

ANALYSIS OF POTATO PRODUCTION PERFORMANCE AND YIELD VARIABILITY IN INDIA

Rani Saxena¹ and Prasoon Mathur²

ABSTRACT: In India, during last six decades potato production increased significantly. The study analyses (a) temporal and spatial growth rates of area, production and yield during 2000-01 to 2010-11 of some important states of India to provide an updated assessment of recent performance in last decade (b) relative contribution of area and yield in enhancing production and (c) categorize them on the basis of yield variability. The analysis showed that during the last decade the potato yield and production grew at 1.10 and 5.98% per annum respectively at national level. Highest growth in area was observed in Bihar (12.74%) followed by Gujarat (9.53%) however remarkable production growth was seen in Bihar, UP and Gujarat to the extent of 23.64, 15.10 and 12.39% respectively. Bihar witnessed highest productivity growth. States like UP, Haryana and Gujarat were in the category of 'High yield-low yield variability' *i.e.* the most desirable category. At national level the contribution of yield in enhancing the production was substantially low (11.76%) as compared to area (82.62%). Tripura and Himachal Pradesh registered negative area effect to the extent of -12.44 and -48.33% respectively. The yield effect was highest in Himachal Pradesh. Yield component was found to be the driving force in production enhancement in some states.

KEYWORDS: Production performance, yield, yield variability, potato, growth rate

INTRODUCTION

Potato popularly known as 'The king of vegetables', has emerged as fourth most important food crop in India after rice, wheat and maize. In world scenario, India became the second largest producer of potato (Scott and Suarez, 2011). India produced 42.34 million t from 1.86 million ha with an average yield of 22.72 t/ ha of Potato during 2010-11 (Agricultural statistics at a glance, 2012). Though, during the recent past the productivity of potato in India has registered noticeable increase, but can this level be sustained or enhanced in future, is a matter of concern today. Knowledge of the past trends in area, production and productivity will aid the planners in deciding the growth rates to be achieved in accordance with the planned targets. Besides these, trends in area, production and productivity provide basis for

forecasting the future supply. Many of the studies (Horton, 1987; Jain, 1990; Samanase *et al.*, 1990 and Pandey and Sarkar, 2005) estimated growth rates.

Technological development in the state can be well assessed by looking at the trend in the yield. Keeping in view the year to year variation in yield, the relationship between yield and yield variability needs to be looked into. Since, production of a crop is a function of area and average yield of the crop, hence the decomposition analysis (*i.e.* relative contribution of area and yield on production of potato) is necessary as it would be of immense value for policy formulation for the future. This study was carried out with the objectives to examine the past performance of area, production and productivity of potato in important states of India (Samanase *et al.*, 1990; Singh and Singh, 2007 and Pandit and Chandran, 2011) and the

¹Rajasthan Agricultural Research Institute, Jaipur, Durgapura-302 018, Rajasthan, India.

Email: mathurrani@rediffmail.com

²Religare Commodities Ltd., GYS Global, Sec-125, Noida-201 301, India.

country as a whole. An attempt has also been made to evaluate the mean yield and yield variability with respect to potato in these states of India and to assess the relative contribution of area and yield on growth of production of potato in these states.

MATERIALS AND METHODS

To carry out this study, the following potato-growing states of India were selected. The selected states include Uttar Pradesh, West Bengal, Bihar, Punjab, Gujarat, Orissa, Madhya Pradesh, Himachal Pradesh, Assam, Tripura, Tamil Nadu, Meghalaya, Haryana and Karnataka. In 2010-11, Uttar Pradesh, West Bengal and Bihar contributed to 68.6% in area and 77.4% to production and the remaining 31.4 % area and 22.6 % production is contributed by other states selected for this study. To fulfil all the objectives, secondary data of potato crop were collected from various government publications (Agricultural statistics at a glance, 2012) of India for the duration of 1950-51 to 2010-11. The study aimed at examining the updated growth rates of potato area, production, yield, and yield variability; and relative contribution of area and yield towards growth of output during last decade.

Growth rate analysis

Growth rates were worked out to study the tendency of the selected attributes over time, such as increase, decrease or stagnancy and the magnitude of the rate of change over time. The compound growth rates were worked out by fitting the semi-log form of the exponential growth function in the time series data on area, production and productivity (Prajneshu and Chandran, 2005).

Mean yield and yield variability

To evaluate the mean yield and yield variability, mean yield (t/ha) and coefficient variation of yield (%) [CV= (standard deviation/ mean) * 100] were calculated

from last decade data and the states were categorized in to the following categories-

- I. High yield- high yield variability
- II. High yield- low yield variability
- III. Low yield- high yield variability
- IV. Low yield- low yield variability

Ten years average yield and cv of yield (%) was calculated to reveal the ranges both in yield and yield variability in different states and to examine the relationship between yield and yield variability, if any.

Additive decomposition

Additive decomposition was carried out for the period 2000-01 to 2010-11. In this method, the total change in production is decomposed into three effects *i.e.* area effect (% contribution of area), yield effect (% contribution of yield) and interaction effect (% contribution of interaction). The contribution of area is the part of production due to additional area with the base year average yield, the contribution of average yield is the part of production due to additional yield with base year area and the contribution of the interaction is the part of production jointly due to additional yield and additional area. This is elaborated as below:

Let P_o and P_n be production in base year and n^{th} year.

$$P_o = A_o \cdot Y_o \dots\dots\dots 1$$

$$P_n = A_n \cdot Y_n$$

Where A_o, A_n represent area Y_o, Y_n represent yield for the base year and n^{th} year, respectively. The base year and n^{th} year observations are triennium averages.

$$P_n - P_o = \Delta P$$

$$A_n - A_o = \Delta A \dots\dots\dots 2$$

$$Y_n - Y_o = \Delta Y$$

From 1 and 2 we can write

$$P_o + \Delta P = (A_o + \Delta A) (Y_o + \Delta Y)$$

$$\begin{aligned} \Delta P &= (A_o + \Delta A) (Y_o + \Delta Y) - P_o \\ &= (A_o + \Delta A) (Y_o + \Delta Y) - A_o \cdot Y_o \\ &= (A_o \cdot Y_o + \Delta A Y_o + \Delta Y A_o + \Delta A \Delta Y - A_o \cdot Y_o) \\ \Delta P &= \Delta A Y_o + \Delta Y A_o + \Delta A \Delta Y \end{aligned}$$

Thus, total change in production is decomposed into three effects *viz.* area effect, yield effect and interaction effect. The representation of these in terms of per cent change in production (δP) results in percentage that provide the estimate of per cent contribution of area, productivity and their interaction.

RESULTS AND DISCUSSION

Growth in area, production and productivity

The temporal and spatial growth rates of area, production and yield of potato in different states of India were estimated from

the analysis of time series data (2000-01 to 2010-11). **Table 1** presents the compound growth rate in area, production and productivity of potato in different states of India and for the country as a whole. The estimated compound growth rates are discussed below:

Growth in production: Annual potato production in India was 1.66 million t in 1950-51 which increased to 22.49 million t in 2000-01. It showed an increasing trend and rose to as high as 42.34 million t in 2010-11 which represents the growth in production at 5.98% per annum at the national level. Bihar (23.64%), Uttar Pradesh (15.10%) and Gujarat (12.39%) were among the states showing tremendous growth in the level of production during last decade. In these states, not only increase in area contributed in enhanced production but also the introduction of new processing varieties like Chipsona-1 *etc.* (Rana *et al.*, 2009) might have contributed to enhanced production.

Table 1. Compound growth rates in area, production and productivity of potato in different states of India during the period of 2000-01 to 2010-11.

State	Compound growth rate (%)			Coefficient of multiple determination (R ²)		
	Area	Production	Yield	Area	Production	Yield
West Bengal	4.14*	6.12**	1.82**	0.63*	0.24**	0.001#
Uttar Pradesh	5.07*	15.10*	0.91#	0.93*	0.74*	0.54**
Punjab	3.98*	8.17*	3.88**	0.85*	0.74*	0.38***
Madhya Pradesh	7.19*	5.63**	-1.44#	0.78*	0.42**	0.07#
Karnataka	5.51*	0.95#	-4.03#	0.22#	0.01#	0.09#
Himachal Pradesh	-3.09#	-3.09#	-5.11#	0.26	0.08	0.24
Tripura	0.50***	-5.27#	-5.74#	0.07#	0.86#	0.86*
Tamil Nadu	0.08#	-2.99#	-3.07#	0.00#	0.22#	0.50***
Meghalaya	0.92**	6.80*	5.83*	0.21#	0.79*	0.86*
Orissa	6.23*	9.39*	2.98***	0.47***	0.43***	0.23#
Haryana	7.18*	9.80*	2.44***	0.84*	0.89*	0.22#
Gujarat	9.53*	12.39*	2.24**	0.81*	0.88*	0.44**
Bihar	12.74*	23.64*	9.73**	0.72*	0.62**	0.48**
Assam	1.31***	1.52#	6.62**	0.24#	0.03#	0.80*
All India	4.81*	5.98*	1.10**	0.89*	0.72*	0.18#
All India (1950-51 to 2009-10)	3.28*	5.47*	2.11*	0.98*	0.98*	0.91*

* = Significant at 1% level; ** = Significant at 5% level; *** = Significant at 10% level and # = Non-significant.

Secondly, improved efforts to disseminate scientific crop husbandry practices, farmers' friendly policies and improvement in marketing infrastructure aided in enhanced potato production in these states. However there were some states like Tripura, Tamil Nadu and Himachal Pradesh which registered a negative growth in production (**Table 1**). In Himachal Pradesh, decline in area resulted in deceleration in the potato production. While in Tripura and Tamil Nadu, decline in yield affected the production. Similar results were observed by Bardhan *et al.* (1999); Pandey (2007) and Pandey *et al.* (2005).

Growth in productivity: In India, the productivity of potato was 6.9 t/ha in 1950-51 and increased to 18.4 t/ha in 2000-01. The productivity of potato in India increased to 22.72 t/ha in 2010-11. As far as the productivity growth in the last decade is concerned, it was at the level of 1.10 % per annum at all India level (**Table 1**). However, Bihar and Assam are the two states which have shown high growth in productivity due to low base effect. The increase in the productivity level in these states is mainly due to development and adoption of yield increasing varieties and better technological adoption. Interestingly in the states of Tripura, Tamil Nadu, Madhya Pradesh, Karnataka and Himachal Pradesh the trend in yield growth has remained negative (Pandey *et al.*, 2005). This decline in growth in productivity in some states is due to decline in water table, non-judicious use of fertilizer and low soil fertility (CPRI, 2011).

Mean yield and yield variability

Use of modern technology, which is also expensive, depends upon yield stability. High yield risk restricts the use of such technology, so it is important to know if the movement of area and production of potato is towards high or low yield variability states. Movement towards low yield variability states

ensures stability in production and vice versa. Coefficient of variation has been computed for this purpose for the period (2000-01 to 2010-2011) to capture the most recent trends and further, these were used to categorize the states in different categories of variability. Bihar has got maximum variability in yield (36.3%), followed by Karnataka (34.2%) and Assam (23.8%) (**Table 2**). The results revealed the existence of all four categories of states (**Table 3**). West Bengal and Punjab were under the category of high yield and high yield variability group. The area in these states increased from 370.87 thousand ha in the triennium ending 2002-03 to 474.93 thousand ha in the triennium ending 2010-11, but in percentage term, the area under this group declined in the triennium ending 2010-11 as the growth in area was not as that at national level. Production of potato has also increased (8.82 to 12.81 million t) during this period. In the high yield and low yield variability category (the most desirable category) (Uttar

Table 2. State-wise mean yield and CV of yield (%) of potato (2000-01 to 2010-11).

State	Mean yield (t/ha)	CV of yield (%)
West Bengal	23.78	21.5
Uttar Pradesh	22.69	6.4
Tripura	15.72	9.2
Tamil Nadu	14.93	8.0
Punjab	20.73	16.2
Orissa	10.49	11.6
Meghalaya	9.00	12.5
Madhya Pradesh	12.91	14.4
Karnataka	8.02	34.2
Himachal Pradesh	10.54	20.1
Haryana	19.52	12.7
Gujarat	26.14	8.5
Bihar	11.51	36.3
Assam	6.81	23.8
All India	18.09	14.4

Table 3. States falling in different categories with triennium average area and production ending 2002-03 and 2010-11, respectively.

Scenario	Name of the states	TE (2002-03)		TE (2010-11)	
		Area (#)	Production (##)	Area (#)	Production (##)
I	West Bengal & Punjab	370.87 (29.60)	8820.30 (37.74)	474.93 (25.78)	12806.30 (33.91)
II	Uttar Pradesh, Haryana & Gujarat	453.27 (36.18)	7547.70 (32.30)	626.57 (34.01)	14802.73 (39.19)
III	Madhya Pradesh, Karnataka, Himachal Pradesh, Bihar & Assam	314.20 (25.08)	3051.40 (13.05)	556.83 (30.23)	7553.50 (20.00)
IV	Tripura, Tamil Nadu, Orissa & Meghalaya	36.70 (2.92)	419.97 (1.80)	39.40 (2.14)	475.35 (1.26)

values in parenthesis represent the percentage of national figure; TE = triennium ending average; # = thousand ha; ## = thousand t; Scenario I: High yield-high yield variability; II: High yield-low yield variability; III: Low yield-high yield variability; IV: Low yield-low yield variability; CV of potato yield = 14.4%.

Pradesh, Haryana and Gujarat), the area has increased substantially because the growth in potato area in these states was higher than that at national level. The states (Madhya Pradesh, Karnataka, Himachal Pradesh, Bihar and Assam) were under low yield and high yield variability category. These states have registered increase in area as well as production. The states (Tripura, Tamil Nadu, Orissa and Meghalaya) were under low yield and low yield variability category, which showed decline in area and production in percentage term, though the absolute level of area and production increased.

In the high yield and high yield variability category states, attempt should be made to reduce yield variability and thereby ensure stability in production. On the other hand, in the states with low yield and high yield variability, technologies that raise yield as well as reduce variability should be developed and adopted. In the low yield and low yield variability states, yield increasing strategies like provision of healthy seed potato at reasonable price, timely availability of consumable farm inputs and weather/ disease forecast should be the focus. The results

are in close agreement to the findings of Chakraborti (1989); Jain (1990) and Samanse *et al.* (1990).

Relative contribution of area and yield

The decomposition analysis of production into 'yield effect', 'area effect' and 'interaction effect' reveals the states where production can be increased by increasing area or by augmenting the yield or by increasing both. It is helpful in identifying states where area expansion is possible and where it is constrained by relative yield advantage. The results showed that the contribution of area was much higher than that of yield in accelerating the production growth during last decade (Table 4). At the national level the contribution of yield was 11.76 % in comparison to area effect (82.62 %). States like Tripura and Himachal Pradesh registered negative area effect to the extent of -12.44 % and -48.33 % respectively, while the yield effect was highest in Himachal Pradesh (137.81 %). The yield component was found to be driving force for the increase in potato production in many states. Similar results were observed by Gupta (1989) and Kumar and Singh (1992). Thus in India, both yield

Table 4. Per cent contribution of area and yield to production of potato in different states of India during triennium average ending 2010-11 over triennium average ending 2002-03.

State	Area effect	Yield effect	Interaction effect
West Bengal	66.38	26.22	7.40
Uttar Pradesh	35.82	47.56	16.62
Tripura	-12.44	110.39	2.04
Tamil Nadu	0.00	100.00	0.00
Punjab	44.67	43.54	11.79
Orissa	61.52	30.40	8.08
Meghalaya	8.85	88.73	2.42
Madhya Pradesh	159.38	-38.08	-21.30
Karnataka	354.35	-133.32	-121.03
Himachal Pradesh	-48.33	137.81	10.52
Haryana	70.61	18.87	10.52
Gujarat	73.59	15.80	10.62
Bihar	38.44	27.80	33.76
Assam	127.76	-25.62	-2.14
India	82.62	11.76	5.62

and area have contributed towards increased potato production during previous decade.

CONCLUSIONS

The study carries out an empirical analysis of production performance and yield variability across important potato growing states of India for past decade *i.e.* 2001-2011 to find out growth trend of area, production and productivity and identify and classify the states into various categories on the basis of yield variability so as to make them enable to formulate appropriate strategies to sustain or enhance production and reduce yield variability. Highest area growth was seen in Bihar and Gujarat, impressive production growth was observed in Bihar, UP and Gujarat however yield growth was phenomenal in Bihar. Emergence of potato processing industry in certain states and realization of lucrative prices can be the important growth triggers for future as farmers can replace other crops to improve their farm net returns. Lowest yield variability

was seen in UP, Haryana and Gujarat only. In the states where high yield variability persists attempt must be made to develop technologies and methods that raise yield and reduce yield variability.

In north Indian states damage from cold wave and losses due to pests and diseases are some of the important reasons of yield variability. Further, premature harvesting to capture higher prices is also an important factor for yield variability. Thus extension efforts should be made to promote the cultivation of the early rabi season (October to March) potato. In the states with low yield, issues related to agronomic practices, extension education to the farmers and availability of critical inputs like quality seed must be addressed. Contribution of area was substantially high as compared to yield in enhancing the production in most of the states. Since further area increase is constrained, yield increasing measures must be developed to make potato an economically viable enterprise

for small and marginal farmer as high per unit returns can only be realized through productivity enhancement.

LITERATURE CITED

- Anonymous (2012) Agricultural statistics at a glance. Directorate of Economics and Statistics, Ministry of Agriculture, New Delhi
- Bardhan RSK, Waker TS, Khatana VS, Saha NK, Verma VS, Kadian MS, Haverkort AJ and Bowen WT (1999) Intensification of potatoes in rice based cropping systems: a rapid appraisal in West Bengal. International potato centre (CIP), Lima, Peru. Social Science department Working paper No. 1999-1: 24p
- Chakraborti S (1989) Wheat productivity: an exploration of interstate variation. *Economic Affairs, Calcutta* 34(3): 182-85
- Chandran KP, Pandit A and Pandey NK (2005) Evaluation of models for estimating potato production trends in major states of India. *Potato J* 32(3-4):219-20
- CPRI (2011) Vision 2030. Central Potato Research Institute, Shimla, India: 40p
- Gupta SK (1989) Aspatio-temporal analysis of non-traditional edible oil seeds in India; 1970-71 to 1985-86. *Agril Situation India* 44(7): 567-70
- Horton D (1987) Potatoes: production, marketing and programs for developing countries. West view Press, Boulder: 244p, ISBN (US) 0-133-7197-X
- Jain RP (1990) High yielding varieties and correlated response of yield of wheat and rice in Uttar Pradesh. *Indian J Agril Econ* 45(1): 61-68
- Kumar PR and Singh NP (1992) Growth analysis of rapeseed mustard. *Agril Situation India* 44(11): 915-20
- Pandey SK and Sarkar D (2005) Potato in India: emerging trends and challenges in the new millennium. *Potato J* 33(3-4): 93-104
- Pandit A and Chandran KP (2011) Growth of potato production in India: a non-metric analysis of time series data. *Potato J* 38(1): 32-40
- Prajneshu and Chandran KP (2005) Computation of compound growth rates in agriculture: revisited. *Agril Econ Res Review* 18(2): 317-24
- Rana Rajesh K, Pandey NK, Pandit Arun SK (2009) Profitability analysis of Kufri Chipsona-1 cultivation in Uttar Pradesh. *Potato J* 36(3-4): 166-72
- Sananse SL, Borude SG and Patil HN (1990) A study on variability and trends in area, production and productivity of rice in Konkan region of Maharashtra. *J Maharashtra Agril Univ* 15(1): 86-89
- Scott GJ and Suarez V (2011) Growth rates for potato in India and their implications for industry. *Potato J* 38(2): 100-12
- Singh N and Singh H (2007) Productivity and econometrics of potato under irrigated conditions in Western Uttar Pradesh. *Potato J* 34(1-2): 119-20

MS received: 14 January 2013; Accepted: 17 April 2013