



Growth Performance of Principal Crops in North Bihar during last four decades: Empirical Evidences

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ABSTRACT

The present study is designed to examine the changes in cropping pattern, area, production and productivity of principal crops along with their growth in North Bihar during last 40 years. It is emanated from analysis of data that the cropping pattern of the area under study is dominated by cereal crops. Among the cereals, wheat has emerged as the second most important cereal crop during period under study whereas rice experienced deceleration in area. Maize also gained in area due to adoption of winter maize at large scale in post seventies period. Winter maize is now preferred crop due to its higher yield potential. There has been significant change in cropping pattern during last four decades in north Bihar. All the principal crops recorded growth in production but performance of rice – the most important staple food crop in the area, has not been impressive during the period under study. Research priority should be assigned for innovation and spread of appropriate technology of rice production for unfavourable ecology of north Bihar. Pulses and oilseeds production witnessed a setback due to decline in area and almost stagnant productivity of most of pulses and oilseeds. Special efforts are needed to evolve the varieties of pulses and oilseeds for increasing their production to meet their requirement.

Keywords: Area, Bihar, cropping intensity, principal crops, production, yield

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INTRODUCTION

Agricultural sector is still important for Indian economy, particularly in providing employment to more than 50 per cent of our working force (Singh *et al.*, 2017). It exerts a significant influence on national economic system also. The general price level tends to decline in the year of bumper agricultural harvest whereas a sharp increase in general prices is experienced in abnormal agricultural year. The agricultural sector has performed impressively in terms of increased productivity and intensity of cultivation. It is by no means a small achievement that per capita foodgrain availability at country level has increased over the last four decades, even after facing an assault of population pressure, declining per capita land availability and unfavorable weather. An important dimension of agricultural growth is the spatial and temporal variations, which is very relevant in a large country like India having a wide range of crop-soil-weather conditions. The scenario of agricultural growth is quite different for Bihar state in general and North Bihar in particular. North Bihar faces weather menace of drought & flood simultaneously, which creates a unique situation for agricultural development.

The present study is designed to examine the changes in cropping pattern; changes in area, production and productivity of principal crops along with their growth in North Bihar during last 40 years. The desired cropping pattern should provide enough food for the family, fodder for cattle and generate sufficient cash income for domestic and cultivation expenses. In North Bihar, cropping pattern has been evolved based on climate, soil and water availability for

efficient use of available natural resources. However, the increase in population has put pressure on land for increasing food production through increasing area under food grains, productivity per unit area, per unit time and per unit resource used.

North Bihar is located in the North of river Ganga and is spread over 5.3 million hectares. It supports 5.20 per cent of Indian population with only 1.62 per cent of landmass. It is most densely populated region in the country because more than 50 per cent districts have more than 1400 persons per square km. It has a typical agro-climatic situation and landscape. About 17 per cent of area is waterlogged, particularly in rainy season which is not available for cultivation in kharif season (GoB, 2016). Rainfall varies from 1050 mm to 1700 mm per annum; however, its distribution is uneven. There were four severe draught years and three bumper years in North Bihar during last 24 years which caused decline in food grain production up to 17 per cent during draught years and spectacular increase of up to 39 per cent in bumper years. This alone speaks the role of weather in causing instability due to poor infrastructure in the region.

MATERIALS AND METHODS

Study is based on Secondary data obtained from published documents and reports of Government of Bihar. Data were analyzed by computing data in different tables. There is substantial variation in year to year agricultural data because crop production is still dependent on rainfall pattern. Hence, data were made smooth by estimating series of triennium (three years average) data for area, production and productivity of principal crops.

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In order to find out the compound growth rates of area, production and productivity of important crops exponential function was used which is as follow:

$$Y_t = AB^t$$

Where,

Y_t = area/ production/ productivity of concerned crop in the year,

A=intercept,

t=year

$$B = 1 + r/100$$

Percentage rate of compound growth per annum was calculated as:

$r = (B - 1) \times 100$ or (antilog B -1), which represents a rate of change from observation to observation during the period under study.

The change in cropping pattern was also measured over period of time. Based on the share of each crop to total cropped area, percentages were worked out and ranks were assigned to each crop according to their respective proportion to gross cropped area in the particular year. The concordance coefficient (W) was found out between the ranking of the different crops in the triennium ending 1974, 1984, 1994, 2004 and 2014. The formulae used for calculating the concordance coefficient (W) is given as under:

$$W = 12 \sum_{i=1}^n (x_i - \bar{x})^2 / m^2 (n^3 - n)$$

where,

$$x = m(n+1)/2$$

x_i = sum of the ranks allotted to crop over the period (i= 1, 2, 3 ... n)

m = number of years

n = number of crops

The value of concordance coefficient measures is the degree of agreement between numbers of crop sets. A complete randomness in the ranking leads to $w = 0$ on the one hand, and perfect agreement among patterns result in $w = 1$, on the other. The greater the departure from complete agreement, the smaller is the value of concordance coefficient. In the present study, Chi square (χ^2) was also calculated by using following formula:

$$\chi^2 = m(n-1)w$$

If the table value exceeds the calculated chi square value, the coefficient of concordance is not significant and ranking of crops in different cropping pattern at different points of time under study are compatible.

RESULTS AND DISCUSSION

Cropping Pattern

The cropping pattern has been defined as distribution of acreages expressed in percentages of total cropped area (Ramasubban, 1963). Temporal and spatial output mix is determined by the cropping pattern. It has significant bearing on widening the inequality in income distribution in different regions over time. The new agricultural technology has influenced the crop-mix which is more prominent in agriculturally developed states. During the post-Green Revolution period a decline in area under rice, millets and arhar, and an increase in area under wheat and maize was observed in the state of Bihar (Singh and Kumar, 1998). Keeping in view the dynamics of cropping pattern in the

process of agricultural development, an analysis of cropping pattern of North Bihar has been undertaken.

The cropping pattern has been studied at five points of time that is; triennium ending 1974, 1984, 1994, 2004 and 2014 (Table 1). North Bihar has a cereal dominated cropping pattern as nearly three fourth of gross cropped area (GCA) was covered by cereals. The proportion of area under cereals increased from 74.50 per cent at triennium ending 1974 to 79.03 per cent at TE2014. The share of pulses in GCA declined from 9.70 per cent at TE 1974 to 6.91 per cent at TE 2004 which further declined to 4.83 per cent at TE 2014. Oilseeds, no doubt, are of minor importance in North Bihar but the proportion of area under them increased from 1.83 per cent at TE 1974 to 2.09 per cent at TE 1994 but declined to 1.72 per cent at TE 2014.

Table 1: Share of major crop categories in cropping pattern of north Bihar at five different points of time after green revolution period

Crop Categories	Triennium Ending				
	1974	1984	1994	2004	2014
Total Cereals	74.50	74.97	79.61	80.80	79.03
Total Pulses	9.70	9.68	9.06	6.91	4.83
Total Oilseeds	1.83	1.92	2.09	1.96	1.70
Other Crops	13.97	13.43	9.22	10.33	14.41
Gross Cropped area	100.00	100.00	100.00	100.00	100.00

An attempt was made to study the cropping pattern with respect to proportion of principal crops in GCA during period under study (Table 2). An analysis of data revealed that the area under rice observed declining trend and its percentage to GCA declined continuously from 45.37 per cent at TE 1974 to 40.51 per cent at TE 2014 whereas wheat showed steady increasing trend in area and increased from 15.78 per cent at TE 1974 to 25.61 per cent at TE 2014. Wheat has been emerged as an important rabi-cereal crop in North Bihar during last forty years which occupied nearly one-fourth of gross cropped area at TE 2014. The decline in area under rice has attributed by costly and unreliable irrigation facility, low productivity and higher fluctuation in productivity due to erratic rainfall during last 10 years. On the other hand wheat is less risk prone crop and almost disease free in north Bihar. It requires less water for successful cultivation.

Maize is the third important cereal crop in the cropping pattern in North Bihar. It is grown in all the three crop seasons. Maize was grown mainly in *kharif* season till 1970 but introduction of winter maize had adverse effect on *kharif* maize cultivation. Area under maize increased by about 50 per cent during 1974-84 due to adoption of winter maize at large scale in north Bihar during the period. But there was setback to this crop in nineties due to un-remunerative price of maize. Winter maize is produced for market purpose and there were a few buyers in Bihar in late nineties. However its area started increasing from 2002 when buyers from Gujarat, Maharashtra and Haryana started purchasing maize for feed factories. Now Indian railways is also playing main role in transportation of winter maize from North Bihar. In 2014-15,

about 14.30 lakh tonnes of winter maize was transported from north Bihar to different states (Damodarn and Singh, 2015). The share of maize area increased to 12.49 per cent of CGA at TE 2014 and it constituted about 40 per cent of total maize area in north Bihar. Winter maize increased from less than 10 thousand hectares at TE 1974 to 1.84 lakh hectares at TE 2014 in north Bihar. Winter maize is grown mainly in north Bihar and establishment of maize processing industry in Khagaria district of north Bihar is likely to boost production of winter maize in this region.

Table 2 : Share of principal crops in cropping pattern of north Bihar during last forty years in north Bihar

Crops	Triennium Ending				
	1974	1984	1994	2004	2014
Rice	45.37	45.24	44.08	42.91	40.51
wheat	15.78	20.40	27.01	25.72	25.61
Maize	8.54	12.79	10.06	9.87	12.49
Barley	1.05	0.92	0.24	0.08	0.04
Other Cereals	1.74	1.46	1.25	2.21	0.39
Pigeon pea	0.99	0.86	0.64	0.50	0.19
Gram	0.92	0.69	0.33	0.18	0.05
Lentil	1.07	1.07	1.18	1.14	0.92
Other Pulses	8.38	7.20	3.97	5.09	3.67
Rapeseed & Mustard	1.64	1.11	1.60	1.36	1.27
Other Oilseeds	1.21	0.86	0.31	0.61	0.45
Miscellaneous Crops	13.29	7.41	9.23	10.33	14.41

Area under barley continuously declined from 1.05 per cent at TE 1974 to 0.04 per cent at TE 2014 of respective GCA. It was only due to preference of farmers towards wheat to barley because higher productivity of wheat as well as consumption consideration of farming community. Other cereals include pearl millet (Bajra), Sorghum, Oats, Ragi etc. are now minor in North Bihar and their proportionate area in GCA declined to 0.39 per cent at TE 2014. Pulses are also important crops in cropping pattern of north Bihar. Lentil, pigeon pea and Chickpea are main pulses whereas other pulses include lathyrus, green gram, black gram, pea, faba bean, horse gram (kulthi) etc. The proportions of area under major pulses like; pigeon pea and gram and other pulses to gross cropped area declined continuously during the period 1974-2014. Area under lentil observed increasing trend during the period under study. Chickpea and pigeon pea have been the main loser because their area declined sharply from about one per cent to GCA at TE 1974 to 0.19 per cent and .05 per cent, respectively at TE 2014. These two pulses are more prone to diseases and pests than other pulses in north Bihar (Gupta *et al.*, 2014).

The high rate of infestation of diseases and pest and low productivity caused sharp decline in area of these pulses in

north Bihar. Other pulses also observed sharp decline in their area because their productivities were also low and these pulses are generally not part of consumption basket in north Bihar. Lathyrus and horse gram are now grown in negligible area due to unavailability of any improved varieties whereas green pea and black gram are not preferred pulses crops due to high labour cost in their harvesting.

Rapeseed and mustard is the major oilseed crop in North Bihar and its area increased during period under study but its proportion of area to GCA had mixed trend. Proportion of area under other oilseeds crops declined sharply during the period under study and it was only due decline in linseed area which was common oilseeds crop up to mid-nineties. Its area also declined due to consumption consideration because it is now considered poor men oil seeds and not consumed in even rural area of Bihar.

Above discussion clearly indicates the pattern of shift in cropping pattern during the period under study. However, the co-efficient of concordance was estimated to test the compatibility of cropping pattern at different points of time to have a precise conclusion about shift in cropping pattern in North Bihar during last 40 years (Ramasubban, 1963 and Sridharan and Radhakrishnan, 1978). The concordance coefficient (W) was found out between the rankings of the different crops at TE 1974, 1984, 1994, 2004 and 2014 for north Bihar. The chi-square value was also worked out to interpret the findings (Raghav Rao, 1983).

The calculated values of Chi square (49.95) exceeded the table value of Chi square at 01 per cent of probability (24.73) hence the co-efficient of concordance was significant at 01 per cent level of probability, indicating that the ranking of crops in the cropping pattern at five points of time were incompatible and there has been a significant change in cropping pattern during 1974-2004 in north Bihar (Table 3).

Table 3: Estimated co-efficient of concordance and estimated chi square value of cropping pattern followed in the year 1974, 1984, 1994, 2004 and 2014 in north Bihar

Item of concordance test	Value
Estimated co-efficient of concordance (W)	0.91
Estimated X ² value	49.95
Table value (11d.f.) at 01 per cent level of probability	24.73

Production and Productivity of Principal Crops

To minimize the effect of fluctuations and get the normal data, the trienniums of production of principal crops were calculated at five points of time that is ending 1974, 1984, 1994, 2004 and 2014. Contrary to the common belief of poor growth in agricultural production and productivity, cereal crops maintained the increasing trend in production and productivity in North Bihar during the period under study. Cereal production increased from 28.98 lakh tonnes at TE 1974 to 91.13 lakh tonnes at TE 2014. Increase in area and productivity helped increase in cereal production in north Bihar. Production of rice, wheat and maize recorded comparatively high increase than pulses and oilseeds during the period under study. An increase in rice production was mainly due to sustained increase in productivity from only 681 kg/hectare at TE 1974 to 1891 kg/ha at TE 2014. Whereas

increase in production of wheat and maize was due to increase in area and productivity of both crops. Wheat area increase by about 78 per cent and productivity increase by two fold during period under study. Maize area increased by 60 per cent during the period under study however winter (Table 4). Maize emerged as an important maize crop, constituting 40 per cent area and more than 50 per cent production of maize in north Bihar. Productivity of maize recorded more than 6 fold increase, mainly due to increase in area of winter maize. In north Bihar, the majority of farmers produce about 60 quintals per hectare winter maize, particularly in Begusarai and Khagaria Districts (Kumar, 2004). There was sharp decline in area under pulses, from 5.07 lakh hectare at TE 1974 to 2.37 lakh hectares at TE 2014. Despite increase in producer price of pulses, output did not keep pace due to the vagaries of weather and allocation of smaller area for cultivation of pulses by farmers.

However, 50 per cent decline in pulses area did not make any changes in pulses production which hovered around 2 lakh tonnes during period under study. It was made possible due sustained increase in productivity which increased from 3264kgs/ ha at TE 1974 to 768 kgs/ha at TE 2014. Oilseeds

Table 4: Area, production and productivity of principal crops in North Bihar 1974-2014

Crop category	TE	TE	TE	TE	TE
	1974	1984	1994	2004	2014
	Area (lakh ha)				
Rice	20.24	21.62	19.77	21.39	19.85
Wheat	7.04	9.75	12.15	12.82	12.55
Maize	3.81	6.11	4.51	4.92	6.12
Total cereals	32.34	35.60	37.80	40.28	38.73
Total pulses	5.07	4.59	4.41	3.44	2.37
Total oilseed	1.07	0.91	1.01	0.98	0.84
	Production (lakh tonnes)				
Rice	13.78	17.97	18.31	24.79	37.54
Wheat	8.56	14.03	22.82	21.14	30.11
Maize	2.25	7.26	9.03	12.32	23.22
Total cereals	28.98	35.96	51.29	59.94	91.13
Total pulses	1.85	2.02	2.15	2.26	1.82
Total oilseed	0.48	0.58	0.76	0.84	1.10
	Productivity (Kg./ha)				
Rice	681	831	926	1159	1891
Wheat	1216	1439	1878	1649	2399
Maize	590	1188	2002	2504	3794
Total cereals	896	1010	1357	1488	2353
Total pulses	364	441	488	656	768
Total oilseed	450	634	748	859	1313

observed an increasing trend in north Bihar and production crossed the one lakh at TE 2014. It was only due to increase in productivity from 450 kg/ ha to 1313 kg/ ha during period under study. It is worth pointing out that oilseeds were generally grown as mixed crop with pulses up to mid-nineties but farmers switched over to pure oilseeds crop hence helped increase in productivity.

Growth performance

In this section, an attempt has been made to analyse the compound annual growth rates (CAGR) in area, production and productivity of principal crop categories/crops during the study period; that is 1970-71 to 2010-11 to 2014-15. Annual growth rate data were analysed for sub-periods that is; 1970-71 to 1979-80, 1980-81 to 1989-90, 1990-91 to 1999-2000, 2000-01 to 2009-10 and 2010-11 to 2014-15. Despite decline in area under rice, it was still a major crop with respect to area and occupied nearly 41 per cent of GCA in north Bihar at TE 2014. Annual growth rates in area of principal crops namely; rice, wheat and maize increased during first three decades of study period whereas barley, arhar and gram observed decline in area during these decades (Table 5). However, Barley showed an increase in area during 1980-81 to 1989-90 and arhar during 1990-91 to 1999-2000. These two crops are minor crops in north Bihar and cover less than one per cent of gross cropped area. Rice is most important crop but observed declining trend in area after 2000. Wheat is only crop which recorded positive growth in area during all the five sub period of study however, there was deceleration in area growth of this crop also during the period under study because it is now facing tough competition with winter maize with respect to allocation of area at farm level. Maize also got set back during 2000-01-2009-10 when area observed declining trend due to poor price realization by farmers however it recovered after 2010 when external traders entered in maize market of north Bihar.

Pulses like arhar and gram are minor crops in North Bihar and area under these crops experienced declining trend during last 45 years with minor year to year variations. Lentil is now most important pulse crop in north Bihar but still grown on less than one lakh hectare. Area growth of this crop also had mixed picture and declined by 5.70 per cent during 2010-11 to 2014-15. Oil seed is also minor crop and area under oilseeds showed almost declining trend during last 45 years and sub period also.

As mentioned earlier, there was spectacular increase in food grain production in north Bihar. Cereal production increased by three fold and rice production at TE 2014 (37.54 lakh tonnes) was more than cereal production at TE 1974 (28.98 lakh tonnes). Production of rice, wheat and maize recorded high growth rate (more than 4 %) during first 20 years of green revolution (1970 to 1990), mainly due to growth in area and productivity of wheat and maize and only productivity of rice. The low production base of these crops in pre- green revolution period also attributed to high growth in production of these crops because they experienced mixed performance of production in later period of study. There was poor production performance of barley, pulses and oilseeds during period under study.

Table 5: CAGR in area, production and productivity of principal crops in North Bihar (% per annum)

Crop category	1970-71 to 1979-80	1980-81 to 1989-90	1990-91 to 1999-2000	2000-01 to 2009-10	2010-11 to 2014-15
Area					
Rice	1.50	0.00	0.03	-0.60	-0.45
Wheat	5.70	3.20	0.78	0.02	0.23
Maize	3.50	2.20	1.30	-4.13	2.36
Barley	-10.80	13.30	-7.80	-4.98	3.34
Arhar	-4.40	-4.50	0.19	-7.07	-10.80
Gram	-1.20	-4.20	-10.47	-11.87	5.85
Lentil	0.40	0.70	-0.71	0.03	-5.70
Oilseeds	2.60	-0.30	-0.48	-1.04	-2.70
Production					
Rice	5.50	4.40	3.12	-2.45	1.49
Wheat	9.30	5.00	2.57	0.72	-11.49
Maize	4.50	5.80	2.79	-3.09	4.65
Barley	12.00	-11.10	-3.35	-7.92	2.72
Arhar	-2.60	-4.60	1.29	-8.14	-15.48
Gram	0.08	-0.60	-10.23	-7.86	12.76
Lentil	1.70	3.30	1.33	-0.57	-10.00
Rapeseed & Mustard	2.40	1.60	0.28	0.58	-4.70
Productivity					
Rice	3.80	4.00	3.09	-1.87	1.95
Wheat	3.40	2.00	1.77	0.70	-11.69
Maize	1.10	8.50	1.47	1.08	2.23
Barley	-1.40	2.70	4.83	-3.09	-0.61
Arhar	1.70	-0.10	1.10	-1.15	-5.25
Gram	2.20	-2.00	0.27	4.54	6.52
Lentil	1.20	2.20	2.06	-0.60	-4.57
Rapeseed & Mustard	0.10	1.90	0.77	1.64	-2.06

To analyse the long term growth patterns of major crops, the compound annual growth rates calculated for the period 1967-68 to 2007-08 have been grouped into four categories, viz., high (>4.0 per cent), medium (2.0-3.9 per cent), low (0-1.9 per cent) and negative. This long-term growth analysis will help to identify lagging crops and suggest suitable technology, policy and institutional options for accelerating growth. [Table 6](#) shows growth production matrix of major crops in order to

have easy understanding of production trend of various crops across the period under study. It is clear that the principal crops namely; rice, wheat and maize had high production growth rate up to 1990 and moved to medium growth rate in nineties. Rice and maize had negative production growth rate in 2000-2011 however maize came back to high production growth rate category in 2010-11 to 2014-15. This resilience production behaviour of maize was only due to increasing

Table 6: Compound Annual growth rates of production for major crops by five sub study periods in north Bihar

Period	High (4% and above)	Medium (2 - 3.9%)	Low (0-1.9%)	Negative
1970-71 to 1979-80	Rice, wheat, maize barley	Rapeseeds & mustard	Lentil, gram	arhar
1980-81 to 1989-90	Rice, wheat, maize	lentil	Rapeseeds & mustard	Barley, arhar, gram
1990-91 to 1999-2000		Rice, wheat, maize	Lentil, arhar, Rapeseeds and mustard	Barley, gram
2000-01 to 2009-10			wheat	Rice, maize Barley, arhar, gram lentil, Rapeseeds & mustard
2010-11 to 2014-15	Maize, gram	barley	rice	Wheat, arhar, lentil, mustard

area under winter maize in north Bihar. Wheat, no doubt, emerged as an important crop but production behaviour of the crop was adversely affected by menace of terminal heat in last few years which pushed its production growth in negative growth category. Production growth of pulses pushed to negative growth category by the later part of study, however, none of pulses had higher production growth and deceleration in production growth of pulses production is quite evident.

It was probably due to low yield and risk proneness of pulses crops. However, the main competing crop of these crops was wheat which had higher yield potential and almost immune to insect, pests and diseases hence farmers preferred wheat cultivation to cultivation of uneconomic crops and invested more on inputs and deployed more labour to production of wheat crop in north Bihar. Recently, Government of India initiated massive programme for increasing pulses production to meet the increasing demand of pulses in the country. North Bihar can play a major role in increasing pulses production if pulses cultivation is made profitable through providing quality seeds and, creating awareness among farmers about improved package of practices and close monitoring their crops for minimizing hazards from insects,

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pests and diseases.

CONCLUSIONS

All the principal crops recorded growth in production but performance of rice – the most important staple food crop in the area, has not been impressive during last 15 years because growth in productivity declined during 2001 -2009. It is worth mentioning that more than 50 per cent of rice area is still under unfavourable *eco – system*, either as non-irrigated or under water logged situation. Research priority should be assigned for innovation and spread of appropriate technology of rice production for unfavourable ecology of north Bihar. Wheat has, no doubt, performed better but it can be further improved by providing quality seeds and making available affordable irrigation facility to farmers. Pulses and oilseeds production witnessed a setback due to decline in area and almost stagnant productivity of most of pulses and oilseeds. Special efforts are needed to evolve the varieties of pulses and oilseeds for increasing their production to meet the local requirement. The impact of recent initiative of government for pulses production is still awaited, however, efficient implementation of this programme at field level may increase pulses production in north Bihar.

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