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ORIGINAL ARTICLE

Scenario of Rice crop production of last four decades in Uttar Pradesh

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ABSTRACT
In the present study, an attempt has been made to study the scenario of rice production during last four decades (1970-71 to 2009-10) in the state of Uttar Pradesh using time series data on rice crop area, production and productivity. The time series data have been collected from the Bulletins of Directorate of Agricultural Statistics and Crop insurance, Krishi Bhawan, Lucknow, Government of Uttar Pradesh. Therefore, the time series data has been classified into four decade to study the decadal growth pattern of the area, production and productivity of wheat. Cropping pattern, effect of change in acreage and productivity on differential production of rice crop and measure of instability in rice production has been measured in the study. An attempt has been made to capture a general feature of development of the rice production in state of Uttar Pradesh since 1970-71 onwards.
Key words: *Area, Production, Productivity, Decade, Rice crop, Scenario*

INTRODUCTION

Rice (*Oryza sativa*) is the most important cereal food crop of India. It occupies about 23.3% of gross cropped area of the country (2009-10). Rice contributes 43% of total food grain production and 46% of the total cereal production of the country (2012-13). Among the rice growing countries in the world, India has the largest area under rice crop and ranks second in production next to China. It is grown in all continents except Antarctica, occupying 150 million ha, producing 573 million tonnes paddy with an average productivity of 3.83 tonnes / ha. Rice is grown in Uttar Pradesh during Kharif season from June to October/ November. Rice is grown in all type of soils (clay, clay loam and loamy) and are most suited for its cultivation. The traditional rice farming systems in India broadly include wetland system.

The crop grows well in areas receiving more than 100 cm of rainfall and 25 degree Celsius temperature.Crop yield is mostly affected by technological changes and weather variability. It can be assumed that the technological factors will increase yield smoothly through time and therefore, year or other parameters of time can be used to study the overall effect of technology on crop yield. Many researchers have been done the same study in different regions. Some studies are as follows; Gajja *et al.* [4] attempted to analyse the growth and instability in area, production and productivity of sesamum and acreage response to sesamum crop in the arid zone of Rajasthan, India. Gajbhiye *et al.* [3] evaluated the growth and instability of chickpea in Vidarbha region of Maharashtra. Awaghad *et al.* [1] studied of growth and instability of kharif sorghum in Western Vidarbha region. Rao *et al.* [7] studied to assess the performance of area, production and productivity of sugarcane in Andhra Pradesh. The variability both within and between seasons is the second and uncontrollable sources of variability in yields, Weather variables affect the crop differently during different stages of development. Cultivated rice varieties take normally 110-210 days from germination to physiological maturity of seed for completing their life cycle. Uttar Pradesh is one of the major states of rice growing in the country. It accounts about 13.53 and 13.54 per cent towards the total acreage and production of the rice in the country (2011-12). It has first rank in area as well as production among all the states of India. The productivity of rice has increased 2358kg/ha in 2011-12 from 519kg/ha in 1950-51 i.e. four and half times during the last 60 years. However, productivity of rice in Uttar Pradesh has been a little low (2358kg/ha, 2011-12) as compared to leading states of rice growing.

Previous studies along trend, growth rate and instability were Singh and Sisodia [8]; Borthakur [2]; Singh and Srivastva [9]; Verma *et. al* [10]; Pochanna [5] and Rao and Raju [6] relevant to this study. In the present investigation, the scenario of rice production of last four decades in the state of Uttar Pradesh have been studied using data from the Bulletins of Directorate of Agricultural Statistics and Crop insurance, Government of Uttar Pradesh.

MATERIAL AND METHODS
Study region and methodology adopted
The time series data pertaining to the period from 1970-71 to 2010-11 on area, production and productivity of Rice crop have been used to study the scenario of rice production in Uttar Pradesh state. These time series data have been collected from the Bulletins of Directorate of Agricultural Statistics and Crop-Insurance, Krishi Bhawan, Lucknow, Government of Uttar Pradesh. A lot of efforts were made by Government of India to improve the scenario of rice production in the country in the past. Therefore, the time series data has been classified into four decade to study the decadal growth pattern of the area, production and productivity of rice crop.
Statistical Methodologies
To study the overall scenario of rice production in Utter Pradesh, some appropriate statistical methodologies have been used. These statistical methodologies are systematically described here as given below:
Cropping pattern
The cropping pattern in Uttar Pradesh has been worked out by ratio of area under a crop to gross cropped area multiplied by 100 to express it in percentage in a particular year, i.e.

$$\text{Cropping Pattern} = \frac{\text{Area under crop}}{\text{Gross cropped area}} \times 100$$

Effect of change in acreage and productivity on differential production of wheat crop
An attempt has been made to the study the effect of change in acreage and productivity of wheat crop on the differential production between two points of time.
Let Y, A and P be the production, acreage and productivity of a particular potato crop at a given point of time. The Y can be expressed as

$$Y = P. A$$

Let ΔY, ΔA, ΔP be change in production, acreage and productivity of the crop after a specific period of time. So, we have

$$Y+ \Delta Y = (A+ \Delta A) (P+ \Delta P)$$
$$Y +\Delta Y = AP + \Delta A\, P + \Delta P\, A + \Delta P \Delta A$$

Therefore, we have

$$\Delta Y = \Delta A\, P + \Delta P\, A + \Delta P \Delta A$$

Thus, the total differential production is composed of three components:
P ΔA: Effect of change in acreage of the crop
A ΔP: Effect of change in productivity the crop
ΔPΔA: Interaction effect due to change in acreage and productivity of the crop.
The contribution of change in acreage, productivity and their interaction to the total differential production of the crops has been worked out for each period separately and also for overall period.
Measure of instability in wheat production
High growth and low instability in wheat production are prerequisites for sustainable agricultural performance. Important concern, that technological change in wheat production has increased variability, which is considered to be one of the threats to food security. Since the magnitude of growth and instability in wheat production has serious implications for policymakers, the level of instability in the area, production and productivity of different wheat crop will be estimated using suitable statistical tools. The simple coefficients of variation (C.V.) often contain the trend component and thus overestimate the level of instability in time series data characterized by long term trend. To overcome this problem, a measure of instability is estimated by using Cuddy Della Valle Index which corrects the coefficient of variations and it is given by

$$\text{Instability index} = cv\sqrt{1 - R^2}$$

where, R^2 is the coefficient of determination from a time trend regression adjusted by the number of degree of freedom.

RESULTS AND DISCUSSION

An attempt has been made in this section to capture a general feature of development of the rice production in Uttar Pradesh since 1970-71 onwards.

Cropping pattern

The decadal cropping pattern since 1970-71 onwards has been worked out and is presented in the Table 1. It is obvious from the result of the Table 1 that technological changes in crop production, during green revolution and past green revolution period, particularly in rice and wheat have marginalized the production of other cereal crops. Area under cereal crops have almost remained same and varies 67.75 to 67.80 per cent of gross cropped area over last forty years, and presently it constitutes about 68 per cent of the gross cropped area.

Table 1 Cropping pattern (in % of gross cropped area)

S.No	Crops	1970-71	1980-81	1990-91	2000-01	2010-11
1	Total Cereal	67.80	71.65	68.04	69.61	67.75
(i)	Rice	19.04	21.52	22.03	23.34	22.10
(ii)	Wheat	25.45	33.01	33.62	36.51	37.63
(iii)	Other cereal	23.31	17.12	12.39	9.76	8.02
2	Total pulses	16.05	11.78	8.01	10.64	9.56
3	Total oil	3.00	2.88	3.10	3.40	4.31
4	Sugarcane	5.80	5.55	7.28	7.66	8.30
5	Potato	0.70	1.08	1.32	1.56	2.15
6	Other crops	6.66	7.19	7.42	7.13	7.92
7	Total gross cropped area	23207144 (100)	24573897 (100)	25479842 (100)	25304147 (100)	25615000 (100)

However, the area under wheat and rice has steadily increased over the last four decades. The area under rice has increased from 19.04 per cent in 1970-71 to 22.10 per cent in 2010-11. The area under wheat has increased from 25.45 per cent in 1970-71 to 37.63 per cent in 2010-11. On the other hand, area under other cereal crops has drastically decreased from 23.31 per cent in 1970-71 to 8.62 per cent in 2010-11. This shows that most of the area under other cereal crops (barley, etc) has shifted to rice and wheat crop. The situation of total pulses during last forty years has been very gloomy. The area under total pulses has steadily decreased over every decade since 1970-71 onwards, and it has reduced to near half, i.e. about 9.56 per cent at present from about 16.05 per cent in 1970-71. Among the pulse crops, drastic reduction in the area has been found during eighties (from 16.05 to 11.78 %), which was period of active green revolution period, indicating thereby that some of the area under pulses have shifted to rice and wheat crops.

The area under Total oilseeds has increased to 4.31 % in 2010-11 from 3.00 % in 1970-71. This shows that oilseeds crops have also taken over some of the area from the area under pulse crops during the last forty years.

Two cash crops, *viz*. sugarcane and potato have also showed increasing trend in its area since 1970-71 onwards. The potato registered a continuous growth in its area (from 0.70 % to 2.15%), and same case is with sugarcane (from 5.80 % to 8.3%) over last forty years. The most significant result has been found in other crops, which has registered about 8.00 per cent as compared to 6.66 per cent in 1970-71. This is probably because of diversification of agriculture in recent years and farmers have shifted the area towards more remunerative crops like vegetable, medicinal, aromatic plants, fruit crops etc.

Changing pattern in area, production and productivity of wheat

The triennium averages of area (in million hectares), production (in million tonnes) and productivity (in Q/ha) and its per cent change in different decadal periods under rice crop are given in Table 2

Area

The results of the table reveal that there has been increasing pattern of the area under rice over the different decadal except during the last decade (2000-01 to 2010-11). The maximum increase in the area has been recorded during seventies, i.e. up to 18.85 per cent. This increase has been found to be 6.00 and 8.76 per cent, respectively, during eighties and nineties. The last decade has witnessed downfall by 6.04 per cent. This shows that area under rice is likely to reach at the stagnation stage in times to come if this trend of changing pattern continues to be so. However, the overall change in area since 1970-71 till 2010-11 has been found to be 28.74 per cent.

Production

The triennium averages of production (in million tonnes) and its per cent change in different decadal periods with respect to rice crop are presented in Table 2. A quite rosy picture of rice production has

been observed in the State during the entire period under study. Its production has accounted for about 268 per cent increase since 1970-71 till 2010-11. The maximum increase of 78 per cent was obtained during seventies, followed by about 68 per cent during eighties, about 24 per cent during nineties. However, there has been slight downfall during the last decades.

Table 2: Triennium average ending at year shown of area (in million ha.), production (in million tonnes) and productivity (in Q/ha.) of rice and its changing pattern over four decades

Description	1970-71	1980-81	1990-91	2000-01	2010-11	Percent Change in 1980-81 over 1970-71	Percent Change in 1990-91 over 1980-81	Percent Change in 2000-01 over 1990-91	Percent Change in 2010-11 over 2000-01
Area	4.35	5.17	548	5.96	18.85	6.00	8.76	-6.04	28.74
Production	3.23	5.76	9.73	12.09	78.32	68.75	24.38	-1.57	268.42
Productivity	7.42	11.11	17.74	20.29	49.73	60.39	14.37	4.73	186.39

The changing pattern of rice production over different decades indicated a likely stagnation in future, unless efforts are made to increase its productivity because there is little scope to bring more area under rice in the state.

Productivity

The triennium averages of productivity of rice crop in different decadal period are given in the Table 2. The per cent changes over different decades are also depicted in this table. There has been increase in the productivity of rice by about 168 per cent since 1970-71 till 2010-11. It can be also observed from the table that the maximum increase of about 60 per cent in the productivity of rice has been found during eighties followed by about 50 per cent during seventies. It can also be observed from the table 4.1.2 that the productivity remained between 20 and 21.25 Q/ha during nineties onwards. This shows that the productivity of rice has been stable during the last two decades, which is not a desirable state of affairs as far as rice production is concerned in state.

It is also important to note that rice production in the state can only be increased by increasing the productivity of rice as there is no chance of increase in its area. It may be noted that rice productivity in the state is still relatively less (21.25 q/ha) during 2011-12 than some of the states like Punjab and Haryana (about 46 to 47 q/ha). Therefore, there is still scope of increasing rice production in the state. Such increase in rice productivity can be achieved through intervention of proper policy by state government, farm scientists and farmers.

Effect of changes in acreage and productivity and their interaction on differential production of rice crop

It is obvious that production of a crop is the product of its acreage sown and its productivity. Any change in its acreage or productivity or simultaneous changes in both would result change in production. In order to study the effect of these changes on differential production of rice crop, the differential production during the last four decades has been decomposed into three components *viz*. (i) effect due to changes in acreage, (ii) effect due to changes in productivity and (iii) interaction effect due to simultaneous changing in acreage and productivity, using the methodology described in material and methods section. The results are presented in the Table 3 for each period separately.

Decade I

During the first decade, the rice production has increased substantially and positive differential production of 253 million tonnes has been found. A large share of it can be attributed to the effect of positive change in its productivity, i.e. 63.64 per cent, while 24.11 per cent due to effect of positive change in its acreage and 12.25 per cent due to interaction effect of change in productivity and acreage.

Decade II

Positive differential production has been found maximum of 3.96 million tonnes during decade II. The effect of positive change in its acreage has contributed 8.69 per cent to it, while share of upward change in its productivity has been found to be 86.62 per cent. The share of interaction effect due to positive change in acreage and productivity simultaneously has been found to be 4.70 per cent.

Table 3 Effect of change in area and productivity on differential production of rice (million tonnes)

Period	Year	Differential Production (ΔY)	Area effect ($P\Delta A$)	Productivity effect ($A\Delta P$)	Interaction effect ($\Delta A\Delta P$)
I.	1970-71 to 1979-80	2.53 (100%)	0.61 (24.11%)	1.61 (63.64%)	0.31 (12.25%)
II.	1980-81 to 1989-90	3.96 (100%)	0.34 (8.69%)	3.43 (86.62%)	0.186 (4.70%)
III.	1990-91 to 1999-00	2.37 (100%)	0.85 (35.86%)	1.40 (59.07%)	0.12 (5.06%)
IV	2000-01 to 2010-11	-0.19 (-100%)	-0.73(-384.21%)	0.57 (-300%)	-0.03 (-15.79%)

Decade III

The production of rice has increased during the third decade also and consequently positive differential production of 2.37 million tonnes has been recorded. This has been achieved due to upward change in acreage and its share to it was 35.86 per cent. The effect of change in productivity was found to be positive and its share stood at 59.07 per cent. The interaction effect due to positive change in acreage and productivity simultaneously has contributed to it by 5.06 per cent.

Decade IV

However, the production has gone down by 0.19 million tonnes during the last decade. The effect of change in its acreage, productivity, and their interaction has contributed -384.21, 300 and 15.79 per cent, respectively, to its negative differential production. The overall results of this table show that differential production in rice in different decades has been found largely due to change in productivity.

Measures of instability index in area, production, and productivity of rice crop

High growth and low instability in agricultural production are essential components for sustainable agricultural development. It is a matter of paramount concern that variability has increased due to technological changes in crop production in general as well as in rice production in particular. Therefore, the measure of instability in rice production has been determined by using Instability Index (%) as described in material and methods section. The instability index for area, production and productivity have been computed for four decades, i.e. 1970-71 to 1979-80 (I-decade), 1980-81 to 1889-90 (II-decade), 1990-91 to 2000-01 (III-decade), 2000-01 to 2009-10 (IV-decade) and also for the entire period (1970-71 to 2009-10, overall) under study. The results are presented in Table 4.

Area

The instability index in case of area of rice has ranged between 2.43 to 5.33 per cent. However, it was maximum during the last decade and minimum during the third decade. Low value of instability indicates stability in the area. This shows clearly that the area under rice has been more stable during third decade as compared to other decades. It can also be observed that the area under rice has been quite instable during seventies and eighties which was active period of green revolution in the state. More fluctuation in area under rice has been observed during 2000 onwards that has resulted instability index of 5.33%. such phenomena has been caused probably because of frequent floods/droughts during this period, otherwise area under rice was expected to be more stable as there was little scope of bringing more area under rice.

Table 4 Measures of instability index (in %) of area, production and productivity of rice in last four decades and overall

Decades	Period	Area	Production	Productivity
I	1970-71 to 1979-80	3.49	2044	13.87
II	1980-81 to 1989-90	4.56	10.52	7.16
III	1990-91 to 1999-00	2.43	5.47	4.65
IV	2000-01 to 2009-10	5.33	9.38	6.54
Overall	1970-71 to 2009-10	5.25	13.87	11.85

Production

The instability index has been found to be quite high in rice production. It has varied 5.047 per cent to 2.44 per cent. The maximum instability index has been recorded during the first decade and it was found minimum during the third decade. The production of rice remained more instable during the first decade. This could be attributed is the uncertainty of adoption of new varieties of rice by the farmers, which were launched as a package of green revelation in the state. During the last three decade, the instability was less as compared to the first decade. This means that technological changes have induced steady increase in the rice production during three last decades.

Productivity

Similar results have been obtained in case of productivity; the low value of instability index of productivity (4.65 to 7.16 per cent) shows that the productivity of rice has increased steadily during the last three decades.

On the other hand, it was quite high (13.87%) during the first decade indicating thereby more fluctuation in the productivity of rice during this period, probably because of early stage of start of green revolution period.

CONCLUSION

The main objective of this investigation is to study the scenario of rice production of last four decades in Uttar Pradesh using the time series data pertaining to the period from 1970-71 to 2010-11 on area, production and productivity of rice crop. The area under used crops remained almost same during last four decades in the Uttar Pradesh state of the total gross cropped area. The absolute area under rice has increased by 18.85 per cent during the last four decades. However this increase was found maximum during seventies, i.e. about 29 per cent, which was active period of green revolution in the state. The production of rice has increased by about 268 per cent during the last four decades. The maximum increase of about 78 per cent has been observed during eighties. The productivity of rice has also increased by about 168 per cent during the period 1970-71 to 2010-11. The maximum increase was found during eighties i.e. about 60 per cent. The second period has witnessed low instability in area and production. The overall instability index in the area, production and productivity of rice has been found to be 1.61 per cent, 3.43 per cent and 1.40 per cent, respectively. It has been found that the increase in the productivity has contributed about 300 per cent to increased production of the rice and the rest because of change in area and interaction effect of change in area and productivity.

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