesh which are about one fifth of the total cultivable land area of the country (Karim *et al.*, 1982). These soils are mostly monocropped with rice with poor yield during the rainy season. The cultivation of winter crops is very limited due to the accumulation of salts in the surface soil and the lack of fresh water irrigation during the dry season. The recent approach is that the salinity can be controlled by leaching the dissolved salts from the soil (Michael, 1986). Many a workers have studied the preleached and non-leached saline soils and found significant increase in the grain

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yield of rice in the former case (Saravanan *et al.*, 1991, Aich *et al.*, 1996). This indicated that if the soil could be leached either through subsurface drainage or through surface wash, the production would be better than that of the unwashed soils. So, it was thought how to bring the soil in the field to the leached condition which was performed in the laboratory. However, it is not practically possible to maintain the salt concentration to the desired level unless the salt-loaded soil solution is thrown out. The good subsurface drainage has been found to be a prerequisite and beneficial in overcoming and reclaiming the saline soils (Kovda *et al.*, 1973, Singh, 1982; Michael, 1986). The main constraint for adopting the subsurface drainage is its cost involvement which depends on the cost of materials, labour, depth of the tile placement, spacing, etc. Most of the investigators used the cement concrete, asbestos, plastic pipe, etc. as drainage materials which are very costly (Lovas, 1972; Gupta and Gupta, 1987). Alternatively, the locally available bamboo is cheaper than these materials. So, an experiment was designed with the objective to foresee the economic feasibility of the bamboo subsurface drainage with three different grades of the brackish irrigation water using a semi-salt-tolerant cultivar of rice (cv. Purbachi) during the Boro season for the potential utilization of the coastal saline soils.

MATERIAL AND METHODS

A field experiment was conducted in a saline soil of Magura, Satkhira. The soil was clayey in nature having an initial salinity (ECe) in the range of 11.4 to 13.0 dSm^{-1} with pH 5.8-5.9. The depth of water table varies from 0.7 m to 1.9 m during the growing period. The experimental area was divided into the subsurface drained and non-drained blocks. Each block was further subdivided into nine sub-blocks (200 m^2 surrounded by a buffer zone of 2 m wide and 25 cm high ridge). Three sub blocks of each block were irrigated with low (0.7 dSm^{-1}), medium (2.5 dSm^{-1}) and high (5.0 dSm^{-1}) brackish water with two replications each. For installation of the subsurface drainage, the trenches were made manually to a depth of 0.75 m and with a spacing of 10 m. The bamboos selected were of uniform size with diameter 60-70 mm. They were split into two equal halves longitudinally. The internal nodes were carefully removed and the holes were bored (0.5 mm dia) at an interval of 15 cm in a single line and the halves were put together again and tied with a nylon rope. A nylon net was used to cover the bamboo logs for protection against the entrance of the foreign materials into the log. The prepared bamboo logs were then placed on the ready trenches in such a way that the perforated halves remained on the upper side with a slope of 0.1% and the rice straw was spread around the logs. The soil was replaced in the same order as was dug out and compacted manually with water (EC 1.2 dSm^{-1}). The drainage logs were connected to the outlet channel having 1 m depth from the surface. This outlet channel was connected with the natural canal outside the experimental plot from where the effluents were removed to the river through a sluice gate.

The plots with the subsurface drainage were drained by intermittent ponding with brackish water (EC 1.2 dSm^{-1}) four times (each time 7.5 cm depth of water) for a period of seven days, while the non-drained plots received the same number of irrigations but three times less amount of water than that of the drained plots for the same period. At the time of the final land preparation another irrigation to a depth of 1.25 cm was applied in all the subplots. The plots were fertilized with 80 kg P, 40 kg K and one third of 90 kg N ha^{-1} as the basal doses at the time of final land preparation and the rest two third of N was applied in two equal splits after 30 and 50 days of transplantation. The weedings and plant protection measures were taken whenever needed.

On the following day of the final land preparation, the 35 days old seedlings were transplanted on 15 cm squarely set hills (three seedlings $hill^{-1}$) and the flocculated muddy soil with 2.5 cm standing water upto 10 days. After transplantation, the flood irrigation was given with the different brackish waters (low, medium and high brackish) to the respective plots upto a depth of 5 cm standing water. Thereafter, the irrigation water was added to the plots according to the need (no time schedule was followed). This operation was continued upto the maturity of rice.

The cost of installation as well as of maintenance of the subsurface drainage was estimated as per the market price and the actual cost involved for the subsurface drainage alongwith annual interest and the cost of cultivation were also calculated on the basis of the actual expenses involved. The total expenditure and the income obtained from the sale value of the returns were determined. The benefit cost ratio and the extra benefit with the subsurface drainage over the non-drained plots were also calculated.

RESULTS AND DISCUSSION

The data show that the difference in the yield between the bamboo subsurface drainage (BSSD) and the non-drained (ND) plots was substantially high (Tables 2 and 3). In the first year, the grain yield of rice was 2.81, 2.22 and 1.36 t ha^{-1}, respectively with low, medium and high brackish water irrigation in the non- drained field, while the yield was 4.40, 3.24 and 2.74 t ha^{-1} with the respective salinities in the bamboo subsurface drained plots. In the subsequent year, the grain yield was higher to some extent than that of the previous year (Tables 2 and 3), except the provision of irrigation with the high brackish water (EC 5.0 dSm^{-1}) in the non-drained plots. Now it was necessary to see the extra cost involved in setting the bamboo subsurface drainage and the benefit, if any, with the use of the bamboo subsurface drainage i. e. to consider whether the system adopted was beneficial or not. So, to get an overall

TABLE 1

Detailed cost (Tk. ha^{-1}) of installation of the subsurface drainage

S. No.	Items	Quantity	Rate (Tk.)	Amount (Tk.)
1.	Cost of bamboo (125 Nos. of bamboo having average length of 8 m)	1000 Rm	6/Rm	6000
2.	Cost for trenches of earthen work (1000 m x 0.75 m x 0.25 m)	187.5 cum	1400 per 100 cum	2625
3.	Labour charges for the preparation of bamboo logs (cutting of bamboo into two halves, cleaning of internal nodes, binding with nylon, etc.)	10 labour	40/day/person	400
4.	Digging of the collector drain (100 Rm x 1 m x 0.5 m)	50 cum	1400 per 100 cum	700
5.	Installation cost for the placement of bamboo logs	5 labour	40/day/person	200
6.	Cost of nylon net (100 m x 2.5 m)	100 Rm	12/Rm	1200
7.	Cost of straw	L. S.	375	375
			Total Tk.	.11500

It is expected that the longevity of the bamboo subsuface drainage would be 5 years or more. Therefore, the actual cost would be one fifth of the total cost ha^{-1} i. e. Tk. 2300 ha^{-1} annually. In the second year, maintenance cost was Tk. 250 ha^{-1}. So, the total cost was Tk. 2550 ha^{-1} in the second year.

view of the system the expenditures incurred at every stage of installation and the maintenance thereafter were recorded systematically.

From the records (Table 1) it was evident that the total cost for installing the bamboo subsurface drainage (cost of bamboo, nylon net, straw, labour charge, etc.) was Tk. 11500 (This calculation was based on the market price at the time). The usual life of the bamboo subsurface drainage was supposed to be five years or more. Therefore, the total cost for the subsurface drainage would be Tk. 2645 ha^{-1} (Tk. 2300+ annual interest Tk. 345) in the first year and Tk. 2932 ha^{-1} (Tk. 2550+annual interest Tk. 382) in the subsequent years annually. The maintenance cost of the drain in the subsequent year was calculated to be Tk. 250 ha^{-1} which was about 10% of the total cost involved for the subsurface drainage yearly. The cost of the subsurface drainage system varied widely with the labour cost, spacing and depth of placement. Lovas (1972) reported that the cost of the drainage system with asbestos pipes amounted to Rs. 3000 ha^{-1} when placed at a depth and spacing of 1.0 m and 10.0 m, respectively. Similarly, the cost of asbestos tile amounted to Rs. 2 m^{-1} (1979 price level)

TABLE 2

Impact of the bamboo subsurface drainage on the grain yield, cost of production, gross return, net income, extra income and the benefit cost ratios of the rice grown in a saline soil irrigated with brackish water during 1993

	Treatment	Grain yield (t ha^{-1})	Cost of cultivation (Tk. ha^{-1})	Cost of subsurface drainage (Tk. ha^{-1})	Total cost of production (Tk. ha^{-1})	Gross return (Tk. ha^{-1})	Net income (Tk. ha^{-1})	Extra net income over ND (Tk. ha^{-1})	Benefit cost ratio
	Low BW (0.7 dSm^{-1})	2.81	12950	-	12950	20625	7675	-	1.6
N D	Medium BW (2.5 dSm^{-1})	2.22	12950	-	12950	16650	3700	-	1.3
	High BW (5.0 dSm^{-1})	1.36	12950	-	12950	10200	-2750	-	-0.7
	Low BW (0.7 dSm^{-1})	4.40	12950	2645	15595	32400	16805	9130	2.1
BSSD	Medium BW (2.5 dSm^{-1})	3.24	12950	2645	15595	24300	8705	5005	1.6
	High BW (5.0 dSm^{-1})	2.74	12950	2645	15595	21600	6005	3255	1.4

ND= Non-Drained, BSSD= Bamboo Subsurface Drainage, BW= Brackish Water. Annual interest has been added with the cost of subsurface drainage.

TABLE 3

Impact of the bamboo subsurface drainage on the grain yield, cost of production, gross return, net inocme, extra income and the benefit cost ratios of the rice grown in a saline soil irrigated with brackish water during 1994

	Treatment	Grain yield ($t\ ha^{-1}$)	Cost of cultivation ($Tk.\ ha^{-1}$)	Cost of subsurface drainage ($Tk.\ ha^{-1}$)	Total cost of production ($Tk.\ ha^{-1}$)	Gross return ($Tk.\ ha^{-1}$)	Net income ($Tk.\ ha^{-1}$)	Extra net income over ND ($Tk.\ ha^{-1}$)	Benefit cost ratio
ND	Low BW ($0.7\ dSm^{-1}$)	2.95	13986	-	13986	23244	9258	-	1.7
	Medium BW ($2.5\ dSm^{-1}$)	2.34	13986	-	13986	18252	4266	-	1.3
	High BW ($5.0\ dSm^{-1}$)	1.35	13986	-	13986	9984	-4002	-	-0.7
BSSD	Low BW ($0.7\ dSm^{-1}$)	4.52	13986	2932	16918	34788	17870	8994	2.1
	Medium BW ($2.5\ dSm^{-1}$)	3.38	13986	2932	16918	26364	9446	5562	1.6
	High BW ($5.0\ dSm^{-1}$)	2.91	13986	2932	16918	26364	17870	8994	2.1

ND= Non-Drained, BSSD=Bamboo Subsurface Drainage, BW=Brackish Water. Annual interest has been added with the cost of subsurface drainage.

and the tile drains with 20 m and 50 m spacings cost Rs. 12600 and 6600 ha^{-1}, respectively (Gupta and Gupta, 1987). In the present investigation, the locally available bamboo logs and the labour engaged during the dry season (when there is no work for the farmers i.e. the off time) reduced the installation cost of the subsurface drainage significantly. The detailed cost of production as well as the gross return is presented for the first and the second year, respectively in Tables 2 and 3. It in evident from Table 2 that the net income from the non-drained field was Tk. 7675, Tk. 3700 and Tk. 2750 ha^{-1}, when provided with low, medium and high brackish water irrigation, while on the other hand it was Tk. 16805, Tk. 8705 and Tk. 6005 ha^{-1}, respectively, from the bamboo subsurface drained field. It was clear that the extra net income from the subsurface drained over the non-drained condition was Tk. 9130, Tk. 5005 and Tk. 3255 ha^{-1} with respect to the three grades of brackish irrigation water (Table 2). In the following year the more or less similar trend was observed (Table 3). The benefit cost ratios were 1.6, 1.3 and 0.7, respectively, when provided with low, medium and high brackish water irrigation in the non-drained plots, while, in contrast, they were 2.1, 1.6 and 1.4 for the drained plots (Table 2). In the subsequent year also the similar benefit cost ratios were obtained (Table 3). It was worth noting that in the coastal area the availability of the low brackish water was meagre, but the medium and high brackish waters were abundant from the shallow/deep tubewell (Sattar and Aich, 1988). It was also important to note that the high brackish water irrigation showed the negative returns under the non-drained situation. The situation in the drained fields was the other way round. In this case, the benefit cost ratio was 1.4. Hence, the cultivator can use for irrigation the water having the salt content even very high (EC 5.0 dSm^{-1}).

The picture/pattern was different when the plots were provided with the bamboo subsurface drainage. The excess returns after deducting all the cost were found to be feasible even under the high brackish irrigation water. The return was considered to be economic because the benefit cost ratio was 1.4 (greater than the permissible limit). In the subsurface drainage, the low, medium and high brackish water irrigations were found to be beneficial. even if the benefit cost ratio was lower than the set mark, whatever returns came (marginal), they were for the benefit of the cultivator. In other words, even if the benefit cost ratio index was less than the permissible one, still it could be considered beneficial to the farmer because there is no work for the cultivator at that time. If the index was found to be very low than the permissible limit, then the land would remain fallow.

So, the subsurface drainage is a key to increase the crop yield and the benefit thus obtained cannot be overruled in all the saline zones. Furthermore, this type of subsurface drainage is in no way beyond the capacity of the farmer, since the material is locally available and is of low cost. Therefore, the adoptation of bamboo subsurface drainage may be advocated in the coastal saline soil and for this the loan can be obtained from the Grameen Bank as well as the Krishi Bank.

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