J. Farm Sci., 36(4): (393-397) 2023

RESEARCH PAPER

Dynamics of production and export of potato from India: Markov chain approach

SHREESHAIL RUDRAPUR[1] AND DEEPA HIREMATH[1]

[1]Department of Agricultural Economics
Navsari Agricultural University, Navsari, Gujarat - 396 445, India
E-mail: shreeshail@nau.in

(Received: November, 2023 ; Accepted: December, 2023)

DOI: 10.61475/JFS.2023.v36i4.15

Abstract: The present study was conducted to know the growth in area, production, productivity, and export of potatoes from India as well as to understand the change in direction and magnitude of the export of Indian potatoes to different countries. The study is based on secondary data collected from different e-resources like *APEDA (Agricultural and Processed Food Export Development Authority)* and *Indiastat.* The data was collected for a period of 15 years from 2006-07 to 2020-21. The study revealed that all the variables like area, production, productivity, export quantity, and export values showed positive growth rates and were found to be significant at 1 percent. Markov chain analysis and transition probability matrix indicated that Nepal, Oman, and other minor countries pooled under the category "other" were found loyal to India in importing Indian potatoes since they retained a considerable share of their trade whereas Saudi Arabia is less stable and Malaysia is least stable among the competing countries considered over the study period of 15 years. Hence India can rely upon Nepal, Oman, and other minor countries in the export of its potato and therefore policies need to be oriented towards these countries in the export of potatoes in the near future.

Key words: Export, Growth rate, Instability, Markov chain analysis, Potato

Introduction

India has been bestowed with wide range of climate and physic-geographical conditions as such is most suitable for growing various kinds of horticultural crops such as fruits, vegetables, flowers, nuts, spices and plantation crops. Fruits and vegetables are important supplements to the human diet as they provide the essential minerals; vitamins and fibre required for maintaining good health. Fruits and vegetables account for nearly 90 per cent of the total horticulture production in the country. India produces 11.78 per cent of world's vegetable production. Thousands of farmers, businessmen and industries (seeds, fertilisers, pesticides, *etc*.) are dependent on vegetables. India's geographical condition varies from region to region has got immense potential for vegetable production. India produced 191 million metric tonnes of vegetables during 2019-20 (National Horticultural Board, 2020). The area under cultivation of vegetables was stood at 10.35 million hectares. According to FAO (2019), India is the largest producer of ginger and okra amongst the vegetables and ranks second in the production of potatoes, onions, tomatoes, cauliflowers, brinjal, cabbages, *etc*. The vast production base offers India tremendous opportunities for export. During 2020-21, India exported vegetables worth ₹ 4,971.22 crores. Onions, mixed vegetables, potatoes, tomatoes and green chillies contribute largely to the vegetable export market. Potato (*Solanum tuberosum*) is one of the most important food crops across the world after rice and wheat. Asia alone contributes around half of the world's potato production, out of which China and India accounting for nearly 38 per cent of the production. India ranks 3rd in the potato cultivated area and 2nd in the production in the world after China. During 2020-21, World's potato production was increased from 354.8 million tonnes to 359.07 million tonnes. The value of export was around 1.678 per cent of total world's export. The area under potato in India was increased from 20.51 lakh hectares during 2019-20 to 22.48 lakh hectares during 2020-21 whereas its production was increased from 485.62 lakh tonnes to 542.30 lakh tonnes. In India on an average, the domestic consumption of Indian potato varies from 320-350 lakh tonnes. Hence there is a lot of scope to export the Indian potato to the different countries. With thus backdrop the present study was undertaken to examine the growth and stability in area, production, productivity and export of potato and thereby changing magnitude and direction of trade in the export of Potato from India to different export destinations.

Material and methods

Data: Study is based on secondary data on area, production, productivity and export of Potato from India over the period of 15 years (2006-07 to 2020-21). The required data was collected from different sources like APEDA (Agricultural and Processed Food Export Development Authority) and Indiastat, *etc.*

Analytical techniques:

Growth rate analysis

For computing compound annual growth rate of area, production, productivity and export of Potato, the exponential function of the following form was used.

$$Y = a\, b^t e^{Ut} \quad \text{.....(1)}$$

Where,

Y = Area /production /productivity/export

a = Intercept

b = Regression coefficient

'a' and 'b' are the parameters to be estimated

t = time period

U_t = Disturbance term in year 't'

The equation (1) was be transformed into log linear form and written as;

$$\log Y = \log a + t \log b + U_t \quad \text{..... (2)}$$

Equation (2) was estimated by using Ordinary Least Squares (OLS) technique.

Compound annual growth rate (g) was then computed by using the formula;

$$g = (b - 1)*100 \quad \text{..... (3)}$$

Where,

g: Compound growth rate in per cent per annum

b: Antilog of log b

The standard error of the growth rate was estimated and tested for its significance with student's t test.

Instability analysis

The coefficient of variation was used as measure of the variability in area under cultivation, production, productivity and export of Potato. The coefficient of variation or index of instability was computed by using the following formula;

$$CV = \frac{\text{Standard Deviation (s)}}{\text{Mean (X)}} \times 100 \quad \text{.....(4)}$$

Linear trend was fitted to the original data of area, production, productivity and export of Potato from the country for a period of 15 years. The trend coefficients were tested for their significance. Whenever the trend of series found to be significant; the variation around the trend rather than the variation around mean was used as an index of instability. The formula suggested by Cuddy and Della was used to compute the degree of variation around the trend. The Coefficient of variation was multiplied by the square root of the difference between the unity and coefficient of multiple determinations (R^2) to obtain the Instability Index.

$$\text{Instability index } (I_x) = CV* [(1-R^2)]^{1/2} \text{.....(5)}$$

Markov chain model

Annual export data of Potato was used for analysing the direction of trade and changing pattern of export of Indian Potato. The trade directions of Indian Potato exports were analysed using the first order Markov chain approach (Naik and Nethrayini, 2017). The lingo software was adopted to study the transition probability matrix. Central to Markov chain analysis is the estimation of the transitional probability matrix 'p' whose elements, p_{ij} indicate the probability of exports switching from country 'i' to country 'j' over time. The diagonal element p_{ij} where i=j, measures the probability of a country retaining its market share or in other words, the loyalty of an importing country to a particular country's exports.

Annual export data for the period 2006-07 to 2020-21 for the period of 15 years was used to analyse the direction of trade and changing pattern of Indian Potato exports. The average exports to a particular country was considered to be a random variable which depends only on the past exports to that country, which can be denoted algebraically as

$$E_{jt} = \sum_{i=1}^{n} [Ei_{t-1}] p_{ij} + e_{jt} \quad \text{..... (6)}$$

Where,

E_{jt} = exports from India to the j^{th} country in the year t

Ei_{t-1} = exports of i^{th}country during the year t-1

p_{ij} = the probability that exports will shift from i^{th} country to j^{th}country

e_{jt} = the error term which is statistically independent of Ei_{t-1}

n = the number of importing countries

The transitional probabilities p_{ij}, which can be arranged in a (c x n) matrix, have the following properties.

$$\sum_{i=1}^{n} p_{Ij} = 1 \text{ and } 0 \text{ £}p_{ij}\text{£ } 1$$

Thus, the expected export share of each country during period 't' was obtained by multiplying the exports to these countries in the previous period (t-1) with the transitional probability matrix. The probability matrix was estimated for the period 2006-07 to 2020-21. Thus, transitional probability matrix (T) was estimated using linear programming (LP) framework by a method referred to as minimization of Mean Absolute Deviation.

Min. OP* + I e

Subject to

X P* + V = Y

GP* = 1

p* ³ 0

Where

p* is a vector of the probabilities P_{Ij}

O is the vector of zeros

I is an appropriately dimensioned vector of export.

e is the vector of absolute errors

Y is the proportion of exports to each country.

X is a block diagonal matrix of lagged values of Y

V is the vector of errors

G is a grouping matrix to add the row elements of p arranged in p* to unity.

Results and discussion

Growth and stability in area, production, productivity and export of Indian potato

Growth and stability in area, production, productivity and export of potato from India for the period of 15 years (2006-07 to 2020-21) are depicted in Table 1. It is evident from the table that area under potato was 1482.30 thousand hectares during

Table 1. Growth rate and stability in area, production, productivity and export of Indian potato

Year	Area	Production	Productivity	Export	
	(000'ha)	(000' MT)	MT/ha	Quantity(000'MT)	Value Crore ₹
2006-07	1482.30	28599.50	19.30	89.02	57.70
2007-08	1795.00	34658.30	19.30	78.45	41.43
2008-09	1828.30	34390.90	18.80	184.96	115.04
2009-10	1835.30	36577.30	19.90	94.09	74.21
2010-11	1863.20	42339.40	22.70	185.95	155.20
2011-12	1907.00	41482.80	21.80	193.09	133.45
2012-13	1992.20	45343.60	22.80	163.19	148.72
2013-14	1973.20	41555.40	21.10	220.93	251.14
2014-15	2075.90	48009.20	23.10	373.93	835.06
2015-16	2117.00	43417.00	20.50	279.65	361.55
2016-17	2179.00	48605.00	22.30	396.34	661.48
2017-18	2142.00	51310.00	24.00	395.75	411.82
2018-19	2173.00	50190.00	23.10	367.39	440.78
2019-20	2051.00	48562.00	23.70	427.08	580.09
2020-21	2203.00	56173.00	25.50	323.69	549.46
Mean	1974.49	43414.23	21.86	251.57	321.14
CAGR	2.08***	3.84***	1.73***	12.20***	20.95***
Instability Index	4.65	6.44	4.91	21.86	34.47

Note: *** Significant at 1 per cent level

2006-07 and it has been increased to 2203.00 thousand hectares during 2020-21 with the annual growth rate of 2.08 per cent. Table also indicates that there was increase in the productivity of the potato from 19.30 metric tonnes per hectare to 25.50 metric tonnes per hectare during the study period with the growth rate of 1.73 per cent per annum. It is evident from the table that since there was increase in both area and productivity; there was tremendous increase in the production of potato in the country from 28599.50 thousand metric tonnes in 2006-07 to 56173.00 thousand metric tonnes in 2020-21 with the annual growth rate of 3.84 per cent.

Apart from the area, production and productivity, the growth in export quantity as well as export value was also estimated and tested for its significance. The growth in export of potato in terms of both its export quantity and export value was higher compared to that of production. The export quantity has showed a positive growth rate of 12.20 per cent per annum whereas the export value has showed the annual growth rate of 20.95 per cent. Potato was exported to the different parts of the world to the extent of 89.02 thousand metric tonnes during 2006-07 and it has been increased to 323.69 thousand metric tonnes during 2020-21. The export value was also increased form ₹ 57.70 crores in 2006-07 to ₹ 549.46 crores during 2020-21. It is also important to notice from the table that, all the variables; such as, growth in area, production, productivity and export of potato were found to be significant at 1 per cent level (Kumaraswamy and Sekar, 2014).

In order to assess the consistency of growth performance of these variables, instability analysis was carried out and the instability indices are presented in the table 1. Cursory look at the table reveals that a significant instability was observed in growth of area, production, productivity and export of potato. Highest instability was observed in case of growth of export value of potato (34.47%) over the study period followed by its export quantity (21.86%) and its production in the country (6.44 %) whereas instability in the growth of area and productivity was under 5 per cent (4.65% & 4.91%, respectively). The results are in conformity with the findings of, Rudrapur (2022) and, Rudrapur and Hiremath (2023).

Direction of trade in export potato from India

The transition probability matrix presented in table 2 indicates the broad idea of change in the direction of trade in export of potato from India over the study period. The five major countries imported potato from India were Nepal, Oman, Saudi Arabia, Malaysia and Indonesia. The export to remaining countries was pooled under the category "other countries". The diagonal elements in the Transitional Probability Matrix (TPM) indicate the probability of retention of the previous year's trade value by the respective country. The row values of the TPM represent the losses of trade to other countries whereas the column values indicate probability of gain in the trade from the other competing countries by a particular country.

It is evident from the table 2 that among the major importing countries of potato from India, Nepal was more stable and loyal

Table 2. Transition probability matrix of Indian potato to different destinations

	Nepal	Oman	Saudi Arabia	Malaysia	Indonesia	Others
Nepal	**0.5640**	0.0361	0.0000	0.0479	0.0000	0.3520
Oman	0.1398	**0.4660**	0.0000	0.0000	0.3942	0.0000
Saudi Arabia	0.6571	0.0000	**0.3429**	0.0000	0.0000	0.0000
Malaysia	0.8002	0.0000	0.0000	**0.1998**	0.0000	0.0000
Indonesia	0.4524	0.0000	0.1188	0.1679	**0.2608**	0.0000
Others	0.5428	0.0000	0.0000	0.0000	0.0000	**0.4572**

Table 3. Actual and projected exports of Indian potato (Crore Rs.)

Year	Nepal		Oman		Saudi Arabia		Malaysia		Indonesia		Others	
	A	P	A	P	A	P	A	P	A	P	A	P
2006-07	16.11	31.88	0.20	0.67	0.03	0.01	1.14	1.00	0.00	0.08	40.23	24.06
	(27.91)	(55.24)	(0.35)	(1.17)	(0.04)	(0.02)	(1.97)	(1.73)	(0.00)	(0.14)	(69.72)	(41.70)
2007-08	24.36	23.06	0.00	0.88	0.00	0.00	0.24	1.21	0.00	0.00	16.83	16.27
	(58.79)	(55.68)	(0.00)	(2.12)	(0.00)	(0.00)	()0.57	(2.93)	(0.00)	(0.00)	(40.63)	(39.27)
2008-09	28.26	63.10	0.42	1.21	0.41	0.14	0.68	1.49	0.00	0.16	85.27	48.93
	(24.56)	(54.85)	(0.36)	(1.06)	(0.35)	(0.12)	(0.60)	(1.30)	(0.00)	(0.14)	(74.13)	(42.54)
2009-10	40.70	41.39	0.00	1.47	0.09	0.03	0.93	2.14	0.00	0.00	32.48	29.17
	(54.85)	(55.78)	(0.00)	(1.98)	(0.12)	(0.04)	(1.26)	(2.88)	(0.00)	(0.00)	(43.77)	(39.32)
2010-11	49.48	87.46	0.32	1.93	0.00	0.00	8.93	4.16	0.03	0.13	96.44	61.51
	(31.88)	(56.35)	(0.21)	(1.25)	(0.00)	(0.00)	(5.75)	(2.68)	(0.02)	(0.09)	(62.14)	(39.63)
2011-12	64.87	74.71	0.07	2.37	0.00	0.00	3.58	3.83	0.03	0.04	64.91	52.51
	(48.61)	(55.98)	(0.05)	(1.78)	(0.00)	(0.00)	(2.68)	(2.87)	(0.02)	(0.03)	(48.64)	(39.34)
2012-13	108.26	83.78	0.21	4.00	0.00	0.00	3.26	5.84	0.00	0.08	36.99	55.01
	(72.79)	(56.33)	(0.14)	(2.69)	(0.00)	(0.00)	(2.19)	(3.93)	(0.00)	(0.06)	(24.87)	(36.99)
2013-14	105.49	136.55	6.75	6.95	0.00	0.00	2.76	5.61	0.00	2.66	136.14	99.37
	(42.00)	(54.37)	(2.69)	(2.77)	(0.00)	(0.00)	(1.10)	(2.23)	(0.00)	(1.06)	(54.21)	(39.57)
2014-15	328.28	454.58	16.70	19.62	0.00	0.02	4.25	16.62	0.21	6.64	485.62	337.58
	(39.31)	(54.44)	(2.00)	(2.35)	(0.00)	(0.00)	(0.51)	(1.99)	(0.02)	(0.79)	(58.15)	(40.43)
2015-16	208.56	195.09	18.48	16.13	0.05	0.02	7.22	11.44	0.00	7.29	127.23	131.58
	(57.69)	(53.96)	(5.1)	(4.46)	(0.01)	(0.00)	(2.00)	(3.16)	(0.00)	(2.02)	(35.19)	(36.39)
2016-17	493.79	359.68	32.77	33.07	0.01	0.13	13.39	26.53	1.09	13.20	120.43	228.86
	(74.65)	(54.38)	(4.95)	(5.00)	(0.00)	(0.02)	(2.02)	(4.01)	(0.17)	(2.00)	(18.21)	(34.60)
2017-18	203.01	217.43	32.59	22.50	0.10	2.07	16.51	15.90	17.11	17.31	142.50	136.61
	(49.30)	(52.80)	(7.91)	(5.46)	(0.02)	(0.50)	(4.01)	(3.86)	(4.15)	(4.20)	(34.60)	(33.17)
2018-19	252.65	226.11	55.94	35.17	2.21	3.02	21.36	19.57	19.01	27.01	89.62	129.90
	(57.32)	(51.30)	(12.69)	(7.98)	(0.50)	(0.68)	(4.85)	(4.44)	(4.31)	(6.13)	(20.33)	(29.47)
2019-20	297.56	308.45	46.31	32.31	29.51	15.49	25.76	27.00	45.22	30.05	135.73	166.79
	(51.30)	(53.17)	(7.98)	(5.57)	(5.09)	(2.67)	(4.44)	(4.65)	(7.80)	(5.18)	(23.40)	(28.75)
2020-21	306.21	295.79	45.60	32.29	33.06	14.72	31.88	25.82	28.44	25.39	104.26	155.45
	(55.73)	(53.83)	(8.30)	(5.88)	(6.02)	(2.68)	(5.80)	(4.70)	(5.18)	(4.62)	(18.98)	(28.29)
2021-22	-	297.55	-	25.71	-	8.06	-	23.60	-	19.35	-	175.18
		(54.15)		(4.68)		(1.47)		(4.30)		(3.52)		(31.88)
2022-23	-	299.45	-	22.71	-	5.06	-	22.23	-	15.18	-	184.82
		(54.50)		(4.13)		(0.92)		(4.05)		(2.76)		(33.64)
2023-24	-	300.38	-	21.38	-	3.54	-	21.34	-	12.91	-	189.90
		(54.67)		(3.89)		(0.64)		(3.88)		(2.35)		(34.56)
2024-25	-	300.74	-	20.79	-	2.75	-	20.83	-	11.80	-	192.55
		(54.73)		(3.78)		(0.50)		(3.79)		(2.15)		(35.04)

Note: A-Actual, P- Projected, Values in the parenthesis indicate percentage to total

country to India in importing potato as the probability that the Nepal retained its original share in the trade from the previous year was 56.40 per cent. Nepal lost its trade share of about 35.20 per cent to other countries, 4.79 per cent to Malaysia and 3.61 per cent to Oman but at the same time Nepal gained considerable amount of trade from the competing countries like 80.02 per cent from Malaysia, 65.71 per cent from Saudi Arabia, 54.28 per cent from other countries, 45.24 per cent from the Indonesia and 13.98 per cent from the Oman.

Oman and the countries pooled under 'others' were also found to be stable in importing the potato from India and found loyal to India after Nepal. Oman retained its trade to the extent of 46.60 per cent whereas other countries retained around 45.72 per cent. Oman lost its trade share to Indonesia and Nepal (39.42% & 13.98%, respectively) and gained from only Nepal to the extent of just around 3.61 per cent. The other countries lost their trade to Nepal around 54.28 per cent. Saudi Arabia was also found stable in retaining the trade with 34.29 per cent probability. It lost its trade to Nepal to the extent of 65.71 per cent and gained from Indonesia around 11.88 per cent. Malaysia and Indonesia were less stable since the probability of retaining the trade from the previous year was less than the competing countries and it was under 30 per cent. Indonesia retained just 26.08 per cent of its previous year's trade and Malaysia retained just 19.98 per cent of the previous year's trade.

It can be concluded from the table that Nepal, Oman and other minor countries were found loyal to India in import of Indian potato since they retained considerable share of their trade whereas Saudi Arabia is less stable and Malaysia is least stable among the competing countries considered over the study period of 15 years. Hence India can rely upon Nepal, Oman and other minor countries in export of its potato and

therefore policies need to be oriented towards these countries in export of potato in the near future. Saudi Arabia is somewhat less stable in importing the Indian potato but policies need to think on the ways and means to attract the Saudi Arabia to improve its retention share in the future. Malaysia's retention share was under 20 per cent; hence India cannot rely on Malaysia since it's not so trust worthy in importing potatoes from India in the future (Kusuma *et al.,* 2014 and, Kusuma and Shreeshail, 2016).

Actual, estimated and projected export of Indian potato

The actual, estimated and projected market shares of export of Indian Potato to other countries have been represented in table 3. All the fie countries considered for the study (Nepal, Oman, Saudi Arabia, Malaysia and Indonesia) were showed an increasing trend in importing the Indian potato except the other minor countries grouped as 'others' in the study. It can be concluded from the table that all the five countries were able to gain the market share from the other minor countries.

The actual export share of Indian potato to Nepal was increased from 27.91 per cent during 2006-07 to 55.73 per cent during 2020-21, whereas its estimated value showed decreasing trend. The actual export market share of Indian potato to Oman was just 0.35 per cent during 2006-07 and has been increased to 8.30 per cent during 2020-21. The estimated value was also increased from 1.17 per cent to 3.78 per cent (Ganghadar, 2021).

Similarly, the actual as well estimated market share of Indian potato to Saudi Arabia also found to show an increasing trend. Its market share was just 0.04 per (actual) during 2006-07 and has been increased to 6.02 (actual) during 2020-21 where as its estimated value was also increased from 0.02 per cent to 2.68 per cent.

Malaysia also showed an increasing trend in terms of its market share in importing Indian potato. The actual market share of export of Indian potato to Malaysia was just 1.97 per cent during 2006-07 and it has been increased to 5.80 per cent during 2020-21 whereas its estimated market share also showed increasing trend. Interestingly, the export of Indian potato to Indonesia was nil during 2006-07 and it has been increased to 5.18 per cent (actual) and 4.62 (estimated) during 2020-21. On the contrary the market share of export of Indian potato to other minor countries had showed a decreasing trend. The market share of export of Indian potato to other minor countries was 69.72 per cent (actual) and it came down to just 18.98 per cent during 2020-21. Its estimated market share as was also decreased from 41.70 per cent to 28.29 per cent.

The export projections of Indian potato to different countries have also been depicted in table 2. It could be observed from the table that market share of export of Indian potato to Oman, Saudi Arabia, Malaysia and Indonesia is expected to decrease by the year 2024-25 whereas the export to Nepal and other minor countries are expected to increase. The market share of export of Indian potato to other minor countries is expected to increase by 6.75 per cent by 2024-25 *i.e.*, It is expected to increase to 35.04 per cent during 2024-25 from 28.29 per cent during 2020-21. Oman is expected to lose its market share gradually from 5.88 per cent (2020-21) to 3.78 per cent (2024-25). Similarly, it is expected that the Saudi Arabia, Malaysia and Indonesia were also losing their market share gradually by 2.18 per cent, 0.91 per cent and 2.47 per cent, respectively by the year 2024-25 compared to last year of the study period (2020-21).

Conclusion: Potato showed a positive growth in case of area, production, productivity and export as well. The major export destinations of Indian potato are Nepal, Oman, Saudi Arabia, Malaysia and Indonesia. Among these countries, Nepal was found to be more stable in importing Indian potato and thereby found more loyal country to India followed by Oman and other minor countries pooled under 'others'. Hence Indian export policies on potato need to be oriented towards these countries and also there is a need to identify those minor countries which are gaining and retaining attractive shares of their trade and formulate the policies accordingly in order to export more quantity of potato to these countries in the near future. The future research studies need to focus on identifying those minor countries which are grouped under the category 'others' and gaining major trade share, workout their individual trade shares and make suitable suggestions to formulate policies related to export of vegetables like potato accordingly.

References

Ganghadar Varun, 2021, Forecasting of instant coffee exports of India using transition probability matrix. *Research Journal of Mathematical and Statistics*, 7(2): 13-20.

Kumaraswamy N and Sekar C, 2014, Export of fresh and frozen potatoes from India-An economic analysis. *International Journal Processing and Post Harvest Technology*, 5(2): 173-178.

Kusuma D K, Basavaraja H and Shreeshail Rudrapur., 2014, Changing direction and magnitude of Indian Mango export. *Ecology Environment and Conservation*, 20(4): 1865-1868.

Kusuma D K and Shreeshail Rudrapur, 2016, Production and export performance of Indian onion-Markov chain analysis. *Agriculture Update*, 11(1):70-74.

Naik Vinod R and Nethrayini K R, 2017, Changing direction and magnitude of India's coffee export in the post liberalisation era. *Agricultural Situation in India*, 74(2): 12-20.

Rudrapur S 2022. Export Performance of Papaya from India. *Vigyan Varta* 3(9): 134-136.

Rudrapur S and Hiremath D 2023. Export performance of fresh pomegranates from India, *Vigyan Varta* 4(1): 90-92. www.indiastat.com www.apeda.gov.in