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# Exploring the performance of wheat production in India

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## Abstract

**Performance of Indian wheat production in terms of growth and instability was examined in the present study. Conventional techniques like compound annual growth rate and instability indices were used to analyse the production performance of the crop. With the implementation of All India Coordinated Wheat Improvement Project (AICWIP) during 1964-65, self-sufficiency status was achieved through the introduction of high yielding semi dwarf varieties so called green revolution technologies. Significant positive growth and low instability were noticed in area, production and productivity of wheat. The study indicates that yield growth surpassed the acreage growth and is attributed to the coordinated research and increase in area under irrigation. However, growth in acreage can be attributed to the rising MSP over years. Instability analysis indicated that wheat production is stable in the country. However, more efforts are needed to ensure food and nutritional security put forth by the burgeoning population.**

**Keywords:** Wheat, growth and instability, coordinated research, AICWIP

## Introduction

Wheat is the second most important crop in India and a principal source of calorie intake. It has been under cultivation in the Indian subcontinent from pre-historic times and is an integral part of the country's economy and food security. Systematic research in the crop has started in India way back in 1960s through the coordinated system of multi-location research to cater the needs of diverse population. The country achieved rapid strides in wheat production during the last four decades resulting in self-sufficiency and surplus production. This has enabled the country to meet domestic demand from its own production and reduce dependence on wheat imports. In 1978, for the first time in the post-independence period, India emerged as a net exporter of wheat (Chand, 2001). However, feeding burgeoning population through the next 25 years remains an uphill task. Increasing domestic and international demand owing to population growth should meet the future challenges of food and nutritional security. The country will have to feed about 1.30 billion people by 2020 requiring 5-6 million tons (henceforth 'mt') of additional foodgrains every year. India by 2030, will require approximately 100 million tons of wheat to cover an estimated demand of 345 million tons of foodgrains (Annual Report, 2011-12). The country as per the national policy on agriculture has set a target of 4 per cent growth rate for which high growth in wheat production becomes a mandate owing to its importance in food basket. The growth rate can be achieved by increasing the production and bridging the existing yield gap. Regional surveys reveal large variation in yield across research farm, farmers and fields attributed to management, site and season differences. Punjab and Haryana recorded 4.3 and 4.2 t $ha^{-1}$ respectively in wheat production and the yield gap between farm and potential yield was about 45 and 35 per cent respectively in those states (Fischer, 2009). Bhattacharya (2011) estimated 28.22 per cent yield gap I (difference between potential yield and national average yield) in India and 57.01 per cent yield gap II (difference between potential yield and state average yield) and 0.98 per cent yield gap III (difference between potential yield and on-farm yield) in Uttar Pradesh. Aggarwal *et al.* (2008) found that wheat registered a yield gap of 70 kg $ha^{-1}$ between research farm and farmers field.

Wheat is a staple crop in many countries and hence its consumption is directly proportional to the population growth. Consumption of wheat in rural India has increased apparently due to the availability of nutritious cereal. The share of wheat in total cereals consumption has increased from 25.43 per cent (3.88 kg $month^{-1}$) in 1972-73 to 37.36 per cent (4.24 kg $month^{-1}$) in 2009-10 (rural India) while a marginal increase from 42.88 per cent (4.82 kg $month^{-1}$) to 43.54 per cent (4.08 kg $month^{-1}$) was observed in urban India (Sendhil *et al.*, 2012). The difference in consumption pattern could be the result of sustainable production and consumption in rural areas, rural-urban price divergence, varied preferences due to higher incomes in the urban areas, and variety of foods available in urban markets (Nasurudeen *et al.*, 2006). At global level, consumption has been constantly increasing during the last 10 years with the increase in population. Alarmingly, the global consumption will shoot up further due to the demand put forth by rising population and is expected to reach 775 mt in 2020. The world population is projected to be more than 8 billion by 2030 and the food demand is expected to increase by about 55 per cent (Annual Report, 2011-12). Since India's contribution to world wheat production is substantial, the crux of the problem centres towards our own country. In the milieu, the present paper analyse the performance of wheat production in India.

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## Material and methods

*Data source:* The study was primarily based on the secondary data published from various authentic sources and records. Data on area, production and productivity were collected from Food and Agricultural Organisation (FAO) statistics, portals of indiastat and portals of indexmundi. For identifying the phase having high growth and less instability, and the impact of coordinated research and green revolution technologies, the collected data were divided into different decades and interpreted accordingly.

*Compound annual growth rate (CAGR):* The following functional form was used to estimate the growth in area, production, and productivity: $Y_t = Y_{t-1}(1+r)^t$. Here, $Y_t$ is the variable for which growth is calculated and r is the compound growth rate. The above equation can be estimated by Ordinary Least Square (OLS) method and the CAGR is interpreted in terms of percentage (Gujarati, 2003).

*Instability (Cuddy-Della Valle Index):* Instability in area, production, and productivity was estimated to examine the extent of risk in those variables using the coefficient of variation for no-time trend series and Cuddy-Della Valle instability index for the series following a time trend. The Cuddy-Della Valle Index (Cuddy and Della Valle, 1978) was computed as, $I = CV \times \sqrt{(1-\bar{R}^2)}$

where,

I is the instability index (%),

CV is the coefficient of variation (%), and

$\bar{R}^2$ is the coefficient of determination from a time trend regression.

## Results and discussion

*Growth in wheat production:* Wheat, the cold tolerant crop is cultivated in *Rabi* season. The crop is sown during 2nd fortnight of October to 1st week of January and harvested during the months of March to May across diverse agro-ecosystems. India currently occupies second position in wheat production next to China and the position continues for more than a decade (FAO trade statistics).

Fig. 1 indicates the rising trend in area, production and productivity of the crop right from the inception of the coordinated research (1964-65) till 2011-12. Indeed, India produced an historic 93.90 mt of wheat during 2011-12 owing to the favourable economic and weather factors. This increase in production over previous year (7.03 mt) was due to increase in area (0.83 mha) and yield (152 kg $ha^{-1}$). The contribution to historic production (8.09 %) is attributed to yield growth (5.08 %) followed by area (2.87 %). Fig. 2 shows the share of area and productivity growth to wheat production. Barring few years, rest explicitly indicated the yield growth surpassed the acreage growth. Increased yield is due to the factors like adoption of high yielding genotypes through well-established coordinated research system coupled with increase in area under irrigation and favourable weather factors during the crop season. Whereas, rising support price over years led to the increase in wheat area (Fig. 3). However, Fig. 2 indicated the negative growth in both area and yield for few years. The factors those are responsible for the negative growth has to be identified with deep insight and explained coherently.

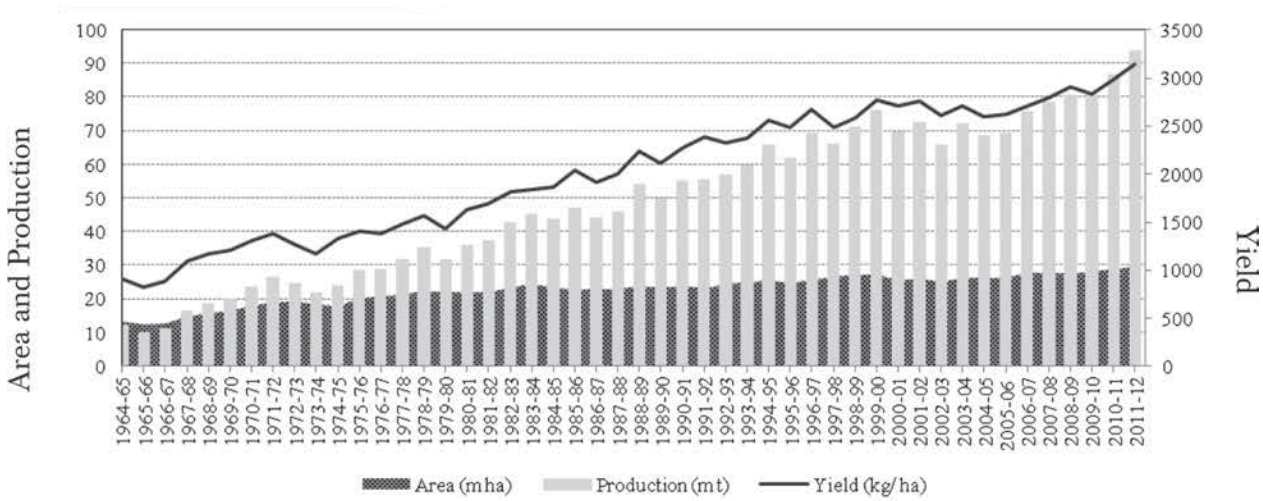


**Fig. 1.** Trends in area, production and yield in Indian wheat (1964-65 to 2011-12)

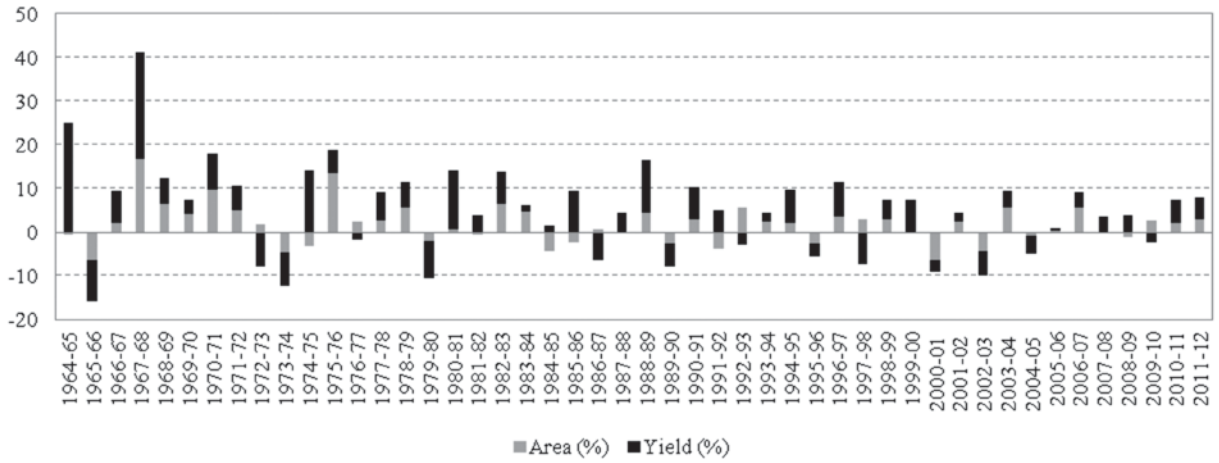


**Fig. 2.** Contribution of area and yield to production growth (1964-65 to 2011-12)

Generally, there exists a direct relationship between previous year market price and current year acreage. Fig. 3 indicates positive correlation between the current year acreage and previous year Minimum Support Price (MSP) with a coefficient of 0.79. However, a miniscule change was noticed in correlation (0.77) when the observations were taken for the same year. Under remunerative price, farmers tend to allocate more area than the usual acreage devoted to a particular crop. But in the case of wheat, support price dominates the market price. MSP - recommended by the Commission for Agricultural Costs and Prices (CACP) and announced by the government - as an unwritten rule, play a dominant role in procurement. Since it is announced prior to sowing, farmers are on safer side to decide the acreage in comparison to profitability of the competing crops like barley and mustard.

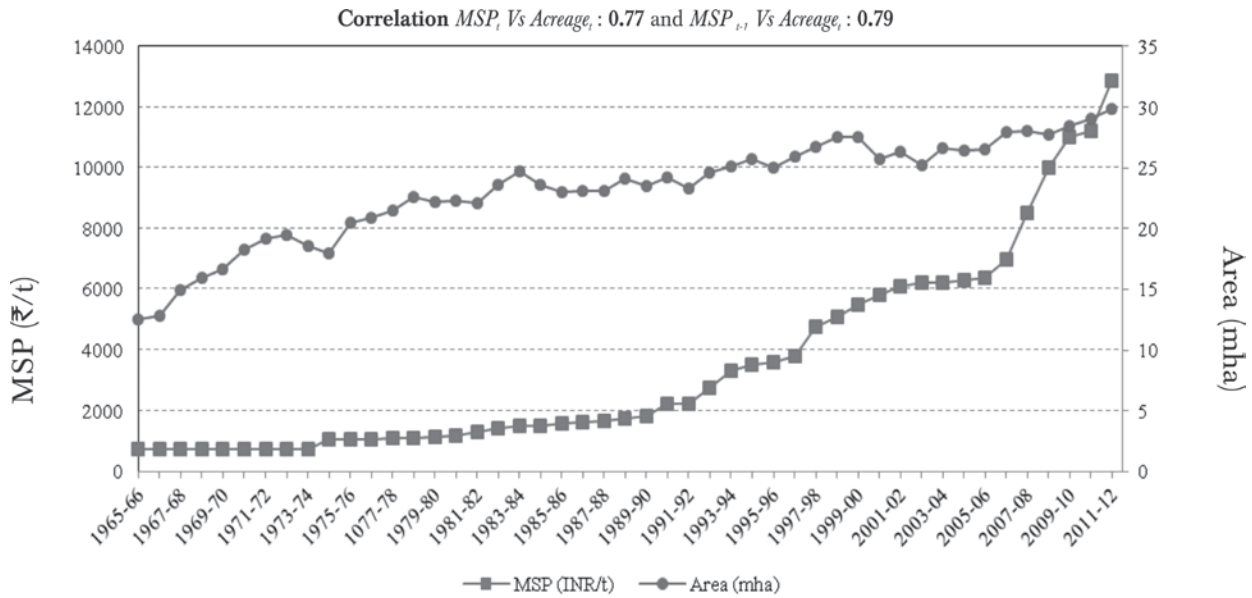


**Fig. 3.** Growth in MSP and its relationship with the wheat acreage

The decadal growth analysis indicated that increase in wheat production is contributed both by area and yield in all the periods considered for the study (Table 1). The percentage growth in production was more pronounced during the green revolution phase (1960-61 to 1969-70). Growth during this phase was attributed more to the increased area under irrigation followed by the massive adoption of HYVs developed by the breeders. The spread of input responsive high yielding genotypes played a major role in quantum jump during the initial phase of green revolution (Chand *et al.*, 2011; Byerlee, 1993 and Fischer, 2009). During 1960s four dwarf varieties (Sonara 63, Sonara 64, Lerma Rojo and Mayo 64) and 613 advanced breeding lines provided by Dr.N.E.Borlaug,

CIMMYT (Mexico) set the dawn for green revolution in India and helped to achieve the self-sufficiency status. India once a wheat importer now changed its status to wheat exporter (Chand, 2001). Thereafter, growth in area under irrigation declined thereafter since more than 90 per cent under the crop is already brought under irrigation. It is also evident from the table that high production in 2011-12 over 2010-11 is credited to yield increase followed by increase in area under wheat. Overall analysis (1950-51 to 2011-12) indicated that increase in yield (2.80 %) has contributed more to production growth rate. The increase in yield is mainly due to the coordinated research done to develop HYVs which is explicitly indicated by the yield recorded in Front Line Demonstrations (FLDs) conducted across India (Anonymous, 2012).

**Table 1.** Period wise growth in wheat area, production, yield and area under irrigation

| Period | Estimated growth (%) | | | |
|---|---|---|---|---|
| | Area | Production | Yield | Area under irrigation |
| 1950-51 to 1959-60 | 4.05 | 5.17 | 1.08 | 2.37 |
| 1960-61 to 1969-70 | 2.25 | 6.82 | 4.46 | 8.31 |
| 1970-71 to 1979-80 | 2.39 | 4.31 | 1.87 | 5.12 |
| 1980-81 to 1989-90 | 0.46 | 3.58 | 3.10 | 1.47 |
| 1990-91 to 1999-00 | 1.72 | 3.57 | 1.82 | 2.32 |
| 2000-01 to 2009-10 | 1.20 | 1.90 | 0.69 | 1.78 |
| Growth in 2011-12 over 2010-11 | 2.87 | 8.09 | 5.08 | NA |
| Overall (1950-51 to 2011-12) | 1.77 | 4.62 | 2.80 | 4.08 |

Period wise instability in area, production, yield and area under irrigation were estimated and presented in Table 2. As expected, variables that exhibited high growth rate were highly instable as evident from the instability index. This was more pronounced during the 60's. High and intensive use of inputs during this phase leads to high growth and instability in yield. Among the decades, 2000-01 to 2009-10 exhibited low instability coupled with low growth.

**Table 2.** Period wise instability in wheat area, production, yield and area under irrigation

| Period | Instability (%) | | | |
|---|---|---|---|---|
| | Area | Production | Yield | Area under irrigation |
| 1950-51 to 1959-60* | 13.13 | 16.65 | 7.45 | 7.72 |
| 1960-61 to 1969-70* | 9.88 | 27.84 | 17.54 | 26.42 |
| 1970-71 to 1979-80* | 8.26 | 15.68 | 8.09 | 15.63 |
| 1980-81 to 1989-90* | 3.29 | 11.79 | 9.89 | 5.56 |
| 1990-91 to 1999-00* | 5.48 | 11.16 | 6.33 | 7.07 |
| 2000-01 to 2009-10* | 4.06 | 7.23 | 3.74 | 4.91 |
| Overall (1950-51 to 2011-12)^ | 6.99 | 11.60 | 7.88 | 9.48 |

* indicates the coefficient of variation and ^ indicates the Cuddy-Della Valle instability index.

Table 3 presents the state wise wheat area, production and productivity for 2011.12. Uttar Pradesh (30.29 mt) leads the country in wheat production (2011-12) followed by Punjab and Haryana. These three states contributed a share of 64 per cent in total wheat production in the country during 2011-12. The crop was grown more in the same state (9.73 mha) during 2011-12 holding a share of 32.54 per cent to the total area under wheat in India, a factual reason for its high production. Wheat yield in 2011-12 was highest in Haryana (5030 kg $ha^{-1}$) followed by Punjab (4898 kg $ha^{-1}$) and Rajasthan (3175 kg $ha^{-1}$). In the case of productivity, all the top three states *viz.,* Haryana, Punjab and Rajasthan recorded their historic yield. These states productivity coupled with their high area under wheat cultivation helped to achieve the historic Indian wheat production of 93.90 mt during 2011-12.

**Table 3.** Comparison of wheat area, production and yield in different states (2011-12)

| State | Area (mha) | Share (%) | Production (mt) | Share (%) | Yield (kg ha$^{-1}$) |
|---|---|---|---|---|---|
| Andhra Pradesh | 0.01 | 0.03 | 0.01 | 0.01 | 1000.00 |
| Assam | 0.05 | 0.17 | 0.06 | 0.06 | 1134.62 |
| Bihar | 2.17 | 7.26 | 4.79 | 5.10 | 2206.00 |
| Chhattisgarh | 0.11 | 0.36 | 0.13 | 0.14 | 1185.50 |
| Gujarat | 1.35 | 4.52 | 4.10 | 4.37 | 3034.79 |
| Haryana | 2.52 | 8.43 | 12.68 | 13.51 | 5029.50 |
| Himachal Pradesh | 0.36 | 1.19 | 0.60 | 0.63 | 1670.85 |
| Jammu & Kashmir | 0.29 | 0.97 | 0.41 | 0.43 | 1404.24 |
| Jharkhand | 0.18 | 0.60 | 0.34 | 0.36 | 1876.29 |
| Karnataka | 0.23 | 0.77 | 0.19 | 0.21 | 843.48 |
| Madhya Pradesh | 4.89 | 16.35 | 10.58 | 11.27 | 2164.00 |
| Maharashtra | 0.84 | 2.82 | 1.31 | 1.40 | 1557.53 |
| Orissa | 0.00 | 0.01 | 0.00 | 0.00 | 1551.72 |
| Punjab | 3.51 | 11.75 | 17.21 | 18.32 | 4898.00 |
| Rajasthan | 2.94 | 9.82 | 9.32 | 9.92 | 3175.00 |
| Uttar Pradesh | 9.73 | 32.54 | 30.29 | 32.26 | 3113.00 |
| Uttarakhand | 0.37 | 1.23 | 0.87 | 0.93 | 2368.56 |
| West Bengal | 0.32 | 1.06 | 0.88 | 0.94 | 2800.49 |
| Others | 0.04 | 0.13 | 0.13 | 0.14 | 3470.60 |
| India | 29.90 | 100.00 | 93.90 | 100.00 | 3140.35 |

Source: Directorate of Economics and Statistics, Ministry of Agriculture, India (4th Advance Estimates)

Quantum change in area, production and yield during 2011-12 over 2010-11 is furnished in Table 4. Area increase was more prominent in Rajasthan and Madhya Pradesh while it decreased much in Maharashtra by 4.64 lakh ha which is a matter of serious concern. The reason might be switching over to other competing crops that offer more profit. Wheat production in 2011-12 over 2010-11 has increased immensely in Madhya Pradesh followed by Rajasthan and Haryana. A drastic reduction in production was noticed in Maharashtra owing to decreased area and productivity. Haryana and Madhya Pradesh experienced a significant increase in crop productivity and contributed a lot in the country's record production. Few states like Karnataka, Maharashtra, Jammu & Kashmir and Gujarat showed yield reduction over previous year. Among the wheat growing states in India, only three states *viz.,* Haryana, Punjab and Rajasthan (Fig. 4) recorded yield more than the national average (3140.35 kg ha$^{-1}$) during 2011-12. This skewed distribution is a matter of serious concern for the scientists as well as development workers who aim to bridge the yield gap (Anonymous, 2012). Haryana surpassed all the states in wheat yield with a record yield of 5030 kg ha$^{-1}$ which is more than the national average yield by 1889 kg ha$^{-1}$. The reason was due to the increasing mechanisation through the National Food Security Mission (NFSM) along with proactive measures taken by the Directorate and state government in containing biotic and abiotic stresses. Karnataka recorded the lowest productivity (843.48 kg ha$^{-1}$) which is far down from the Indian average by 2297 kg ha$^{-1}$. Other states which recorded low productivity were Chhattisgarh followed by Maharashtra, Himachal Pradesh and Jharkhand. Plausible reasons were the differences in method of cultivation, climate and incidence of rusts. It is strange that Uttar Pradesh, the leading state in wheat production registered less yield in comparison with the national average yield.

Change in wheat production during 2011-12 over previous year indicated that majority of the states have registered increased production (Fig. 5). The percentage increase was more in Jharkhand (117.70 %), followed by Madhya Pradesh and Rajasthan. From Fig. 6 it is clear that the increase in Jharkhand's production was due to the growth in wheat area (85.40 %) followed by yield (14.19 %). Similar kind of pattern was noticed for Gujarat and Rajasthan. On the contrary, yield growth contributed more to Madhya Pradesh, Bihar, Haryana, Uttarakhand and West Bengal wheat production.

It is also evident from the Fig. 6 that excluding Gujarat, Jammu and Kashmir, Karnataka, Maharashtra and Uttar Pradesh rest of the states have registered increased yield in 2011-12 over the previous year. The reason for higher yield could be due to the adoption of improved varieties developed by the scientists of State Agricultural Universities and Directorate of Wheat Research coupled with favourable monsoon during the crop season.

**Table 4.** Quantum change in area, production and yield during 2011-12 over previous year

| State | 2010-11 | | | 2011-12* | | | Quantum change in | | |
|---|---|---|---|---|---|---|---|---|---|
| | Area (000'ha) | Production (000't) | Yield (kg ha$^{-1}$) | Area (000'ha) | Production (000't) | Yield (kg ha$^{-1}$) | Area (000'ha) | Production (000't) | Yield (kg ha$^{-1}$) |
| Punjab | 3510.00 | 16472.00 | 4693 | 3513.00 | 17206.67 | 4898 | 3.00 | 734.67 | 205 |
| Haryana | 2515.00 | 11630.00 | 4624 | 2522.00 | 12684.40 | 5030 | 7.00 | 1054.40 | 406 |
| Uttar Pradesh | 9637.00 | 30001.00 | 3113 | 9731.00 | 30292.60 | 3113 | 94.00 | 291.60 | 0 |
| Bihar | 2103.50 | 4097.60 | 1948 | 2170.13 | 4787.31 | 2206 | 66.63 | 689.71 | 258 |
| Rajasthan | 2479.20 | 7214.50 | 2910 | 2935.34 | 9319.71 | 3175 | 456.14 | 2105.21 | 265 |
| Madhya Pradesh | 4341.00 | 7627.10 | 1757 | 4889.20 | 10580.23 | 2164 | 548.20 | 2953.13 | 407 |
| Chhattisgarh | 110.80 | 126.80 | 1144 | 108.50 | 128.63 | 1186 | -2.30 | 1.83 | 42 |
| Gujarat | 1274.00 | 4019.50 | 3155 | 1351.00 | 4100.00 | 3035 | 77.00 | 80.50 | -120 |
| Maharashtra | 1307.00 | 2301.00 | 1761 | 843.00 | 1313.00 | 1558 | -464.00 | -988.00 | -203 |
| West Bengal | 316.80 | 874.40 | 2760 | 315.66 | 884.00 | 2800 | -1.14 | 9.60 | 40 |
| Uttarakhand | 379.20 | 878.00 | 2315 | 369.00 | 874.00 | 2369 | -10.20 | -4.00 | 54 |
| Himachal Pradesh | 357.20 | 546.50 | 1530 | 356.58 | 595.78 | 1671 | -0.63 | 49.28 | 141 |
| Jammu & Kashmir | 290.70 | 446.30 | 1535 | 289.37 | 406.34 | 1404 | -1.33 | -39.96 | -131 |
| Jharkhand | 96.40 | 158.40 | 1643 | 178.73 | 335.34 | 1876 | 82.33 | 176.94 | 233 |
| Karnataka | 255.00 | 279.00 | 1094 | 230.00 | 194.00 | 843 | -25.00 | -85.00 | -251 |
| Others | 95.80 | 201.90 | 2108 | 99.73 | 201.56 | 2021 | 3.93 | -0.34 | -87 |
| India | 29068.60 | 86874.00 | 2989 | 29902.23 | 93903.56 | 3140 | 833.63 | 7029.56 | 151 |

Source: Directorate of Economics and Statistics, Ministry of Agriculture, India (* indicates the 4th Advance Estimates)

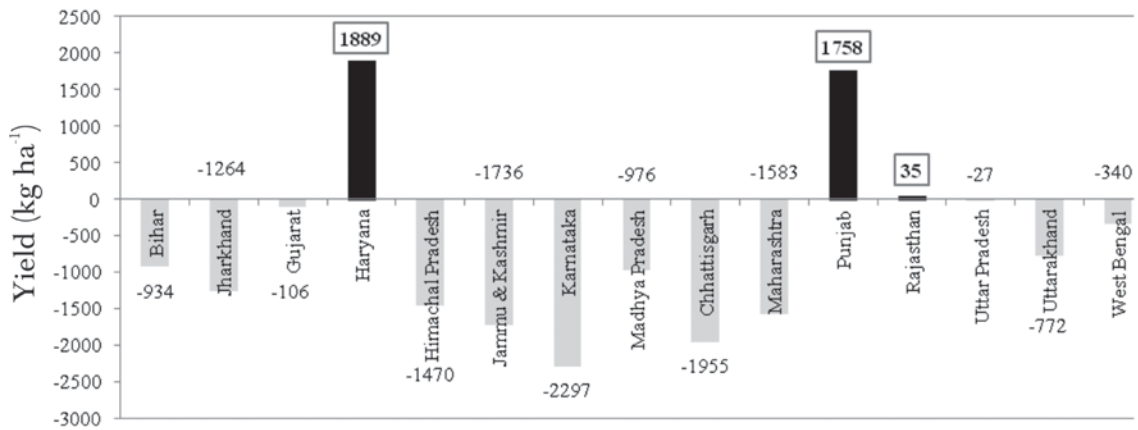


**Fig. 4.** Deviation of state yield from national average yield (2011-12)

*Instability in wheat production:* Table 5 furnishes the growth-instability matrix for area, production and productivity of wheat across states. Most of the wheat growing states were placed in the comfortable zone (positive growth coupled with low instability) for the variables under consideration as evident from the quadrant of the matrix. Few states like Punjab, Bihar, Haryana, Chhattisgarh, Rajasthan and Uttar Pradesh were the most consistent states in wheat production during the 2001-02 to 2011-12. These states have to continue their strides in production as they contribute a lot in grain pool towards achieving national food security. It is worth to note that none of the states exhibited negative growth cum high instability in the selected variables. On the whole, India is placed under positive growth and low instability quadrant in all the variables for the period under consideration for which the researchers deserve their deeds.

**Table 5.** Growth-instability matrix for wheat (2001-02 to 2011-12)

| Growth (CAGR) | Instability (Coefficient of variation) | |
|---|---|---|
| | Low (<20) | High (>20) |
| *Area* | | |
| Negative | Himachal Pradesh (-0.20) [1.16], Uttarakhand and West Bengal (-3.61) [12.97] | -- |
| Positive | Punjab (0.35) [1.34], Bihar, Haryana, Jammu & Kashmir, Karnataka, Madhya Pradesh, Chhattisgarh, Rajasthan (3.12) [13.57], Uttar Pradesh and India (1.43) [5.08] | Maharashtra (4.59) [23.48], Gujarat (10.66) and Jharkhand [38.22] |
| *Production* | | |
| Negative | West Bengal (-0.87) [8.25] and Himachal Pradesh (-1.76) [18.64] | -- |
| Positive | Jammu & Kashmir (0.03), Punjab [6.15], Bihar, Haryana, Chhattisgarh, Uttar Pradesh, Uttarakhand, Rajasthan (4.53) [17.65] and India (2.93) [10.97] | Madhya Pradesh (4.47) [21.39], Maharashtra, Karnataka, Gujarat (13.74) and Jharkhand [44.64] |
| *Productivity* | | |
| Negative | Jharkhand (-0.03) [15.79], Himachal Pradesh [18.36] and Jammu & Kashmir (-1.75) | -- |
| Positive | Punjab (1.00) [5.43], Bihar, Haryana, Chhattisgarh, Uttar Pradesh, Rajasthan, West Bengal, Uttarakhand, Madhya Pradesh, Maharashtra (2.89), Gujarat [13.00] and India (1.47) [6.09] | Karnataka (5.34) [22.65] |

Figures in parenthesis and square bracket indicate the range of growth and instability respectively of the states in that quadrant to all states.

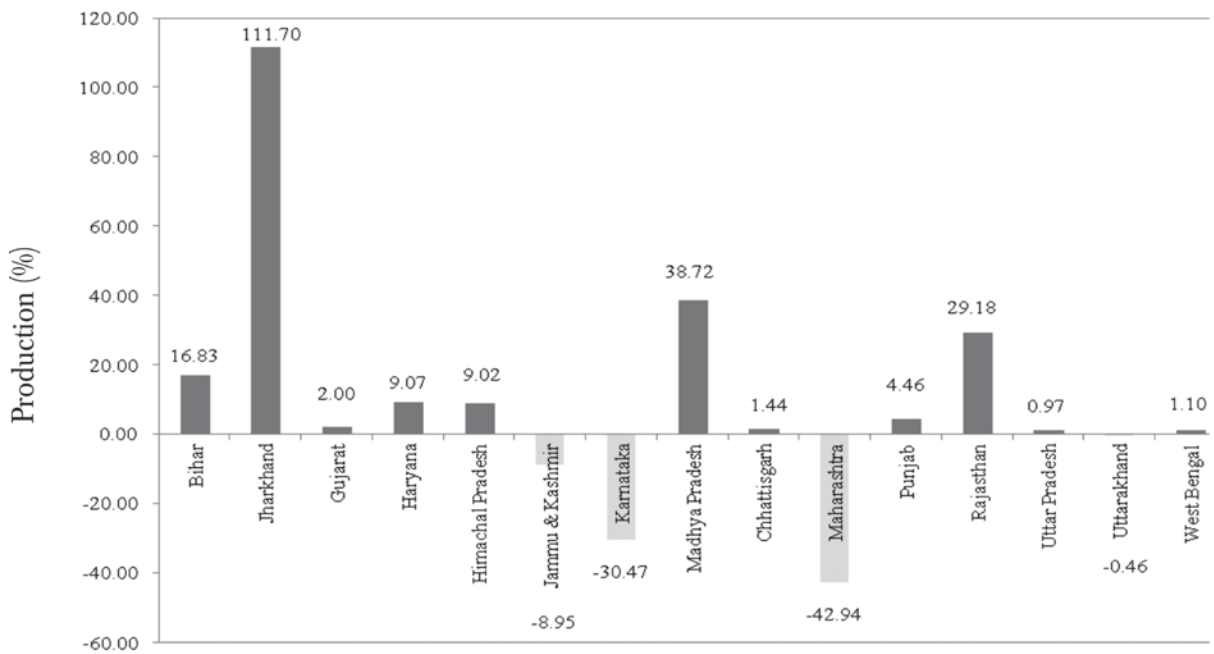


**Fig. 5.** Percentage change in wheat production during 2011-12 over 2010-11

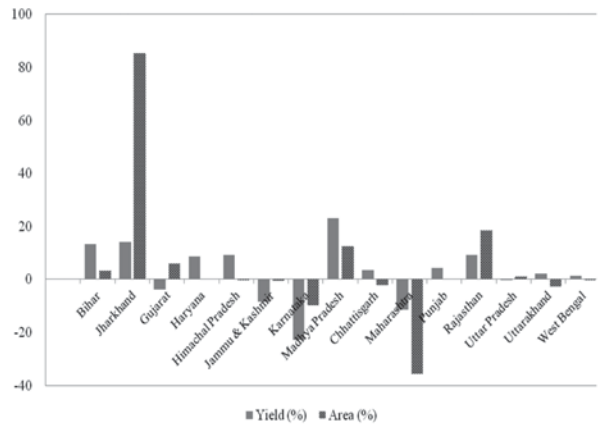


**Fig. 6.** Contribution of area and yield to wheat production during 2011-12 over 2010-11

## Policy implications

Since the inception of All India Coordinated Wheat Improvement Project (AICWIP) followed by the green revolution technologies, the country moved ahead in a fast phase in wheat production and reached its self-sufficiency status eons ago. Overall performance of the crop in terms of growth in area, production and productivity indicated a significant positive growth and low instability. Support price is the backdrop in deciding the area under wheat, and yield growth is attributed to increased area under irrigation and adoption of high yielding varieties that are responsive to resource use. The study identified that barring Haryana, Punjab and Rajasthan, productivity in rest of the states were below the national level. Expecting the impediments for wheat production in the coming years such as climate change, dynamics of pests and diseases, deteriorating soil nutrients, increasing cost of cultivation, global price volatility and changing consumption pattern, researchers have to put tremendous effort to sustain the existing growth trend by developing and sustaining the HYVs having tolerance to biotic and abiotic stresses. However, a major role has to be played by the extension personnel in disseminating those improved genotypes through FLDs at farmers' field and try to bridge the existing yield gaps to meet our mission on ensuring food and nutritional security to all population.

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