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**Original Research Article**

# Growth and Instability Analysis of Potato Cultivation in Pithoragarh District of Uttarakhand

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**A B S T R A C T**

This paper analyses on area, production and yield of potato to understand the question of instability in potato production in most important district of Uttarakhand. It can be inferred that there are wide fluctuations in area, production and productivity. Overall area effect is more important factor for increasing the production of the crop. The analysis shows that the compound annual growth rates of area, production and yield of potato have been positive. During the period under study the important source of growth in potato production has been the area, which contributed about 97 per cent of total growth in production. The highest level of instability observed was in case of production followed by productivity and area. Further, major source of instability in potato production was due to productivity effect, which contributed about 57 per cent instability, while interaction effect played very minimal role in production instability. The important factor responsible for increase in instability in area under potato was the lagged area, while the lagged relative price and rainfall during previous year reduced the same. Further, the lagged production and time trend increased the instability in potato productivity, while the relative price and rainfall during previous year reduced the same. The situation warrants an assured pricing policy with the objective to obtain acreage and productivity gains; and evolution of location-specific technologies for different agro-ecological situations.

**Keywords**

Instability, Compound growth rate, Decomposition, Pithoragarh

## Introduction

Potato (*Solanum tuberosum* L.) is the fourth most important food crop in India after rice, wheat and maize. It is the cheapest and richest source of nutrients and calories with comparatively higher carbohydrate, fibre, vitamin C and Vitamin B than other major food crops (Bisht and Sharma (1997). It is a short duration and important cash crop with wider flexibility in planting and harvesting dates. Potato is the most important non-cereal crop of the world, with a production of 377 million tonnes from an area of 19.25 million hectares with an average productivity of 19.58 tonnes per ha in 2016 (FAO STAT). In india the area, production and productivity of potato during 2017-18 was 2.14 million hectares, 51.31 million tonnes and 23.96 tonnes per ha, respectively against 0.24 million hectares, 1.66 million tonnes and 6.91 tonnes per ha, respectively during 1950-51. In India, five major potato producing states viz. Uttar Pradesh, West Bengal, Bihar, Gujrat, Madhya Pradesh, together produce about four-fifth of total production in the country. And most of potato in India (85-90%) is produced during rabi season. In

kharif season it is cultivated in Karnataka, Maharashtra, Himachal Pradesh and Uttarakhand.

Uttarakhand produces 112259 tonnes of potato annually from an area of 12422 hectares with a productivity of 90.37 q/ha, but this productivity in Uttarakhand is less than half of the same at national level (205 q/ha) (Agriculture Statistics Data, 2015-16). In Uttarakhand about 95 percent of potato crop is grown in hilly areas with about 93 percent of total potato produced in the state. Although, potato in hilly regions of the state is grown in bothkharif as well as rabi seasons, but it is mainly grown in kharif season because of suitability of kharif season climatic conditions and unsuitable and erratic climatic conditions during rabi season. Potato cultivation in kharif season, which is sown in April–May and harvested in July–September, provides a great advantage to the producers, since it serves as off-season crop for the people in plain areas and enables them fetch a premium price in the market.

The major potato growing hilly districts of Uttarakhand are Nainital, Uttarkashi, Chamoli, Pithoragarh, Dehradun, etc. Pithoragarh, a hilly district of Uttarakhand covering about 1027 hectares of area under potato cultivation, produces 11440 tonnes of potato with a productivity of 111.39 quintals per ha during 2015-16, which is higher than average productivity in the state. Potato is among the popularly cultivated crops in Pithoragarh and has evidenced expansion of area from merely 667 hectares during 2004-05 to 1027 hectares during 2015-16, coinciding with increased production level from 7337 tonnes to 11440 tonnes during similar period. However, potato productivity in Pithoragarh is higher than that in other hilly districts of the state as well as average productivity of the state, but the same has become almost stagnant over the years and only a nominal increase in the same has been observed from 110 quintal per ha in 2004-05 to 111.39 quintal per ha in 2015-16.

The stagnated growth behaviour of potato productivity in Pithoragarh may be due to poor attention on fertilizer application, availability of disease resistant high yielding varieties, knowledge dissemination of latest production technology, etc. District Pithoragarh has a potential to influence the overall potato production scenario in the state, therefore growth rates of area, production and productivity of potato in the district need to be monitored.

Despite a leading role of the district in potato area, production and productivity in the state, the same have been fluctuating from one year to another, the level of production in the district during the year 2004–05 was 7337 tonnes, which reached to 20794 tonnes in the year 2013–14, but further declined to 11440 tonnes in 2015–16. Similar pattern has been observed in area and productivity, primarily due to variations in market prices of potato and competing crops, besides variation in climatic conditions.

A better understanding of different sources of growth and their magnitude would provide empirical support for the design of policies to improve the pace of agricultural growth (Joshi *et al.*, 2004). So, estimating growth rates and decomposition analysis of agricultural growth are very important issue from the view point of policy makers. In view of the above this study was taken up to estimate the growth rates of area, production and productivity of potato; to estimate the contribution of area and productivity in production growth; and to measure instability in area, production and productivity of potato, and ascertain the causes of instability thereof in Pithoragarh district of Uttarakhand.

## Materials and Methods

The secondary data related to area, production and productivity; prices of potato along with the competing crop (common bean) and rainfall data of district Pithoragarh of Uttarakhand for a period of 12 years from 2004–05 to 2015–16 were collected from different sources such as journals, publications of District Agriculture Office, Directorate of Agriculture, Directorate of Economics and Statistics, agriculture produce markets of Uttarakhand, official website of National Aeronautics and Space Administration, etc.

## Growth rate analysis

The time series analysis of area, production and productivity of potato for the period 2004-05 to 2015-16 was done. The growth rates in area, production and productivity were worked out using growth function of the following form as suggested by Dandekar (1980) and Agarwal *et al.* (2014):

$Y_t = ab^t$
$\text{Log } Y_t = \log a + t \log b$

Assuming log b = B, the same expression could be put as:

$\log Y_t = \log a + Bt$

Where,
$Y_t$ = Area / production / productivity in the year't'
t = Time period in years
a = Intercept indicating Y in the base year (t=0)
b=Regression coefficient

The 'a' and 'b' are calculated by applying the method of Least Squares. Finally the compound growth rates were worked out as described below:

Compound annual growth rate (CAGR) (%) = (Antilog B – 1) x 100

## Decomposition analysis

The total change in production was decomposed into three effects i.e. area effect, yield effect and the interaction effect. To measure the contribution of area and productivity towards the growth of production, decomposition analysis was used. The formula used:

$\Delta P = \Delta A \times Y_0 + \Delta Y \times A_0 + \Delta A \times \Delta Y$ or

$$100 = \frac{\Delta A.Y_0 \times 100}{\Delta P} + \frac{\Delta Y.A_0 \times 100}{\Delta P} + \frac{\Delta A.\Delta P \times 100}{\Delta P}$$

Change in production = area effect + yield effect + interaction effect

Where,
$\Delta P$ = change in production
$Y_o$ = yield in base year
$Y_n$ = yield in current year
$A_o$ = area in base year
$A_n$ = area in current year
$\Delta A$ = change in area
$\Delta Y$ = change in yield

## Instability analysis

Instability is the deviation from the trend. To measure instability in area, production and productivity of potato, coefficient of variation formula is of the following form:

$$\text{Coefficient of variation (CV)} = \left[\frac{\sigma}{\overline{X}}\right] \times 100$$

Where,
$\sigma$ = Standard deviation of variable concerned i.e. area/production/productivity
$\overline{X}$ = Mean value of the variable.

## Causes of instability in area, production and productivity

The causes of area, production and productivity were determined in the following ways;

## Causes of production instability

For decomposition of production instability, following model was employed:

Production function $P = A \times Y$

Where,
P = Production, A = Area Y= Yield

By taking log, we obtained,

$\log P = \log A + \log Y$

Taking the variance of this function, we have

$$V(\log P) = V(\log A) + V(\log Y) + 2\,(\text{Cov} \log A \times \log Y)$$

Production instability =

Area instability factor + Yield instability factor + Interaction factor

## Causes of acreage instability

In order to examine the causes of instability in area, linear and double-log forms of acreage instability model were tried and finally following double log form was selected on the basis of value of coefficient of multiple determination ($R^2$), absence of multicollinearity and significance of explanatory variables.

Double-log form: $\log A_t =$

$b_0 + b_1 \log A_{t-1} + b_2 \log PR_{t-1} + b_3 \log W_{t-1} + b_4 \log RY_t + U_t$

Where,
$A_t$ = Area under potato in current year t
$A_{t-1}$ = Area under potato in the previous year (t-1)
$PR_{t-1}$ = Price relative of potato with respect to competing crop (common bean) in previous year (t-1).
$W_{t-1}$ = Rainfall during the growing period of potato in the previous year (t-1).
$RY_t$ = Yield risk; calculated as coefficient of variation of past 3 years yield of the crop.
$b_i$ = regression coefficient for $i^{th}$ variable (i = 0,1, 2, 3, 4)
$U_t$ = error term

Price relative for potato with its competing crop was calculated as under;

$$PR_{t-1} = \frac{\text{Average price of common bean (Rs./quintal)}}{\text{Average price of potato (Rs./quintal)}}$$

## Causes of productivity instability

The yield instability models in linear and double log forms were tried; and linear function in the following form was finally selected on the basis of 'best fit' criteria.

Linear form:

$Y_t = b_0 + b_1 Y_{t-1} + b_2 P_{t-1} + b_3 W_{t-1} + b_4 T + U_t$

Where,
$Y_t$ = Productivity of potato in current year (t)
$Y_{t-1}$ = Productivity of potato in previous year (t-1)
$PR_{t-1}$ = Price relative of potato with respect to competing crop (common bean) in previous year (t-1).
$W_{t-1}$ = Rainfall during the growing period of potato in the previous year (t-1)
T = Time trend. This variable was incorporated to capture the effect of improvement in production technology over years (T=1 for the year 2004-05 to T = 12 for

the year 2015–16).
$b_i$ = regression coefficient $i^{th}$ variable (i = 0,1, 2, 3, 4)
$U_t$ = error term

## Results and Discussions

The growth rates, factors affecting the production growth and instability analysis of potato cultivation in Pithoragarh district are discussed under the following heads:

### Analysis of growth in area, production and productivity of potato

The growth of a variable indicates the rate at which the variable changes over time. Growth rates of area, production and productivity are presented in Table 1.

A perusal of the table indicates that area under potato cultivation registered a positive growth rate of 5.13 percent per annum during the period of 12 years from 2004–05 to 2015–16. Though, the production of potato moved along a zigzag path over the period under study, but showed an overall upward trend with the positive growth rate of 8.22 percent per annum. However, the productivity of potato also shown a positive growth with a magnitude of 2.84 percent per annum, but the regression coefficient of the same was found non-significant. It may be noted that the growth rate in productivity was lower than that in area and production of potato in the district during period under consideration. This impressive growth in potato production led by expansion in area under crop in the district was due to unavailability of suitable alternative cash crop in the kharif season to the farmers.

### Decomposition of growth in potato production

The growth in production of a commodity is assumed to be comprised of area effect, productivity effect and interaction effect. An understanding of source-wise magnitude of growth in production of an agricultural commodity will help devise better policy by the policy makers. The growth in potato production in Pithoragarh district has been decomposed into area, yield and interaction effects (Table 2). An overview of the table shows that major source of growth in potato production in the district was increase in area under crop. The area effect is the dominant factor contributing the production. Area effect alone accounted for about 96.52 percent growth in potato production in the district, while only 2.26 percent growth in the same was attributed to increase in yield of the crop. The effect of interaction between area and yield on growth in potato production was very small (1.22%). The results are in collaboration with the studies conducted by Sagolsem *et al.*, (2017).

It can be inferred that during a period of 12 years from 2004–05 to 2015–16 there has been a very minimal improvement in productivity of the crop in the district either due to lack of suitable variety seeds, lack of standardized crop management practices or due to poor geographical situation and poor infrastructure facilities or due to above all.

### Analysis of instability in area, production and productivity of potato in Pithoragarh

The instability in area, production and productivity of potato in Pithoragarh district has been given under two heads viz. (i.) level of instability (ii.) decomposition of instability in potato production and (iii.) causes of instability.

### Level of instability in area, production and productivity of potato over time

The instability in area, production and productivity of potato in Pithoragarh district measured in terms of coefficient of variation

(CV) is presented in table 3. A perusal of the table shows that the instability was the highest in production with a magnitude of coefficient of CV 44.29 percent, followed by productivity and area with the magnitudes of CV 26.18 percent, 24.43 percent, respectively. A high level of instability in production implies that an emphasis should be given on production stabilization so that the district can achieve a higher rate of success in terms of potato production. The stability in area under potato cultivation implies that potato crop hold a significant portion in cropping pattern of the district.

## Decomposition of instability in potato production in Pithoragarh

In order to ascertain factors responsible for instability in potato production the decomposition analysis was done and the results of decomposition analysis have been presented hereunder in Table 4. It can be depicted from the table that yield instability factor was the prime source of instability in potato production, accounting for about 57 percent of instability.

The contribution of acreage instability factor was slightly more than 42 percent of total production instability. However, yield and acreage instability together account for approximately 99 percent of total production instability and the contribution of interaction factor was relatively negligible (about one percent). Thus, it can be concluded that productivity and area factors were equally important to stabilize potato production in the district.

## Causes of area instability in area, production and productivity of potato in Pithoragarh

The instability in area, production and productivity is caused differently by different factors. Factors cause instability in area, production and productivity have been dealt under following heads.

## Causes of instability in area

In order to ascertain factors causing instability in area under potato cultivation, different combinations of price and non-price factors were hypothesized as explanatory variables. Results of regression analysis have been presented in Table 5. Table shows that lagged area under potato cultivation ($A_{t-1}$), lagged price relative ($PR_{t-1}$) and yield risk ($RY_t$) along with rainfall in previous year ($W_{t-1}$) together explained about 79 percent of instability in area under potato cultivation in the district. It is also evident from the table that lagged area played an important role in determining area under potato cultivation in current year. It may be noted that common bean grown in the same season and competes with potato crop for production resources, hence was considered as competing crop.

The lagged price relative of potato with reference to competing crop i.e. common bean was taken as explanatory variable for describing the relation with area under potato cultivation in the current year. It was found that lagged price relative showed negative impact on the area under potato in the current year. Singh and Srivastava (2003) in their study also found that the lagged area by one year and price relative affect the sugarcane area instability significantly.

Further, the rainfall during potato growing season (kharif season) in the previous year also showed a negative and significant impact on area under potato cultivation in the district in the current year, implying that excess rainfall suppressed the area expansion of crop. However, the direction of regression coefficient of yield risk (coefficient of variation) with area under potato in the

current year was negative (-0.087), but was found insignificant.

## Causes of instability in productivity

The results of regression analysis with the regressors viz. lagged yield, lagged price relative of potato with respect to competing crop, lagged year rainfall and time trend, while the potato productivity as dependent variable, are presented in Table 6. A glance on the table reveals that the lagged yield, lagged price relative, time trend and lagged rainfall together explained about 71 percent of instability in potato productivity.

The regression coefficient of 'Trend' was found to be significant, which indicates that improvement in technology over years would have increased the yield considerably. It is also clear from the table that on the basis of magnitude of regression coefficient, lagged price relative was the second most important factor affecting the potato productivity in the area, which exercised negative impact on potato productivity. Singh and Srivastava (2003) also found that lagged price relative and time trend had significant impact on current year productivity. These results highlighted the significant role of prices in motivating the potato growers to adjust the level of inputs like fertilizer, pesticides, etc. and thereby improving the potato productivity.

Further, the regression coefficient of lagged productivity was observed to be positive (0.340) and significant at 20 percent level of significance. This means that the potato productivity in the previous year affects the current year productivity in the positive direction. However, potato productivity also showed a significant but negative relationship with rainfall, thereby indicating that excess rainfall in the previous year during growing season would discourage the potato growers to allocate more resources for potato cultivation in the current year.

**Table.1** Growth rate of area, production and productivity of potato in Pithoragarh district

| S. No. | Variables | Area | Production | Productivity |
|---|---|---|---|---|
| 1. | Constant | 6.527 | 8.594 | 2.067 |
| 2. | Regression coefficient | 0.050* | 0.079* | 0.028 |
| 3. | Standard error | 0.017 | 0.026 | 0.026 |
| 4. | $R^2$ | 0.457 | 0.473 | 0.109 |
| 5. | Growth rate (%) | 5.127 | 8.220 | 2.839 |

Note: *indicate level of significance at 5%

**Table.2** Decomposition of growth in potato production in Pithoragarh district

| S. No. | Components | Value |
|---|---|---|
| 1. | Area effect ($\Delta A.Y_0$) | 3960.00 (96.52) |
| 2. | Yield effect ($\Delta Y.A_0$) | 92.87 (2.26) |
| 3. | Interaction effect ($\Delta A.\Delta Y$) | 50.13 (1.22) |
| 4. | Total change in production | 4103 (100.00) |

**Note**: Figures in parentheses indicates the percentage of total change in production

**Table.3** Level of instability in area, production and productivity of potato in Pithoragarh

| S. No. | Particulars | Area (ha) | Production (Tonnes) | Productivity (Tonnes/ha) |
|---|---|---|---|---|
| 1. | Mean value | 976.08 | 9745.75 | 98.82 |
| 2. | Standard deviation | 238.43 | 4316.72 | 25.88 |
| 3. | Coefficient of variation (C.V.) | 24.43 | 44.29 | 26.18 |

**Table.4** Decomposition of production instability

| S. No. | Particulars | Source of instability | |
|---|---|---|---|
| | | Value | Percentage |
| **1.** | Area instability factor (Variance in log A) | 0.0717 | 42.22 |
| **2.** | Productivity instability factor (Variance in log Y) | 0.0961 | 56.62 |
| **3.** | Interaction factor (2 Cov log A.log Y) | 0.0020 | 1.16 |

**Table.5** Estimated regression coefficients of factors causing instability in area under potato cultivation in Pithoragarh

| S. No. | Variables | Coefficients | Standard Error |
|---|---|---|---|
| 1. | Intercept | 5.657 | 1.090 |
| 2. | Area under potato in previous year ($A_{t-1}$) | 0.891* | 0.201 |
| 3. | Price relative of potato with respect to competing crop (common bean) in previous year($PR_{t-1}$) | -0.892** | 0.362 |
| 4. | Rainfall during growing period in previous year ($W_{t-1}$) | -0.420*** | 0.193 |
| 5. | Yield risk ($RY_t$) | -0.087 | 0.066 |
| 6. | Coefficient of multiple determination ($R^2$) | 0.789 | |

**Note:***,**and*** indicate 1%, 5% and 10% level of significance respectively

**Table.6** Estimated regression coefficients of factors causing instability in potato productivity in Pithoragarh

| S. No. | Variables | Coefficients | Standard Error |
|---|---|---|---|
| 1. | Intercept | 115.561 | 30.151 |
| 2. | Productivity of potato in previous year ($Y_{t-1}$) | 0.340*** | 0.189 |
| 3. | Price relative of potato with respect to competing crop (common bean) in previous year ($PR_{t-1}$) | -6.487* | 2.552 |
| 4. | Rainfall during the growing period of potato in previous year (W t-1) | -0.235** | 0.116 |
| 5. | Time trend (T) | 5.111* | 1.704 |
| 6. | Coefficient of multiple determination ($R^2$) | 0.709 | |

*, **and *** indicate 5%, 10% and 20% level of significance respectively

In conclusion, the study revealed a moderate to high growth in area, production and productivity of potato during a period of 12 years 2004-05 to 2015-16. This rising trend in the growth characterized by high degree of variability is a sign of vulnerability in the growth process. A widespread fluctuation in the area, production and productivity of such a crop shatters the rational expectations of the cultivators and leads to many disruptive consequences. Thus, there is a need for proper policies and programmes to concentrate on increasing the production and productivity of potato by introducing high yielding variety seeds and by increasing area under cultivation to include non-traditional areas and encourage the farmers to perform recommended package of practices in terms of intercultural operations, fertilizer application and plant protection, etc. A low contribution of yield in growth of potato production in Pithoragarh is indicating an undesirable phenomenon. This calls for adequate measures to improve location specific production technology through research and development and extension efforts and also through assured input supply mechanism. However, lagged price relative was found dominant factor, exercised significant impact on potato productivity as well as on area under potato in the current year. Thus, the overall situation warrants an assured pricing policy with the objective to obtain acreage and productivity gains. The research and development programs must address the problem of evolution of location-specific technologies for the agro-ecological situation of the district.

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