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GROWTH AND INSTABILITY IN PRODUCTION OF PRINCIPAL FOODGRAIN CROPS: A CASE OF BACKWARD ECONOMY

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ABSTRACT

Analysis of growth performance of principal foodgrain crops in North Bihar (India) revealed that their production recorded positive growth rates during post green revolution period. Wheat was the only crop which recorded positive growth rates in area, production and productivity across the zone over different sub-periods. There has not been substantial increase in area under rice during period under investigation. Moreover, a declining trend in rice area has been observed during early nineties. The study of instability indicated that wheat, maize and arhar witnessed a continuous decline in instability over the period under study. The decline in stability in the production of these crops has been caused mainly by adoption of improved technology in crop production. The spectacular growth in production was associated with increase in instability but it started declining after the perfection in technology.

1. INTRODUCTION

Indian agriculture sector has performed impressively in terms of increasing productivity and intensity of cultivation. It is by no means a small achievement that the per capita foodgrain availability at country level has increased to high level over the last four and a half decades, in the face of an assault of population pressure and declining per capita land availability. This could be possible due to cutting edge of science coupled with fast adoption of technology by farmers and above all the government decisions to accord a high priority to agriculture by making large investments on infrastructure, particularly just after the advent of green revolution. Unlike in the past, crisis situations of draught and/or flood are now considerably well managed without any panic or large scale imports. The country successfully managed the worst draught of the century in the year 1987-88 which speaks the resilience of Indian Agriculture. But the country is still to manage spatial and temporal variations in agricultural production which is mainly caused by a wide range of crop-soil-weather conditions. The stability fo agricultural production in the sense of elimination of year to year fluctuations in output due to weather and rainfall changes has been an important aspect for steady agricultural growth over time since the fluctuation in agricultural production disturbs the rhythm and the mutual balance among many inter-dependent process in the economy and enhances the degree of uncertainty about future that is faced by policy makers as well as by producers and the consumers in the economy (Rao, 1986).

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A large number of studies have been conducted on growth and instability in agricultural production, in general and foodgrain production in particular. Almost all the studies observed a substantial gain in area, production and productivity of wheat in all the indian states during postgreen revolution period. Rice also recorded an increase in area, production and productivity, particularly in states which adopted rice cultivation during post-green-revolution period. Pulses did not show any sustained growth in area across the states but their productivities picked up in most of states. Moreover, there has not been any clear cut treand in stability of foodgrain production. It is difficult to identify and even more difficult to quantify the causes of fluctuation in foodgrain production. However, Hazel] (1982) assigned much importance to the growth for increasing instability, but Ray (1983), assigned much importance to the growth for increasing instability, but Ray (1983), mahendradev (1987) and Rao (1988) identified rainfall,irrigation and agro-physical situatins as important factors influencing instability in foodgrain production during post-green revolution period. The application of new technology (Seed-fertilizer) has also been found responsible for variability in foodgrain production during post green revolution period (Mehra, 1981).

Most of the studies in the field of growth and instability of foodgrain production dealt with the post-green revolution period and almost all of them are based on national and state level data. If rainfall and agro-climatic situations are major factors influencing stability which vary much even within the state, regional studies with different sub-periods of post-green revolution would generate more meaningful information on these important aspects of agricultural development. To bridge this information gap, the present study was undertaken to analyse the nature and extent of growth in foodgrain production and to examine whether the introduction of seed-fertilizer technology has made the crop production more stable or unstable in backward region like North Bihar.s

The present analysis has edge over to the existing studies on agricultural,growth and instability on at least four counts: (i) It examines the growth rate and instability of principal foodgrain crops separately, (ii) Analysis was done for two sub-agro-climatic zones of North Bihar, (iii) It covers the period upto 1994-95 (i. e., triennium average from 1970-71 to 1994-95), the latest year for which revised estimates are available and (iv) It analyses production growth and instability during three sub-periods of post green revolution.

II. STUDY AREA

North Bihar, with 1.62 per cent of the national landmass supports nearly 4.61 per cent of population of the country. The region has almost the lowest foodgrain productivity (1016 kg/ha) and per capita cultivable land (0.08 ha) but provides livelihood of comparatively larger number of

per hectare population (12). It has a typical agro-climatic situation and land scape. Annual rainfall varies from 1050 mm to 1700 mm, however, its distribution is uneven. The recurrent flood menace makes the region agriculturally quite different from other regions of the country, in general and other parts of Bihar, in particular.

A major portion of cropped area (10%) is under rainfed situation and irrigated areas do not g adequate water at right time. There has been absolute decline in canal irrigated area from 3f thousand ha in 1980 to 336 thousand ha in 1995. The cropping intensity is less than 120 and tl cropping pattern is dominated by foodgrain crops (89%). Agriculture still contributes nearly 55 p cent of gross domestic product and provides employment to more than 80 per cent of working forl in North Bihar.

North Bihar has been diveded in two agro-climatic zones on the basis of bio-physi parameters. Zone-1 comprises districts of Saran, Siwan, Gopalganj, Muzaffarpur, East Champaran, West Champaran, Sitamarhi, Vaishali, Darbhanga, Madhubani, Samastipur and begusarai whereas zone II covers districts of Saharsa, Purnea, ATaria, Madhepura, khagaria, kishanganj, Matihar and Naugachia, subdivision of Bhagalpur. The topography of zone-I is plain with a slope towards south-east. There are three major river basins in this zone namely, Gandak, Adhwara and Kosi. The depression caused due to change of course of these rivers facilitate the water logging. Zone-II comprising the alluvial plains of Kosi, Mahananda and Ganga rivers, is undulating to rolling land scope with slope towards south-east. The soils of zone-I are modrately rich to poor in nitrogen and have wide variation in their available phosphorus from very low to moderate but medium in potassium

Soils of zone-II are low to medium in nitrogen and available phosphorus and rich in available potassium. Zone-II receives comparatively higher anaual precipitation (1387 mm) than zone-I (1208 mm). The commencement of monsoon is early in zone-II (5-10 June) than zone-I (10-115 June). In both zones, the highest values of maximum temperature are recorded during mid-March to mid June but the maximum temperature ranges from 34°C to 37°C in zone-I, and 32°C to 34°C in zone-II. The lowest minimum temperature fluctuates generally between 7°C to 10°C in zone-I, and from 4°C to 9°C in zone-II. The mean relative humidity is also comparatively highe in zone-II (74%) than zone-I (67%) North Bihar is endowed with adequate ground water resources. On an average per square extractable good quality water locked in the aquifers of zone-I and zone-II were estimated to be 0.31 and 0.35 M, 'cm respectively. The post-monsoon water table depth is comparatively higher in zone-II (2.04 metres) than zone-I (1.81 metres).

III. METHODOLOGY

The study is based on secondary data which were obtained from various Government publications and reports. The analysis of decadal change in area, production and productivity of principal food grain crops was done for two subperiods. These periods were early period of green revolution (1975-85) and later period of green revolution (1985-95). However, the growth performance and instability in area, production and productivity were analysed for the study period (1970-71 to 1994-95), 1970s 1980s and early 1990s.

In North Bihar, there has been an increase in area, production and productivity of principal foodgrains but there were many troughs due to uncontrollable factors like floods and/or droughts. Hence, it was assumed that the sum of deviations of actual values from the trend line is zero. There had been an incrase in area, production and productivity of principal crops at varying rates, hence the equation of exponential curve was used to measure the growth in area, production and productivity of principal crops.

The following model was used:

$$Y_t = Ab^t$$

where Y_t refers to area, production and productivity of concerned crop in particular year, A refers to intercept b refers to slops co-efficient and t refers to year.

The percentage rate of compound growth rate (r) of area, production and productivity of concerned crop per annum was calculated by using the following formala :

$$r = (b - 1) \times 100$$

Since our objective was to examine the fluctuations or deviations in area, productivity and production of principal crops, their standard deviations (SD) were estimated for the study period and all the three specified periods. Of the various measures of absolute dispersion, the standard deviation was used because it is most suitable for measuring deviations in time series data (Croxton, Cowden and Klein 1975). Annual per cent changes in output and then the standard deviation in such anaual changes were estimated which gave a measure of fluctuations around the trend line.

The standard deviation is an absolute measure of dispersion, hence the corresponding relative measure i. e. coefficient of variation was used to measure the relative variation. The greater value of co-efficient of variation indicates the more instability. On the other hand, when value of the co-efficient of variation is low, the instability is less. Variability in annual output growth rates

provides a measure of the degree of instability in production over the specified period. Moreover, decomposition of the variability in annual output growth rates may help to identify the sources of change in instability in production over different periods. Besides the institutional, technological, economic and weather factors, the quantifiable and most closely associated factors like area, productivity and their interaction are likely to influence instability in agricultural production. The variability in annual output growth rates over a specified period of length 'T' can be decomposed as:

$$G(Go) = V(Ga) + V(Gy) + 2\,Cov.(Ga\ Gy)$$

Where Ga, Gy and Go are growth rates in area, yield and output estimated over the period under study.

VI. DECADAL CHANGE

At first, the changes in area, production and productivity of principal foodgrain crops at three points of time that is, ending 1975, 1985 and 1995 were computed to have an idea of these changes during early period of green revolution (1975-85) and later period of green revolution (1985-95). To minimise the effect of fluctuations and get the normal data, the triennium of area, production and productivity of principal foodgrain crops were computed at three specified points of time.

Area under foodgrain crops increased during green revolution period in North Bihar but wheat was the only crop which recorded a spectacular increase in area throughout the period under study (Table 1).

Rice is still the most important crop in the project area since it occupies nearly 48 per cent area under foodgrain crops. Moreover, there has not been any substantial increase in area under rice even during early period of green revolution. During the later period of green revolution, area under rice has almost been stagnant in the project area but a declining treand in rice area has been observed during early nineties[1].

There was, no doubt, a jump in rice production during early period of green revolution (1975-85) which was mainly due to increase in rice productivity from 681 kg/ha at ending 1975 to 831 kg/ha ending 1985 which contributed nearly 72 per cent increase in rice production during the early period of green revolution in North Bihar (Appendix-I) It is worth pointing out that the rice productivity increased by less than 100 kg/ha during later period of green revolution (1985-95) which speaks the performance of research and other institutional arrangements for increasing rice production in North Bihar. Due to marginal increase in rice productivity and decline in coverage,

rice production increased by only 1.18 lakh tonnes during period of ten years (1985-95) in project area. It is a matter of great concern because rice is the main staple food and poor performance of this staple crop would threat the food security in North Bihar.

Table 1. Area, production and productivity of principal foodgrain crops in North Bihar at triennium ending 1975, 1985 and 1995

Sl No.	Crop	Year ending 1975	Year ending 1985	Year ending 1995	Change from 1975-85 (%)	Change from 1985-95 (%)
			Area in lakh ha			
1.0	Foodgrain	39.71	40.19	42.21	1.20	5.02
1.1	Rice	19.25	20.69	20.50	7.48	-0.91
1.2	Wheat	7.04	9.00	11.39	27.71	26.61
1.3	Maize	7.87	4.78	4.51	-39.26	-5.56
1.4	Other cereals	1.16	1.13	1.40	-2.59	23.89
1.5	Pulses	4.59	4.41	4.59	-3.90	
			Production in lakh tonnes			
2.0	Foodgrain	31.89	38.02	53.46	19.22	40.61
2.1	Rice	13.11	17.20	18.98	31.16	10.35
2.2	Rice	13.11	17.95	21.41	51.09	65.31
2.3	Maize	4.64	5.68	9.03	22.30	59.08
2.4	Total Pulses	1.60	2.03	2.15	26.66	6.22
			Yield in kg/ha			
3.0	Foodgrain	803	946	1266	17.80	33.83
3.1	Rice	681	831	926	22.02	11.43
3.2	Wheat	1216	1439	1878	18.33	30.50
3.3	Maize	590	1188	2002	101.35	68.51
3.4	Total Pulses	364	441	488	21.15	10.65

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As mentioned earlier, wheat has emerged as the most important food crop in North Bihar. Area, production and productivity of wheat showed a continuous increasing trend during period under study. During the early period of green revolution, wheat was placed on the third position after rice and maize with respect to area but it gained area and now placed on second place only after rice. At the first time, wheat production exceeded the production of rice in North Bihar during early nineties. It may be noted that the increase in wheat production contributed 60 per cent increase in foodgrain production during 1975-95 in the study area.

Maize was the second most important foodgrain crop with respect to coverage in the project area but witnessed a continuous decline in area during period under study. The decline was much higher in early period of green revolution (-39.26%) than the later period (-5.56%). Despite the decline in area, maize production recorded a spectacular increase, particularly during later period of green revolution which has been due to adoption of winter maize inthe study area[2].

Area under pulses also increased during the period under study but the increase was more pronounced during early period of green revolution (1975-85). Area under pulses, no doubt, showed declining trend during later period of green revolution but had edge over area covered at the end of 1975. Pulses production increased during the study period but the increase was comparatively higher during early period of green revolution than that of later period. The comparatively lowers growth in production during study period ingeneral, and later period in particular, caused by slow rate of increase in area and productivity of pulse crops in North Bihar.

V. GROWTH PERFORMANCE

In the present section, an effort has been made to examine the growth rates in area, production and productivity of principal crops like rice, wheat, maize, barley, arhar, gram and lentil which constituted nearly 90.50 per cent of area and 96.89 per cent of production of foodgrain crops in North Bihar. The study covers the post-green revolution period which commenced in mid 60s.

Moreover, its wide spread impact on farmers' fields was observed after five years in the North Bihar. Hence, the present study covers the period 1970-71 to 1994-95.

The performance of fertilizer-seed-technology, the main components of green revolution has not been uniform through out the period under study. It has been observed that the green revolutin lost steam particularly in the state of Bihar because the agricultural growth slided down from 2.32 per cent during 1966-70 to 1.25 per cent during 1971-85 (Rao, 1988). In this back drop an attempt is made here to examine the growth in food grain crops for three sub-periods. There is, no doubt, some arbitration in choosing the cut off points for determining sub-periods but care was taken to choose normal years as bases of the sub-periods. These sub-periods are termed as 1970s (1970-71 to 1979-80), 1980s (1980-81 to 1989-90) and early 1990s (1990-91 to 1994-95).Abnormal agricultural years could have been excluded for estimating growth rates to avoid its adverse influence on estimated growth rates but it was not done due to presence of five abnormal years during the period under study that is, 1977-78, 1979-80, 1982-83, 1987-88 and 1990-91. The precise understanding of growth and fluctuations could only be possible by considering good as well as bad years in analysis. The growth rates and fluctuations have also been estimated for moving periods of five years length. A set of successive five years was constituted from the entire series by excluding the first year of the previous set and including the immediate next year from the series. The information generated through this analysis would serve as a supplement to teh growth analysis for the three distinct periods. The five years length of moving periods has been considered to even out the possible effects of weather cycle whcih is of five years in the state of Bihar.

Our analysis of growth rates indicates increasing trend in rice production during period under study but the rate of increase has declined in subsequent sub-periods and turned out to be negative during early nineties (Table 2). Almost similar trends of rice production have been obsered in both the zones under study. Moreover, rice production had positive growth rate in zone-II during early 1990s but it was only 0.1 per cent and statistically non-significant. The deceleration in rice production was mainl due to poor growth in rice prodctivity during 1970s and 1980s and decline thereof during early 1990s (Appendix-II). Area under rice increased durin 1970s but it was almost stagnant during 1980s and increased marginally during early 1990s, mainly due to increase inrice area in zone-II which was made possible due to shift of area from Jute cultivation to rice cultivation and introductuin of winter (Boro) rice cultivation in zone-11[3] (Appendix-III). However, there is no further scope to increase area under rice particularly in kharif season since it occupies more tan 60 per cent of net area sown in North Bihar. Hence, rice production could only be increased by increasing productivity which is possible by making investment on location specific rice research and infrastructure facilities.

Table 2. Annual growth rates in production of principal crops of North Bihar during study period and sub-periods

(in per cent)

Sl. no.	Crop	Study period	Sub-periods		
			1970's	1980's	Early 1990's
		(1970-7 to 1994-95)	(1970-71 to 1979-80)	(1980-81 to 1989-90)	(1990-91 to 1994-95)
			NORTH-BIHAR		
1.1	Rice	1.7	5.5	4.0	-4.3
1.2	Wheat	3.8	9.3	5.0	5.7
1.3	Maize	3.1***	4.5	5.8**	4.0
1.4	Barley	-9.2**	12.0	-11.1	0.2
1.5	Arhar	-0.7	-2.6	-4.6	-3.6
1.6	Gram	-1.3	0.08	-0.06	-3.4
1.7	lentil	2.2	1.7**	3.3	-6.0**
			ZONE-I		
2.1	Rice	1.8	4.2	4.0	-6.5
2.2	Wheat	3.7	10.9	5.3	3.8*
2.3	Maize	2.5	2.5	5.3**	2.8
2.4	Barley	-9.1***	-12.6	-9.7	0.2
2.5	Arhar	-0.08*	-4.8	-3.7	-2.5
2.6	Gram	-1.6	0.08	-5.3	-3.2
2.7	Lentil	2.1	1.3	3.9	-8.6
			ZONE-II		
3.1	Rice	1.6	8.7	4.0	0.10
3.2	Wheat	4.5	2.2	4.1	10.9
3.3	Maize	5.5	12.5	8.1	9.1
3.4	Barley	10.1	-8.6*	-13.8	-3.8
3.5	Arhar	0.5*	-4.6**	3.3	27.4
3.6	Gram	-1.2	1.0	-9.2	7.6
3.7	Lentil	2.4	3.7	0.5	6.9

*** Significant at 1% level
** Significant at 5% level
* Significant at 10% level

Like other states/regions of the country, wheat production showed spectacular growth rate particularly during 1970s (9.3%) that is, just after commencement of green revolution which experienced deceleration during 1980s but again picked up during early 1990s (5.7%). Area growth rate showed the same trend that is, deceleration in 1980s and acceleration in early 1990s but the

productivity growth rate declined during subsequent sub-periods under study. It is worth pointing out that there has been increasing rate of growth in area, production and productivity of wheat in the subsequent sub-periods in zone-II. It was probably due to slower exploitation of agricultural potentiality of the zone which is endowed with better quality of soils and comparatively higher and even distributed rainfall. Moreover, zone-II is late starter in adoption of biomical technology for agricultural production, due to poor infrastructure facilities, low level of institutional creadit, higher illiteracy, and recurrent floods upto mid `70s (Ranjan, 95).

Despite the significant decline in area under maize in North Bihar, production increased significantly during period under study. Among three sub-periods, a significant increase in mazie production was witnessed in 1980s, however, a deceleration in growth rate of maize production was observed during early 1990s. Zone-II performed much better than zone-I in maize production since there was much higher production growth rates during all the sub-periods in the former which was mainly due to increase in area under maize, in general and winter maize, in particular. But zone-I record--d comparatively higher growth in maize productivity through out the period under study, mainly due to decline in low yielding kharif maize and increase in adoption of high yielding winter maize during the period. Principal pulse crops like arhar, gram and lentil constituted nearly 25 per cent of area put to pulse cultivation in the study area. Our analysis revealed that the production performance of arhar has been poor during period under study and through all the three sub-periods since arhar production showed declining trend throughout the period under study, which was mainly due to deceleration in area growth rates during 1970s and 1980s and decline in productivity growth rates during study period, in general and early 1990s, in particular. The similar trend was observed in zone-1 but in zone-II arhar production recorded a growth of 3.3 per cent during 1980s and much higher growth rate of 27.4 per cent during early 1990s which was due to increase in productivity (5.1%) during the period. It is worth mentioning that zone-II withnessed a significant growth rate in arhar production (0.5%) during study period whereas, a significant decline in production growth rate was also observed during 1970s which was due to significant decline in area and productivity of arhar in the zone during the period. It is worth pointing out that the production growth rate of arhar picked up in 1980s and early 1990s probably due to adoption of September sown arhar4 in the zone. Despite the deceleration in production growth rate, arhar seems to have better prospect in the study area due to technological advancement in agronomical practices of arhar production.

Gram is a traditional pulse crop of the region which observed almost the similar trend of growth rates in production, area and productivity as observed in case of arhar throughout the period under study. Gram production declined during the period under study in the study area (-1.3%) but there was a marginal increase in gram production (0.08 per cent) during 1970s though it was not

statistically significant. The deceleration in production growth rate of gram in the study area has been mainly due to decline in area and productivity growth in the study area. The similar trend was observed in zone-I. Zone-II no doubt also witnessed a decline in gram production (-1.2%) during period under study but recorded positive growth rates of 1.0 per cent during 1970s and 7.6 per cent in early 1990s, mainly due to increase in area growth during these sub-periods. However, the declining trend in gram production during 1980s was mainly due to significant decline in area during the period.

Lentil was the only pulse crop which recorded growth in production during study period (2.2%) and significant production growth of 1.7 per cent in 1970s but a significant decline in lentil production was observed during early 1990s (-6.0%). It was again due to fluctuations in productivity growth rate of lentil in respective periods. Zone-II performed much better than zone-I in lentil production since an annual growth rate of 1.6 per cent in lentil area was observed during the study period and almost accelerated area growth have been observed through three subsequent periods. The decline in production growth rates of pulse crops especially of arhar and gram has been due to decline in area under these crops. It was probably of arhar and gram has been due to decline in area under these crops. It was probably due to shift of better quality of land from pulses to wheat cultivation, and poor quality Ind remained under pulses coverage, resulting in declining productivity of pulses in the study area.

VI. -INSTABILITY IN PRODUCTION

Since our objective was to examine the fluctuations or deviations in output of principal crops, annual changes in output of principal foodgrain crops in percentage and their standard deviations (SD) were estimated for the study period and all the three specified sub-periods. Among the principal foodgrain crops, the comparatively higher fluctuation in output was observed in case of barley (70.18%) and the lowest in case of gram (17.54%) during the study period (Table 3). When production instability were measured for three periods, it was found that the instability in barley production had declining trend which reached its lowest level (1.29%) during early 1990s whereas, instability in gram production had increasing trend in subsequent periods. Decline in instability in barley production was probably due to significant and steady decline in its area and production in the project area. Our analysis further revealed that the declining production growth rate was accompanied with the decline in instability in barley production but it was not true for gram. Hence, the declimng growth in production may not be considered a suffic ient factor for declining instability in all the crops as observed in several earlier studies.

There are only three crops that is wheat, maize and arhar which recorded continuous decline in production instability in the study area. It is worth pointing out that about ninety per cent of wheat and hundred per cent of winter maize are cultivated in irrigated eco-system and use of

chemical fertilizers and high yielding varieties of seeds has compartively been much higher in cultivation of these crops in the study area. Arhar which also showed declining treand in production instability through subsequent sub-periods under study is, no doubt, an unirrigated kharif crop but the majority of farmers used improved seeds and agronomical practices for its cultivation in the study area.

Table 3. Instability in crop production during study period and sub-periods in Norht Bihar

(in per cent)

Sl No.	Crop/Crop group	Study period	Sub-periods		
			1970's	1980's	Early 1990's
		(1970-71 to 1994-95)	(1970-71 to 1979-80)	(1980-81 to 989-90)	(1990-91 to 1994-94)
1.0	Food grain	21.17	12.66	17.06	5.41
2.0	Total cereals	20.22	11.44	16.32	6.61
2.1	Rice	29.20	19.61	36.91	27.52
2.2	Wheat	34.63	50.04	16.87	6.94
2.3	Maize	26.41	22.26	20.69	11.77
2.4	Barley	70.18	38.64	47.31	1.29
3.0	Barley	70.18	38.64	47.31	1.29
3.1	Arhar	21.45	25.75	18.39	5.93
3.2	Gram	17.54	11.33	21.63	19.25
3.3	Lentil	20.29	11.10	17.77	6.02

On the other hand, rice witnessed comparatively higher instability in production and did not observe any trend through different sub-periods under study. There was a marginal decline in instability of rice production in early nineties but it was comparatively higher than production instabilites of other crops under study. It may be noted that the rice is cultivated in diversifed land situations in the project area (Kumar 1991). About 60 per cent of rice is produced as rainfed crop. The adoption of new technologies has also been at loer level for rice cultivation. These factors might have contributed to higher instability in rice production in North Bihar.

In various studies, instabilities in production of pulses have declined in most of the states but it is not true for all pulse crops under study. As explained earlier arhar witnessed declining production instability but gram and lentil did not show any specifec trend in their production instabilities during different sub-periods. These crops are also rainfed and farmers are still to adopt any new technologies for their production.

VII. INSTABILITY IN AREA AND PRODUCTIVITY

Instability in production of food grain crops is expected to be caused by respective changes in instabilities in area and productivity. The nature of association between the variations in these components is important as it influences variability i annual output growth rates. In our analysis, the instability in area and productivity in most of the principal foodgrain crops fluctuated in the same direction (Table 4). The crops like wheat, maize and arha which experienced decline in production instablity through three sub-peirods under investigation observed a continuous decline in instabilities in area and productivity. On the other hand, instability in area and productivity of rice and barley also moved in the same direction which increased from 1970s to 1980s but declined during early 1990s. The production instabilities o these two crops moved in the same direction.

Our analysis clearly indicates that the synchronized decline in instability of these two components would make the production of respective crop more stable whereas, the synchronized increase or opposite movement would make the crop production more unstable. Hence, the instability in production of principal foodgrain crops seems to be associated with instability in area and productivity which generally move in the same direction but it could not be ascertained in the present investigation that which of the components played important role in stabilizing foodgrain production.

Table 4. Instability in area and productivity of principal crops during three sub-periods in Norht Bihar

(in per cent)

Sl. No.	Crop		(1970's	(1980's)	(Early 1990's)
1.	Rice	A	7.21	11.54	8.01
		Y	15.52	35.80	21.70
2.	Wheat	A	19.01	10.47	6.17
		Y	37.85	7.88	2.55
3.	Maize	A	66.72	11.95	4.37
		Y	90.03	29.21	8.35
4.	Barley	A	33.43	40.90	5.22
		Y	13.38	31.37	6.25
5.	Arhar	A	22.04	16.05	10.17
		Y	21.42	5.59	6.65
6.	Gram	A	5.75	15.08	10.60
		Y	14.42	15.41	2.37
7.	Lentil	A	46.72	9.04	5.10
		Y	25.00	12.70	9.21

A = Area, Y = Yield.

However, their respective contribution to producion instability has been estimated. The variability in annual output has been decomposed into variabilities in area, yield and synchronous movements in area and yield of respective principal foodgrain crops (Table 5). Analysis revealed that the yield variablity had been the major factor (89.58%) for instability in rice production in the project area during study period. The contribution of correlated factor (area and yield) was negative in rice production, indicating stabilizing influence on production instability. Yield variability also caused comparatively more instability in wheat and maize than the instability caused by their respective area variability. Moreover, the instability caused by vaiation in yield was more pronounced even in crops like wheat and maize which experienced decline in production instability. The relative contribution of correlated changes in area and yield of these crops have also been substantial. Despite the higher contribution of correlated changes in area and yield, the instability in production of wheat and maize declined continuously through all the three sub-periods. This was made possible due to adoption of improved package and practices by the farmers for cultivating wheat and winter maize in the study area.

Talbe 5. Decomposition of instability in annual crop output growth rates during study period (1970-71 & 1994-95) in North Bihar

(in per cent)

Sl. No.	Crop	Area	Yield	Interaction
1.	Rice	34.22	89.58	- 23.80
2.	Wheat	16.95	24.51	58.52
3.	Maize	8.52	8.91	82.56
4.	Lentil	19.90	12.87	67.21

VIII. CROWTH AND INSTABILITY

An attempt has also been made to examine the relationship between growth and instability. A comparative analysis of growth rates with levels of instability of principal foodgrain crops for sub-periods revealed that they were not moving in similar direction (Table 6). The regression estimates of various crops on the relationship between growth and instability of study period was estimated which are presented as below:

Trends in instability and rates of growth in Rice, Wheat and Maize production in North Bihar during post green revaluation period (1970-75 to 1990-95):

Rice : INST = 102.5845-0.005 GR

R^2 = 0.00004

N = 20

Wheat :	INST	=	106.7643-0.94932 GR
	R^2	=	0.020
	N	=	20
Maize :	INST	=	92.4523 + 0.756 GR**
	R^2	=	0.54974
	N	=	20

Where,

INST	=	Instability (SD in year to year change)
GR	=	Growth rate
N	=	Number of observation
**	=	Significant at 5% level of probability.

Table 6. Annual Growth rates and S. D. in production of principal crops in North Bihar during sub-periods

(in per cent)

Sl. No.	Crop		1970's (1970-71 to 1979-80)	1980's (1980-81 to 1989-90)	Early 1990's (199-91 to 1994-95)
1.	Rice				
		Growth	5.5	4.0	-4.3
		S.D.	19.61	36.91	27.52
2.	Wheat				
			9.3	5.0	5.7
			50.04	16.87	6.94
3.	Maize				
			4.5	5.8**	4.0
			22.26	20.69	11.77
4.	Barley				
		Growth	-12.0	-11.1	0.2
		S.D.	38.64	47.31	1.29
5.	Gram				
			0.08	-0.6	-3.4
			11.33	21.63	19.25
6.	Arhar				
		Growth	-2.6	-4.6	-3.6
		S. D.	25.72	18.39	5.93
7.	Lentil				
		Growth	1.7**	3.3	-6.0**
		S. D.	11.10	17.77	6.02

** Significant at 5% level

In contrary to the earlier findings, the principal crops like rice and wheat did not show any significant relationship between growth and instability during study period. Moreover, wheat the most promising crop of the area had inverse relationship between growth and instability during the study period. But our analysis further revealed that even maize did not have any significant relationship between growth and instability through different sub-periods under study. There has been deceleration in growth rate in maize production accompanied with declining production instability, resulting in their positive and significant relationship during the study period.

We identified four type of foodgrain crops through analysing their growth and instability. The first set of crops includes wheat and maize which show higher growth rate with declining instability. Second set of crops includes rice and gram which has declining without having any specific trend in growth rate. The third set includes barley and lentil which had no trend either in growth rate nor in instability. Arhar may be categorized in fourth set which is the only crop with almost declining growth rate and instablity during sub-periods under study. Among the four categories of crops, the first set has the desirable characteristics of high growth and declining instability. It may be worthpointing out that the growth is a necessary condition for increasing agricultural production. Declining instability without growth has no meaning. Rice does not have desirable characteristics because it is gown in diversified unfavourable land situations which discourages farmers to adopt modern technology in rice cultivation. Other crops like barley and pulses do not have desirable charactristics because these crops are generally grown on marginal and less fertile lands with traditional technology.

Our analysis indicates that the increase in growth in production accompanied with decline in instability could only be achieved by encouraging farmers to adopt improved crop technologies and improving infrastructure (irrigation) facilities in the study area.

XI. CONCLUSIONS

Following findings emanated from the analytical evidences on production of principal foodgrain crops.

1. While analysing the production of principal foodgrain crops in North Bihar, it has been observed that the production of almost all the principal cereals and pulses increased druing post green revaluation period however the increase was more pronounced in wheat and maize crops. The increase in production of wheat was caused by increase in area and productivity, where as increase in maize production was caused by increase in productivity, whereas increase in maize production was caused by increase in productivity only which was made possible due to introduction of winter maize at large scale in the project area.

2. On the basis of grwoth rate analysis it may be concluded that the production growth rates of wheat and maize were ahead of population growth in the study area during green revolution period (1970-71 to 1994-95) but main staple food of rice did not achieve the growth rate even equal to population growth during the period. Rice is mainly growin in kharif season (June -Dec.) which is adversely affected by flood/drought resulting in poor growth performance and increasing instability. Winter rice (Boro rice) has recently been introduced in North Bihar but it requires an indepth financial analysis with respect to high cost of irrigation. Moreover, financial viability of winter maize cultivation is limited due to its production in specific land situation. Major pulses like Arhar and Gram showed declining growth rate during the period under study. Lentil is the only pulse crop which recorded production growth in the study area. Almost all principal foodgrain crops experienced deceleration in their production growth rates during subsequent sub-periods however, production growth rate of wheat showed acceleration during early nineties. The production growth rates of all the principal foodgrain crops except rice recovered during early nineties, particularly in zone-II which might be due to late spread of bio-chemical technology in this zone. In contrary to the national scenario, growth rate of wheat seems to be picking up whereas that of rice seems to be sliding down. The deceleration in rice production- the staple food in the region, would pose a threat to food security in the agriculturally backward region of Bihar. A negative production growth rates of major pulses in the region may be of great concern to policy makers since it would have adverse effect on nutrition security of vegetarian poor population of the area.

4. It is interesting to observe that the crops like wheat and maize had comparatively high production growth rate and declining instability during the period under study. Rice recorded comparatively lower production growth rate during study period and negative growth during early nineties but increasing production instability through three sub-periods. Rice and maize are principal kharif crops which are adverselty affected by flood and/or drought. The better growth performance of maize has been mainly due to production of winter maize in the area. Pulses like gram and lentil did not have any clear cut trend in production and instability but the instability in arhar production declined through sub-periods under study. Analysis on relationship between production growth rate and instability revealed that there has not been any empirical evidence to establish any relationship between growth and instablity. Our analysis clearly indicated that the crops grown with modern technology were more stable than the crops grown with treaditional technology. On the other hand, the increasing instability in production was observed in crops grown in diversified rainfed land situation with low level of bio-chemical technology. Hence, the priority should be given to evolve fertilizer responsive varieties befitting to different land situations for increasing output and stability in foodgrain production in the study area. The creation of infrastructure facilities particularly irrigation would help reducing instability and increasing foodgrain production in the study area.

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Notes.

1. Early nineties covers the period 1990-91 to 1994-95 which is, no doubt, a short period but it is sufficient to have an idea of direction in changes / growth in area, production and productivity of foodgrain crops.

2. Winter maize is sown in October-Novermber and harvested in March-April. It is grown in irrigated situation only with almost full package of practices. Average per hectare yield on farmers field has been more than 75 quintals. On the other hand, yield of kharif maize is much lower becuase it is generally grown in rainfed situation. After introduction of winter maize, area under maize (Kharif + Winter) declined but the production increased significantly due to spectacular increase in productivity of winter corp.

3. As per experiments conducted at experimental stations of the Rajendra Agricultural University, Pusa the potential per ha yield of winter rice is more than 80 quintals. A survey conducted at Regional Agricultural Station, Agwanpur, Saharsa revealed that the farmers are harvesting nearly 65 quintals of winter paddy with the modest application of inputs.

4. Improved varieties of arhar like Bahar and Sharad are popular in the project area. These varieties are fertilizer responsive which can be sown up to September.

APPENDIX-I

Variation in production of principal crops due to change in area and productivity in North Bihar during early and later period of green revoluation

Sl. No.	Crop	Due to change in area		Due to change in productivity	
		1975-85	1985-95	1975-85	1985-95
1.	Rice	27.91	-9.55	72.09	109.55
2.	Wheat	64.38	53.05	35.61	46.95
3.	Maize	-174.81	-9.58	274.92	109.58
4.	Total cereals	32.07	19.48	67.92	80.51
5.	Total Pulses	17.91	-72.50	82.09	172.50

APPENDIX-II

Annual growth rates in area of principal crops of North Bihar during study period and sub-periods

(in per cent)

Sl. No.	Crops	Study period	Sub-Periods		
			1970's	1980's	Early 1990's
		(1970-71 to 1994-95)	(1970-71 to 1979-80)	(1980-81 1989-90)	(1990-91 to 1994-95)
			NORTH-BIHAR		
1.1	Rice	0.3	1.5	0.00	0.2
1.2	Wheat	2.2	5.7	3.2	4.5
1.3	Maize	-0.7*	3.5	2.2**	1.9
1.4	Barley	-11.10	-10.8	13.3*	-0.08
1.5	Arhar	-3.0	-4.4	-4.5	4.7
1.6	Gram	-3.3***	-1.2	-4.2	-2.6
1.7	lentil	-0.2	0.4	0.7	0.08
			ZONE-I		
2.1	Rice	0.3	0.08	0.4	-1.8
2.2	Wheat	2.3	6.9	2.9	1.6*
2.3	Maize	-2.9	-6.5	-3.1**	-0.2
2.4	Barley	-11.1	-11.2	-13.1***	-1.4
2.5	Arhar	-3.2	-4.5	-4.1	4.5
2.6	Gram	-3.6	-2.6	-3.4	-2.5
2.7	Lentil	-0.7	0.0	0.2	-0.2
			ZONE-II		
3.1	Rice	0.4	3.1	-0.3	5.2
3.2	Wheat	2.4	2.9	4.3	14.0*
3.3	Maize	1.5	5.7	-0.5	8.9
3.4	Barley	-11.2*	-8.3***	-14.9	0.08
3.5	Arhar	-2.1	-1.0*	-0.7	43.5
3.6	Gram	-2.3	2.7	-6.3**	23.6
3.7	Lentil	1.6	2.1	2.1	5.2

***Significant at 1%; **Significant at 5%; *Significant at 10%.

APPENDIX-III

Annual growth rates in productivity of principla crops of North Bihar during study period and sub-periods

(in per cent)

Sl. No.	Crops	Study period	Sub-Periods		
			1970's	1980's	Early 1990's
		(1970-71 to 1994-95)	(1970-71 to 1979-80)	(1980-81 1989-90)	(1990-91 to 1994-95)
			NORTH-BIHAR		
1.1	Rice	1.3	3.8	4.0	-4.3
1.2	Wheat	1.5	3.4	2.0	1.2
1.3	Maize	3.8*	1.1*	8.5*	1.9
1.4	Barley	2.2**	-1.4	2.7	1.4
1.5	Arhar	2.3	1.7	-0.1	-7.7
1.6	Gram	2.1	2.2	-2.0	-5.6
1.7	lentil	2.4	1.2*	2.2	-6.9**
			ZONE-I		
2.1	Rice	1.5	3.3	3.5	-4.7
2.2	Wheat	1.5	4.0	2.6	2.3
2.3	Maize	5.6	9.6	8.7*	2.6
2.4	Barley	2.2***	-1.4	3.9	1.6
2.5	Arhar	2.6**	-0.1	-1.5	-6.2
2.6	Gram	2.1	3.8	-1.9	-0.5
2.7	Lentil	2.8	1.1**	3.5	-8.4
			ZONE-II		
3.1	Rice	1.2	5.5	4.6	-3.2
3.2	Wheat	2.1	-0.7	-0.2	-2.7
3.3	Maize	3.9**	6.6	8.5	0.2
3.4	Barley	1.4	-0.3*	1.4	-3.4
3.5	Arhar	2.6**	-3.4*	5.1	-11.3
3.6	Gram	1.1	-1.7	-3.1	-12.9
3.7	Lentil	0.08	1.6	-1.6	2.8

*** Significant at 1%
** Significant at 5 %
* Significant at 10%