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Instability and Trend in Area, Production and Productivity of Rice Crop in Haryana and India

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Authors' contributions

This work was carried out in collaboration among all authors. Author MN and Nisha designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author Nisha and DRA managed the analyses of the study. Author Sanjeev managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The study examined the performance of rice production in Haryana and India during 47 years period, 1966/1967 to 2012/2013, consisting of five sub-periods i.e. P-I (1966/1967 to 1975/1976), P-II (1976/1977 to 1985/1986), P-III (1986/1987 to 1995/1996), P-IV (1996/1997 to 2005/2006) and P-V (2006/2007 to 2012/2013). Quantitative analysis is used to perform linear and exponential functions estimation using exclusively secondary data. The study reveals positive trends in area, production and yield of rice for both Haryana and India. The production of rice at the state level and at country level increased mainly due to increase in area. Similar results are obtained on triennium bases. Area, production and yield of rice crop have shown positive growth rates in Haryana during entire study period and five sub-periods, except for the yield in P-V. The overall trend in production of rice crop for India was found to be similar to that of Haryana; yield has shown positive growth rates during the entire study period and five sub-periods while negative growth rates were observed in area under the rice crop during P- IV and P-V.

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1. INTRODUCTION

Green revolution was initiated during the mid sixties at a time when the country was whirling through the tyranny of food deficit. With the advent of introduction of dwarf wheat germplasm and cultivars from Mexico in 1964/1965 and the new dwarf high yielding variety of Rice (IRS) released in 1966 from the International Rice Research Institute (IRRI), Manila, the food production increased in manifold, which transformed the status from food deficit to a food surplus country.

Rice is the most important crop in India which plays a critical role in food security. It is the important staple food for more than half of the world population and provides 60-70 per cent of body calorie intake to the consumers. It is a supreme commodity to mankind, because it is truly life, culture, tradition and a means of livelihood to millions of people. In recognition to these important traits, the United Nations General Assembly, in a resolution, declared the year 2004 as the International year of Rice [1]. The resolution very eloquently upheld the need to heighten awareness for the role of rice in alleviating poverty and malnutrition. The global perspective of rice is relevant to agricultural development in India. Rice is a choice of the millions of poor and small farmers not only for the purpose of income but also for household food security. Sekhara [2] studied growth rates of area, production and productivity of rice crop in India and observed a declining trend in its production from 2014/2015 to 2015/2016. Jain [3] analyzed growth and instability in area, production and yield of rice in India during 1970/1971 to 2011/2012 showed that compound growth rate of area, production and yield were positive but showed declining trend over the periods at all India level. Laitonjam et al. [4] studied production of pulses in India for the period 1950/1951 to 2014/2015 and found that increase in production of pulses was mainly due to yield effect. Keeping in view the importance of rice, the present paper is an attempt to examine the trend and instability in area, production and productivity of rice in Haryana and India.

2. MATERIALS AND METHODS

The study was exclusively based on secondary data. The data relating to area, production and yield of rice in Haryana and India for the 47 years period from 1966/1967 to 2012/2013 were collected from various governmental source (Statistical Abstract of Haryana, 2019) [5] and governmental web sites (agristat, 2019) [6].

To have a period-wise investigation of growth and variability patterns of area, production and productivity of rice the analysis was carried out by dividing the entire period (1966/1967 to 2012/2013) under study into five sub-periods as shown in Table 1.

Table 1. Definition of data time periods

Period I	1966/1967 to 1975/1976	Period IV	1996/1997 to 2005/2006
Period II	1976/1977 to 1985/1986	Period V	2006/2007 to 2012/2013
Period III	1986/1987 to 1995/1996		

Linear as well as exponential functions were fitted for computing various growth rates by taking area/production/yield as dependent variable (Y_t) and year number (t) as independent variable. The Coefficient of determination (R^2) was also computed to examine whether or not the linear and exponential functions adequately fit the available data.

To study the contribution of area, yield and their interaction of area and yield towards increasing the rice production in state as well as country, a decomposition analysis has been performed and is expressed as

$$\Delta Q = A_0 \Delta Y + Y_0 \Delta Q + \Delta A \Delta Y \quad (1)$$

Where, A_0 and Y_0 are the area and the yield of base year and Δ indicate a small change in the corresponding quantities.

The first term on the right hand side of equation (1) can be considered as the yield effect, the second term as the area effect and third as the interaction effect. Thus the total change in production can be decomposed into three effects, viz.; yield effect, area effect and the interaction effect due to the change in yield and area.

To measure the magnitude of variability in area, production and productivity, the coefficient of variation was computed using the formula:

$$\text{Coefficient of Variation (C.V.)} = \frac{S.D.}{\bar{X}} \times 100 \quad (2)$$

where,

S.D = Standard Deviation of area/production/ yield

$\bar{X}$ = Mean value of area/production/yield of the rice crop

Instability in the area, production and productivity of rice was measured by Cuddy-Della Valle index (CDI) [7].

$$CDI = C.V. \sqrt{1 - R^2} \quad (3)$$

where,

C.V. =Coefficient of Variation

R^2 =ESS/TSS i.e. ratio of explained variation to total variation.

ESS =Variation explained by explanatory variable

TSS = Total Variation

3. RESULTS AND DISCUSSION

The total area of rice crop in Haryana which was 192 thousand hectares during 1966/1967 shot up to 1215 thousand hectares in 2012-13 showing an increase of 1023 thousand hectares whereas at country level it increased from 35.25 to 42.75 million hectares giving a net increase of 21.28% (Tables 2 and 3) during the period under study. Haryana state showed an enormous increase in the area of rice as compared to that of India. The production of rice crop increased from 223 to 3976 thousand tonnes in Haryana whereas in India it increased by 245.73 per cent i.e. from 30.44 to 105.24 million tonnes during the same period.

Similarly, yield of rice in Haryana shot up from 1161 kg/ha in 1966/1667 to 3272 kg/ha in 2012/2013 showing an increase of 181.8 per cent whereas similar results were obtained for area and production of wheat in Haryana and India by Sharma et al. [8]. India is inflated from 863 kg/ha to 2462 kg/ha with an increase of 185.28 per cent in the corresponding period.

Changes in area, production and yield of wheat in Haryana and India during study period are shown in Table 2 and Table 3, respectively.

Similar results were obtained on triennium basis. There was an increase of 479.15 per cent in average area of rice crop in Haryana i.e. from triennium (1966/1967 to 1968/1969) it became 1231.67 thousand hectares in triennium 2010-11 to 2012-13 (Table 2). At country level there was an increase of 19.27 per cent in India during the same period (Table 3) showing thereby that more area came under the rice crop in Haryana as compared to India. While the average production of rice inflated from 260.67 thousand tonnes to 3735.67 thousand tonnes giving a net change of 3475 thousand tones in Haryana, and from 35.94 million tonnes to 102.17 million tonnes at country level with a net change of 66.23 million tonnes during the corresponding trienniums. Its average yield has also improved from 1223.67 to 3035 kg/ha and from 990.33 to 2364.67 per cent kg/ha for state and country level respectively. Similar results were obtained by Gautam and Sisodia [9] for area, production and yield of wheat crop in Uttar Pradesh for the period 1970/1971 to 2010/2011. Change in productivity of rice during this period has been almost same for both Haryana and India. Similar results were obtained for rice crop in Haryana by Bhatnagar [10].

Contribution of different factors in the production of rice in Haryana and India is given in Table 3.

In Haryana the increase in rice production due to yield, area and their interaction was 43.1, 32.1 and 24.8 per cent respectively during Period-I, while for India, corresponding contributions were 71.6 per cent, 20 per cent and 8.4 per cent respectively (Table 4). During the period from 1976/1977 to 1985/1986, area has 76.7 per cent contribution in the production of rice in Haryana whereas yield and its interaction with area have 13.2 and 10.1 per cent contribution. However, the production of rice has been inflated by 81.4 per cent due to yield effect, 13.1 per cent due to area effect and 5.5 per cent due to [area x yield] effect in India. So area has a major contribution in the increasing the production in Haryana whereas yield has played a significant role for the increase in production of rice in India during the period from 1976/1977 to 1985/1986. Similar results were obtained by Singh et al. [11] revealed the similar result for the rice crop in different states of the region of North-East India during 1972/1973 to 1997 /1998.

Table 2. Changes in area, production and yield of rice in Haryana from 1966/1967 to 2012/2013 and on triennium basis

	Yearly basis				Triennium basis			
Variable	**Base year (1966-67)**	**Current year (2012-13)**	**Net change**	**% Change**	**Base triennium (1966-67 to 1968-69)**	**Current triennium (2010-11 to 2012-13)**	**Net change**	**% Change**
Area ('000 ha)	192.00	1215.0	1023.00	532.8	212.67	1231.67	1019.00	479.15
Production ('000 tonnes)	223.00	3976.0	3753.0	1683.0	260.67	3735.67	3475.00	1333.12
Yield (kg/ha)	1161.00	3272.0	2111.0	181.8	1223.67	3035.00	1811.33	148.02

Table 3. Changes in area, production and yield of rice in India from 1966/1967 to 2012/2013 and on triennium basis

	Yearly basis				Triennium basis			
Variable	**Base year (1966-67)**	**Current year (2012-13)**	**Net change**	**% Change**	**Base year (1966-67 to 1968-69)**	**Current year (2010-11 to 2012-13)**	**Net change**	**% Change**
Area (m ha)	35.25	42.75	7.50	21.28	36.22	43.20	6.98	19.27
Production (m tonnes)	30.44	105.24	74.80	245.73	35.94	102.17	66.23	184.28
Yield (kg/ha)	863.00	2462.00	1599.00	185.28	990.33	2364.67	1374.34	138.76

Table 4. Contribution of different factors in the production of rice in Haryana and India

Period	Effect	Rice	
		Haryana (%)	India (%)
I	Area	32.10	20.00
	Yield	43.10	71.60
	Yield × Area	24.80	8.40
II	Area	76.70	13.10
	Yield	13.20	81.40
	Yield × Area	10.10	5.50
III	Area	163.20	14.90
	Yield	-47.80	81.60
	Yield × Area	-15.00	3.50
IV	Area	87.50	4.30
	Yield	10.00	95.10
	Yield × Area	2.50	0.60
V	Area	93.10	-19.00
	Yield	5.90	122.40
	Yield × Area	1.00	-2.60
Overall	Area	31.60	8.50
	Yield	10.60	75.50
	Yield × Area	57.60	16.00

In Period-III, there was a negative effect of yield on the production of rice and therefore whatever increase in the production is visible it is due to area which seems to contribute as high as 163.2 per cent; yield and its interaction with area have both negative effects i.e. 47.8 and 15.0 per cent respectively. So, the change in the production of rice in Haryana is only due to increase in area during this period. But in case of India the pattern of contribution is as in period-I i.e. 81.6 per cent effect has been shown by yield, 14.9 per cent by area and 3.5 per cent by their joint effect during this period. During the period from 1996/1997 to 2005/2006, area has played a major role in the improvement of production of rice i.e. 87.5 per cent, followed by 10 per cent, 2.5 per cent due the yield and area and its interaction with yield, in Haryana. While in India, the production has been increased 95.1 per cent due to yield, 4.3 per cent and 0.6 per cent due to area and its interaction with yield respectively. So, area has shown a great impact on the production of rice in Haryana and yield is the major contributor for India during this period. Similar results were found by Rao et al. [12] during 1990/1991 to 2014/2015 in India. Similarly, in Period-V the yield, area and their interaction increased the production by 5.9, 93.1 and 1.0 per cent respectively. Area has the major effect in production of rice in Haryana. Since area and its interaction with yield had negative effects to the extent of 19 per cent and 2.6 per cent respectively on production in this period, the production of rice in India is solely due to yield in the period from 1996/1967 to 2005/2006. Mech [13] examined the growth trend for the rice crop in Assam over the period 1972/1973 to 2014/2015 and determined that rice production was mainly due to increase in yield than area.

For the overall period, the production of rice has increased by an extent of 10.8 per cent due to yield, 31.6 per cent due to area and 57.6 per cent from their interaction in Haryana whereas at country level, it has increased 75.5 per cent due to yield, 8.5 per cent due to area and 16 per cent from their interaction Thus the interaction between area and yield has increased the production of rice in Haryana whereas yield has played a significant role in increasing production of rice in India.

Growth rates of area, production and yield of rice crop in Haryana and India is given in Table 5.

In Haryana, during Period-I area under the rice crop has increased with highly significant compound growth rate of 4.74 per cent and with a increase of 11.49 thousand hectares annually (Table 5). Production and yield have also shown highly significant compound growth rates i.e. 9.99 and 5.02 per cent respectively, giving an annual increment of 36.64 thousand tonnes and 75.35 kg/ha, respectively. Netam and Sahu [14] studied trend in area, production and productivity of paddy in Bastar region of Chhattisgarh state and noticed a downward trend in the growth pattern of area at state and district level for the period 2000/2001 to 2011/2012. During the same

period, the national level compound growth rates in area, production and productivity of rice crop were i.e. 0.85, 3.10 and 2.24 per cent, respectively which were highly significant and there was an annual increment of 0.32 m ha, 1.20 m tonnes and 23.17 kg/ha in terms of area, production and yield respectively. Similar results were obtained for wheat in Haryana by Bhatnagar and Saxena [15].

The production of rice crop in Haryana, during Period-II, has inflated with highly significant compound growth rate of 6.24 per cent with an annual increase of 70.7 thousand tonnes, growth rates of area and yield were also significant i.e. 5.43 and 0.77 per cent, respectively showing an average annual increase of 23.96 thousand hectares in area and 18.01 kg/ha in yield every year. Nimbrayan et al. [16] studied growth and instability in area, production and productivity of Barley and found positive growth rates of yield in both Haryana and India. At the all India level, during the same period, the compound growth rates for area has been found to be 0.46 per cent with an annual increase of 0.19 million hectares whereas the production and yield have increased with significant growth rates of 3.31 and 2.83 per cent with an annual increase of 1.71 million tonnes and 36.47 kg/ha, respectively. The per annum increase in yield was much higher at the country level (almost double) than at the state level in Period-II. Jili et al. [17] studied growth and instability of rice in Pakistan and revealed positive growth rates for all the three aspects i.e. area, production and yield.

Highly significant trend coefficients have been observed in area and production of rice crop i.e. 4.76 and 5.41 per cent, respectively while yield has increased at the rate of 0.62 per cent in Haryana during Period-III. The per annum increase in area, production and productivity for rice in Haryana were 30.79 thousand ha, 86.40 thousand tones and 16.85 kg/ha, respectively. At the country level, the rate of increase were highly significant for area, production and yield i.e. 0.68, 3.29 and 2.59 per cent, respectively for the corresponding period and there was very high annual rate of increase (42.78 kg/ha) in yield for India which was the case in Period-II also. Ganjeer et al. [18] scrutinized positive growth rate for area, production and productivity for wheat crop during 1979/1980 to 2012/2013.

The trend coefficients for area, production and yield during Period-IV were 1.21, 2.48 and 1.26 per cent respectively for rice crop in Haryana whereas in case of India its production and yield have increased with growth rates of 0.4 and 0.84 per cent respectively. Despite decrease in area, production have increased with growth rate of 0.40 and at was 0.37 million tonnes per annum for the country during 1996/1996 to 2005/2006. Similar results were observed by Abid et al. [19] for rice crop in Pakistan for period 1980-81 to 2011/2012. In Period-V, the values of trend coefficients for rice crop were positive and statistically significant for both area and production (i.e. 2.79 and 2.26 per cent respectively) while yield of rice has decelerated with a rate of 0.51 per cent in Haryana. The production of rice crop in India has shown a growth rate of 1.79 per cent whereas its yield has increased with highly significant growth rate of 2.27 per cent though its area has decelerated with a rate of 0.41 per cent. Kumar et al. [20] determined negative trends in the production and area of major cereal crops excluding maize and buckwheat during period 2003/2016. The production in Haryana increased at the rate of 81.46 thousand tonnes per annum despite decrease in yield.

The trend coefficient for area, production and productivity for the entire period under study were positive and highly significant for rice crop in Haryana i.e. 4.05, 5.66 and 1.55 per cent respectively. The linear growth rates shows that 24.01 thousand hectares more area was put under cultivation by rice growers every year. The annual increase in the production and yield were 78.89 thousand tonnes and 33.22 kg/ha respectively. At all India level, compound growth rates 0.41, 2.40 and 1.98 per cent have been observed for area, production and productivity of rice crop respectively giving an annual increment of 0.17 million hectares, 1.52 million tonnes and 30.7 kg/ha every year. Thus, overall period changes were at par for both Haryana and India. Similar results were obtained by Bhatnagar et al. [21] for food grains in Haryana.

Coefficient of Variation and Instability Index of Rice Crop in Haryana and India are given in Table 6.

The coefficient of variation was higher in Haryana as compared to India in terms of the three components i.e. area, production and productivity of rice crop (Table 6) in all the periods and the overall period, except for yield in period-II, period-III and the overall period, showing thereby wide variation occurred in Haryana as compared to the country with respect

Table 5. Growth rates of area, production and yield of rice crop in Haryana and India

Period	Variable	Haryana		India	
		Linear growth rate (b)	Compound growth rate (%)	Linear growth rate (b)	Compound growth rate (%)
I	Area	11.49**	4.74**	0.32**	0.85**
	Production	36.64**	9.99**	1.20**	3.10**
	Yield	75.35**	5.02**	23.17**	2.24**
II	Area	23.96**	5.43**	0.19	0.46
	Production	70.70**	6.24**	1.71**	3.31**
	Yield	18.01**	0.77**	36.47**	2.83**
III	Area	30.79**	4.76**	0.28**	0.68*
	Production	86.40**	5.41**	2.24**	3.29**
	Yield	16.85	0.62	42.78**	2.59**
IV	Area	10.92	1.21	-0.19	-0.44
	Production	68.08**	2.48**	0.37	0.40
	Yield	32.96	1.26	16.97	0.84
V	Area	31.32*	2.79*	-0.20	-0.46
	Production	81.46*	2.26*	1.77	1.79
	Yield	-16.75	-0.51	51.29**	2.27**
Overall	Area	24.01**	4.05**	0.17**	0.41**
	Production	78.89**	5.66**	1.52**	2.40**
	Yield	33.22**	1.55**	30.70**	1.98**

*significant at 5% **significant at 1%

Table 6. Coefficient of variation and instability index of rice crop in Haryana and India

Period	Variable	Haryana			India		
		R^2 (%)	Coefficient of variation (%)	Instability Index	R^2 (%)	Coefficient of variation (%)	Instability Index
I	Area	83.53	14.54	8.08	69.14	3.07	1.71
	Production	73.25	31.43	20.70	56.79	11.71	7.70
	Yield	58.49	19.11	13.40	50.62	9.01	6.33
II	Area	79.84	16.43	14.10	26.76	2.68	2.29
	Production	78.51	19.82	14.10	49.3	13.68	9.74
	Yield	4.31	10.13	7.04	51.77	11.48	7.97
III	Area	72.24	15.75	11.50	46.29	2.92	2.14
	Production	60.03	18.63	10.10	70.85	10.99	5.93
	Yield	4.53	8.54	4.35	74.09	8.69	4.42
IV	Area	16.57	8.56	7.74	18.25	3.11	2.81
	Production	67.73	9.30	9.18	2.63	7.24	7.14
	Yield	15.05	9.52	8.53	19.74	5.66	5.07
V	Area	68.27	6.96	6.45	14.07	2.68	2.48
	Production	56.15	6.50	5.06	39.47	6.09	4.75
	Yield	1.91	7.94	4.23	71.59	5.82	3.10
Overall	Area	95.08	48.65	23.50	76.68	6.37	3.08
	Production	91.03	60.20	16.30	92.71	31.54	8.52
	Yield	63.79	22.56	5.57	93.90	26.54	6.55

to all the three parameters of production. Similarly, instability indices were also higher in Haryana as compared to the country in all the sub-periods and overall period, except for yield in period II, period III and the overall period.

In Haryana, highest coefficient of variation in area under rice crop was 16.43 per cent in period-II followed by 14.54 per cent during Period-I while least variation has occurred in its area i.e. 2.89 per cent during Period-V. There was generally, decreasing trend in the coefficient of variation for area, as we move from Period-I to Period-V. Similar trends were observed for coefficient of variation and stability index in production and yield in Haryana.

4. CONCLUSION

The study reveals positive trends in area, production and yield of rice for both Haryana and India. The production of rice in Haryana and India increased mainly due to increase in area.

Area, production and yield of this crop have shown positive growth rates in Haryana during entire study period and five sub-periods and except for the yield in Period- V. The overall trend its production for India was found to be similar to that of Haryana, yield has shown positive growth rates during the entire study period and five sub-periods while negative growth rates are observed in area under the rice crop during Period- IV and V.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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