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IMPACT OF NEW TECHNOLOGY ON PRODUCTION VARIABILITY IN BANGLADESH AGRICULTURE

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ABSTRACT

Changes in production variability and their sources were measured for six crops - Aus rice, Aman rice, Boro rice, jute, wheat, and sugarcane between two time periods - pre-modern technology adoption period (1947/48 - 1967/68) and modern technology (MT) adoption period (1968/69 - 1986/87). For wheat, these periods were 1947/48 - 1971/72 and 1972/73 - 1986/87 respectively. The results showed that in MT period (i) both the absolute and relative variability decreased in case of Aus, Aman and sugarcane; (ii) both the absolute and relative variability increased in case of jute; and (iii) absolute variability increased but relative variability decreased in case of Boro rice and wheat. The decrease in coefficient of variation (CV) of Aus, Aman and sugarcane production is due to decrease in variance and increase in production . The decrease in CV of Boro rice and wheat production is attributed to an increase in average production of Boro rice and wheat. But the increase in production variance is not attributed to MT. The increase in relative variability of jute is due to increase in absolute variability and decrease in average production of jute during MT period.

I. INTRODUCTION

Agricultural production has increased after the introduction of new seedfertilizer-irrigation technology in the late sixties. In 1960-61, Bangladesh produced 9.55 million tons of foodgrain (Tolley et a1.1982). In 1987-88, total foodgrain production rose to 16.77 million tons of which 15.74 million tons

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were rice and 1.03 million tons were whe&t (GOB 1989). The growth of output has increased from 1.57 per cent during 1949-64 to 2.49 per cent during 1965-80 (Boyce 1988). Although new seed-fertilizer-irrigation technology is an important vehicle for increasing area, yield and production, "there is less consensus whether modern technology has increased or reduced production variability" (Flinn and Garrity 1985).

Hazell (1989) observed that production variability in world cereal production increased since the rapid adoption of modern technology. Mehra (1981) also argues that instability in Indian total foodgrain production has increased due to the widespread adoption of the improved seed-fertilizerintensive technologies since the mid 1960s. Similar arguments are also put forward by Rao (1975), by Barker, Gabler and Winckelmann(1981) and by Griffin (1988). Carlson(1985) examined the causes of rice yield variability using panel data from 13 Asian countries. He concluded that the coefficients of variation of both rice yields and total production decreased significantly with higher adoption of modern varieties and irrigation development. Mclntire and Fussell (1985) estimated sources of variation in millet grain yield from farm level data in India. The results showed that improved cultivars did not generally contribute to increased absolute or relative variance if accompanied by appropriate package of inputs.

The variability in crop production has serious consequences in Bangladesh. It may create problem in the attainment of food self-sufficiency goal, may discourage farmers to adopt new technologies and it may cause year to year fluctuations in production. This fluctuation in production may destabilize farm incomes and consequently this can have serious destabilizing impact on the national income, employment and balance of payments.

The present study was undertaken with a view to identify and analyze the magnitude of crop production variability and its sources with special emphasis on the role of modern technology.

The specific objectives of the study were as follows:

i. to determine the magnitude of variability in agricultural production in Bangladesh; and

ii. to analyse the sources of variability particularly to assess the impact of modern technology on the instability in crop production in Bangladesh.

Section II of this paper briefly discusses the sources of data and the analytical procedures of the study. The magnitude of production variability for different crops and the sources of variability are discussed in section III. Section IV discusses the role of MV on production variability and the conclusions are summarised in the final section.

II. DATA AND ANALYTICAL METHODS

Data used in this study were collected from the published documents of the Bangladesh Bureau of Statistics. Data relating to the period 1947/481971/72 were obtained from BBS(1976) and those relating to the period 1972/73 - 1986/87 were obtained from BBS(1976, 1978, 1980, 1982, 1984, 1985, 1986, 1988, 1989). These data were however checked with other published and unpublished data sources and corrected when major errors were detected. But the data relating to the first period could not be checked because BBS(1976) was the only source of those data.

Relative and absolute changes in production variability were measured in the study. For measuring absolute change in production variability production variance was used. But for measuring relative production variabilty we used standardized (or dimensionless) coefficient of variation (CV) defined as CV = sd/m where, sd is standard deviation and m is arithmetic mean of production. The sources of change in production variance were calculated by following the model developed by Hazell (1982). The magnitude of production variability and the sources of variability for the different crops were measured both at national and regional level. In this study, the country was disaggregated into 17 regions which coincided with the old 17 greater districts. The regions under study were Dhaka, Mymensingh, Faridpur, Chittagong, Chittagong Hill Tracts, Noakhali, Comilla, Sylhet, Rajshahi, Dinajpur, Rangpur, Bogra, Pabna, Khulna, Barisal, Jessore and Kushtia.

crop can be represented as :

Following Hazell's model, the variance of the production of a particular crop can be represented as:

$$V(Q) = \sum_{i=1}^{17} \sum_{\substack{j=1 \\ i \neq j}}^{17} COV(A_i Y_i A_j Y_j) \qquad \ldots (1)$$

Where, A denotes area under cultivation in ha; Y denotes yield (metric ton/ha); i and j denotes regions and this can be partitioned as:

$$V(Q) = \sum_{j=1}^{17} V(A_j Y_j) + \sum_{i=1}^{17} \sum_{\substack{j=1 \\ i \neq j}}^{17} COV(A_i Y_i, A_j Y_j) \qquad \ldots (2)$$

In words, V(Q) = [sum of the variances within regions] (i = j)

+ [sum of interregion covariances of the crop] (i ≠ j)

The variance of production of a particular crop, therefore, depends not only on the production variances of the respective crop in each region, but also on covariances between the production in different regions.

Following Bohrnsted and Goldberger (1969) the inter-region covariances can be measured for the first period as:

$$COV(A_{Ii}\, Y_{Ii},\, A_{Ij}\, Y_{Ij})$$
$$= \bar{A}_{Ii}\ \bar{A}_{Ij}\ COV(Y_{Ii}, Y_{Ij}) + \bar{A}_{Ii}\ \bar{A}_{Ij}\ COV(Y_{Ii}, A_{Ij})$$
$$+ \bar{A}_{Ii}\ \bar{A}_{Ij}\ COV(A_{Ii}, Y_{Ij}) + \bar{A}_{Ii}\ \bar{A}_{Ij}\ COV(A_{Ii}, A_{Ij})$$
$$- COV(A_{Ii}, Y_{Ii})\ COV(A_{Ij}, Y_{Ij}) + R_I \qquad \ldots (3)$$

and for the second period as:

$$COV(A_{IIi}\, Y_{IIi},\, A_{IIj}\, Y_{IIj})$$
$$= (\bar{A}_{Ii} + \Delta \bar{A}_i)\ (\bar{A}_{Ij} + \Delta \bar{A}_j)[COV(Y_{Ii}, Y_{Ij} + \Delta\, COV(Y_i, Y_j)]$$

$$+ (\bar{A}_{Ii} + \Delta \bar{A}_i)(\bar{Y}_{Ij} + \Delta \bar{Y}_j)\,[COV(Y_{Ii}, A_{Ij}) + \Delta COV(Y_i, A_j)]$$
$$+ (\bar{Y}_{Ii} + \Delta \bar{Y}_i)(\bar{A}_{Ij} + \Delta \bar{A}_j)\,[COV(A_{Ii}, Y_{Ij}) + \Delta COV(A_i, Y_j)]$$
$$+ (\bar{Y}_{Ii} + Y_i)(\bar{Y}_{Ij} + \Delta \bar{Y}_j)\,[COV(A_{Ii}, A_{Ij}) + \Delta COV(A_i, A_j)]$$
$$- [COV(A_{Ii}, Y_{Ii}) + \Delta COV(A_i, Y_i)][COV(A_{Ij}, Y_{Ij}) + \Delta COV(A_j, Y_j)]$$
$$+ (R_I + \Delta R) \qquad \ldots (4)$$

The change in the inter-region covariance between the two periods can then be calculated as {equation (4) - equation (3)} = $\Delta COV(A_i Y_i, A_j Y_j)$. The terms in this expression have been described in Table 1 so that they can be attributed to different sources.

Now, the change in variance of production, $\Delta V(Q)$, is decomposed by applying the decomposition results in Table 1 to each of the covariance terms in equation (1). The components of change is then aggregated as grouped in equation (2). A detail description of this method is given in Deb (1990).

III. MAGNITUDE OF PRODUCTION VARIABILITY AND ITS SOURCES

This section first describes the level in the variance of production. Secondly, it discusses the sources of changes in variance of production.

Magnitude of Production Variability

Absolute change in production variability, measured in terms of production variance, for different crops at national and regional level are presented in Table 2. It indicates that production variance at national level increased about 11 and 238 times in Boro rice and wheat production, respectively. For these two crops, production variance also increased in all the regions. But production variance decreased in aus rice, aman rice and sugarcane by about 71, 2, and 85 per cent respectively. This is true for almost all the regions. Jute production variance increased about 64 per cent at national level, but it declined in all the regions except Faridpur, Rajshahi, Rangpur, Bogra, Pabna, Khulna, Jessore and Kushtia.

Empirical evidence on the changes in relative variability of production and yield, measured in terms of coefficient of variation (CV), of different crops between the two periods are shown in Tables 3 and 4. Coefficient of variation of different crops at national level declined in the second period for all the crops under the study, except jute. This implies that relative production variability reduced in the second period. It might have occurred due to the adoption of seed-fertilizer-irrigation technology.

Table 1. Components of change in the production covariance.

SOUCE OF CHANGE		COMPONENTS CHANGE
Description	Symbols	
Change in mean yield	$\Delta\bar{Y}$	$\bar{A}_{Ii}\Delta\bar{Y}_j Cov(Y_{Ii},A_{Ij}) + \bar{A}_{Ij}\Delta\bar{Y}_j Cov(A_{Ii},Y_j)$ $+[\bar{Y}_{Ii}\Delta\bar{Y}_j + \bar{Y}_{Ij}\Delta\bar{Y}_i + \Delta\bar{Y}_i\Delta\bar{Y}_j]Cov(A_{Ii},A_{Ij}]$
Change in mean area	$\Delta\bar{A}$	$\bar{Y}_{Ij}\Delta\bar{A}_j Cov(A_{Ii},Y_{Ij}) + \bar{Y}_{Ij}\Delta\bar{A}_i Cov(Y_{Ii},A_{Ij})$ $+[A_{Ii}\Delta\bar{A}_j + \bar{A}_{Ij}\Delta\bar{A}_i + \Delta\bar{A}_i\Delta\bar{A}_j]Cov(Y_{Ii},Y_{Ij})$
Change in yield variance	$\Delta V(Y)$	$\bar{A}_{Ii}\bar{A}_{Ij}\Delta Cov(Y_i,Y_j)$
Change in area variance	$\Delta V(A)$	$\bar{Y}_{Ii}\bar{Y}_{Ij}\Delta Cov(A_i,A_j)$
Interaction between changes in mean yield and mean area	$\Delta\bar{Y}\Delta\bar{A}$	$\Delta\bar{A}_i\Delta\bar{Y}_j Cov(Y_{Ii},A_{Ij}) + \Delta\bar{Y}_i\Delta\bar{A}_{Ij} Cov(A_{Ii},Y_{Ij})$
Change in area-yield covariance	$\Delta Cov(Y,A)$	$\bar{A}_{Ii}\bar{Y}_{Ij}\Delta Cov(Y_i,A_j) + \bar{Y}_{Ii}\bar{A}_{Ij}\Delta Cov(A_i,Y_j)$ $-[Cov(A_{Ii},Y_{Ii})+\Delta Cov(A_i,Y_i)]\Delta Cov(A_j,Y_j)$ $-Cov(A_{Ij},Y_{Ij})\Delta Cov(A_i,Y_i)$
Interaction between Changes in mean area and yield variance	$\Delta Cov(Y,A)$	$\bar{A}_{Ii}\bar{Y}_{Ij}\Delta Cov(Y_i,A_j) + \bar{Y}_{Ii}\bar{A}_{Ij}\Delta Cov(A_i,Y_j)$ $-[Cov(A_{Ii},Y_{Ii})+\Delta Cov(A_i,Y_i)]\Delta Cov(A_j,Y_j)$ $-Cov(A_{Ij},Y_{Ij})\Delta Cov(A_i,Y_i)$
Interaction between changes in mean yield and area variance	$\Delta\bar{A}, \Delta V(Y)$	$[\bar{A}_{Ii}\Delta\bar{A}_j + \bar{A}_{Ij}\Delta\bar{A}_i + \Delta\bar{A}_{Ii}\Delta\bar{A}_j]\Delta Cov(Y_i,Y_j)$
Interaction between changes in mean area and yield and changes in area-yield covariance	$\Delta\bar{Y}, \Delta V(A)$ $\Delta\bar{Y}, \Delta\bar{A}, \Delta Cov(Y,A)$	$[\bar{Y}_{Ii}\Delta\bar{Y}_{Ij} + \bar{Y}_{Ij}\Delta\bar{Y}_i + \Delta\bar{Y}_i\Delta\bar{Y}_j]\Delta Cov(A_i,A_j)$ $[\bar{Y}_{Ij}\Delta\bar{A}_i + \bar{A}_{Ii}\Delta\bar{Y}_j + \bar{A}_i\Delta\bar{Y}_j]\Delta Cov(Y_i,A_j)$ $+[\bar{Y}_{Ii}\Delta\bar{A}_j + \bar{A}_{Ij}\Delta\bar{Y}_i + \Delta\bar{Y}_i\Delta\bar{A}_j]\Delta Cov(A_i,Y_j)$
Change in residual	ΔR	$\Delta R = \Delta Cov(A_iY_i, A_jY_j)$ - sum of other components

Note : A denotes area sown, Y, Yield, and V, variance.

Table 2. Changes in Variance of Production Between Two Periods, by Crop and Region (in Per Cent).

Region/Crop	Aus	Aman	Boro	Jute	Sugarcane	Wheat
Dhaka	-69.79	-29.85	826.99	-7.72	-92.41	29307.88
Mymensingh	9.87	-9.80	524.87	-25.70	-79.74	98634.81
Faridpur	-76.44	-62.88	4433.74	41.14	1.51	2618.15
Chittagong	1.24	-34.66	732.29	-31.27	-63.38	-
Chittagong H.T.	27.21	-5.94	79.08	-98.92	-55.24	-
Noakhali	-51.57	44.32	8589.32	-9.69	-56.56	-
Comilla	-9.23	-3.55	3839.13	-31.93	-56.34	27354.44
Syhet	172.14	-26.76	81.12	-39.19	-77.04	-
Rajshahi	-67.61	-59.17	5275.25	72.95	-91.29	19086.01
Dinajpur	-17.67	-9.49	41590.79	-64.27	-40.37	437958.30
Rangpur	-59.36	-46.41	154477.6	91.35	-80.36	491082.70
Bogra	-34.75	-29.44	128869.2	128.64	-50.70	73695.96
Pabna	-32.32	45.05	105865.2	-1.57	-46.44	2800.17
Khulna	-22.60	-9.91	542.07	58.39	-26.50	-
Barisal	-51.85	15.82	70882.26	-42.68	101.56	-
Jessore	-5.30	77.09	47252.06	79.50	-72.09	37704.15
Kushtia	-12.99	109.47	9537.97	515.79	-64.41	12304.09
Other Regions	-	-	-	-	-	154492.80
Bangladesh	-70.91	-2.22	1131.96	63.79	-85.42	23825.58

Note: 1. For all the crops except wheat, first period refes to 1947/48-1967/68 and second period refers to 1968/69-1986/87. For wheat, first period covers 1947/48-1971/72 and second period covers 1972/73-1986/87. This definition of periods will hold true for the subsequent analysis/tables.

2. Other regions include Chittagong, Chittagong H.T., Noakhali, Khulna, Barisal and Sylhet. This definition is valid only for wheat and will hold true for subsequent analysis.

Source: Calculated from BBS data.

Table 3. Changes in Coefficients of Variation of Production by Crops and Regions Between First and Second Periods (in Per Cent).

Region/Crop	Aus	Aman	Boro	Jute	Sugarcane	Wheat
Dhaka	-57.96	-10.72	-115.93	13.91	-61.37	52.05
Mymensingh	-27.62	-34.30	-65.23	-0.63	-60.78	-0.13
Faridpur	-57.57	-12.30	21.80	6.83	-58.74	-31.96
Chittagong	-24.04	-37.12	-1003.24	-14.50	-52.47	-
Chittagong H.T.	13.60	-27.76	-821.65	-50.23	-38.79	-
Noakhali	-53.66	-16.76	-398.22	122.99	-51.50	-
Comilla	-24.87	-4.46	-78.08	28.74	-6.00	-56.56
Sylhet	-16.47	-22.36	-63.42	127.58	-66.82	-
Rajshahi	-56.66	-45.91	-5.87	79.54	-85.85	54.39
Dinajpur	-58.96	-32.36	-92.09	-32.59	16.69	6.78
Rangpur	-45.87	-61.34	-2.36	2.24	-70.70	287.20
Bogra	-51.22	-39.93	-126.06	106.62	-50.61	-17.89
Pabna	-31.50	9.52	2.17	20.06	-78.01	-39.72
Khulna	-35.12	-6.90	-57.74	-20.08	-71.58	-
Barisal	-63.30	3.88	-52.75	96.34	96.13	-
Jessore	-25.43	12.99	-97.30	-32.65	-76.31	-27.67
Kushtia	-15.61	41.98	-110.49	13.13	-71.10	-19.73
Other Regions	-	-	-	-	-	-11.01
Bangladesh	-61.33	-18.09	-61.47	31.55	-74.05	-4.42

Source: Calculated from BBS data.

Table 4. Changes in Cofficients of Variation of Yield by Crops and Regions Between First and Second Periods (in Per Cent).

Region/Crop	Aus	Aman	Boro	Jute	Sugarcane	Wheat
Dhaka	-46.74	25.18	-54.21	-16.81	-69.97	55.39
Mymensingh	-10.79	-25.54	-49.55	-27.22	-48.86	117.62
Faridpur	-31.20	-9.56	-36.53	14.33	-39.22	110.78
Chittagong	-21.06	-33.44	-54.52	-22.17	-53.11	-
Chittagong H.T.	73.80	-6.57	-61.38	-13.29	-51.32	-
Noakhali	-19.14	-24.71	-27.54	-41.92	-51.53	-
Comilla	-24.71	-12.37	30.22	-30.88	-36.90	-48.93
Sylhet	14.38	-48.24	-29.25	49.75	-49.57	-
Rajshahi	-55.94	-28.91	-38.31	-11.37	-79.51	74.96
Dinajpur	-34.33	-41.32	-66.51	-6.07	23.33	0.06
Rangpur	-28.89	-46.01	-36.09	-30.37	-69.08	36.77
Bogra	-12.89	-38.72	-22.60	-8.88	-39.19	-41.03
Pabna	-44.06	-08.77	-36.47	-33.32	-61.88	31.94
Khulna	-26.81	-0.56	-31.54	6.83	-45.54	-
Barisal	-0.72	-4.77	-5.92	-50.51	-8.89	-
Jessore	-20.76	10.10	-72.18	-49.87	-31.22	86.27
Kushtia	3.67	-9.33	-21.03	17.32	-15.02	50.33
Other Regions	-	-	-	-	-	98.50
Bangladesh	-37.57	-13.35	-56.98	-32.32	-66.28	44.08

Source: Calculated from BBS data.

It is known that production is an ultimate effect of area and yield. Yield, among many other factors, depends on assured water availability. New seed fertilizer irrigation technology ensures this. This is also supported by Table 4 which indicates that the CV of yield of all the crops except wheat decreased in the second period. This implies that yield level was more stable in the second period. But why has this happened? Is it due to the adoption, of new technology or have any other things influenced it? An attempt is made to answer this question in the subsequent sections.

Sources of Changes in Variance of Production in Bangladesh

This section describes the components of change in variances of production of all the crops under study. The magnitude and direction of changes in variance of production of different crops as well as their sources are summarised in Table 5. The last row of Table 5 is the reproduction of the last row of Table 2. Positive signs of the value of the last row imply increases in variance and negative signs imply decreases in variance. The first ten rows of Table 5 show the decomposition of the total change in the variance assuming the total change as 100. As variance of Aus, Aman and sugarcane production decreased, negative values of the sources of production variance of Boro, jute, and wheat imply that the corresponding sources have destabilizing effect.

Table 6 shows the contribution of different regions and interregion covariance to the change in production variance for the country. If a region contributes positively (negatively) to the decrease (increase) in the .total variance of national production of a particular crop production, negative (positive) values of the components of changes in variances imply their destabilizing (stabilizing) effect.

Aus

Tables 5 and 6 present the components of change in production variance of Aus. Inter-region covariance was the principal contributor (96 per cent)' to the change in production variance. Amongst the regions Faridpur, Rajshahi, Rangpur and Barisal had a positive impact on changes in production variance and each of them accounted for about one per cent of the change. But Sylhet region had a negative impact on this change which meant that it destabilized Aus production at national level.

Changes in mean yield and mean area have destabilizing effect on Aus production. Mean area variance and mean yield variance contributed positively to the reduction in production variance. Change in area-yield covariance was the major source of variation of production of Aus rice. It had a positive covariance was the major source of variation of production of Aus rice. It had a positive contribution to the reduction' of production variance in the country.

The contribution of interaction between changes in mean yield and changes in mean area was not substantial. Other interaction effects are also important' in case of reduction of Aus production variance. Three interaction effects together contribuied positively to the reduction of production variance.

Aman

As we have discussed earlier, variance of production of Aman rice has reduced only to a smaller extent. Table 5 indicates that major source of this reduction in variance is area-yield covariance. Inter-region covariance contributed negatively to the reduction in aman production variance by about 26 per cent which means that it increased production variance. Among the regions Rajshahi and Rangpur made large contributions (Table 6). These two regions in combination contributed about 88 per cent of the reduction. Except Noakhali, Pabna, Barisal and Jessore regions, all the regions contributed positively to the reduction of production variance. Noakhali, Pabna, Barisal and Jessore regions contribution was negative. This means that these regions had destabilizing effect on production variance.

Boro

As it was discussed earlier, the variance of Boro production increased by about 1132 per cent (Table 5). Table 6 reveals that the production variance increased mainly due to the inter-region production covariance and that it contributed about 84 percent of the change. Among the regions, Mymensingh contributed about 7 per cent of the change in variance. Contribution of each of Dhaka, Comilla, Sylhet, Rangpur, Bogra, Pabna and Barisal regions was about 1 per cent. But Chittagong H.T. and Kushtia region had no impact. All the regions contributed positively to the increase in production variance or in other words they had destabilizing effect on production variance.

At the national level three interaction term appeared to be the major sources of increase in variance. These three sources together accounted for about 56 per cent of the change. Changes in mean area contributed about 19 per cent to the increases in variance.

Table 5 . Components of Change in Variance of Production of Individual Crops in Bangladesh, Between Two Periods (in Per Cent).

Source of Change in Variance of Production	Symbol	Aus	Aman	Boro	Jute	Sugarcane	Wheat
Change in mean yield	$\Delta\bar{Y}$	-15.46	-367.82	8.26	-30.67	-16.76	1.16
Change in mean area	$\Delta\bar{A}$	-41.16	-174.72	18.59	4.76	-23.31	1.51
Change in mean yield variance	$\Delta V(Y)$	19.14	-131.34	-0.48	-73.01	11.33	0.35
Change in mean area variance	$\Delta V(A)$	34.68	50.59	14.54	46.75	36.45	7.90
Interaction between changes in mean yield and mean area	$\Delta\bar{Y}, \Delta\bar{A}$	-1.71	-5.34	5.68	1.90	-1.59	0.92
Change in area-yield covariance	$\Delta Cov(Y,A)$	60.09	488.69	0.98	172.62	37.33	0.22
Interaction between changes in mean area and yield variance	$\Delta\bar{A}, \Delta V(Y)$	12.55	-6.53	-3.97	-13.40	8.86	12.22
Interaction between changes in mean yield and area variance	$\Delta\bar{Y}, \Delta V(A)$	0.05	0.63	29.69	-0.37	205.44	27.36
Interaction between changes in mean area and yield and changes in area-yield covariance	$\Delta\bar{Y}, \Delta\bar{A}$ Cov(Y,A)	24.97	102.19	4.96	-7.02	18.78	36.71
Change in residual	ΔR	6.84	143.64	21.75	-1.55	-176.52	11.64
Change in the variance of production in Bangladesh		-70.91	-2.22	1131.96	63.79	-85.42	23825.58

Source : Calculated from BBS data.

Jute

The principal contributor to variance of jute production was inter-region covariance, accounting for about 97 per cent change in variance at the national level (Table 9). Dhaka, Mymensingh, Noakhali, Comilla, Sylhet, Dinajpur, Pabna and Barisal regions contributed negatively to this increase in production variance. This means that these regions had 4 stabilizing impact on production variance at national level. But Faridpur, Rajshahi, Rangpur, Bogra, Khulna, Jessore and Kusfitia region had a positive effect on this increase. In other words, these regions had contributed to destabilize production variance.

Among the sources of production variance change in area- yield covariance had a destabilizing effect on the production variance in the country as a whole.

Sugarcane

Tables 5 and 6 show different sources of change in variance of sugarcane production. Variance of sugarcane production has decreased over the period and inter-region covariance was responsible for about 82 per cent of this change. All the regions except Faridpur and Barisal had a positive contribution to this change. These two regions had negative impact, but the magnitude was too small. Chittagong H.T. region had no effect because sugarcane is not grown in that region. Apart from interaction term, change in mean area variance and change in area-yield covariance appeared to be a leading stabilizing factor in sugarcane production.

Wheat

The last columns of Tables 5 and 6 show the contribution of different sources to the increase in production variance of wheat. Inter- region covariance was the largest source of this increase. It accounted for about 89 per cent of the change in national production variance. All the regions had destabilizing impact on wheat production vadance. Among the regions, the contribution of Bogra was the highest and it was 3 per cent. The contribution of all the regions was positive.

Table 6. Contribution of Different Regions and Inter Regional Coveriances to the Changes in Production Variance of Differen Crops Between the Two Peiods (in Per Cent).

Region/Crop	Aus	Aman	Boro	Jute	Sugarcane	Wheat
Dhaka	0.53	10.42	0.69	-0.20	0.82	0.30
Mymensingh	-0.34	11.49	6.67	-4.74	0.39	1.05
Faridpur	0.92	18.06	0.38	1.27	-0.02	0.68
Chittagong	-0.01	12.58	0.49	0.00	0.01	0.00
Chittagong H.T.	-0.01	0.05	0.00	0.00	0.00	0.00
Noakhali	0.35	-9.30	0.47	-0.02	0.01	0.00
Comilla	0.09	1.29	1.45	-1.09	0.02	1.18
Sylhet	-0.88	10.68	0.69	-0.06	0.03	0.00
Rajshahi	0.60	34.55	0.72	0.57	12.87	0.05
Dinajpur	0.13	2.72	0.06	-0.77	1.11	1.04
Rangpur	1.52	53.58	1.58	4.58	0.48	1.37
Bogra	0.09	6.34	1.41	0.37	0.22	3.00
Pabna	0.09	-3.37	0.62	-0.02	0.19	0.27
Khulna	0.03	8.65	0.04	0.11	0.01	0.00
Barisal	1.03	-20.88	0.55	-0.13	-0.27	0.00
Jessore	0.05	-9.28	0.31	1.62	0.46	0.58
Kushtia	0.07	-1.68	0.01	1.47	1.76	0.42
Inter Regional Covariance	95.74	-25.86	83.86	97.02	81.90	89.16 (0.89)
Bangladesh	100.00	100.00	100.00	100.00	100.00	100.00

Figure in the parenthesis indicates coefficient for other regions.
Source : Calculated from BBS data.

Interaction effect was the largest source of increase in variance both at national and regional level. At national level three interaction effects contributed about 77 per cent. This source contributed more than 55 per cent in all the regions. Change in mean area and change in mean yield had very little effect on the increase in production variance. This implies that change in mean area and change in mean yield had no serious destabilizing impact on production variance. On the other hand, change in mean area variance had a destabilizing effect on wheat production variance.

IV. ROLE OF MODERN TECHNOLOGY (MT) ON PRODUCTION VARIABILITY

The analysis in section III shows that absolute production variability measured in terms of production variance decreased during modern technology period in Aus rice, Aman rice and sugarcane but increased in Boro rice, wheat and jute. However, relative production variability measured in terms of coefficient of variation (CV) decreased during modern technology period in all the crops except jute. Thus, we can see three different patterns regarding changes in production variability. Firstly, both the absolute and relative variability decreased in MT period in case of Aus, Aman and sugarcane. Secondly, both the absolute and relative variability increased in MT period in jute. Thirdly, absolute variability (variance) increased but relative variability (CV) decreased during MT period in case of Boro rice and wheat.

In this section, we will discuss the role of MT on increasing or decreasing variance or coefficient of variation of these crops.

Aus

In MT period, variance of Aus production decreased by 71 per cent and CV of production decreased by 61 per cent. This decrease is due to decrease in variance (71 per cent) and increase in production (39 per cent). The major source of decrease in variance of Aus production is area-yield covariance.

$$Cov(A,Y) = \rho\,[V(A),\ V(Y)]^{1/2},$$

where ρ is the correlation coefficient between area and yield; then changes in the covariance can arise through changes in ρ,V(A) or V(Y). In fact,

$$Cov(A,Y) = \rho_1[\delta Y l\ \Delta\delta A + \delta A l\ \ \Delta\delta Y + \Delta\delta A\ \Delta\delta Y\,]$$
$$+ \Delta\rho[\delta A l\ \delta Y l + \delta Y l\ \Delta\delta A + \delta A l\ \Delta\delta Y + \Delta\delta Y\ \Delta\delta A]$$

where $\Delta\delta A$ and $\Delta\delta Y$ denote the standard deviations of area sown and yield respectively.

The area-yield correlations for both periods are reported in Table 7. The area-yield correlation decreased for aus both at national and regional level except for Khulna region (Table 7). At the same time standard deviation of area and yield also decreased during MT period (Table 8). Thus we can say that MT reduces area-yield covariances and thereby reduces production variance. Tables 5 and 8 also reveal that decrease in Aus yield variance and area variance in MT period has a stabilizing effect on Aus production. Several studies (Dey 1988, Hossain 1988) showed that adoption of MT has increased yield and area of agricultural crops and thereby increase production. Thus, it can be concluded that MT reduces absolute as well as relative variability of aus production in Bangladesh.

Table 7. Area-Yield Correlations in Different Periods, by Crop and Gegion.

Region/Crop	Aus	Aman	Boro	Jute	Sugarcane	Wheat
Dhaka						
First Period	0.57	0.50	0.67	-0.26	0.05	0.67
Second Period	-0.23	-0.22	0.58	-0.31	-0.33	0.73
Mymensingh						
First Period	0.25	0.49	0.87	-0.34	0.18	0.20
Second Period	-0.04	0.37	0.82	-0.44	-0.13	0.63
Faridpur						
First Period	0.42	0.06	0.15	-0.43	0.59	0.51
Second Period	0.15	0.20	0.47	-0.16	0.00	0.74
Chittagong						
First Period	0.39	0.11	0.72	-0.17	-0.37	-
Second Period	-0.04	0.37	-0.42	0.65	0.46	-
Chittagong H.T.						
First Period	0.49	-0.08	0.71	0.70	0.01	-
Second Period	-0.66	0.48	0.30	-0.24	0.38	-

Table 7. Continued.

Region/Crop	Aus	Aman	Boro	Jute	Sugarcane	Wheat
Noakhali						
First Period	0.25	-0.13	0.72	-0.07	-0.21	-
Secon Period	0.71	0.40	-0.35	0.26	0.07	-
Comilla						
First Period	0.36	0.002	0.72	-0.30	0.33	0.89
Second Period	0.03	-0.37	0.09	-0.19	0.23	0.45
Sylhet						
First Period	0.57	-0.12	0.60	0.13	0.38	-
Second Period	0.55	0.07	0.59	0.49	0.50	-
Rajshahi						
First Period	0.41	0.51	0.65	-0.53	0.69	0.64
Second Period	0.02	0.19	0.53	-0.17	0.005	0.78
Dinajpur						
First Period	0.53	0.60	0.65	-0.36	0.26	0.80
Second Period	0.11	0.50	-0.03	-0.25	0.52	0.61
Rangpur						
First Period	0.35	0.59	0.29	-0.48	0.63	-0.57
Second Period	-0.12	0.82	0.49	0.10	-0.37	0.89
Dinajpur						
First Period	0.61	0.11	0.72	-0.42	0.63	0.83
Second Period	-0.33	0.09	0.61	0.16	0.74	0.67
Pabna						
First Period	-0.20	0.42	0.62	-0.12	0.48	0.74
Second Period	0.03	0.44	0.62	-0.04	0.24	0.47
Khulna						
First Period	0.33	0.14	-0.01	0.02	0.55	-
Second Period	0.60	0.73	0.66	0.33	0.14	-

Table 7. Continued.

Region/Crop	Aus	Aman	Boro	Jute	Sugarcane	Wheat
Barisal						
First Period	0.57	0.36	0.01	-0.33	0.11	-
Second Period	0.19	0.58	0.29	0.72	0.86	-
Jessore						
First Period	0.34	0.51	0.70	0.03	0.67	0.81
Second Period	-0.37	0.22	0.38	-0.03	-0.73	0.48
Kushtia						
First Period	0.37	-0.40	0.93	-0.19	0.58	0.73
Second Period	-0.07	0.41	0.25	0.59	-0.05	0.54
Other Regions						
First Period	-	-	-	-	-	0.33
Second Period	-	-	-	-	-	0.57
Bangladesh						
First Period	0.75	0.57	0.87	-0.56	0.78	0.86
Second Period	0.02	0.36	0.49	-0.05	0.12	0.75

Source: Calculated from BBS data.

Aman

In MT period, variance of Aman decreases by 2.21 per cent and coefficient of variation decreased by 18.09 per cent. Decrease in relative variability is due to decrease in variance and increase in average production of Aman (21 per cent). The single most important source of decrease in variance of Aman production is a change in area yield covariance (488.69 per cent). Decomposition of changes in area-yield covariance shows that area-yield covariance of Aman decreased due to decrease in correlation coefficient between area and yield, and due to decrease in standard deviation of Aman area during MT period. This reduction in standard deviation or variance of area may be attributable to MT . Due to the introduction of MT, Aman production became more profitable and as a result farmer do not keep their land fellow. It is also true that due to the introduction of MT, farmer are leaving B.Aman cultivation, whose acreage were very much unstable. Thus, we can say that MT has reduced variance of Aman production. Similarly, using the arguments made in previous section, we can say that MT reduces relative variability of Aman production.

Sugarcane

Both absolute and relative variability of sugarcane decreases by 85 and 74 per cent respectively during MT period. Decomposition of variance shows that changes in area variance, changes in yield variance, their interaction and changes in area- yield covariance have helped in stabilizing sugarcane production. As shown in the last section, area yield covariance depends on standard deviation of area, standard deviation of yield and on area- yield correlation. Tables 7 and 8 show that standard deviation of area, ,standard deviation of yield and area yield correlation have decreased during the MT period. Thus it may be concluded that MT has reduced both absolute and relative variability of sugarcane.

Table 8. Changes in the Standard Deviations of Yield and Area Sown of Different Crops in Bangladesh, Between the Two Periods.

Crop	Changes in Standard Deviation of Yield (Δ δ Y)	Changes in Standard Deviation of Area (Δ δ A)
	(Percent)	
Aus	-31.45	-49.99
Aman	2.23	-6.82
Boro	-17.56	184.67
Jute	-40.34	9.51
Sugarcanne	-62.15	-54.12
Wheat	275.31	590.82

Source : Calculated from BBS data.

Boro

Table 5 shows that the variance of Boro paddy production increased in MT period by 1131.96 percent. But coefficient of variation of Boro rice production decreases by 61.77 per cent. Thus decreases in CV of Boro production is attributable to increase in average production of Boro rice (467 per cent). The decomposition of variance of Boro production shows that major sources of this increase in variance are changes in mean area, changes in mean area variance and interaction between area-yield variance. Changes in yield variance has however stabilizing effect on boro yield. But these changes in mean area and mean area variance are not directly attributable to MT. Thus we can say that, although Boro production variance has increased in MT, this, change in variability is not attributable to MT. On the other hand, reduction in relative variability can be attributed to the adoption of MT.

Wheat

Absolute variability of wheat has increased during MT period but relative variability has decreased. Modern technology played a vital role in decreasing the relative variability by increpsing production. Table 5 shows that MT has no direct role in increasing variance of wheat as three interaction terms are the major sources of increase in variance.

Jute

Both absolute and relative variability of jute increased by 64 and 31 per cent, during MT period. Increase in relative variability is due to increase in absolute variability (vartance) and decrease in average production of jute during MT period. Decomposition of variance of jute production show that main source of this increase in variance are changes in mean area variance and changes in area-yield covariance. In fact, over the last decade jute area fluctuated substantially due to fluctuation in jute price and this fluctuation is not attributable to adoption of MT in jute. Thus we can say that although variability of jute production increased in MT, MT has no direct role for this increase.

V. CONCLUSIONS

The results showed that (i) both the absolute and relative variability decreased in MT period in case of Aus, Aman and sugarcane; (ii) both the absolute and relative variability increased in MT period in case of jute; (iii) absolute variability (variance) increased but relative variability `(CV) decreased during MT period in case of Boro rice and wheat.

Variance of Aus production decreased by 71 per cent and CV of production decreased by 61 per cent. This decrease is due to decrease in variance (71 per cent) and increase in production (39 per cent). The major source of decrease in variance of Aus production is area-yield covariance.. Variance of Aman decreased by 2.21 per cent and coefficient of variation decreased by 18.09 per cent. Decrease in relative variability is due to decrease in variance and increase in average production of aman (21 per cent). The single most important sources of decrease in variance of Aman production is change in area yield covariance (488.69 per cent). Both the absolute and relative variability of sugarcane decreased by 85 and 74 per cent respectively, during MT period. Decomposition of variance shows that situation of sugarcane is similar to that of Aus. So, we may conclude that MT has reduced both absolute and relative variability of Aus rice, Aman rice and sugarcane.

Variance of Boro production increased in MT period by 1131.96 per cent. But coefficient of variation of Boro rice production decreases by 61.77 per cent. Thus decreases in CV of Boro production is attributable to increase in average production of Boro rice (467 per cent). But the increase in production variance is not attributable to MT. Situation of wheat is similar to that of Boro. Both absolute and relative variability of jute increased by 64 and 31 per cent, during MT period. Increase in relative variability is due to increase in absolute variability (variance) and decrease in average production of jute during MT period. And the increase in variance is not attributable to adoption of MT in jute.

Thus the findings of the study confirm that the production variability decreased in Bangladesh agriculture with the adoption of modern technologies. It is also suggested that plant breeders as well as planners and policy makers need not be worried about production variability with the gradual adoption of modern technologies.

Limitations of the Study

The study has a number of limitations: i) the study was conducted on the basis of official macro level statistics compiled and published by the Bangladesh Bureau of Statistics (BBS). But proper assessment of the production variability should ideally be based on individual farm level time series data. Such data set is not available; ii) different agro-climatic factors such as rainfall, flood, drought, severe insect and pest attacks etc., have significant influence on production variability. But these could not be taken care of in this analysis; and iii) changes in irrigation coverage and fertilizer use rates, government policies such as price policy, credit policy etc. and the changing role of extension programmes do also influence production variability. These were beyond the scope of the study.

The above limitations indicate that there is a wider scope for further research. It would be worthwhile to carry out further studies on production variability for each agro-climatic zone with special emphasis on the role of government policy.

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