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Assessment of Varietal Replacement Rate of Potato in India: Constraints and Extension Strategies for Improvement

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ABSTRACT

The assessment of varietal replacement rate is as important as the adoption rate of improved varieties in estimating the performance of crop improvement programs, especially for countries approaching moderate to full adoption level. In India, more than 95 percent of the total potato area is under improved varieties. There are many studies pertaining to the extent of adoption of improved potato varieties, but there is a scarcity of studies about the varietal replacement of potato varieties in India. Thus, this study attempted to assess the varietal replacement by measuring the weighted average age of the improved varieties and also to examine the constraints for slow replacement rate and the extension strategies for improvement. The study revealed that more than 50 percent of the total supply of breeder seed by the ICAR-CPRI were varieties that were about 40-50 years old. Varieties lesser than 10 years old constituted only about 8 percent of the total supply. The weighted average age of improved varieties supplied from plains, hills and total supply was 30.18, 29.44 and 30.16 years old, respectively. This indicates that significant potato area in India is still under old varieties. The study also revealed that there are many institutional, technical and socio-economic constraints, responsible for the low varietal replacement rate in India. Extension strategies like participatory varietal development, frontline demonstrations, use of ICT tools, capacity building for farmers and other stakeholders, establishment of seed villages and encouragement of public-private partnership in the seed sector are recommended for rapid varietal replacement rate so that farmers will get the benefits offered by the new varieties.

Key words: *Varietal replacement, Weighted average, Potato, Improved varieties, Seed Supply*

Introduction

To meet the constantly rising and diverse food demand, the production needs to be doubled from the available resources that are already under pressure and other factors like, depletion of natural resources and diminishing total productivity (Kumar *et al.*, 2019; Raju *et al.*, 2019). Frequent replacement of cultivated crop varieties (cultivars) with new and improved ones is a critical means of simultaneously increasing yields and reducing the potential damage posed by evolving and newly emergent pests, diseases, and abiotic stresses (Krishna *et al*., 2016). Economists have also emphasized the importance of varietal turnover as a means of demonstrating the high returns to public investment in crop improvement (Day-Rubenstein *et al*., 2005; Dixon *et al*, 2006; Walker and Alwang, 2015). The success of the crop

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breeding programs occurs when millions of farmers adopt, or replace older varieties with superior material (Dixon *et al.*, 2006).

With about 487.40 million tons produced annually (FAOSTAT, 2020) and consumed by more than one billion people, potato is the third-most important human food crop in the world after rice and wheat (Devaux *et al.*, 2014). Potato had been designated by the FAO as the crop to address future global food security and poverty alleviation in 2008. India is ranked second in potato production in the world, only behind China. According to the ICAR-Central Potato Research Institute (ICAR-CPRI), India will require about 125 million tons of potatoes from an area of 3.62 million ha by the year 2050, with a compound annual growth rate (CAGR) of 3.2% up to 2050 (CPRI, 2015). To achieve this, it has to harvest potato with average productivity of 34.5 t per ha by 2050 at a CAGR of 1.46 per cent (CPRI, 2015). Breeding and dissemination of improved varieties are important strategies to increase the yield of the potato crop in the future.

As of 2020, the ICAR-CPRI has developed 68 varieties for different agro-climatic regions of the country. Around 95 percent of the India's total potato acreage was planted with the institute's varieties, which are very popular among the farmers. There are many studies conducted by the institute and other agriculture-related institutes/organizations for analyzing the extent of adoption (both intensity and incidence) of potato varieties, however the studies on varietal replacement are still lacking. The knowledge regarding crop varietal replacement rate is equally crucial, particularly for countries where adoption rates are already high. However, there is a dearth of studies on the varietal turnover of improved potato varieties in India, as well as at the global level. With this background in our mind, an attempt has been made to estimate the varietal replacement by analyzing the supply of breeder seeds of improved potato varieties in India using the method given by Brennan and Byerlee (1991) and also to examine the constraints for slow replacement rate and the extension strategies for rapid varietal replacement rate.

Materials and Methods

Sources of data

In this study, we used secondary data for calculation of varietal replacement. It is measured by the weighted average age of the improved potato varieties. Originally, Brennan and Byerlee (1991) applied area sown to a particular variety for calculating the weighted average age of the varieties. However, in this study, the calculation of the weighted average age was calculated based on the supply of breeder seed by the ICAR-CPRI. ICAR-CPRI, established in the year 1949, is a premier non-profit scientific institution responsible for the entire research programs on potato and supply of breeder seeds in the country. The data was collected from the annual reports for the year 2017-18 and 2018-19 of the ICAR-CPRI, available at https://ICAR-CPRI.icar.gov.in//content/Index/?qlid=4121&Ls_is=4233&lngid=1. The two years average (2016-17 and 2017-18) of the supply was taken for calculation of weighted average age. Year of the release of varieties was obtained from the Technical Bulletin No. 78 of the institute, entitled, "Indian Potato Varieties and Their Salient Features" available at https://cpri.icar.gov.in//content/Index/?qlid=4125&Ls_is=4229&lngid=1.

Empirical measurement

In this study, we followed the Varietal Replacement Index developed by Brennan and Byerlee (1991) to estimate the weighted average age of varieties. We used the proportion of the quantity of breeder seed supplied for a particular variety for weighting. The formula for calculating the weighted average age is as follows:

$$A_t = \sum_{i=1}^{n} P_{it} \, (t - y_i)$$

where A_t = the weighted average age of varieties in year t (t=2019 was selected for calculation of varietal age), P_{it}= the proportion of the quantity of supply for particular variety i, y_i= year of release of variety i. The larger the At, the slower is the varietal replacement, and the older is the stock of the varieties being planted.

Results and Discussion

Supply of breeder seed of improved potato varieties

Every year, ICAR-CPRI supplied about 2500 tons of breeder seed to various states in India, for further

multiplication in three more cycles, viz. Foundation Seed-1 (FS-1), Foundation Seed -2 (FS-2) and Certified Seed (CS) under strict health standards. In India, the major potato growing area is concentrated in Northern plains (80-85%). The hilly areas of North India account for 6 to 7 percent and plateau areas of the country represents about 8 to 9 percent area. The remaining area is present in the Nilgiri and Palani hills of Tamil Nadu and Sikkim and North Bengal. For plain areas, the seeds were supplied by the ICAR-CPRI's regional stations located at Modipuram (Uttar Pradesh), Jalandhar (Punjab), Gwalior (Madhya Pradesh), Patna (Bihar). From Figure 1, it is noticed that *Kufri Bahar*, was the top supplied variety from plains, contributed about 27 per cent of the total supply of breeder seeds. This variety is supplied by Modipuram station and is the most popular variety in Uttar Pradesh. The second most popular variety is *Kufri Jyoti*, a very old variety, released in the year 1968, constitutes about 13.1 per cent of the total breeder seed supply. *Kufri Jyoti* is a unique variety, which can be grown both in hilly as well as plain regions. Other popular varieties are *Kufri Khyati* (10.4 %), *Kufri Pukhraj* (9.8 %), *Kufri Sindhuri* (7.2) and *Kufri Chipsona*-1 (6.0 %). *Kufri Pukhraj* is popular among farmers because it is an early bulker, fits well in various cropping systems, drought tolerant and high yielder. These six top varieties altogether constitute about 73. 5 percent of the total supply of breeder seeds from plains.

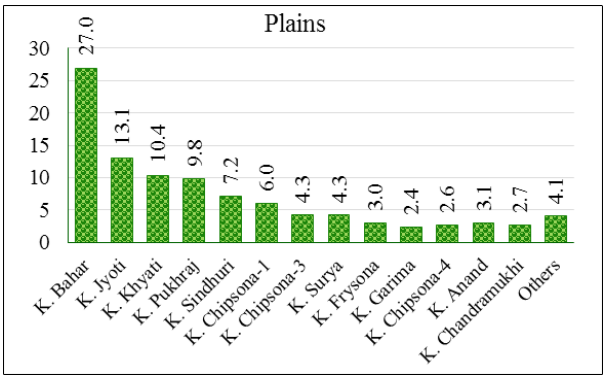

Fig. 1. Percentage of quantity of potato breeder seed supply for plain regions

For hilly regions, the breeder seeds were supplied from regional stations located at Kufri Fagu (Himachal Pradesh), Shillong (Meghalaya) and Ooty (Tamil Nadu). ICAR-CPRI regional station located in plains also supplied seeds to the hilly areas for some varieties. For hilly regions, *Kufri Jyoti* was the most supplied varieties, constituted about 43 percent of the total supply of breeder seed (Figure 2). Other important are *Kufri Himalini* (26.8 %), *Kufri Girdhari* (18.3 %), a late blight resistant variety, and *Kufri Shailja* (6.6 %). These four varieties altogether account for about 95 percent of the total potato supplied for the hilly regions.

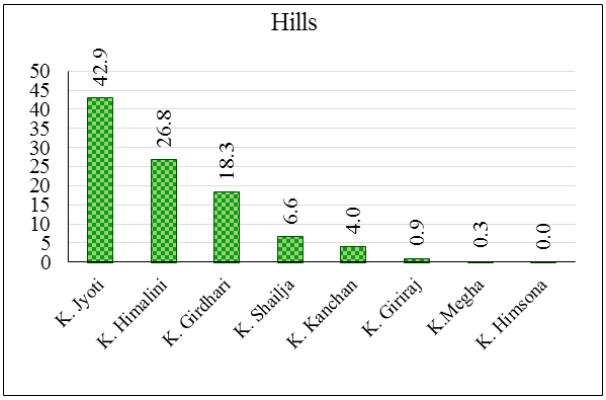

Fig. 2. Percentage of quantity of potato breeder seed supply for hilly regions

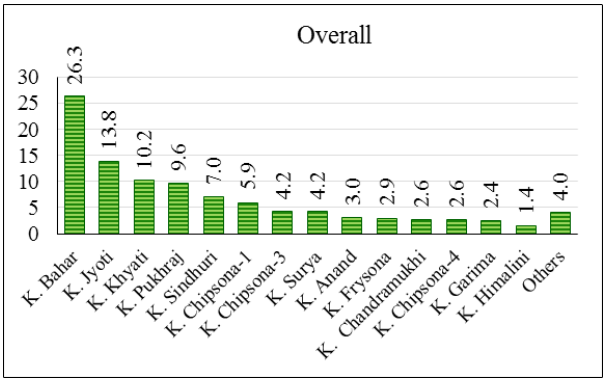

Fig. 3. Percentage of quantity of potato breeder seeds supply for plain and hilly regions

The total supply is similar to that of plain area, since more than 97 percent are supplied to plain regions (Figure 3). Overall, *Kufri Bahar* (26.3 %) was the most popular variety supply, followed by *Kufri Jyoti* (13.8 %), *Kufri Khyati* (10.2 %), *Kufri Pukhraj* (9.6 %), *Kufri Sindhuri* (7.0 %) and *Kufri Chipsona* -1 (5.9 %). These six varieties constituted about 73 percent of the total breeder seed supply by the ICAR-CPRI in India.

Weighted average age of improved potato varieties

The weighted average age of potato varieties supplied from plains, hills and the total supply is pre-

sented in Table 1, and 3, respectively. There were 28 improved varieties supplied to different potato growing states in India. The age of these varieties ranges from 5 to 52 years old as of 2019. Most of the popular varieties are very old. There were only five varieties whose ages are equal or lower than 10 years old, namely, *Kufri Frysona* (10 years), *Kufri Chipsona-4* (9 years), *Kufri Garima* (7 years), *Kufri Lalit* (5 years) and Kufri Gaurav (7 years). These varieties constituted only a small portion of the supply; about 8.45 percent of the total supply. Out of 28 varieties, 13 varieties were more than twenty years old. Old varieties like *Kufri Bahar* (39 years), *Kufri Jyoti* (51 years), *Kufri Sindhuri* (52 years), *Kufri Chandramukhi* (51 years), *Kufri Lauvkar* (47 years) and *Kufri Badshah* (40 years) are still prevalent, constituted about 51 per cent of the total supply of breeder seed.

The overall weighted average age of improved varieties supplied from plains and hilly areas was found to be 30.18 years and 29.44 years old, respectively. Likewise, the overall weighted average age for the total improved varieties supplied was 30.16. In the Indian context, the average time for the development of potato variety through pedigree method takes around 10–12 years, which implies that on an average, the seed producers produced certified seeds of improved varieties that had been selected more than 40 years ago.

In India, the old varieties across crops still dominate the scene and some of them got the status of megastar varieties (Singh *et al*., 2017). In other crops also, the weighted average age in India is older than most of the developed countries. Various studies related to varietal turnover reported that farmers continued to grow crop varieties that are very old, as a result, varietal replacement was very low (Pingali 1999; Smale *et al.,* 2008; Ghimire *et al*., 2012; Krishna *et al.,* 2016; Atlin *et al.,* 2017). Walker and Alwang (2015) suggested that in addition to the overall adoption rate, a weighted average age under 10 years indicated progress in plant breeding from an

Table 1. Weighted average age of improved potato varieties in plains

Varieties	Year of release	Age as of 2019	Supply in 2016-17 (q)	Supply in 2017-18 (q)	2 years average supply (q)	Proportionate quantity of supply	Weighted average age (years)
K. Bahar	1980	39	6528.5	5143.9	5836.2	0.27	10.52
K. Jyoti	1968	51	2994.7	2685.2	2840.0	0.13	6.69
K. Khyati	2008	11	2276.0	2228.0	2252.0	0.10	1.14
K. Pukhraj	1998	21	2378.2	1868.1	2123.1	0.10	2.06
K. Sindhuri	1967	52	1634.2	1468.0	1551.1	0.07	3.73
K. Chipsona-1	1998	21	1118.8	1485.8	1302.3	0.06	1.26
K. Chipsona-3	2006	13	1004.9	864.5	934.7	0.04	0.56
K. Frysona	2009	10	657.3	633.5	645.4	0.03	0.30
K. Surya	2006	13	606.7	1253.3	930.0	0.04	0.56
K. Garima	2012	7	568.0	490.5	529.3	0.02	0.17
K. Chipsona-4	2010	9	818.6	328.0	573.3	0.03	0.24
K. Anand	1999	20	607.0	716.0	661.5	0.03	0.61
K. Chandramukhi	1968	51	525.7	623.8	574.7	0.03	1.35
K. Lauvkar	1972	47	120.0	264.7	192.4	0.01	0.42
K. Sadabahar	2008	11	152.2	198.5	175.4	0.01	0.09
K. Badshah	1979	40	116.0	151.5	133.8	0.01	0.25
K. Himalini	2006	13	109.1	205.2	157.2	0.01	0.09
K. Arun	2005	14	39.5	0.4	20.0	0.00	0.01
K. Ashoka	1996	23	116.0	33.5	74.8	0.00	0.08
K. Lalit	2014	5	0.0	242.7	121.3	0.01	0.03
K. Kanchan	1999	20	13.0	1.8	7.4	0.00	0.01
K. Gaurav	2012	7	0.0	6.6	3.3	0.00	0.00
K. Pushkar	2005	14	1.3	0.0	0.7 0.0	0.00	0.00
Overall			22385.5	20893.4	21639.4	1.00	**30.18**

Note: K stands for "*Kufri*" (All potato varieties released by ICAR-CPRI, Shimla have a prefix "*Kufri*"; *Kufri,* located in Himachal Pradesh was the first potato breeding station in India)

economic perspective, while that approaching 20 years implies that recent releases are not competing well with earlier materials. According to Atlin *et al*. (2017), breeding and seed systems for smallholder farmers should aim to utilise varieties developed within the last ten years. Past researches suggested that if newer materials are not replacing their older counterparts, returns to genetic improvement stagnate (Brennan and Byerlee, 1991). Thus, in India, the weighted average age of improved potato varieties of about 30 years old is very high, taking into consideration that almost every year, ICAR-CPRI developed at least one variety. Other agricultural institutes/SAUs are also engaged in potato breeding programs. Thus, potato growers are losing the genetic gains (which may be for increasing yield and other important traits like nutritional improvement, drought tolerance, disease and insect resistance, processing quality, good storability, etc.) from the breeding programs.

Constraints responsible for low varietal replacement rate of improved potato varieties

For most of the crops including potato, evidences do not suggest that new varieties are failing to replace old ones because they lack superiority. Normally, new varieties released are more superior to the old ones. In potato breeding programs, before releasing a variety, several multi-location trials, which also include trials at farmers' fields, were conducted; the advanced hybrids are crosschecked with the old popular varieties for their performance in various important traits. Based on the performance of the hybrids against the popular old varieties, the hybrid is then released as a variety. Thus, there is very less chance that new varieties are inferior than old varieties. Nevertheless, there are some cases where old varieties are very unique and have superior traits, preferred by farmers which cannot be easily developed and replaced. For example, *Kufri Jyoti* is a variety that could be grown both for hilly and plain areas. *Kufri Surya*, a heat resistant variety and *Kufri Pukhraj*, an early bulker, drought tolerant high yielding variety are other examples. There are other constraints that are responsible for the low replacement rate. The constraints were examined by extensive review of related literatures, mostly conducted by the Indian researches (Table 4). They were categorised in to three categories, *viz*., institutional, technical and socio-economic constraints, which are discussed below:

Institutional constraints: The predominant constraints prevailing at institutional level, which hinder the VRR are delay between varieties released and their induction in seed chain (Gautam, 2013; Singh *et al*., 2016; Singh *et al*., 2017), low public investment to develop high-yielding short-duration varieties (Charyulu *et al*., 2015; Kumar *et al*., 2017; Chandusingh *et al*., 2018), major emphasis on production of large quantities of seed but marketing a few varieties with wide adaptation (Louwaars and De Boef, 2012; Singh *et al*., 2017), poor participation of private seed sector (Singh, 2017) and sluggish promotional efforts of potential varieties (Pavitra *et al*., 2017).

Technical constraints: The technical constraints that cripple the VRR are non-availability of seed pertinent to newly released varieties (Patnaik, 2013), preference of climate resilient and locally adapted farmers varieties as compared to modern varieties (Krishna *et al*., 2015), higher seed rate (Peng *et al*., 2010), inefficient conversion of breeder seed to certified seed (Singh *et al*., 2016; Singh *et al*., 2017) and low seed multiplication ratio (Singh *et al*., 2016;

Table 2. Weighted average age of improved potato varieties in hills

Varieties	Year of release	Age as of 2019	Supply in 2016-17 (q)	Supply in 2017-18 (q)	2 years average supply (q)	Proportionate quantity of supply	Weighted average age (years)
K. Jyoti	1968	51	293.1	352.2	228.7	0.43	21.90
K. Himalini	2006	13	172.9	231.3	142.7	0.27	3.48
K. Girdhari	2008	11	132.6	141.5	97.5	0.18	2.01
K. Shailja	2005	14	65.0	31.7	35.2	0.07	0.93
K. Kanchan	1999	20	40.8	17.6	21.4	0.04	0.80
K. Giriraj	1998	21	11.3	2.2	5.0	0.01	0.20
K. Megha	1989	30	2.6	2.4	1.8	0.00	0.10
K. Himsona	2008	11	0.1	0.1	0.0	0.00	0.00
Overall			718.4	779.0	532.46	1.00	**29.44**

Singh *et al*., 2017). The seed multiplication ratio is only 1:4 for potato in comparison to 1:100 for rapeseed/ mustard, 1:80 for paddy, 1:50 for cotton and 1:20 for wheat. Thus, it will take time to produce breeders or certified seeds for the whole country.

Socio-economic constraints: Some of the major socio-economic constraints that lead to low VRR are risk aversion and lack of credit facilities (Feder and Umali, 1993), high transportation cost (Peng *et al*., 2010; Singh *et al*., 2017), lack of awareness about the potential of quality seed (Singh *et al*., 2016; Pavitra *et al*., 2017), high cost of seeds and large storage losses (Singh *et al*.,2016; Singh *et al*., 2017) and extensive use of farmers' own-saved seeds and farmer to farmer seed exchange (Feder and Umali, 1993; Pavitra *et al*., 2017).

Extension strategies for improving varietal replacement rate of improved potato varieties

The extension will play a very important role for enhancing the adoption of new improved varieties which will lead to faster varietal replacement rate of improved potato varieties in India. Some of the extension strategies recommended for improving the varietal replacement rate in India are as follows:

1. **Frontline demonstrations (FLDs) and promotion of new varieties:** Front line demonstrations (FLDs) of new varieties should be planned to demonstrate their superiority over the old varieties. This will enhance requirement for quality seed of new varieties ultimately resulting in higher varietal replacement rate and increased production.
2. **Participatory plant breeding (PPB):** One promising approach for improving the varietal replacement rate is to bring farmers back into breeding which is called as participatory plant breeding. Farmers should be involved in breeding programmes to suit their adaptive needs. PPB approach increases the response to selection,

Table 3. Weighted average age of total supply of improved potato varieties

Varieties	Year of release	Age as of 2019	Supply in 2016-17 (q)	Supply in 2017-18 (q)	2 years average supply (q)	Proportionate quantity of supply	Weighted average age (years)
K. Bahar	1980	39	6528.5	5143.9	5836.2	0.263	10.266
K. Jyoti	1968	51	3287.8	3037.4	3068.7	0.138	7.059
K. Khyati	2008	11	2276.0	2228.0	2252.0	0.102	1.117
K. Pukhraj	1998	21	2378.2	1868.1	2123.1	0.096	2.011
K. Sindhuri	1967	52	1634.2	1468.0	1551.1	0.070	3.638
K. Chipsona-1	1998	21	1118.8	1485.8	1302.3	0.059	1.233
K. Chipsona-3	2006	13	1004.9	864.5	934.7	0.042	0.548
K. Surya	2006	13	606.7	1253.3	930.0	0.042	0.545
K. Anand	1999	20	607.0	716.0	661.5	0.030	0.597
K. Frysona	2009	10	657.3	633.5	645.4	0.029	0.291
K. Chandramukhi	1968	51	525.7	623.8	574.7	0.026	1.322
K. Chipsona-4	2010	9	818.6	328.0	573.3	0.026	0.233
K. Garima	2012	7	568.0	490.5	529.3	0.024	0.167
K. Himalini	2006	13	281.9	436.5	299.9	0.014	0.176
K. Lauvkar	1972	47	120.0	264.7	192.4	0.009	0.408
K. Sadabahar	2008	11	152.2	198.5	175.4	0.008	0.087
K. Badshah	1979	40	116.0	151.5	133.8	0.006	0.241
K. Lalit	2014	5	0.0	242.7	121.3	0.005	0.027
K. Girdhari	2008	11	132.6	141.5	97.5	0.004	0.048
K. Ashoka	1996	23	116.0	33.5	74.8	0.003	0.078
K. Shailja	2005	14	65.0	31.7	35.2	0.002	0.022
K. Kanchan	1999	20	53.8	19.4	28.8	0.001	0.026
K. Arun	2005	14	39.5	0.4	20.0	0.001	0.013
K. Giriraj	1998	21	11.3	2.2	5.0	0.000	0.005
K. Gaurav	2012	7	0.0	6.6	3.3	0.000	0.001
K. Megha	1989	30	2.6	2.4	1.8	0.000	0.002
K. Pushkar	2005	14	1.3	0.0	0.7	0.000	0.000
K. Himsona	2008	11	0.1	0.1	0.0	0.000	0.000
Overall			23103.9	21672.3	22171.9	1.00	**30.16**

adoption, and the returns. This approach combines science-based breeding methods and farmers' experience and thereby reconciliates past and present competencies to find solutions for a better adoption of newly bred varieties in developing countries (Stamp and Visser, 2012).

3. **Use of ICT for creating awareness about the new varieties**: ICT should be promoted among the farmers as they play very important role in providing agro-advisory services to the farmers, thus helping them in deciding wide range of agricultural related activities, including proper selection of improved varieties. ICAR-CPRI has developed ICT tools and decision support systems that are related to varietal selection like potato variety, potato seed bank and potato master mobile app. These should be made aware among extension functionaries and farmers for improving the adoption of new varieties.
4. **Capacity building for farmers for production of quality seeds:** Low adoption of improved potato varieties and scientific potato seed production technologies also account for low productivity in few states. This is because farmers are still unaware of the potato varieties and are not competent enough to produce good quality potato seeds by themselves. Thus, they are still relying on their own saved seeds and traditional practices. Thus, institutional and financial arrangement should be made for enhancing the knowledge and skills of farmers on scientific potato seed production and improved potato varieties through trainings, demonstrations, technical advisories, etc for enabling them to use the technologies in their own fields.
5. **Creation of community seed banks/seed villages:** To assist the production and prompt supply of seed of desired crops/varieties at the grassroots, the creation of community seed bank and seed villages should be promoted. Depending on the quantity of seed needed and the rate of seed replacement, these can be made to cover a specific village or area. These seed banks need to be viewed as an essential component of the common infrastructure for farmers at all levels, especially for small and marginal farmers (Singh *et al*., 2017).
6. **Encouragement of public-private partnership (PPP) in the seed sector**: The time lag between the release and adoption of the new varieties needs to be reduced in order to improve the varietal replacement rate. To enhance the outreach of modern and new varieties, it is necessary to encourage public-private partnership in the seed

Table 4. Constraints responsible for low varietal replacement rate of improved potato varieties

Constraints	References
Institutional Constraints	
Delay between varieties released and their induction in seed chain	Gautam, 2013; Singh *et al*., 2016; Singh *et al*., 2017
Low public investment to develop high-yielding short-duration varieties	Charyulu *et al*., 2015; Kumar *et al*., 2017; Chandusingh *et al*., 2018
Production and marketing a few varieties with wide adaptation	Louwaars and De Boef, 2012; Singh *et al*., 2017
Poor participation of private seed sector	Singh *et al*.,2016; Singh *et al*., 2017
Slow promotional efforts of potential varieties	Pavitra *et al*., 2017
Technical constraints	
Non-availability of seed pertinent to newly released varieties	Patnaik, 2013; Pavitra *et al*., 2017; Singh *et al*., 2017
Preference of local varieties as compared to modern varieties	Krishna *et al*., 2015
Higher seed rate	Peng *et al*., 2010
Inefficient conversion of breeder seed to certified seed	Singh *et al*., 2016; Singh *et al*., 2017
Low seed multiplication ratio (SMR)	Singh *et al*., 2016; Singh *et al*., 2017
Socio-economic constraints	
Risk aversion and lack of credit	Feder and Umali, 1993
High transportation cost	Peng *et al*., 2010; Singh *et al*., 2017
Lack of awareness about the potential of quality seed	Singh *et al*., 2016, Pavitra *et al*., 2017
High cost of seeds and large storage losses	Singh *et al*.,2016; Singh *et al*., 2017
Extensive use of farmers' own-saved seeds and farmer to farmer seed exchange	Feder and Umali, 1993; Pavitra *et al*., 2017

sector along with sustained investments in varietal development and seed supply.

Conclusion

The study has estimated the varietal replacement by measuring the weighted average varietal age of the improved varieties supplied by ICAR-CPRI for various potato growing states of India. The study revealed that even though, in India more than 95 percent of the total potato area is under improved varieties, the weighted average age of the improved varieties is very old. The weighted average age of improved varieties supplied from plains, hills and total supply was 30.18, 29.44 and 30.16 years old, respectively. This indicates that significant potato area is still under old varieties leading to a low varietal replacement rate in the country. Some of the popular varieties supplied are more than 50 years old. New varieties lesser or equal to 10 years old constituted only a small proportion of the supply, about 8.45 percent. As a result, farmers missed out many benefits of the genetic gains, which may be yield gain, economic returns, disease resistance, etc. There are many constraints that hinder farmers to adopt modern varieties, which need to be properly identified. Therefore, in a country like India which has almost reach full adoption rate of improved potato varieties, the state governments, policymakers and researchers should focus more on replacing old varieties with the new ones. Frontline demonstrations, participatory plant breeding, use of ICT tools, capacity building for farmers and other stakeholders, creation of seed villages, encouragement of PPP in the seed sector should be implemented for faster replacement rate.

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