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RICE YIELD GROWTH SCENARIO AND THE FACTORS CONTRIBUTING TO OUTPUT CHANGES OF DIFFERENT RICE VARIETIES AND TYPES IN BANGLADESH.

Shamsul Alam

ABSTRACT

Yield growth of different rice varieties and types have been assessed to highlight the trends and factors influencing output growths during the Bangladesh years. Contributions of component factors for rice output growths have been measured. Area expansion and variety substitution have been the main vehicles for increased rice output growth in the face of declining modern varieties' yield levels in Bangladesh. Real rice prices did not play a significant role in increasing yield levels. Yield augmentation for the rice varieties has been dependent on technological breakthrough in production.

INTRODUCTION

The increase in yield of a crop is taken as an indicator of progress and achievement. Increase in output may be attained through increased area allocation from alternative uses and/or through yield increases. Bangladesh agriculture has attained its extensive margin of cultivation of land and there is practically no additional land to be brought under new cultivation. Therefore, achievement of total rice output growth has to he attempted mainly through yield augmenting efforts and crop intensification. This is more imperative in a land scarcity situation like Bangladesh and while its average rice yield lags behind its neighbouring countries with comparable environmental and physical resources. A large rice area is still under traditional varieties where in absolute terms, HYV (high yielding variety) yield levels have been much higher than the traditional types. Of the total nce area, 30 per cent was HYV in 1986/87 (BBS 1989). Output increasing scope for rice is enormous because the bulk of the rice areas is yet under traditional production method. The HYV area has been increasing continually (Bangladesh rice varietal types, their sowing/planting and harvesting period, and percentage share of rice area by varietal types are' presented in Appendix Table 1).

The intensity of HYV cultivation in 'terms of total cropped area has also increased (Appendix Table 2). Cropping pattern of rice varieties in terms of total gross cropped area has changed between the two periods (1971-1975 and 1983-1987). Aman and Aus areas as proportion of the total gross cropped area have declined and boro area has significantly increased. Aman and Aus areas declined 6 and 16 per cent while boro area increased 40 per cent in the 1983-1987 period compared to the first half of the seventies. All HYV areas have significantly increased while the local rice areas declined (Appendix Table 2).

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Achievement of rapid agricultural growth, particularly self-sufficiency in food, has been the core objective of development planning since independence. To achieve this, massive input subsidies (early seventies) and price support policies have been pursued in combination as policy options for the major crops like rice and jute. A rapid expansion of HYV areas, chemical fertilisers and modern irrigation has been emphasised as a strategy for agricultural development. These efforts should have exerted positive impacts on yield increases, particularly for rice where seed-fertiliser-irrigation technology has been expanding. Analysis of rice yield trends, identification and measurement of the quantitative impacts of the factors influencing yield growth and contribution of yield and area change in rice output increase are the objectives of this paper. The trends of yield growths of both the traditional and HYV rices with their impacts on output increase are analysed. Following this introduction, trends of yield growths of rice varieties and varietal types are highlighted in section II. Influences of product price and other factors on yield growth are analysed in section III. Section IV delineates the contribution of rice area and yield growth to rice production increases. Section V contains some policy conclusions. Statistical methods and the analytical techniques adopted are outlined in the relevant sections. The study period is 1971/72-1987/88 (i. e. as the latest data available during the study). For the sake of comparison, the average growth changes in the 1983-1987 period is compared with the average of first half of the seventies to see the changes so far occurred. Taking a five year average in estimating changes on growth levels helps even out random fluctuations in area, yield and output changes. The Bangladesh Bureau of statistics (BBS) is the major data source.

II. YIELD GROWTHS OF RICE VARIETIES AND VARIETAL TYPES

During the 1983-19877 period, average yield per hectare of aman, aus and boro were 1352, 1015 and 2394 kilograms respectively (Appendix Table 2). Average yield growth shows, variety wise, aman increased by 123 per cent, boro and aus both increased by 118 per cent in the 1983-1987 period compared with the 1971-1975 period. To see the annual rice yield growth over time, a trend model has been estimated by fitting a log linear equation. Specification of the rice yield with a constant percentage growth over a discrete time interval of a year is made as follows:

$Y_t = \alpha(1+g)^t u_t$ .... (1)

Where Y_t is yield of a rice variety or varietal type in time period t, g is annual proportionate rate of growth and, u_t is the error term. Linearisation of the above equation can be done as follows:

$LanY_t = a + bt + \mu_t$ .... (2).

Where LnY_t is assumed to grow at a constant rate, $a = Ln\alpha$; $b = Ln\ (1+g)$, b is the rate of continuous growth, $\mu = Lnu_t$ which is assumed to be normally and independently distributed. The analysis of the annual constant percentage growth of rice yield through the log linear trend model reveals that variety-wise the annual percentage increase was highest for aman (1.87 per cent) followed by boro (1.56 per cent) and aus (1.44 per cent; Table 1).

Table 1. Test of Yield Growth of Different Varieties and Varietal Types of Rice (1971-1987).

Dependent Variable (Yield)		Intercept	Trend Variable	$\bar{R}^2$	Durbin Watson Statistic	Regression Technique	Autocorrelation status (Test at 1 per cent error level)
Aman	=	5.71	0.0187 HS (7.08)	0.78	2.35	OLS	No autocorrelation
Aus	=	5.72	0.0144 HS (4.86)	0.61	1.19	OLS	Inconclusive
Boro	=	6.45	0.0156 HS (4.83)	0.61	1.63	OLS	No autocorrelation
Transplanted Aman	=	5.82	0.0156 HS (4.91)	0.63	1.32	OLS	Inconclusive
Broadcast Aman	=	5.76	0.0137 HS (4.78)	0.62	2.38	OLS	No autocorrelation
HYV Aman	=	8.61	- 0.0123 S (-2.01)	0.22	2.32	OLS	No autocorrelation
Local Aus	=	6.00	0.0086 HS (3.55)	0.46	1.95	OLS	No autocorrelation
HYV Aus	=	10.00	- 0.0291 HS (-12.37)	0.91	2.81	OLS	No autocorrelation
Local Boro	=	6.42	0.0100 S (1.93)	0.20	1.77	OLS	No autocorrelation
HYV Boro	=	8.26	- 0.005 (-0.79)	0.04	—	ML	Autocorrelation corrected

Note: HS highly significant at 1 per cent level. S significant at 5 per cent level. Data sources are mentioned in Appendix Table 2.

A type wise analysis of each variety gives a clearer picture of the contribution of yield growth. The analysis of trend yield growths of different types of rice varieties depict that all local varieties have significant yearly growth trends though with low magnitudes of growth. HYV boro (where there has been a concentration of high yielding rice production technology) has failed to show significant yearly growth trends while both HYV aman and aus have shown significant negative yearly yield growth trends (Table 1).

When HYVs are considered, boro emerges as the highest yielding rice in absolute term (2637 kg) followed by aman (1993 kg) and aus (1861 kg). The yield difference between the local and HYV rice types has been large. On average in 1983-1987, local boro yield was 56 per cent of HYV boro yield, local aus yield was 45 per cent of HYV aus, and transplanted and broadcast aman were 64 and 50 per cent of HYV aman yield levels respectively. The yield difference between local aus and HYV aus has been the sharpest of all local/traditional varieties. An important phenomenon is that all HYV rice yields have decreased during the eighties compared to the initial years (1971-75) of Bangladesh. Thus production increases through HYV yield augmentation has slowed down for aman, aus and HYV boro.

Both HYV aman and aus yields have been decreasing gradually since the mid seventies. In absolute terms, HYV aus yield per hectare decreased 30 per cent in the eighties compared with the 1971-75 period. For the same period HYV aman yield fell 11 per cent and boro 4 per cent. HYV aman and aus yearly decreasing trend rates have been 1.23 and 2.91 per cent respectively. Decline in boro HYV yield level partly also has been due to rapid expansion of this variety onto poorer irrigated and marginal lands (80 per cent of the total boro area is under MA's). Relatively increasing fertiliser prices and irrigation costs due to gradual withdrawal of subsidies are other plausible reasons for decreasing HYV yield levels. But yields of all the local traditional varieties increased though their yield levels were much lower than HYVs. Rice varieties' yield growth levels were though positive and statistically significant, the annual increase in yield was less than 2 per cent for each (aman 1.87, aus 1.44 and boro 1.56 percent).

The upshot of the yield analysis is that overwhelming areas of rice are still covered by local/traditional varieties (Appendix Table 1) and these, having low yield potential relative to the HYVs, should be considered a major obstacle to augment further rice production. This would be frustrating, while in the existing HYV areas growth level has already been slowed down.

III. PRODUCT PRICE IMPACT ON RICE YIELDS

The factors influencing rice yield growth are analysed in this section. It is hypothesised that yields of rice varieties and types are dependent on relative product prices, labour wage rate, rainfall during growing periods (if the crop is rainfed) and a trend variable capturing the effects of technological change (where a quantification of techniques of production e. g., line sowing, and also valuation of all the modem factor inputs is difficult to obtain).

Table 2. Factors Influencing the Yield Growths of Different Varieties of Rices (1973-1987).

Dependent Variable (Yield: Kg.)	Coefficients of							
	Intercept	Deflaed prices	Deflated wages	Rainfall (mm)	Time trend	$\bar{R}^2$	DW Statistic	Autocorrelation status (Test at 1 per cent error level)
Aman	-22.00	0.0811	0.0542	-0.0178	0.0147	0.74	2.14	No autocorrelation
	(-2.85)	(1.35)	(0.80)	(-0.36)	(3.76) HS			
Aus	3.24	-0.0894	0.1255	-0.0030	0.0018	0.50	2.29	No autocorrelation
	(0.35)	(-1.28)	(1.74)	(-0.06)	(0.39)			
Boro	-42.97	0.1582	-0.0142	-	0.0255	0.68	1.52	No autocorrelation
	(-3.79)	(1.58)	(-0.16)	-	(4.46)HS			
HYV Aman	45.78	-0.1136	0.0525	-0.0015	-0.0192	0.22	1.90	No autocorrelation
	(2.47)	(-0.78)	(0.32)-	(-0.01)	(-2.05)C			
HYV Aus	65.43	0.0144	0.0267	0.0288	-0.0292	0.89	1.70	No autocorrelation
	(6.36)	(0.19)	(0.33)	(0.50)	(-5.68)HS			
HYV Boro	-0.23	0.0218	-0.0302	-	0.0040	0.04	1.52	No autocorrelation
	(-0.01)	(0.26)	(-0.37)	-	(0.48)			
Transplanted	-15.00	0.0795	0.0948	-0.0013	0.0111	0.48	1.45	No autocorrelation
Aman	(-13.35)	(0.92)	(0.97)	(-0.02)	(1.98)C			
Broadcast	-11.46	0.0946	0.1693	0.0578	0.0089	0.56	2.20	No autocorrelation
Aman	(-1.03)	(1.04)	(1.89)C	(0.89)	(1.61)			
Local Aus	8.31	-0.1255	0.1476	-0.0268	-0.0007	0.39	2.05	No autocorrelation
	(0.75)	(-1.50)	(1.71)	(-0.43)	(-0.14)			
Local Boro	-19.54	0.0620	-0.0912	-0.0156	0.0133	0.15	1.84	No autocorrelation
	(-0.55)	(0.35)	(-0.53)	(-0.37)	(0.71)			

Notes: All variables are in logarithms except the time trend. HS, S and C denotes significant at 1, 5 and 10 per cent level respectively (two tailed test). Ordinary Least Squares Estimator was used for estimation.

$\bar{R}^2$ is R^2 adjusted for degrees for degrees of freedom. Data sources are referred to in Appendix Tables 3 and 4. Total rainfall in August, September and October (growing season) was incorporated in total aman, transplanted and HYV aman, April, May and June rainfall for broadcast aman, local and HYV aus (rainfall is residual demand though mainly irrigated), and March rainfall for local boro.

Yields of all HYV, local/traditional rices and total aman, aus and boro yields were regressed on last periods harvest prices (deflated by the labour costs; information on wage rate is provided in Appendix Table 4, respective product prices are given in Appendix Table 3), rainfall during growing period (except for HYV boro which is a completely irrigated crop), and a trend variable. All equations were specified in a log linear fashion (on trial having expected results). Results indicated that (Table 2) none of the rice varieties or varietal types are significant with deflated product prices of the preceding season or deflated wages (upto 10 per cent error level is accepted here for significance test). Rainfall of the growing season also failed to show any significance and in some cases showed negative signs. None of the yield growths of rice variety and varietal types is constrained by the growing period level of rainfall.

However, considering the fact that a trend variable maybe correlated with some other time series variables (e. g., price and wage variables, though deflated), the yield equations for rice varieties and types were re-run dropping the time trend variable from each equation (results presented in Appendix Table 5). In the re-run equations, none of the price variables came out positively significant. In some of the re-run equations, deflated wage (the average daily wage is deflated by per kilogram retail medium quality clean rice price) variables become significant with inconceivable positive signs i. e., if real wage increases, yield of the crop concerned also increases. No clear pattern emerges between the deflated wage and rice yield relationship.

The non-responsiveness of HYV aus, aman and boro rice yields to last period's product prices (deflated) indicates that yield augmentation for these varieties is entirely based on technological breakthrough in production and advancement in varietal development. The policy implication of these results is that for rice yield augmentation, emphasis has to be given to technological advancement, varietal research and strengthening extension services rather than influencing product prices.

IV. CONTRIBUTION OF YIELD IN RICE OUTPUT GROWTH

The sources of output change between two periods maybe due to change in area and/or yield, change in cropping pattern i. e., change in the proportion of the crop in the total cropped area and the multiplicative effect of both cropping pattern and yield change. To decompose the components of change in rice output increases and their contributions, the following algebraic equation is estimated[2]:

Change in total output:	$P_t - P_o =$
Contribution of area Change : (absolute change in area)	Yo [At (1 + Co - Ct) - Ao] +
Contribution of Yield Change:	$[A_t(1+(C_o-C_t)(Y_t-Y_o)]+$
Contribution of Cropping Pattern :	[AtYo (Ct - Co)] +
Change in interaction of Cropping pattern and Yield :	[At (Yt - Yo) (Ct - Co)]

Where;

P_o = Production in 1971-1975

P_t = Production in 1983-1987

A_o = Area under the crop in 1971-1975

A_t = Area under the crop in 1983-1987

C_o = The proportion of area under the crop to total gross cropped area under all crops in 1971-1975

C_t = The proportion of area under the crop to gross total cropped area under all crops in 1983-1987

Y_o = The yield in 1971-1975

Y_t = The yield in 1983-1985

with all data as averages of the periods.

In estimating the total change of output between the two periods, the contribution of area change is estimated using the average area in production in 1983-1987 and the yield for 1971-1975. This imply that the technology which generated the 1971-1975 yields remained unchanged in the second period. The change in yield (the difference of yields between the two periods) in the second period is seen in terms of the average area including the proportion of area due to change in cropping pattern. The estimated results are presented in Table 3. The results reveal the relative importance of changes in area, yield, cropping pattern and interactions between cropping pattern and yield changes (the data averages between the two periods used for estimation are provided in Appendix Table 2). Of the three rice varieties, boro output increase was the highest followed by aman and aus. Sixty per cent of the boro output increase was due to area increase while yield increase contributed 33 per cent. In the case of aman, yield increase contributed 86 per cent of output increase and area increase contributed 26 per cent. Aus output increase (relatively much lower level) was solely contributed by yield increase while area, cropping pattern and yield-cropping pattern interaction effects were negative.

In terms of modern and local (traditional) varieties, for all HYVs, effects of yield changes have been negative with positive cropping pattern effects. This has been just reverse for all local varieties. The results indicate that the yield levels for HYVs have fallen while the converse is true for the traditional varieties though in absolute terms, HYVs contributed largely (except transplanted aman to aman variety) to total production increases. All HYV output increases have been due to area increases and thus changes in cropping pattern.

Of the traditional types, except transplanted aman; area, changes in cropping pattern and yield-cropping pattern interaction effects have been negative to total output changes. In the process of substitution of local varieties to HYVs (particularly for broadcast aman, local aus and local boro, best suited lands for cultivation of local types are retained which affected higher yield increases for these types.

In sum, output increases of aman and aus have dominated by yield effects and boro output was dominated by area increase. Large areas of aman and aus varieties were under local types which have had significant yield growths between the two periods of comparison. HYV rice output increase between the first half of the seventies and the eighties (1983-1987) has been solely the contributions of area increases with the positive impacts of cropping pattern change. Output changes have been negative for local types except transplanted aman (the dominating rice type in terms of area coverage) due to large decreases in areas, negative cropping pattern, and also negative impacts of interactions between yield and cropping pattern changes.

Table 3. Sources of Change in Rice Output Growth Between 1971-1975 and 1983-1987 (Average).

Rice Varieties & Types	Change in Output between the periods	Source of Change: Area(1)	Yield(2)	Cropping Pattern(3)	Interaction (2 and 3)	Total
	(percentage)					
Aman	28.57	26.22	85.57	-9.59	-2.20	100
Aus	9.44	-27.93	173.54	-38.74	-6.87	100
Boro	84.08	59.54	33.00	6.30	1.16	100
HYV/Aman	98.66	116.32	-24.82	9.56	-1.06	100
HYV/Aus	106.81	180.40	-84.87	6.38	-1.91	100
HYV/Boro	138.79	98.45	-7.53	9.49	-0.41	100
Transplanted Aman	25.27	22.46	87.42	-8.16	-1.71	100
Broadcast Aman	-14.83	-1.97	102.34	-0.32	-0.05	100
Local Aus	-9.40	-137.79	101.24	-57.36	-6.09	-100
Local Boro	-29.94	-120.62	24.82	-3.77	-0.44	-100

Note: Sources of the data are referred to in Appendix Table 2

V. POLICY CONCLUSIONS

Total rice output, on average, has increased 135 per cent in the terminal period of analysis. The annual rice production increase, on average has been 1.75 per cent. The vehicle for increased rice output has been mainly the expansion of HYV areas and significant changes in cropping pattern while its yield level has been falling. Output increases of aman and aus have dominated by yield effects and boro output by area increase. In varietal terms, all HYV output increases have been due to area increases and thus changes in cropping pattern. HYV boro (a dry season crop) has received a considerable attention in terms of varietal research and adaptation trials in the past. Both aman (a major rice crop; 20 per cent of aman is under modern varieties) and aus (17 per cent is under modern varieties) demand priority attention in terms of research. Aman grows in wet season and therefore there is less need for irrigation concern. Boro and aus need irrigation facilities. Investment in irrigation and extension services are more powerful determinants of the use of fertilisers and hence yields than relative prices. Managing product prices policy would not be helpful in increasing and sustaining yield levels. Relative increase of fertiliser prices, irrigation costs, expansion of boro HYVs onto marginal poorer lands and increasing land use intensity can be partly blamed for decreased yield levels. In the face of declining HYV yield levels in Bangladesh, research priority has to be directed towards sustainable yield growth, as well as, increase in yield levels. All out efforts are needed for increasing and sustaining yield levels. In this regard, more researches on varietal improvements, and spread of research results on yield improvement, inventing new cultivars for aman and aus and adaptations in local conditions are needed in addition to encouraging substitution from local rice areas to HYVs.

1. It would have been better if the prices of fertiliser and irrigation costs in addition to labour costs could be included in the cost structures of inputs to deflate the product prices. But no systematic data on fertiliser prices and irrigation costs could be made available for the whole period. Therefore, wage cost for labour per hectare is used to deflate product price per tonne. With crop production activities being highly labour intensive, cost of labour is a major item in the whole cost structure. For example, on average for all types of aman, the cost of labour accounts for 59 per cent of whole production (variable) cost, the labour cost in aus is 48 per cent and in boro (HYV) this is 45 per cent (Rahman et. al. 1984, p. 77).

2. The decomposition method explaining the changes in output is originally reported by Minhas- Vaidyanathana 1965. The adjusted algebraic formulation adopted here is due to Wennergren, et. al., 1984.

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Appendix Table 1. Sowing/Harvesting Period of Rice Varieties and Types, and Percentage Share of Rice Area by Variety and Types (1983/84-1987/88).

Rice Variety and Type	Per cent of rice area		Sowing Period	Transplanting Period	Harvesting Period
	Of all Rice	Of Respective Variety			
Aman	56.40	-	-	-	-
Transplanted Aman		57.78		mid June to mid August	mid November to mid January
Broadcast Aman		22.61	March	-	mid November to mid January
HYV Aman		19.61		mid June to mid August	mid November to mid January
Aus	28.04	-	-	-	-
Local aus		83.00	mid March mid May		July to mid August
HYV aus		17.00		mid March to mid April	July to mid August
Boro	15.56	-	-	-	-
Local Boro		19.91		December to mid January	mid April to June
HYV Boro		80.09		mid December to mid February	mid April to June

Sources: For sowing/transplanting and harvesting periods, BBS: Agricultural Yearbook 1987-88, p. 6.

Appendix Table 2. Average Area, Yield and Production of Different Verities and Varietal Types of Rice in Bangladesh, 1971/72-1975/76 to 1983/84-1987/88.

Rice Varieties & Types	1971-1975 (Average) Area (.000 hectares) A_o	C_o	Yield kg/hectare Y_o	Production (.000 tonnes) P_o	1983-1987 (Average) Area (.000 hectares) A_t	C_t	Yield kg/hectare	Production ('000 tonnes) P_t
Aman	5610	0.461	1100	6181	5879	0.435	1352	7947
Aus	3130	0.257	860	2701	2922	0.216	1015	2956
Boro	1046	0.086	2021	2112	1622	0.120	2394	3889
HYV Aman	530	0.044	2242	116	1153	0.085	1993	2309
HYV Aus	117	0.009	2656	447	497	0.037	1861	924
HYV Boro	531	0.043	2757	1435	1299	0.096	2637	3426
Transplanted Aman	3278	0.269	1057	3468	3397	0.251	1279	4344
Broadcast Aman	1793	0.147	863	1551	1329	0.098	991	1321
Local Aus	2953	0.243	763	2255	2425	0.179	844	2043
Local Boro	515	0.042	1313	678	323	0.024	1466	475
Total Gross Cropped Area (All Crops)		12158				13515*		

Note: C_o, C_t stand for area as proportion of the total gross cropped area. *The Average is for 1983-1986.

Sources BBS: Area and production data are taken from 1982 Agril. Yearbook pp. 20, 23, 33, 36, 39, 52, 55 and 56; 1979 Statistical Yearbook pp. 170-71; 1980 Statistical Yearbook pp. 225 and 227-28; 1981 Statistical Yearbook p. 171, pp. 173-74; 1983-84 Statistical Yearbook p. 249, pp. 251-52; 1986 Statistical Yearbook pp. 326-28; 1985-86 Agril. Yearbook pp. 40-41, 45-46 and 52; 1987 Statistical Yearbook p. 180 and 1987-88 Agril. Yearbook p. 21.

Appendix Table 3. Harvest Prices of Different Varieties of Rice Per Metric Tonne (in Taka) and Per Tonne Rice Price Deflated by per Hectare Labour Cost[1].

Year	Nominal Prices				Deflated Prices		
	Aman*	Aus	Boro*	All Rice[2]	Aman	Aus	Boro
1971	892	945	903	1530	NA	NA	NA
1972	1113	944	1178	2390	1.40	1.50	1.47
1973	1764	1242	1716	3226	1.55	1.30	1.44
1974	3750	3170	3012	6548	2.26	2.29	1.81
1975	1974	2064	1922	4123	1.11	1.28	0.92
1976	1965	1547	1842	3569	1.13	1.03	0.92
1977	2247	2061	1977	4533	1.25	1.33	0.97
1978	2432	2191	3230	4951	1.18	1.27	1.46
1979	3121	2187	2987	6664	1.32	1.15	1.21
1980	3069	2598	2900	5744	1.24	1.23	1.01
1981	3528	2752	3390	5691	1.18	1.09	1.04
1982	3686	3592	3666	7780	1.15	1.34	1.04
1983	4439	3665	4429	8402	1.22	1.21	1.11
1984	5223	4904	4042	9596	1.22	1.38	0.90
1985	4589	4131	4457	9280	0.82	0.88	0.74
1986	6002	4888	5340	11060	0.96	0.91	0.77
1987a	5894	5010	4742	12260	0.90	0.88	0.63

Notes: *= 1970/71 and 1971/72 variety wise prices are not available (information collection disrupted due to the war of liberation) but for 1969/70 variety wise prices are available. However, the prices of 1970/71 and 1971/72 have been calculated on the basis of average rice prices increase in those years. For average rice prices increase in those years see. Ahmed and Bernard, 1989 P. 23. NA = Not available; Harvest prices of Aus, Aman and Boro are based on harvest prices of August, January and May prices respectively; 1 = Per hectare labour costs are given in Appendix Table 4; 2 = Average retail prices of medium quality clean rice.

Sources: BBS: 1982 Agril. Yearbook, pp. 735-44; 1984-85 Agril. Yearbook, pp. 432-34; 1979 Yearbook, p. 372; 1981 Yearbook, p. 407; 1987-88 Agril. Yearbook, p. 241; 1989 Yearbook, p. 433, p. 437, p. 447. Aus price of 1971, Ahammed, 1981 p. 33.

Appendix Table 4. Average Daily Wage (in Taka) of Agricultural Labourers (without food) and Total Labour Costs per Hectare

Year	Average daily wage				Per hectare total labour cost		
	March to December[1]	March to July[2]	December to June[3]	March to June[4]	Aman[5]	Aus[6]	Boro[7]
1971	NA	NA	NA	3.06	-	-	-
1972	4.03	3.70	3.52	3.69	794	629	803
1973	5.78	5.62	5.21	4.42	1139	955	1188
1974	8.41	8.14	7.28	8.02	1657	1384	1660
1975	9.00	9.48	9.21	9.60	1773	1612	2100
1976	8.83	8.82	8.81	8.72	1740	1499	2009
1977	9.13	9.14	8.90	9.05	1799	1554	2029
1978	10.50	10.14	9.69	9.94	2069	1724	2209
1979	12.00	11.15	10.81	10.79	2364	1896	2465
1980	12.55	12.42	12.63	12.61	2472	2111	2880
1981	15.23	14.80	14.29	14.71	3000	2516	3258
1982	16.23	15.74	15.45	15.56	3197	2676	3523
1983	18.46	17.83	17.45	17.69	3637	3031	3979
1984	21.79	20.89	19.68	20.63	4293	3551	4487
1985	28.53	27.75	26.48	27.71	5620	4718	6037
1986	31.86	31.71	30.26	31.38	6276	5391	6899
1987	33.30	33.60	32.77	33.50	6560	5712	7472

Notes:
NA = Not available
1 = This period covers sowing, growing and harvesting of all types of Aman.
2 = This period is relevant for Aus (all types) rice production. This is also relevant for labour use in jute production.
3 = This period is relevant for Boro (all typs) production.
4 = This period is relevant for jute production.
5 = Average total labour man-days for all types of Aman production activities (from land preparation/sowing to harvesting and threshing) has been calculated at 197 per hectare. For HYV Aman total man-days has been estimated at 264 per hectare and 185 man-days for local varieties. In estimating average total man-days per hectare, area under local and HYV seeds are given proportional weightage. The labour man-days requirement per hectare for Aman has been reported to the author by a senior agricultural scientist working at the Bangladessh Agricultural Research Institute, Bangladesh.
6 = Labour man-days required for local and HYV Aus are 158 and 250 man-days per hectare respectively (Ahmed, 1984 p. 59). Average total man-days giving proportional weightage according to the areas covered by different varieties has been worked out at 170 per hectare.
7 = Average total man-days for Boro production has been worked out at 228 per hectare. The variety wise man-days required in Boro production have been assumed to be similar to Aus varieties.

Source: BBS: 1982 Agril. Yearbook, pp. 673-81; 1984-85 Agril. Yearbook, pp. 382-86; 1985-86 Agril. Yearbook, p. 357; 1987-88 Agril. Yearbook, pp. 192-93.

Appendix Table 5. Factors Influencing the Yield Growths of Different Varieties of Rices (1973-1987) (Estimation without Time Trend).

Dependent Variable (Yield: Kg)	Coefficients of				$\bar{R}^2$	DW Statistic	Autocorrelation Status (test at 1 per cent error level)
	Intercept	Deflated prices	Deflated wages	Rainfall (mm)			
Aman	7.03	-0.0287	0.2012	-0.0090	0.40	1.60	No autocorrelation
	(13.13)	(-0.36)	(2.38) S	(-0.12)			
Aus	6.85	-0.1076	0.1456	-0.0084	0.53	2.35	No autocorrelation
	(20.93)	(-2.15) C	(2.98) S	(-0.18)			
Boro	7.60	-0.0865	0.1350	-	0.16	1.05	Inconclusive
	(70.20)	(-0.65)	(1.00)	-			
HYV Aman	7.82	0.0299	-0.1396	-0.0131	-0.04*	1.30	Inconclusive
	(8.06)	(0.21)	(-0.91)	(-0.09)			
HYV Aus	7.05	0.3104	-0.2982	0.1171	0.57	1.13	Inconclusive
	(9.46)	(1.76)	(-2.68) S	(1.08)			
HYV Boro	7.42	0.0554	-0.0172	-	0.09	1.40	No autocorrelation
	(24.03)	(1.30)		-			
Transplanted Aman	6.88	-0.0032	0.2056	0.0053	0.31	1.75	No autocorrelation
	(12.00)	(-0.04)	(2.27) S	(0.07)			
Broadcast Aman	6.47	0.0151	0.2506	0.0053	0.31	1.75	No autocorrelation
	(13.77)	(0.18)	(3.16) HS	(-0.43)			
Local Aus	6.77	-0.1177	0.1391	-0.0245	0.45	2.03	No autocorrelation
	(17.42)	(-1.98) C	(2.39) S	(-0.43)			
Local Boro	5.90	0.1713	-0.0478	-0.0057	0.18	1.81	No autocorrelation
	(8.96)	(1.49)	(-0.30)	(-0.15)			

Note : $*R^2 = 0.12$; $\bar{R}^2 = \frac{1-k}{n-k} + \frac{n-1}{n-k}R^2$ where n = number of observations and k is the number of explanatory variables. Data (prices and wages) sources. Appendix Tables 3-4.

Sources of rainfall data: Ahmed 1977, p. 150; BBS: 1982 Agril. Yearbook, pp. 550-62: 1984/85 Agril. Yearbook, pp. 313-16; 1987/88 Agril. Yearbook, pp. 169-71.