A-5711
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RESEARCH ARTICLE Indian Journal of Agricultural Research

Dynamics of Area Substitution of Pulses in India

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10.18805/IJARe.A-5711

ABSTRACT

Background: Pulses have been very curial in many aspects like; rich source of protein, economy aspect and contribute to agricultural and environmental sustainability. In this investigation an attempt has been made to evaluate the dynamics of area substitution between pulses and other crops, extent of spatial shift among pulses producing states and some policy measures have been suggested to stabilize the area under pulses across states.

Methods: Secondary data on area of principal crops for the period 1966-2016 was used in this article. By computing quartile values, all states and groups of states were clubbed into four different quartiles for each decade. Area substitution among principal field crops including pulses has been analyzed using first order Markov transition probability matrix (TPM).

Result: This TPM was further used to evaluate the mobility of membership status of states under pulses production. It was found that period 1986-2006 happened to be the golden period for area under pulses in India. Mean area under pulses had increased for first three decades and in the subsequent two decades mean area (quartile values) had declined substantially.

Key words: Decomposition analysis, Markov transition probability matrix (TPM), Pulses area, Yield effect.

INTRODUCTION

Pulses are the biggest and chief source of protein to the vegetarian population of the country and known as "poor man's meat". Besides protein pulses are very rich in iron, iodine, vitamins and minerals and have very high biological and medicinal values. Some pulses consist of malic and citric acids and works as blood purifier and also good source of lysine and leucine amino. It is also use as various derived products of pulses in day to day life. From nutritional point of view pulses are very important for human health and at the same time for the soil health as this is natural restorer of biological nitrogen in the soil (Hernández *et al.*, 2019).

With a holding of almost one third (36%) of the world area, the India is the largest producer of pulses with one fourth (26%) production of total world. At the same time, we are the largest consumer of pulses with a sharing of around 30 percent of the world. Despite being the largest producer India is the largest importer of pulses; during 2016-17 the average gap of six million metric tonnes was met through imports to meet the demand of pulses. The costly import of pulses resulted in prices of pulses not being affordable to the major population of the country. With growing population, the demand of pulses is also increasing day by day. This imbalance of demand and production of pulses is the area of major concern and there is an urgent need to excel the production of pulses in India.

In India, Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, Karnataka and Andhra Pradesh are the top six pulses producing states with around 70 per cent of total production. Chickpea, pigeonpea, mungbean and urdbean are the major pulses grown and also share the big part in the production. Pulses had a share of around 15 per cent of the area under food grains and contribute around 6-7 per cent of the total food grains production in the country. In 1950-51, the area under pulses was 19.09 Million hectare which has been increased to 24.91 Million hectares in 2015-16. About 20% of the area is cultivated under irrigation and rest 80% of pulses are grown under rainfed conditions. Growth rate of total pulses in the year 2015-16 for area, production and yield was 5.8, -4.7 and -9.9, respectively (Anonymous, 2017).

Generally, farmer treat pulses as a time-consuming crop. Insufficient adoption of production technology, higher price volatility, production risk and low level of irrigation are the important factors responsible for stagnation in the productivity of these crops (Ramasamy and Selvraj, 2002). Pulse demand is price elastic among low-income consumers. They would tend to consume less pulses (and protein) and more grains or vegetables when pulse prices are relatively high. Also, in local areas other crop policy adoption may be other reason behind these changes of area in different decades.

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How to cite this article: Vani, G.K., Mishra, P., Devi, M. (2021). Dynamics of Area Substitution of Pulses in India. Indian Journal of Agricultural Research. DOI: 10.18805/IJARe.A-5711.

Submitted: 17-11-2020 **Accepted:** 06-09-2021 **Online:** 28-09-2021

Lastly, marketing of the produce is not proper as major portion of agricultural population in the country is of small and marginal farmers with no risk bearing capacity and lack of formation of good policies is also among the various reasons. With above situations, the investigation has been carried out with following aims:

1. To examine the dynamics of area substitution between pulses and other crops.
2. To analyse the extent of spatial shift among pulses producing states.
3. To provide policy measures to stabilize the pulses area across states.

MATERIALS AND METHODS

This study was conducted in the year 2019 at College of Agriculture, JNKVV, Powarkheda, Hoshangabad, Madhya Pradesh. This study is solely based on secondary data. To meet the above-mentioned objectives data was compiled from DES official website on area of principal field crops from 1966-2016. To analyze the dynamics of area substitution among principal field crops including pulses, first order Markov transition probability matrix (TPM) was estimated using goal programming framework (Srivastava *et al.*, 2010; Rimal *et al.*, 2015).

$$\text{Min}\sum_{t=1}^{s}\sum_{i=1}^{n}(u_{i,t}+v_{i,t})+0*\sum_{i=1}^{n}\sum_{j=1}^{m}P_{ij}$$

$$\text{s.t.}\ \sum_{j=1}^{m}A_{j,t-1}P_{ij}+u_{i,t}-v_{j,t}=A_{j,t}\ \forall\ t\text{ -1 and } i$$

$$\sum_{j=1}^{m}P_{ij}=1\ \forall\ i$$

$$P_{ij}\geq 0\ \forall\ i,j$$

Where,

$A_{j,t}$: Area under j^{th} crop in year t; P_{ij}: Probability of area shift from crop i to j; $u_{i,t}$ and $v_{j,t}$ are respectively, negative and positive deviation associated with area equation of j^{th} crop for t^{th} year.

Transition probability matrix was calculated for each season and each decade starting from 1966-76 till 2006-16. The diagonal elements of this matrix show the retention probability for the respective crop in the rows. The off-diagonal elements show the probability of losing area to crops in columns for a crop in row. Migration probability was calculated as sum of off diagonal elements for pulses. Retention probability and migration probability always sums to 100. Decadal averages of area under pulses in each state were taken beginning with 1966-76 and ending at 2006-16. For simplifying further analysis, all seven north-eastern states were clubbed into group North East with exception of Assam and all union territories including Delhi and Goa were clubbed into Union Territories group. In total, there were 17 states and two state groupings (Union Territories and North East) were used in analysis. Further, quartile values were computed and states and groups of states were clubbed into four different quartiles for each decade. Using pivot table option in MS-Excel®, transition probability matrix for movement of states among different quartile group over two decades was computed. This TPM was used to analyse the mobility of membership status of states for area under pulses to and from various quartile groups.

RESULTS AND DISCUSSION

The descriptive statistics for area under pulses computed for various decades are presented in Table 1. From the Table 1, it can be observed that for first three decades, all three quartile values have increased and in the subsequent two decades quartile values have declined substantially. These three decades coincides with expansion in area under cereals under influence from green revolution and dwarf varieties of Wheat and Paddy. While decline in quartile value for first quartile is very less compared to second quartile. This shows that area under pulses for states belonging to first quartile was more stable than for the states belonging to second quartile. Based on inter-quartile range, it can be inferred that decade 1966-76 was the most stable one for area under pulses while 1986-96 was the most unstable decade. In case of average area, the pattern of increase and decrease is similar to that of quartile values. Since, mean is

Table 1: Descriptive statistics of area under pulses in various states for various decades from 1966-67 to 2006-16 (Unit: million hectares).

Quartile group	1966-76	1976-86	1986-96	1996-06	2006-16
1	36 (5)	34 (5)	50 (5)	32 (5)	24 (5)
2	360 (4)	380 (4)	365 (4)	138 (3)	124 (3)
3	1052 (5)	1136 (5)	1869 (5)	537 (5)	703 (5)
4	3096 (5)	3167 (5)	4681 (5)	3622 (6)	3332 (6)
Mean	1177(19)	1221 (19)	1814 (19)	1165 (19)	1263 (19)
Median	686	623	1141	245	224
1^{st} Quartile value	78	87	116	60	65
3^{rd} Quartile value	1493	1538	2726	1872	1717
Inter-quartile range	707.5	725.5	1305	906	826

Note: Figures in parentheses represent number of states and state groupings.

greater than median, hence the distribution area under pulses was right skewed. This is also evident in few states with large area under pulses while rest of the states had a constant proportion of area compared to large states. This is similar to Stylized facts of economic growth. In case of pulses, average area under first, second and third quartile group was approximately one hundredth (1/100), one tenth (1/10) and one third (1/3) of average area in fourth quartile group.

The data on quartile membership of the states across several decades is presented in Table 2. Among states in first quartile, Himachal Pradesh, Jammu and Kashmir, Kerala and Union Territories including Goa are consistent member. The reason for such consistency could be absence of competition from other crops and consistency of local demand for pulses in these states had sustained the interest of the pulses' farmers. Table 3 provides results of transitional probability matrix of pulses area across states. From Table 3, it can be observed that retention probability in the first group was very high (80-100%). The North-eastern states and Punjab were the only members to leave and join the first quartile during five decades. This could be due to regional factors which prevailed in the states at that time. Second and third quartile group were the two most volatile groups. For second quartile group retention probability ranged from 33 to 100 per cent with transition from 1986-96 to 1996-06 being most stable one. The Assam is the most consistent member of this group. The Punjab was the only member to migrate to lower quartile (1st) during period 2006-16. The state of Haryana, Gujarat as well as West Bengal made transitions at various time periods towards higher quartile group (3rd). Success of Gujarat in shifting from second to third quartile is attributed to impact made by front line demonstrations in increasing the productivity of Chickpea (Poonia and Pithia, 2011). North-eastern states are the latest addition to this group.

Third quartile has its retention probability ranging from 60 to 80 per cent during the 50-year period. The most consistent member is Tamil Nadu with other members being Odisha, Gujarat, Bihar andhra Pradesh, Karnataka, Haryana and West Bengal. The state of Andhra Pradesh and Karnataka has shown good growth during 2006-16 and 1996-06 leading to shift to fourth quartile group. The reason

Table 2: Data on quartile membership of states across decades.

States	1966-76	1976-86	1986-96	1996-06	2006-16
Andhra Pradesh	3	3	3	4	4
Assam	2	2	2	2	2
Bihar	4	3	3	3	3
Gujrat	2	2	3	3	3
Haryana	3	3	2	3	2
Himachal Pradesh	1	1	1	1	1
Jammu and Kashmir	1	1	1	1	1
Karnataka	3	3	3	4	4
Kerala	1	1	1	1	1
Madhya Pradesh	4	4	4	4	4
Maharashtra	4	4	4	4	4
North East States	1	1	1	1	2
Odisha	3	4	4	3	3
Punjab	2	2	2	2	1
Rajasthan	4	4	4	4	4
Tamil Nadu	2	3	3	3	3
Uttar Pradesh	4	4	4	4	4
Union Territory*	1	1	1	1	1
West Bengal	3	2	2	2	3

Note: *Includes states of Goa and Delhi.

Table 3: Results of transitional probability matrix of pulses area across states.

Quartile group	Retention probability (%)				Migration probability (%)			
	1966-76 to 1976-86	1976-86 to 1986-96	1986-96 to 1996-06	1996-06 to 2006-16	1966-76 to 1976-86	1976-86 to 1986-96	1986-96 to 1996-06	1996-06 to 2006-16
1	100	100	100	80	-	-	-	20 (2)
2	75	75	100	33.33	25 (3)	25 (3)	-	33.33 (1 and 3)
3	60	80	80	67.67	20 (2 and 4)	20 (2)	20 (4)	16.67 (2 and 4)
4	80	100	80	100	20 (3)	-	20 (3)	-

Note: Figures in parentheses represents group to which migration took place.

Table 4: Transition probability matrix for *Kharif* and *Rabi* seasons for India for five decades.

Period	*Kharif* pulses				*Rabi* pulses			
	Retention probability (%)	Probability (%) of substitution by			Retention probability (%)	Probability (%) of substitution by		
	-	Paddy	Coarse cereals	Oilseeds	-	Paddy and wheat	Coarse cereals	Oilseeds
1966-76	0	100	0	0	40	0	38	22
1976-86	1	82	0	17	48	14	38	0
1986-96	15	54	31	0	47	19	10	24
1996-06	41	0	0	59	32	53	9	6
2006-16	0	83	0	17	15	85	0	0

Note: Since fiber crops did not substitute area under *Kharif* pulses and hence excluded here.

for this phenomenal shift from lower quartile to higher quartile is chickpea revolution in Andhra Pradesh and pigeon pea revolution in Karnataka.

Fourth quartile group is the most stable group with retention probability ranging between 80 to 100 per cent. Madhya Pradesh, Maharashtra, Rajasthan and Uttar Pradesh are the most consistent states in this group. This stability could be attributed to favorable climate for growing pulses in these states. Bihar is the only state to have left this group at the end of first decade. This could be possibly due to rice-wheat cropping pattern. The Orissa joined this group for two decades (1976-86 and 1986-96) with Karnataka and Andhra Pradesh having joined this group in last two decades. During this period of investigation, ICRISAT released new varieties of pigeon pea and chickpea leading to expansion of area under pulses in Karnataka and Andhra Pradesh, respectively.

From the above analysis it can be observed that mobility is very high, both upward and downward, in second and third group. No member state has shifted from first and second quartile group to fourth quartile group.

Transition probability matrix for *Kharif* and *Rabi* are provided in Table 4. From Table 4, it can be observed that during 1966-76, *Kharif* pulses had zero retention probability while for *Rabi* pulses it was 40 per cent. In case of *Kharif* pulses, paddy substituted 100 per cent of its area while in case of *Rabi* pulses; it was coarse cereals which had substituted 38 per cent of its area. In the next decade (1976-86), *Kharif* pulses had a poor competitive strength to that of paddy with 82 per cent of its area being substituted by it. In case of *Rabi* pulses, during 1976-86, retention probability improved to 48 per cent mean while coarse cereals continued to be the main competitor to it with paddy and wheat gaining ground. In the following decade (1986-96), *Kharif* pulses gained major strength by improving retention probability to 15 percent from meager one per cent and the major competitors were cereals which replaced 85 percent of its area. In case of *Rabi* pulses, during 1986-96, retention probability decreased to 32 percent with dismal competition from oilseeds and cereals. In the ensuing decade (1996-06), *Kharif* pulses could retain 41 percent of its area with intense competition from oilseeds and at the same time, *Rabi* pulses lost nearly half of its area to paddy and wheat with its retention probability decreasing to 32 percent. This trend continued in next decade (2006-16) with *Rabi* pulses losing 85 per cent of its area to paddy and wheat and retention probability dropped to all time low of 15 per cent. Although this setback for *Rabi* pulses was not alone and losing streak was equally observed in *Kharif* pulses as well which had its retention probability dropping to zero per cent from all time high of 41 per cent and 83 per cent of its area being lost to paddy. All these results point to one fact that period 1986-2006 happened to be the golden period of area under pulses in India.

Based on results obtained it can be suggested that 1) area under pulses in states belonging in quartile one should be increased to stabilize it as its retention probability is the highest among all the quartile groups, 2) Since there was zero probability of substitution for *Rabi* pulses by paddy and wheat in 1966-76 which increased to 85 per cent in 2006-16, hence procurement price support and quality seed distribution for *Rabi* pulses should be a policy intervention to avoid further substitution. These measures are important as chickpea is the pulse with highest value addition in food production. 3) Since during 2006-16 decade *Kharif* pulses had zero retention probability, therefore, it is necessary to promote pulses area in irrigated lands where paddy substituted it to the extent of 83 per cent. Vani and Mishra (2019) noted that irrigation accounted for 69 per cent of variation in yields of pulse crops. Thus, it is imperative to enhance irrigated area under pulses.

CONCLUSION

From the preceding analysis of data on area of various crops, it is evident that during green revolution period, pulses were substituted by cereals. However, this trend was halted in the golden period of pulses, 1986-2006, wherein pulses were strengthening to gain the lost area from cereals and other crops. However, weakness remained on output marketing front which caused reduced competitiveness of pulses leading to once again a decade of pulses substitution, 2006-16. This trend however will not be sustained in next decade wherein Government of India has already started procurement of pulses which hitherto was not done. Suggested policy measures once adopted would lead to more stable area under pulses in India.

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