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FULL-LENGTH RESEARCH ARTICLE

Complexity in Technology Choices and Market Access for Pigeon Pea Growers in Semi-Arid Tropics of India

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Abstract India, being the largest producer, consumer and importer of pulses, its demand and supply influences global pulses sector significantly. For several years, there has been consistent import of different types of pulse-grains by India, despite having the largest area under cultivation and their total production. This paper focuses mainly on the production of pigeon pea, second most produced and consumed pulse after chickpea. There has been a major shift in the pigeon pea production in the country. The study is an attempt to examine the adoption of modern variety and other production practices in the highest pigeon pea producing state of India viz. Maharashtra. The marketing behaviour of the pigeon pea growers is also the focus area of this study. The pigeon pea production in India varied dramatically over the last five decades, in terms of its spread, productivity and its importance as an intercrop. At the farmers' level, there is a need for proper intervention in cropping patterns through new and improved crop varieties, information dissemination to farmers, mechanization and service support in reducing operational costs of farmers so as to increase the profitability from pigeon pea cultivation. The lot size and conveniences in terms of distance and time flexibility are some of the major influencers to decide about the marketing destination for the pigeon pea growers in the region.

Keywords Cropping pattern · Pigeon pea · Pulses · Semi-Arid Tropics · India

JEL Classification Agriculture (Q1) · Technological Change: Choices and Consequences (O33) · Government Policy (O38) · Agricultural Markets and Marketing (Q13) · Agricultural Technology (Q16) · Agricultural Policy (Q18)

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Introduction

Pulses continue to be increasingly important source of proteins in the dietary habits of the average Indian consumers. Given the evolving dietary pattern in favour of pulses, there may be a large demand–supply mismatch in coming years, if the current production trend continues [31]. India is the largest producer and consumer of all pulses in the world (producing about 25% of total pulses from 33% of global pulses acreage), particularly for chickpea (67% of global production) and pigeon pea (63% of global production) [1, 12]. The production of pulses in India has varied between 10 and 14 million tonnes (Mt) annually for nearly five decades till 2006–2007. Since then, it leapfrogged reaching the highest production (19.25 Mt) in 2013–2014 from 25.21 million

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hectares (Mha) area, but again declined to 17.06 Mt in 2015–2016 [6, 7]. India imported nearly 5–6 Mt of pulses (primarily peas, lentils, pigeon pea, chick peas, green gram and black gram) from different countries and exports small quantities, mainly chickpeas and lentils, every year [5, 31]. Pulses, in India, seem to have been confined to marginal environments, produced mostly by small and marginal farmers under rainfed conditions [15] and grown as residual crops with low productivity-low input nature [28]. A lack of technological breakthroughs in developing stress-tolerant varieties kept its productivity low [21]. Subramanian stressed on increasing minimum support price (MSP) as immediate measure to improve pulses production [31]. However, Joshi et al. opined that the production of pulses in India has not been very responsive to rises in MSPs, due to high relative production risks involved and its negative elasticity to expansion in irrigation [16].

Although several types of pulses are grown in India, the most important are chickpea (41% of total pulses area), pigeon pea (15%), black gram (10%), green gram (9%), cow pea (7%), lentil (5%) and field pea (5%), while kidney beans, cow peas and other beans are minors. India produces about 67.7% of the global total pigeon pea. Despite that, its import account for more than 30% of the rest of the world's production [31]. The expenditure elasticity for pigeon pea is higher than that for chickpea in both rural and urban area of India, indicating that as income rises, consumers spend a higher share of their income on it [19]. Recently, back-to-back monsoon failure resulted into drastic drop in its production, thereby average retail price of split grain of pigeon pea (commonly known as *tur dal*) increased from about INR (Indian Rupee) 72/kg in January 2015 to as high as INR 143/kg in November 2015 [20].

There are umpteen number of literatures available explaining the production performance of pulses, its regional spread and variability, gaps in implementation of price policy, demand–supply mismatch, etc. [28, 29]. Besides, researchers in the past have also reported various legume-based cropping systems prevailing in India [25, 27, 28]. These studies were conducted with experimental fields. Therefore, very scanty information is available about farmers' field condition, particularly with respect to second most demanded pulse crop in India viz. pigeon pea. There is also lack of study explaining why farmers behave in certain ways in cultivation of pulses, why adoption of technologies to farmers' fields are so low, and how the pulses growers sell their produce in the market? Therefore, the present study (a) examines the changes in production pattern of pigeon pea in India, (b) explores the reasons for structural shift in pigeon pea production in Maharashtra state, (c) determines the adoption of production practices and technologies in pigeon pea, and (d) identifies the factors influencing the marketing behaviour of pigeon pea growers in the selected state.

Materials and Methods

Study Region

Maharashtra state is the largest pigeon pea growing state in India. Out of 3.88 million hectares (Mha) of area under the crop and 2.8 million tonnes (Mt) of production during triennium ending (TE) 2014/15, the Maharashtra state alone contributed about 30.3%, followed by Karnataka, Madhya Pradesh and Uttar Pradesh. Therefore, Maharashtra state was selected for detailed investigation of pigeon pea growers with respect to the technology adoption and their marketing behaviour.

Data Source

In the study, both secondary data as well as field survey data have been used. To analyse the change in production pattern of pigeon pea in India, the secondary data pertaining to area, production and yield of pigeon pea crop in different major growing states have been collected from the Ministry of Agriculture, Government of India. However, to understand the adoption of technology and package of practices, and marketing behaviour of the pigeon pea growers, household survey was conducted in Maharashtra state in India.

Sampling and Household Survey

For the study, we have adopted a four stage sampling framework. Within the State of Maharashtra, at first, two largest pigeon pea growing districts were selected on the basis of its contribution in pigeon pea production. The districts of Amravati and Yavatmal falling under Central Maharashtra Plateau Zone and Central Vidarbha Zone, respectively, are contributing 11–13% each to the total pigeon pea production in the state. At second stage, two largest pigeon pea growing talukas were selected from each district. From each taluka, two villages and from each village, 30 pigeon pea grower farmers were selected randomly. Thus, 60 pigeon pea growing farmers from each taluka (Table 1 and Fig. 1) were selected. Therefore, a total of 240 pigeon pea producer farmers were surveyed for the study using pre-tested questionnaire during May 2016 in the State of Maharashtra.

Empirical Analysis

The paper has used both descriptive and econometric analysis. We first tried to know—is there any structural break in the long-term production of pigeon pea in

Table 1 Sampling framework and basic characteristics of the sample villages

District	Taluka	Village	Geo-reference		Distance from district headquarter (km)	Total households	Number of sample household
			Lat	Long			
Amravati	Nandgaon Khandeswar	Sawaner	20.744	77.800	26	527	30
		Majri Masla	20.770	77.832	24	519	30
	Bhatkuli	Khalkuni	20.913	77.542	30	190	30
		Waigaon	21.027	77.648	21	453	30
Yavatmal	Kalamb	Hiwara Dharne	20.543	78.326	37	221	30
		Kotha	20.532	78.275	31	767	30
	Ghatanji	Bodadi	20.013	78.241	55	302	30
		Shiroli	20.073	78.253	45	766	30

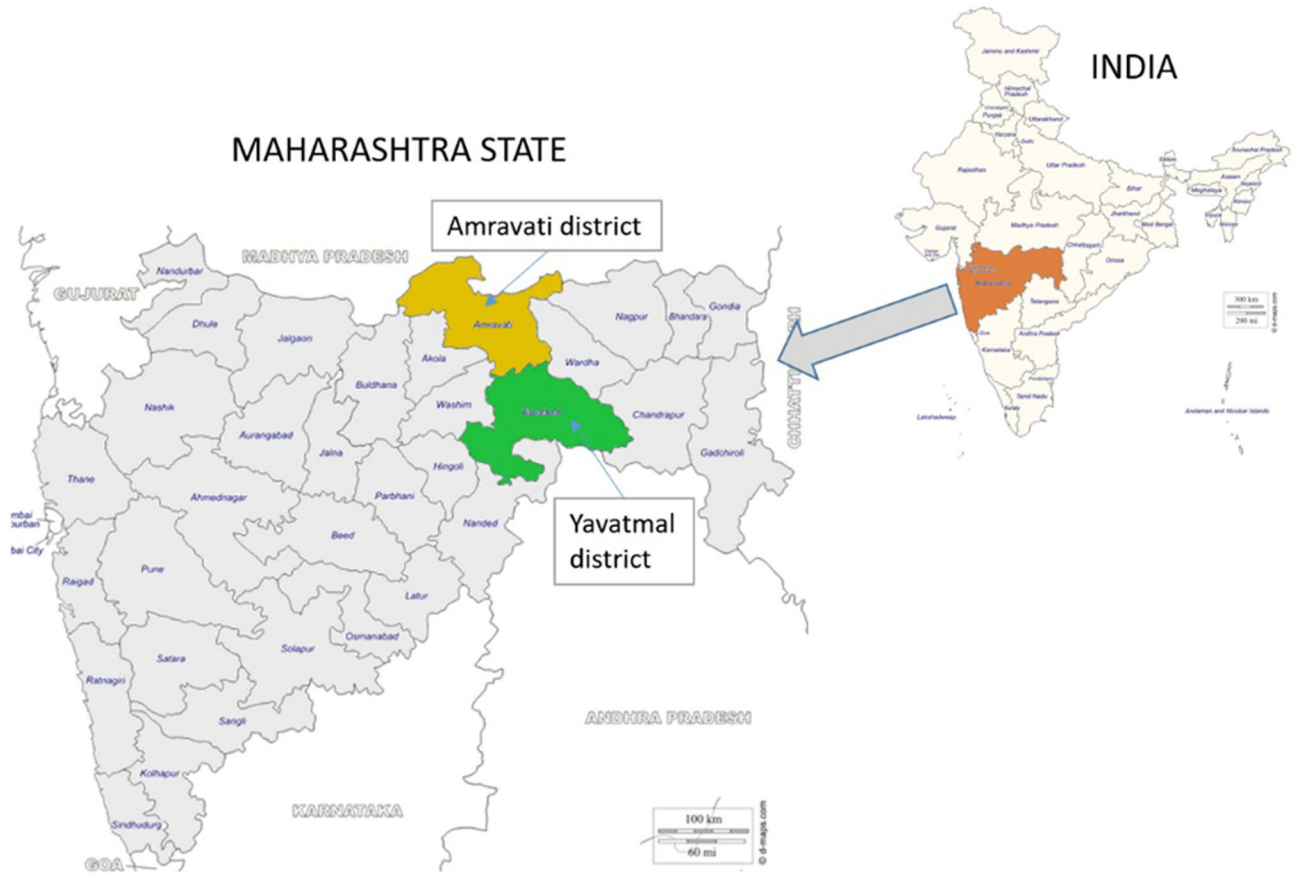

Fig. 1 Location map of the selected districts in the Maharashtra state

Maharashtra state? The Bai and Perron structural break test [2] was used to determine the presence of structural breaks in the year-on- year pigeon pea production. The break dates were corroborated with the events that have occurred to influence the pigeon pea production.

From the field survey of pigeon pea growers, the diversity in pigeon pea production system was analysed to document the complexity in technology adoption in pigeon pea production. Different crop combinations were also compared in terms of its profitability. It also gave an idea about the technology adoption by the growers.

Table 2 Importance of pigeon pea in the basket of pulses in India

Pulses	Per capita consumption[a] (kg/annum)			Area[b] (million hectares)	Production[b] (million tonnes)	Import (TE 2015–2016)[c]	
	1993–1994	2004–2005	2011–2012	TE 2014–2015	TE 2014–2015	Quantity ('000 tonnes)	Values (US $ million)
Chickpea*	2.46	1.85	2.51	8.90	8.56	575.50	341.95
Pigeon pea	3.36	3.02	3.29	3.88	3.00	501.25	408.95
Green gram	1.44	1.24	1.28	3.07	1.40	609.57	579.90
Lentil	1.44	1.18	1.22	1.38	1.08	928.46	673.25
Black gram	1.26	1.02	1.11	3.13	1.80	N.A.	N.A.
Yellow pea	0.18	0.31	0.45	0.76	0.84	1842.60	742.32
All pulses and product	9.72	8.74	9.58	23.86	18.25	4730.73	2974.18

NA not available

Source: [a]National Sample Survey Reports (various years)

[b]Ministry of Agriculture, Government of India

[c]Ministry of Commerce & Industry, Government of India

*Chickpea includes whole grain, split grain and besan consumed at household level. However, major portion of chick pea is being used as flour (besan) by the food industry in making variety of sweets (Besan laddoo, most famous), confectionery items, snacks, etc. which are not covered in household survey by the NSSO

There are many formats of market where farmers in India transact their produce. The regulated markets (APMC *mandi*[1]) are one of the most prevalent organised markets, where many farmers sell their produce and are expected to receive better selling prices. Therefore, Probit model was fitted to determine the factors influencing the decision to sell the pigeon pea produce in these regulated markets. The Probit model can be written as:

$$Y_i^* = \beta_0 + \beta_1 X_{1i} + \varepsilon_i$$

where $Y_i = 1$ if $Y_i^* \geq 0$, and

$$Y_i = 0 \quad \text{if} \quad Y_i^* < 0$$

That means, if the utility index is 'high enough', a farmer will sell the produce in the regulated market, and if the utility index is not 'high enough', he will not sell in the regulated market. In the Probit model, we assume error in the utility index model is normally distributed.

$$\varepsilon_i \sim N\left(0, \sigma^2\right)$$

$$\text{Prob}(Y_i = 1) = F\left(\frac{\beta_1 X_{1i}}{\sigma}\right)$$

where F is the standard normal cumulative density function (c.d.f.)

The marginal effects of all the independent variables were also estimated. With binary independent variables, marginal effects measure the discrete change, i.e. how do predicted probabilities change as the binary independent variable changes from 0 to 1? For continuous variables, it measures the instantaneous rate of change.

Results and Discussion

Importance of Pigeon Pea in India

Pigeon pea, commonly known as *tur* or *arhar*, is being consumed in India as split *dal* (after removing skin) or as major constituent of *sambhar* (gravy recipe mixed with different vegetables). It is almost six-month crop in India, sown in July and harvested in December month. Pigeon pea crop in India is being cultivated in around 4 million hectares, with annual production of around 3.0 million tonnes (Table 2). The household consumption survey of different food commodities collected by the National Sample Survey Organisation (NSSO) in the country present very interesting picture for different pulses. It may be observed that though total production of chick pea in India is much larger than that of pigeon pea, the per capita consumption trend is quite opposite. This may be due to the reason that major portion of chick pea in different forms is being used by the food industry. There are several sweets and recipes, in which chick pea flour remains as basic ingredient. This portion of chick pea consumption is usually uncovered in the NSSO household consumption data. To meet the

[1] Par11 Agricultural Produce Market Committee (APMC) regulates the transaction of agricultural commodities in India, with its network of more than 7000 regulated APMC mandi (as on 31.3.2012). Most of these regulated markets are wholesale markets. Besides, the country has 22,505 rural periodical markets also, about 20% of which function under the ambit of regulation.

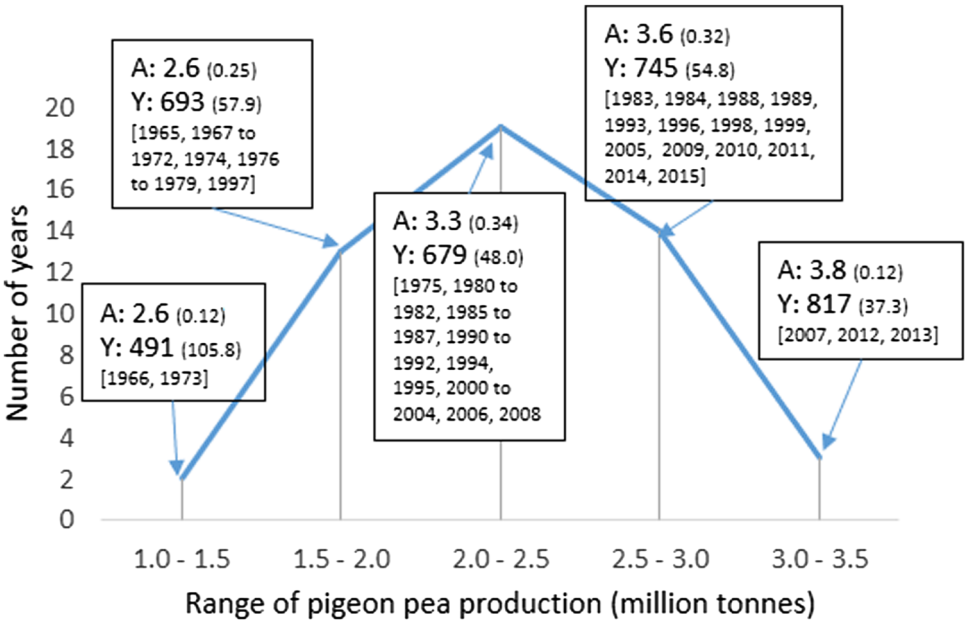

Fig. 2 Production variability in pigeon pea in India during last 5 decades (1965/66–2015/16). Note: 'A' means average area under pigeon pea (in million ha) for those years, and 'Y' means average yield of pigeon pea (in kg/ha) for those years. Figures within parentheses indicate standard deviation for the respective parameters. Figures within square brackets '[]' are the respective years

growing demand of pigeon pea, India has recently signed an agreement to import 100,000 tonnes of pulses from Mozambique in 2016–2017, and doubling it by 2020–2021 [33]. Major import of pigeon pea (50–75%) comes from Myanmar and the balance from the African nations like Mozambique, Tanzania, Malawi and Sudan [4, 8].

Pigeon Pea Production in India

Figure 2 exhibits that in the past 5 decades, pigeon pea production in India was between 2.0 and 2.5 million tonnes (Mt) per year for 19 years, between 1.5 and 2.0 Mt for 13 years and between 2.0 and 2.5 Mt for 14 years. More importantly, the variability in pigeon pea yield (standard deviation) has also reduced in recent years. The area under the crop has almost stabilised near 4.0 million hectares. Though, deficit rainfall in 2015 has caused serious effect on crop productivity. The structural break around the year 2000 may be due to the introduction of Bt cotton in the state, due to which significant reduction in larval load of *Helicoverpa armigera* was reported. While in 2007–2008, the National Food Security Mission (NFSM)-Pulses was introduced and Maharashtra attracted lots of attention for pigeon pea production, thereby large area was brought under Certified Seeds of the crop.

In the last 25 years (TE 1982 to TE 2013), not only area under the pigeon pea crop has increased by almost one million hectares (mha), but the crop has shifted significantly from northern region to southern and central India.

From Fig. 3, it is evident that the acreage expansion under the crop has happened in a big way in the states like Maharashtra (487 K ha), Karnataka (391 K ha), Andhra Pradesh (231 K ha), Bihar (103 K ha) and Orissa (39 K ha), where 'K' stands for 'thousand'. There has been major setback in Uttar Pradesh state, where the crop has lost almost 195 K ha in this period. Besides, the crop yield has seen significant jump in central and southern states, but declined in Punjab, Himachal Pradesh and Uttar Pradesh. The shift in cultivation from pulses to cereals, observed by the main pulses producing states may be attributed to large yield gaps and expansion of irrigation in Bihar, Uttar Pradesh and Punjab [24].

Trend of Pigeon Pea Production in Maharashtra State

The Bai and Perron test was conducted for pigeon pea production in Maharashtra state for the period 1964/65 to 2013/14. The test clearly indicated three structural breaks in 1988, 2000 and 2008 (Fig. 4). It is important to find out the context during these years.

Kannaiyan et al. [17] reported that *Fusarium* wilt, one of the most widespread and destructive diseases of pigeon pea spread in almost 23% of Maharashtra state. It was also a major disease in Malawi, Tanzania and Kenya, causing yield reduction by 50% [30]. Keeping this in view, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) gave high priority to the menace and through national agricultural research system (NARS) released variety named ICP 8863 (*Maruti*) in 1986 for cultivation in Karnataka state and later, variety ICPL 87119 (*Asha*)—a wilt and sterility mosaic resistant in 1993 for central and southern India [3, 14]. Both varieties became very popular in Maharashtra state due to its superior grain and fodder yield. By the year 1989, 24% of Osmanabad district of Maharashtra had 24.3% of pigeon pea area under *Maruti* variety [3, 9]. The year 2000–2002

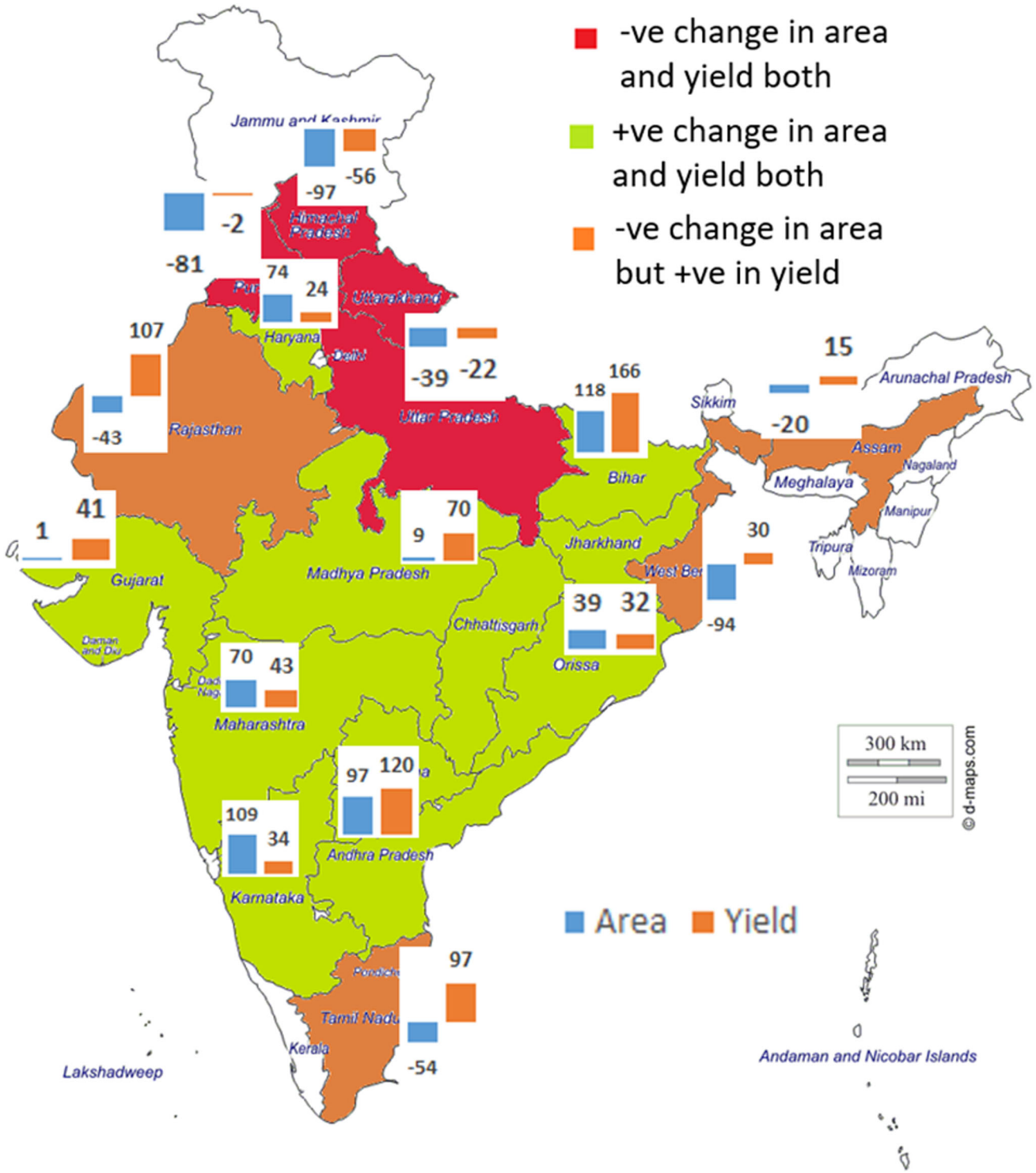

Fig. 3 Percentage change in area and yield of pigeon pea in different states in India (TE 2013/14 over TE 1982/83)

was defining moment for Indian agriculture. However, official approval for Bt cotton was given in the year 2002, which might have reduced the larval load of *Helicoverpa armigera* in the pigeon pea field as the crop was largely cultivated as intercrop with cotton in Maharashtra state, while in 2007–2008, landmark programme by the Government of India was launched known as National Food Security Mission (NFSM). A special emphasis was given to boost the production of pulses. In the process, Maharashtra state was the biggest beneficiary for the

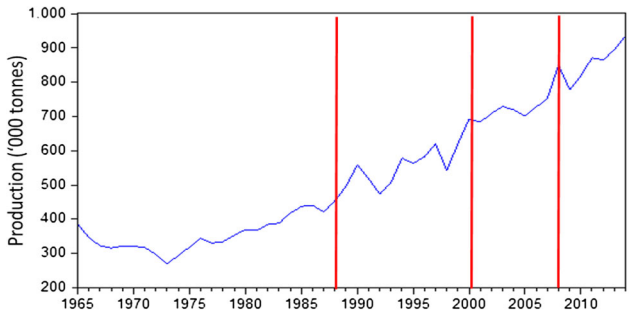

Fig. 4 Structural breaks observed in pigeon pea production in Maharashtra state during 1988, 2000 and 2008

pigeon pea production, as large area of pigeon pea was brought under certified seeds in the year 2008.

Along with Maharashtra, its neighbouring state Karnataka is also known for pigeon pea production. Over the past five decades, yield of pigeon pea has improved in both the states, though with different pace (Fig. 5). Initially, yield in both the states was similar. However, it has grown at about 6 kg/ha/year in Maharashtra but only at 2 kg/ha/year in Karnataka state.

Socio-Economic Profile of the Survey Households in Maharashtra State

There are about 138 million farmers in India, 85% of them are smallholders having operational holding less than 5 acres (2 ha). In case of Maharashtra state, 78.6% of farmers are smallholders out of 13.7 million farmers [7]. The average size of land holding in the state is 3.56 acres. However, in the study districts as Table 3 depicts, the proportion of semi-medium and medium farmers are more; therefore, the sample of farmers also consists of quite good number of semi-medium and larger farmer households. The average age of the head of the households who is the main decision maker in farming is above 50 years across farm size category, which could be a reason for making them more risk averse. The situation gets further compounded with their poor literacy level. Moreover, with continuous efforts from state and central government, the access to formal credit in the state has improved significantly [23]. It may be noted that for all the surveyed households, farming is the main occupation, while it is frequently debated that most of the farmers wish to come out of this profession if given an opportunity elsewhere [10].

Pigeon Pea in Cropping Pattern

Pigeon pea is grown in different ecosystems and in different farming systems, as a sole crop as well as a part of intercrop [32]. Since the study region falls under Semi-Arid Tropics (SAT) region, where average annual rainfall is less than 750 mm, the cropping pattern in the region is highly diversified. On top of that, the years 2014–2015 and 2015–2016 were draught year for the country as a whole. The study districts were even worse affected with more than 30% of deficit rainfall [6]. In this context, the farmers have limited choice of crops which can thrive on limited irrigation or only on rainfall. Therefore, most of the farmers take multiple crops either as intercrop or different crops in different plots during rainy season (*kharif*) only, keeping fields fallow thereafter (Fig. 6). Most prevalent crops grown by majority of the farmers (70%) were pigeon pea intercropped with soybean (A), occupying more than 52% of total cropped area. It was followed by pigeon pea + cotton (B) cultivated in about 26% of cropped area (by 34% of farmers). Other two major crops are cotton (C) and soybean (D), which are cultivated as sole crop and occupy about 5% each of the cropped area. All these plots remained fallow after harvest of A, B, C and D crops.

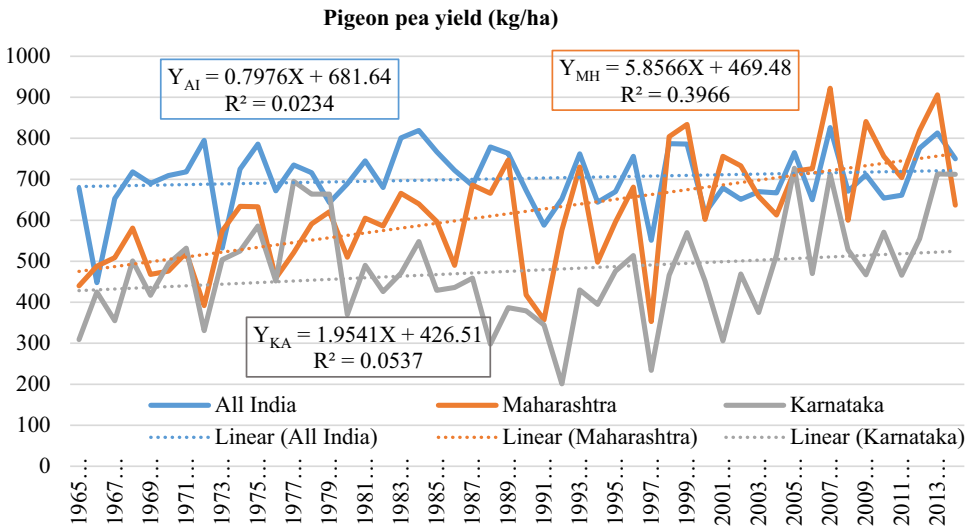

Fig. 5 Long-term trends in pigeon pea yield in two major states and all India. *Source*: Directorate of Economics and Statistics, Government of India

Table 3 Socio-economic profile of survey households in Maharashtra state

Particulars	Small farmers	Semi-medium farmers	Medium farmers	Large farmers
Sample size (n = 240)	69	79	81	11
Average age of household head (HH) (in years)	50	52	49	49
Average number of farm workers in the family	2.5	2.9	2.6	2.7
Educational level of HH (%)				
Illiterate	11.6	8.9	8.6	18.2
Primary	21.7	25.3	11.1	0.0
Secondary	40.6	44.3	35.8	9.1
Higher secondary and above	26.1	21.5	44.4	52.8
Farming as main occupation of HH (%)	100.0	97.5	96.3	100.0
Average operational holding (acres)	3.4	6.6	14.3	35.0
Per cent irrigated area	39.9	33.3	40.8	37.7
Access to formal agricultural credit (%)	40.6	45.6	46.9	81.8
Crop insurance taken (%)	26.1	29.1	43.2	72.7

Ministry of Agriculture, Government of India categorises farm size categories on the basis of size of operational holding. Accordingly, farmers with less than 2 hectares (ha) land are considered as small farmers, while those with 2–4, 4–10 ha and more than 10 ha lands are considered as semi-medium, medium and large farmers, respectively

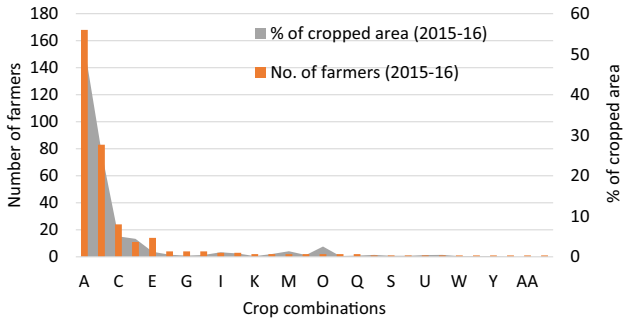

Fig. 6 Different crop combinations (The crop combinations shown with '+' indicates intercropping, while '−' indicates crop cultivated after harvest of previous crop.) cultivated by the sample households (2015–2016). Note: (A) Pigeon pea + Soybean; (B) Pigeon Pea + Cotton; (C) Cotton; (D) Soybean; (E) Sorghum; (F) Pigeon pea + Green gram; (G) Black gram; (H) Green gram; (I) Soybean–Chickpea; (J) Pigeon pea + Soybean–Wheat; (K) Soybean–Wheat; (L) Pigeon pea + Soybean–Chickpea; (M) Soybean–Chickpea, Wheat; (N) Cotton–Chickpea; (O) Pigeon pea + Cotton + Soybean; (P) Orange; (Q) Sugarcane; (R) Pigeon pea + Soybean, Wheat, Onion; (S) Pigeon pea + Cotton–Wheat; (T) Pigeon pea + Black gram; (U) Pigeon pea + Soybean + Green gram + Cotton; (V) Green gram + Cotton; (W) Green gram; (X) Pigeon pea; (Y) Pigeon pea + Turmeric; (Z) Sponge gourd; (AA) Brinjal; (AB) Chilli

There are several other crops and crop combinations which are cultivated by only 1 or 2 farmers each. Farmers having borewells with scope of 1–2 irrigations take second crop like chickpea or wheat in winter season (*rabi*) after harvest of soybean crop. In many studies, it has been opined that the farmers in India treat pulses as secondary crops [13]. However, it should be viewed in other way, as the farmers in such areas are growing highly commercial crops like cotton and soybean intercropped with pigeon pea.

Apart from different crop combinations grown by the sample households in the SAT region, there is huge variability in the production practices also. Pigeon pea crop is being grown with other crops in different ratio. Considering the two most prevalent crop combinations viz. pigeon pea + soybean and pigeon pea + cotton in the study region, different farmers have their own priorities. It may be observed in the Table 4 that the number of rows of pigeon pea with cotton and soybean varies from 1:4 to 1:10. From the discussion with farmers, it emerged that many are growing pigeon pea mainly for their household consumption, in which case more rows are allocated to cotton or soybean. In case of commercial pigeon pea production, farmers prefer to grow pigeon pea intercropped with soybean or cotton in the ratio of 1:4 or 1:5. In case of cotton growers (> 1:5), cotton is always considered as main crop, as even with scanty rainfall, cotton gives some yield, while there is no certainty about pigeon pea yield.

The field experiment conducted by Rathod et al. [25] in the neighbouring state, Karnataka, has shown that intercropping of different pulses and oilseeds significantly decreased the pigeon pea grain yield. Similar experiment was conducted by Kathmale et al. [18] for 5 years (2008–2012) in Solapur, Maharashtra state for different intercropping of pigeon pea with millets, pulses and oilseeds in different row proportion. It was observed that while pigeon pea + groundnut (1:3) was found superior with maximum pigeon pea equivalent yield of 1425 kg/ha. However, in terms of land equivalent ratio (LER),

Table 4 Number of farmers/plots having pigeon pea intercropped with soybean or cotton in different ratios, 2015–2016

Crop combination	No. of rows of pigeon pea: No. of rows of Soybean/Cotton						
	1:4	1:5	1:6	1:7	1:8	1:9	1:10
Pigeon pea + Soybean	34	27	109	nil	4	nil	Nil
Pigeon pea + Cotton	12	3	24	5	24	2	13
Total number of farmers	46	30	133	5	28	2	13

Total number of farmers is more than the actual sample size, due to double count of farmers practicing different combinations

Source: Field survey, 2016

maximum LER (1.51) was obtained with pigeon pea + soybean (1:3) intercropping system.

Technology Adoption

For pulses per se, the major areas of concern are the low yield levels, rainfed and marginal lands devoted to pulse cultivation, absence of technological breakthrough, severe abiotic (climate related) and biotic (insect, pest) stresses, volatility of prices and lack of effective procurement. The accessibility of pulse growers to quality seed of improved varieties is constrained by both limited availability and ineffective seed supply chain. The Expert Group on Pulses set up by the Government of India highlighted that research has not been able to develop pulses varieties tolerant to pests and diseases [5]. Apart from this, the availability of seed of promising varieties to the farmers is the main issue in pulses production. In the study region too (Table 5), more than 75% of pigeon pea growers are growing own seeds of '*Maruti*' variety since last 15 years, while 15% of them are growing another old variety namely '*Asha*'. These farmers keep small quantity of sorted and graded grains from previous year produce as seed for the next year. Reddy et al. [26] also observed that the pigeon pea growers have very low seed replacement rate (2–3%), due to which the yield realisation is lower up to 20–30%. Only few farmers have tried for new varieties or hybrids like ICPH-2740 in the recent years. Availability of seeds of improved pigeon pea varieties is the major constraint. The varieties of pigeon pea for Maharashtra state are *Maruti* (2000 kg/ha), Asha (2500 kg/ha), BSMR 736 (2500 kg/ha) and Hybrid ICPH 2740 (3000 kg/ha). Hybrid ICPH 2740 is highly suitable for intercropping with Cotton and Soybean in Maharashtra state, which was proven with several On-farm demonstration conducted by ICRISAT and Department of Agriculture, Government of Maharashtra.

The nutrients application in pigeon pea field is mainly determined by the intercrops and as per the advisory given by the local fertilizer traders. From Fig. 7, it is evident that out of 281 plots studied, 38% of farmers are applying urea and Diammonium Phosphate (DAP) fertilizers in pigeon pea field, while another 10% of farmers apply urea + DAP + Single Super Phosphate (SSP). Interestingly, many farmers applied different types of fertilizers in

Table 5 Different varieties of pigeon pea being cultivated by the sample farmers

Pigeon pea variety grown	Farmers growing the crop variety (%)	No. of years since grown	*Source of seed	#Sowing method
ASHA	**15.3**	**20**	1	1
BSMR 736	0.8	10	1	1
GANESH	0.4	1	2	2
ICPH-2740	0.8	2	2	1
LOCAL	0.4	45	1	1
MANAK	0.4	3	1	1
MARUTI	**78.6**	**15**	1	1
MUKUR	0.4	15	1	1
NAKJATRA	0.4	2	2	1
PRABHA	0.4	2	2	1
YASHODA	2.0	2	1	1

*Source of seed: 1 = Own/home saved; 2 = Purchased from open market

#Sowing method: 1 = Seed drill; 2 = Dibbling

The Bold values exhibit that the two most popular varieties in the study are are 15–20 years old

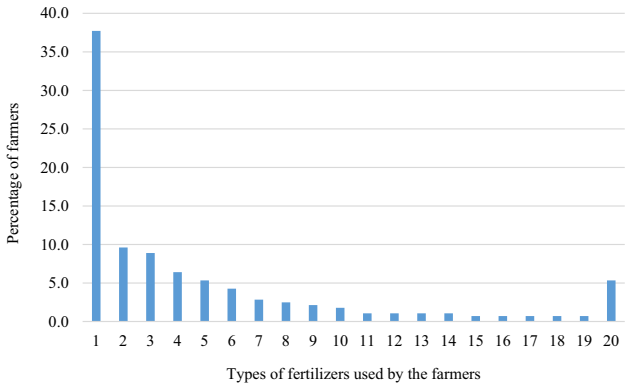

Fig. 7 Different types of fertilizer and its combinations used by the pigeon pea growers. Note (The composition of nutrients in different fertilizers are given in the ratio of Nitrogen (N): Phosphorus (P): Potassium (K): Sulphur (S): Calcium (Ca). For example; DAP (18:46:0); Urea (46:0:0), SSP (0:14.5:0:11:21), Potash (52% K2O) or other complex fertilizer like 10:26:26 has N:P:K in that ratio.): (1) Urea + DAP, (2) Urea + DAP + SSP, (3) DAP, (4) Urea + SSP, (5) SSP, (6) DAP + SSP, (7) Urea + 10:26:26, (8) Urea + 18:18:10, (9) DAP + 10:26:26, (10) Urea, (11) Urea + 18:18:10, (12) Urea + SSP + 10:26:26, (13) Urea + SSP + 18:18:10, (14) Urea + DAP + 10:26:26, (15) 18:18:10 + 20:20:10, (16) DAP + 18:18:10, (17) Urea + DAP + 18:18:10, (18) Urea + DAP + 26:26:10, (19) Urea + DAP + Potash, (20) Others, as 15 farmers applied different combination of fertilizers each

their different plots of pigeon pea, with different intercrops. Out of 240 sample farmers, only 99 farmers could apply 1–2 irrigation in the fields.

Marketing Behaviour and Price

Poulton et al. [22] observed that small farms have an advantage over large farms in terms of labour availability and personal supervision as well as local knowledge; however, larger farms gain the advantage as an economy shifts towards technologically advanced, capital-intensive, and market-oriented agricultural. While Fan et al. [11] argues that for the smallholders to be commercially profitable, they must be linked to urban and global markets, with highly intensive high value agriculture. From Table 6, it is evident that majority of the farmers sold the pigeon pea produce (grain) in the local market to traders or at regulated market, i.e. APMC mandi. The minimum support price (MSP) for pigeon pea grain for the year 2015–2016 was announced at INR 44,250 per tonne plus INR 750 per tonne as bonus, making effective MSP as INR 45,000 per tonne [7]. Thus, except in few cases, all the pigeon pea growers received better than MSP announced. The convenience of selling different lot size and at different time of the day influences the farmers to sell in the local market, though the farmers might get better price in the *mandi*.

To examine the factors influencing the pigeon pea growers to sell their produce in the regulated market, Probit model was used. The descriptive statistics for the variables used in the model is given in Table 7. The results of the estimates are presented in Table 8. Though average land size is quite good, with maximum operational holding of

Table 6 Selling of pigeon pea grains by the growers in the study region

Types of pigeon pea growers	Agency to whom farmers sold pigeon pea produce							
	To Village traders		To trader in the local market		To Co-operative society			At regulated market (mandi)
	SQ (t)	SP (t)	SQ (t)	SP (t)	SQ (t)	SP (t)	SQ (t)	SP (t)
Small	2.55 (2)	65,000	0.53 (40)	56,920	0.20 (1)	52,000	0.47 (18)	58,500
Semi- medium	–	–	0.71 (44)	53,250	0.90 (1)	60,000	0.77 (27)	56,820
Medium	1.10 (2)	45,000	2.01 (37)	52,950	1.90 (2)	67,000	1.54 (34)	55,320
Large	–	–	1.73 (13)	52,000	–	–	4.25 (4)	58,500
Overall	3.65 (4)	55,000	1.25 (134)	53,780	1.00 (4)	42,420	1.76 (83)	57,280

Source: Field Survey (2016)

SQ means 'quantity of pigeon pea grain sold' in tonnes (t); SP means 'selling price of pigeon pea' in rupees per tonne

Figures within parentheses indicate the number of pigeon pea growers in the respective category

Table 7 The descriptive statistics of variables used in the empirical model

Variables	Unit	Mean	Standard deviation	Minimum	Maximum
Explained variable					
Dummy for the farmers selling the produce in regulated market (*mandi*) {y_i)	1 = if selling in mandi; 0 = otherwise	0.38	0.49	0.00	1.00
Explanatory variables					
Operational holding (OHL)	Acres	9.70	8.22	2.00	58.00
Pigeon pea acreage ($Area_{PP}$)	Acres	1.22	0.93	0.20	6.86
Total pigeon pea production ($Prodn_{pp}$)	Quintal	13.15	13.55	1.00	80.00
Village distance from *mandi* (Distn)	km	19.67	8.54	0.00	40.00
Marketed surplus (SQ)	quintal	11.70	13.16	0.50	78.00
Selling price (SP)	₹ per quintal	5526.29	771.76	2000.00	8500.00
Dummy for selling time (DST)	1 = if sold 30 DAH*	0.62	0.49	0.00	1.00
	0 = sold within 30 DAH*				
Dummy for large farm size (DLF)	1 = for large farmers, 0 = for all other farmers	0.05	0.22	0.00	1.00
Dummy for medium farm size (DMF)	1 = for medium size farmers	0.34	0.47	0.00	1.00
	0 = for all other farmers				
Dummy for semi-medium farm size (DSMF)	1 = for semi-medium size farmers,	0.33	0.47	0.00	1.00
	0 = for all other farmers				
Family size (FSZ)	Numbers	4.64	1.54	2.00	10.00

*DAH means days after harvest; 1 quintal = 0.1 tonne, 1 acre = 0.25 hectare

58 acres among sample households, acreage allocation to pigeon pea crop was hardly 10 per cent. The results from Probit analysis indicate that total pigeon pea production, selling price and retaining capacity of the farmers to stock the produce for at least 30 days improve the probability to sell the produce in the regulated market (Table 8). Contrary to it, large farmers who had larger marketed surplus preferred to sell the produce to traders in the market instead of going to *mandi*. Medium and semi-medium category of farmers were more active in availing the service of *mandi*. The marginal effect analysis shows that by increasing operational holding by 1 acre (0.25 ha), the probability of selling the produce in the regulated market declines by 0.0195. The probability increases very fast, when the total production of pigeon pea increases. Moreover, the marketed surplus has totally opposite influence. This may be due to the reason that large number of sample farmers belonged to small and medium category who also had high marketed surplus, but sold their produce to the local markets instead of regulated market. Regarding selling time, if the farmers decide to store the produce for 1 month, the probability for selling his produce in the *mandi* significantly improves. Similarly, as compared to small farmers, the probability of medium farmers to sell pigeon pea in *mandi* is significantly high.

Conclusions

Pigeon pea is the second most important pulse crops in India, the demand of which is continuously growing. The country depends on large imports to meet its domestic demand, and when crop fails on account of biotic and/or abiotic constraints, the price of its product viz. split grain (tur dal) shoots up very swiftly. Moreover, the government's intervention in recent years in terms of NFSM-Pulses along with increasing the MSP has boosted the acreage allocation to this crop. However, relatively high production risks involved in this crop and the high volatility in market price further restricts its expansion.

In the study region of Maharashtra state, typical Semi-Arid Tropics, the farmers have highly diversified cropping pattern. Though most of the farmers cultivate pigeon pea crop, the priorities for this crop vary widely. Some farmers grow it mainly for domestic consumption, while majority take it as supplementary income source. They give high priority to other cash crops, as pigeon pea intercropped with soybean and that with cotton are being cultivated in different combination ranging from 1:3 to 1: 10. While cotton provided better income possibilities at regular intervals, soybean has been preferred by majority due to its short duration, which can give decent yield even with 1–2 rainfall. Most striking features of the findings are the pigeon pea varieties adopted by the farmers are

Table 8 Results of Probit analysis for participation of pigeon pea growers in regulated market (APMC mandi)

Variables	Coefficients	Marginal Effects (dy/dx)
Constant	− 1.7784**	
	(0.8507)	
Operational holding (acre)	− 0.0595*	− 0.0195*
	(0.0353)	(0.0113)
Pigeon pea acreage (acre)	0.0804	0.0263
	(0.2066)	(0.0676)
Total pigeon pea production(quintal)	0.2941***	0.0963***
	(0.1046)	(0.0329)
Village distance from *mandi* (km)	− 0.0138	− 0.0045
	(0.0111)	(0.0036)
Marketed surplus (quintal)	− 0.3033***	− 0.0994***
	(0.1062)	(0.0333)
Selling price (INR/q)	0.0002*	7.04E−05*
	(0.0001)	(0.00004)
Dummy for selling time	0.7774***	0.2547***
	(0.2028)	(0.0595)
Dummy for large farm size	1.2846	0.4209
	(0.9544)	(0.3087)
Dummy for medium farm size	1.1001***	0.3604***
	(0.3932)	(0.1220)
Dummy for semi-medium farm size	0.499*	0.1635*
	(0.2608)	(0.0835)
Family size (no.)	− 0.0936	− 0.0307
	(0.0659)	(0.0214)
Number of observation:	218	
LR chi2(11)	38.53	
Prob > chi2	0.0001	
Pseudo R2	0.1335	
Log likelihood	− 125.08456	

Note: *, ** and *** represent the coefficients are significant at 10, 5 and 1% level of significance, respectively

Note: 1 quintal = 0.1 tonne, 1 acre = 0.25 hectare

15–20 years old. Added to that, majority of growers use their home grown seeds. This is one of the important reasons for lower crop yield. Thus, if the seed replacement rate is stepped up with improved varieties, the crop yield can easily improve by 20–30%. From the discussion with the researchers engaged in pigeon pea breeding and crop improvement, it emerged that for Maharashtra state there are several improved varieties like *Maruti* (2000 kg/ha), *Asha* (2500 kg/ha), BSMR 736 (2500 kg/Ha) and Hybrid ICPH 2740 (3000 kg/ha). Hybrid ICPH 2740 is highly suitable for intercropping with Cotton and Soybean in Maharashtra state (Source: http://www.icrisat.org/improved-pigeonpea-hybrid-helps-farmers-fight-drought-in-maharashtra-india/). Fertilizer application as well as pesticides application is also done in the field keeping in view the intercrops. Farm mechanisation in pigeon pea cultivation is restricted to seed sowing and pesticides spray. Harvesting is done manually, while threshing is done by mechanical thresher.

Since pigeon pea is mainly consumed after primary processing (converting into split dal after removing skin), the marketed surplus is high. Although regulated market offers better price realisation, time-consuming process in the market creates barrier to both small and large farmers. They are also not aware about the prevailing market prices and therefore sell their produce to the traders. In nutshell, increasing the access to the seeds of improved short duration variety may influence the cropping systems in favour of pigeon pea. Enhancing use of mobile for knowledge sharing and information dissemination particularly related to market price and potential buyers can be a great leveller for these farmers.

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