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Seed Production Chain, Varietal Replacement of Minor Pulses in India and Strategies for Enhancing Their Production: A Review

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ABSTRACT

Minor pulses like moth bean, horsegram, grasspea, cowpea, French bean and other lesser grown pulses contributed 9.4%-11.7% and 6.4%-7.1% to total pulses acreage and production, respectively, during 2015-16 to 2020-21. The present paper reviews production scenario, seed production chain of minor pulses during the last decade (2010-11 to 2019-20) and tried to bring out some strategic issues for higher yield and sustainable production. Moth bean and grasspea acreage, production and yield/ha during 2019-20 were appreciably reduced by 41.4%, 60.0% and 31.7% and 39.7%, 47.2% and 40.5%, respectively as compared to that of 2010-11. Despite reduction in acreage by 9.9%, production and seed yield of horsegram were higher by 12.9% and 25.3% during the corresponding period. Of the 94 varieties of minor pulses notified during 2016-24, only 17 were in the seed chain until 2023-24. Despite adequate production of breeder seed of these crops, shortage in foundation and certified seed availability was observed in cowpea, moth bean and other pulses in a few years. The analysis indicated conversion of breeder seed to other classes of seed, low varietal replacement rate and lack of varietal diversity in the seed chain are the major issues impeding productivity of these crops. Seed requirement of different crops has also been assessed and strategy to sustain high production of these crops through seed/variety replacement was proposed.

Key words: Breeder seed, Cowpea, Horsegram, Moth bean, Quality seed, Seed chain, Varietal diversity, Varietal replacement.

Pulses are important components of food crops in India accounting for 20.3%-24.2% and 6.4%-8.9% of the acreage and production of food crops during 2015-16 to 2021-22 (Anonymous, 2023a). Of the record production of food grains 329.7 million tonnes (m t) during 2022-23, the contribution of pulses was 7.9% (Anonymous, 2023b). Large chunk of acreage (88.8%-90.7%) and production (92.9%-93.9%), is accounted by chickpea, pigeon pea, green gram, black gram, lentil and field pea. Minor pulses (Fig 1), *viz*., grasspea (*Lathyrus sativus* L.), moth bean [*Vigna aconitifolia* (Jacq.) Marechel], horsegram [*Macrotyloma uniflorum* (Lam.) Verdc.], cowpea [*Vigna unguiculata* (L.) Walp.] and French bean/ kidney bean/rajmash (*Phaseolus vulgaris* L.) contributed about 2.73 million hectares (m ha) -3.15 m ha (9.4%-11.7%) and 1.13 million tons (m t) -1.65 m t (6.4%-7.1%) to total pulses acreage and production during 2015-16 to 2020-21(Anonymous, 2022a). One of the major reasons for the increased pulses production is the enhanced use of good quality seed through several strategic interventions by the Government of India and National Agricultural Research System (NARS) during the last 10 years resulting in to high seed replacement rate (Chauhan *et al*., 2016a, 2020, 2022). In all the major pulses, except chickpea, seed replacement rate (SRR) was close to the ideal one (33% for self-pollinated and 50% for cross pollinated crops) during 2020-21. Further, it was accompanied by high varietal replacement rate ranging from 61.3% (blackgram) to 90.8% for lentil during 2020-21 (Chauhan *et al*., 2022). Seed is the basic input of crop production and seed and variety replacement is pivotal to enhance and sustain seed yield/ha and consequently, pulses production (Chauhan *et al*., 2016b, 2022). Seed chain having diverse partners, has been discussed elaborately for major pulses earlier (Chauhan *et al*., 2016a, 2020). But similar information is lacking for minor pulses. UN Sustainable Development Goal 2 (SDG 2) advocates to end hunger, achieve food security and improved nutrition and promote sustainable agriculture, mandates that world need to produce and consume more protein sources (www.worldseed.org) and in this scenario minor pulses can play an important role. These crops are also well suited to drought prone areas,

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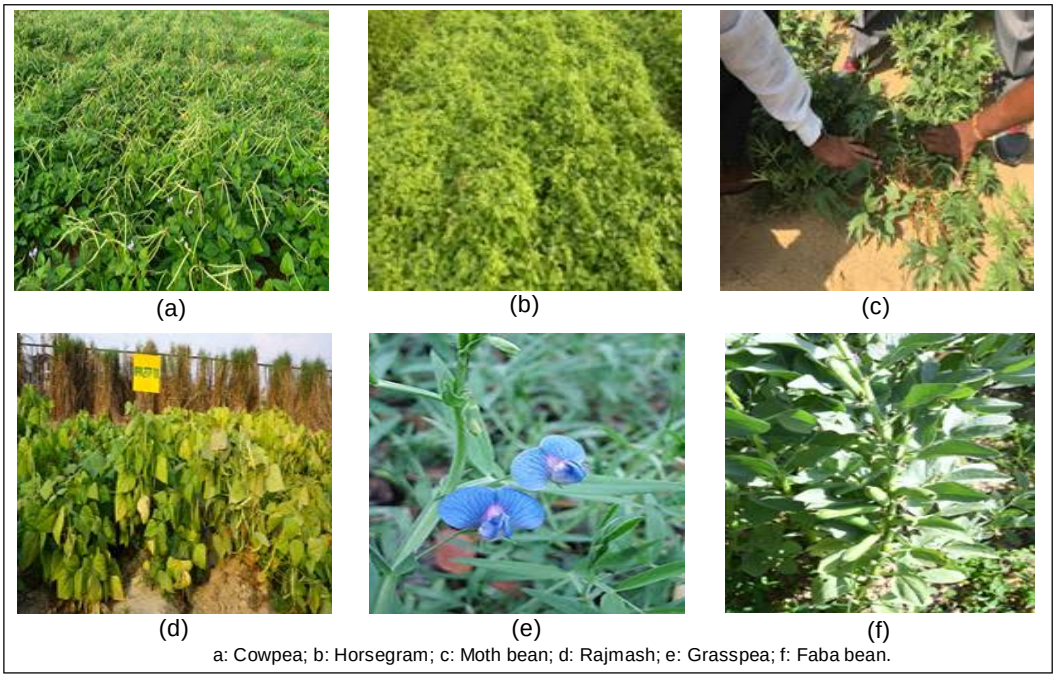

a: Cowpea; b: Horsegram; c: Moth bean; d: Rajmash; e: Grasspea; f: Faba bean.

Fig 1: Important minor pulses grown in India.

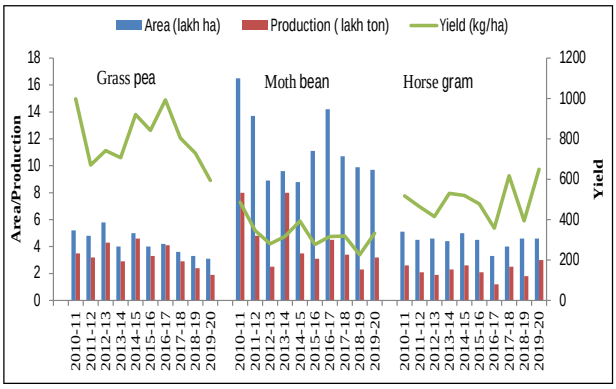

Fig 2: Area, production and yield of grass pea, moth bean and horse gram in India during 2010-11 to 2019-20. (Source: Anonymous, 2022a).

nutrient starved soils as well as grown as *paira*/ sole/inter-mixed crop largely by small and marginal farmers under diverse fragile agro-ecological system. The present paper reviews production scenario (2010-11 to 2019-20) and seed production status of minor pulses in India during 2010-11 to 2022-23 to bring out the strategic issues for increasing and sustaining their production specifically by up-scaling improved seed production and variety replacement.

Trend in acreage, production and yield

Moth bean

Moth bean is an important drought resistant pulse crop in arid and semi-arid regions. It is largely cultivated in *kharif* season in mixed cropping with pearl millet or sorghum. Rajasthan was the major moth bean growing state accounting for 98.6% and 97.8% of the total acreage (9.7 lac ha) and production (3.2 lac t) during 2019-20 (Anonymous, 2022a; Tiwari and Shivhare, 2016). The yield was 462kg/ha in Gujarat and 329 kg/ha in Rajasthan against national average of 332 kg/ha. During 2010-11 to 2019-20, both area and production showed wide annual fluctuations ranging from 8.8 lac ha (2014-15) to 16.5 lac ha (2010-11) an appreciable reduction of 46.7% (Fig 2). The highest and lowest moth bean production was observed during 2010-11 (8.0 lac t) and 2012-13 (2.5 lac t), a decline of 68.8% with concomitant reduction in both acreage by 46.0% and yield/ha by 42.4%. The highest acreage, production and yield/ha were achieved during 2010-11 and during 2019-20; they were reduced by 41.4%, 60.0% and 31.7%, respectively. Mean share of moth bean in total acreage and production of minor pulses was 37.5% (31.2%-45.2%) and 22.1% (13.6%-27.3%), respectively, during the last five years.

Horsegram

Horsegram is widely grown in dry land areas in northern hills as well as in several central and southern states as pure crop as well as intercrop/mixed crop with cereals, groundnut, pigeonpea and sesame or niger. It is grown in both, *kharif* and *rabi* seasons. Its contribution ranged from 10.3% (2016-17) to 16.8% (2018-19) and 7.1% (2016-17) to 19.8% (2019-20), respectively, to the total acreage and production of minor pulses (Anonymous, 2022a). It is widely grown in Karnataka, Andhra Pradesh, Tamil Nadu and Chhatisgarh with a share of 35.2%, 24.9%,17.3% and 7.7%, respectively, to the national acreage (4.6 lac ha) during 2019-20. Their corresponding share in national production (3.0 lac t) was 40.7%, 18.9%, 20.5% and 4.7%, respectively.

Uttarakhand had the highest yield (1000 kg/ha) followed by Tamil Nadu (776 kg/ha), Karnataka (753 kg/ha) and Jharkhand (682 kg/ha) and all India average yield was 649 kg/ha. Nevertheless, it is also grown in Odisha, Maharashtra Rajasthan, Gujarat states and Jammu and Kashmir Union Territory to a very limited extent. Overall, during 2019-20, acreage was lower by 9.9% but production and seed yield were higher by 12.9% and 25.3%, respectively, than that of 2010-11 (Fig 2).

Grasspea

The grasspea or khesari grows well on drought prone, poor soils where lentil and chickpea are not expected to give dependable yields. It is mainly grown as a *paira* crop in standing paddy, where it is broadcasted. It is also grown as sole crop in rice fallows where no oilseed, cereal and pulse crop can be grown as well as mixed crop with linseed or chickpea in *rabi* season. Under *paira* cropping, farmers give more emphasis for its fodder and consider grain yield as an additional advantage (Pandey *et al*., 1996). During the last decade, its acreage varied from 3.3 lac ha (2018-19) to 5.8 lac ha (2012-13). The highest production (4.6 lac t) and seed yield/ha (921 kg) was recorded during 2014-15 (Fig 2). The acreage and production of grasspea during 2019-20 was substantially declined by about 46.0% and 59.2%, respectively, in comparison to the highest ever achieved during the decade (Fig 2). Its contribution to total minor pulses production and acreage during the last five years ranged from 12.4% (2019-20) to 29.5% (2015-16) and 10.1% (2019-20) to 13.6% (2015-16), respectively. Chhatisgarh had the highest share (55.0%) followed by West Bengal (30.9%) and Bihar (13.7%) and together contributed almost total national acreage of 3.1 lac ha during 2019-20. Their corresponding contribution to production was 36.0%, 46.2% and 17.7%. The seed yield was the highest in West Bengal (885 kg/ha) followed by Bihar (760 kg/ha) and Chhatisgarh (389 kg/ha) and national average yield was 594kg/ha.

Cowpea

Cowpea is an important component of farming system in resource constraints agriculture in India and grown as sole/ intercrop/mix-crop and agro-forestry combinations. It is expected that it accounts for about 50.0% of the 13.0 lac ha area in Asian countries (Tiwari and Shivhare, 2016). In India, it is mainly cultivated in arid and semi-arid regions of Rajasthan, Karnataka, Kerala, Tamil Nadu, Maharashtra and Gujarat and in certain pockets of Punjab, Haryana and Western Uttar Pradesh during *kharif* / summer in northern India and throughout the year in peninsular India.

French bean

French bean/kidney bean/common bean/rajmash is mainly grown in Maharashtra, Himachal Pradesh, Uttar Pradesh, NE states and J & K Union Territory and covering about 0.8- 0.85 lac ha and also becoming popular in north Indian plains (Tiwari and Shivhare, 2016). It is grown during *kharif* season in hilly region; *spring* in lower hills/*tarai* and *rabi* in NE plains and hilly tracts of Maharashtra. In hills, it grows as an intercrop with maize/early potato.

Other beans

Faba bean or Broad bean (*Vicia faba* L.) has shown high yield potential with response to inputs and good management and fits well in to intensive cropping season ideally during *spring* season with mild summer. Rice bean [*V. umbellata* (Thunb.) Ohwi and Ohashi] is a tropical to temperate grain legume grown for food and fodder and can be grown under a wide range of soils and climatic conditions in Odisha, West Bengal, Madhya Pradesh, Chhatisgarh and the hilly areas of Himachal Pradesh, Uttarkhand and NE hilly region as dual purpose crop and best suited to tropical climate of *kharif* season. Further, adzuki bean [*V. angularis* (Willd.) Ohwi and Ohashi], Indian bean/Dolichosbean [*Lablab purpureus* (L.) Sweet] and Winged bean [*Psophocarpus tetragonolobus* (L.) DC] are also grown on very limited acreage.

Seed production chain and varietal replacement rate

Seed chain

Among the three systems of seed production, formal seed system involves both public and private sector and indent and production of breeder seed is the beginning of the seed chain followed by its conversion to other classes (foundation and certified) of seed (Chauhan *et al*., 2016 a,c). The leading varieties in the seed chain were identified by their frequency of occurrence in the seed chain (at least four times and/or indented since 2019-20) and their share (%) in breeder seed indent.

Varietal replacement

Moth bean

Seed chain of moth bean comprised 10 varieties varying from one (2021-22) to seven (2014-15). The topmost five varieties accounted for 94.5% (2014-15 and 2015-16) to 100.0% of the breeder seed indent in rest of the years. The major contributors to the seed indent were RMO 40 (5.0%-67.7%), RMO 257 (1.0%-53.4%), Maru Bahar/RMO 435 (5.6%-31.9%), CAZRI Mothbean 2 (8.5%-23.3%) and RMO 2251(75.8%-100.0%). Among the leading varieties, except RMO 2251, released during 2018, others were at least 15 years old and RMO 40 was the oldest, released during 1994. Of the three varieties released during 2016-24, only one was indented during the period of analysis.

Horsegram

Number of varieties of horse gram in the seed chain ranged from three (2014-15) to eight (2023-24). In all, 12 varieties were indented across the 10 years and Birsa Kulthi (3.0%-45.6%), VL Gahat (0.8%-26.4%), CRIDA 1-18 R (15.5%-38.5%), CRIDA Harsha (2.2%-82.5%), Indira Kulthi 1 (5.2%-26.5%), Gujarat Dantiwada Horsegram 1/GHG 5(4.8%-26.4%), Chhattisgarh Kulthi 3 (16.6%-21.2%) and Bilasha Kulthi (4.2%-39.6%) were the principal contributors to the seed indent. Of these, except Chhattisgarh Kulthi 2

(released in 2018), Chhattisgarh Kulthi 3 (released in 2017), Bilasha Kulthi (released in 2017) and CRIDA Harsha (released in 2014), the rest were released prior to 10 years with Bilasha Kulthi, the oldest one (released in 1987) and overall in the seed chain Madhu was the oldest, released during 1978. Of the eight varieties released and notified during 2016-24, only three were in the seed chain during 2023-24.

Grass pea

Only five varieties of grasspea, *viz.,* Prateek (released in 2006), Ratan (released in 1997), Mahateora (released in 2008), Nirmal (released in 1982) and Bidhan Khesari 1 (released in 2018) were in the seed chain during 2015-16 to 2023-24. They correspondingly accounted for 11.4%-68.9%; 4.8%-76.1%; 13.3%-78.3%; 2.7% and 12.0%-84.6% of the breeder seed indent.

Cowpea

Highest number of cowpea varieties, nine each was indented during 2015-16 and 2016-17. The old varieties developed until 1995 were predominant and had the largest share in breeder seed indents during 2017-18, 2020-21 and 2021-22, 55.0% from two varieties, 50.0% from two varieties and 50.7% from two varieties, respectively. Varieties developed during 2006-10 accounted for 44.4% and 24.0% each from one variety during 2015-16 and 2018-19, respectively (Table 1). Varieties developed during 2001-05 and those developed during 2011-15 had the largest share in breeder seed during 2014-15 and 2016-17, respectively.

The contribution of varieties released during 2016-20 was 16.0% during 2016-17 but declined to 8.8% during 2017-18 and gradually increased and reached 72.3% from four varieties during 2023-24 (Table 1). Only five varieties notified during 2016-24 were in seed chain during 2023-24. However, a recently released variety *viz*., Phule Sonali (2023) was also inducted in the seed chain during 2022-23 and contributed 10.7% to the total seed indent during 2022-23 and 2023-24 (Table 1). Contribution of topmost five varieties to breeder seed indent ranged from 92.8% (2015-16) to 100.0% (2014-15 and 2021-22). Nineteen varieties appeared in the topmost five varieties across the years and among them leading ones were Pusa 152 (7.0%-43.4%), RC 19 (6.4%-41.7%), RC 101 (4.9%-28.4%), DC 15 (8.8%-52.7%), Pant Lobia 1 (13.6%-44.4%), Gujarat Cowpea 4 (12.0%-24.5%), Karan Chanwala (17.3%-29.2%), Phule Sonali (10.7%), C 152 (6.7%-11.6%) and KBC 9 (1.5%-7.6%). Several varieties like Pusa Komal (43.7%), Alsando (28.8%), PKB 6 (24.0%), Gujarat Cowpea 3 (26.0%) and C 152 (15.9%) also contributed appreciably to the breeder seed indent but indented only once during the last 10 years. Only Alsando (2015), Phule Vithai (2016), PKB 6 (2012), DC 15 (2017), Karan Chanwala (2018) and KBC 9 (2018) were released during 2011-20. Pusa Komal, RC19, C 152 and Pusa 152 were very old released during 1987, 1987, 1982 and 1978, respectively. Pant Lobia 1 and Gujarat Cowpea 3 were released during 2010 and 1990, respectively. Of the 26 varieties released during 2016-24 only eight were inducted in the seed chain during the last 10 years (2014-15 to 2023-24).

French bean

Six varieties of French bean or rajmash, Amber, Arun, Uttakarsh, Kota Rajmash 1, Phule Rajmash and Phule Viraj were in the seed chain during 2015-16 to 2019-20 and 2022-23. There was no indent during 2023-24. Arun with a share of 50.0%-100.0% was the leading variety followed by Amber (40.0%-50%). Uttarkash and Kota Rajmash 1 were indented only once in 2015-16 and 2018-19 with contribution of 50.0% and 7.7%, respectively. Phule Rajmash and Phule Viraj were inducted in the seed chain during 2022-23 for a very small quantity of 0.05 q for each. Except Kota Rajmash 1, Phule Rajmash and Phule Viraj, released in 2018, 2019 and 2024, respectively, the rest were very old, released prior to 15 years.

Indian bean

One variety of Indian bean, Konkan Bhushan, released during 1993 was indented during 2021-22 for 20q breeder

Table 1: Varietal replacement in cowpea as assessed from the contribution of varieties developed during different phases (quinquennial) to the breeder seed indent.

Year	Indent (q)	Varieties indented (no.)	Up to 1995	1996-2000	2001-05	2006-10	2011-15	2016-20	2021-23
2014-15	38.8	5	3 (45.9%)	-	2 (54.1%)	-	-	-	-
2015-16	163.2	9	3 (6.1%)	1 (24.5%)	2 (17.2%)	1 (44.4%)	2 (7.8%)	-	-
2016-17	31.3	9	2 (21.7%)	1 (12.0%)	2 (6.5%)	1 (13.6%)	2 (30.4%)	1 (16.0%)	-
2017-18	17.1	7	2 (55.0%)	1 (21.9%)	1 (11.7%)	1 (1.2%)	1 (1.2%)	1 (8.8%)	-
2018-19	20.8	6	1 (24.0%)	1 (18.0%)	1 (9.6%)	1 (24.0%)	-	2 (24.0%)	-
2019-20	16.1	6	1 (31.1%)	-	1 (12.4%)	-	-	4 (56.2%)	-
2020-21	13.2	6	2 (50.0%)	1 (0.8%)	1 (16.7%)	-	-	2 (32.5%)	-
2021-22	34.3	5	2 (50.7%)	-	-	-	-	3 (49.3%)	-
2022-23	30.0	7	1 (16.7%)	-	-	1 (0.3%)	-	4 (72.5%)	1 (10.7%)
2023-24	30.0	7	1 (16.7%)	-	-	1 (0.3%)	-	4 (72.3%)	1 (10.7%)

Source: (Anonymous, 2020b, 2021b, 2022c; Yadava *et al*., 2023, 2024; www.seednet.gov.in).

[a]Within parenthesis is the contribution of varieties.

seed production whereas; five varieties were indented for 11.3q breeder seed production during 2022-23. They were Konkan Bhushan, Pusa Early Prolific, Arka Supriya, Phule Gauri and Phule Suruchi released during 1993, 2014, 2021, 2006 and 2015, respectively. The breeder seed indent was 3.5 q during 2023-24 for varieties Bundel Sem 1 (JLP 4) and French yellow released during 1993 and 1978, respectively with corresponding share of 14.3% and 85.7%.

Seed standards

In formal system of seed production, that follows three stages of seed production *viz*., breeder, foundation and certified seed. Seed Certification following Indian Minimum Seed Certification Standards (IMSCS) for Agricultural and Horticultural Crops (Trivedi and Gunasekaran, 2013) is essential for maintaining quality of seed and also vital for marketing. It ensures quality of seed in terms of physical/ genetic purity and identity of a notified kind or variety supplied to the farmers. Foundation and certified seed production is regulated strictly adhering to the IMSCS 2013 through monitoring at different stages of the crop by a duly constituted committee. There are no prescribed limits for regulating quality of breeder seed and no certification. Nevertheless, it is expected to be of utmost purity in terms of parameters prescribed for foundation seed. But, monitoring of breeder seed plots by a duly constituted committee comprising the concerned breeder or designated breeder nominated by the organization sponsoring the variety and officials from National Seed Corporation and State Seed Certification Agency is mandatory as for foundation and certification. The concerned or designated breeder is responsible for maintaining the quality of breeder seed.

Land to be used for seed production should be free of volunteer plants and a minimum of two crops inspections, the first before flowering and the second at flowering and fruit stage should be undertaken by the monitoring team. These minor pulses are self-pollinated and foundation seed production plots should be isolated from fields of other varieties and fields of same variety not conforming to the varietal purity requirement for certification by at least 10 m. The corresponding distance for certified seed plot should be 5 m (Trivedi and Gunasekaran, 2013). The specific requirements for seed certification of minor pulses are given in Table 2.

Indian bean

Bacterial blight (*Xanthomonas spp.*), Anthrocnose [*Colletotrichum lindamuthianum* (Sacc. and magn) Brr. and Cav.] and Ascochyta blight (*Ascochyta spp.*) for hill areas only; Cowpea: Seed borne diseases shall be Ashby stem blight [*Macrophomina phaseoli* (*Maub.*) *Ashby.*]; Anthrocnose [*Colletotrichum lindamuthianum (*Sacc. and magn) Brr. and Cav.]; Ascochyta blight *(Ascochyta spp.)* for hill areas only and Cowpea mosaic and Rajmash : Bacterial blight (*Xanthomonas spp.*), Anthrocnose [*Colletotrichum lindamuthianum (*Sacc. and magn) Brr. and Cav.] and Ascochyta blight (*Ascochyta spp.*) for hill areas only and Bean mosaic (*Macrosiphumpisi* Kalt).

Table 2: Specific requirements for seed certification of minor pulses.

Factor	Moth bean		Horsegram		Grasspea		Cowpea		French bean		Indian bean	
	FS	CS	FS	CS	FS	CS	FS	CS	FS	CS	FS	CS
*Off-types (%)	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20
*Plants affected by seed borne diseases	-	-	-	-	-	-	0.10	0.20	0.10	0.20	0.10	0.20
Pure seed (minimum)	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%
Inert matter (maximum)	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
Other crop seeds (maximum)	5/kg	10/kg	None	10/kg	5/kg	10/kg	None	10/kg	None	None	None	None
Other distinguishable varieties (maximum)	10/kg	20/kg	5/kg	10/kg	10/kg	20/kg	5/kg	10/kg	5/kg	10/kg	5/kg	10/kg
Weed seed (maximum)	5/kg	10/kg	None	None	5/kg	10/kg	None	10/kg	None	10/kg	None	None
Germination including hard seeds (minimum)	75.0%	75.0%	80.0%	80.0%	75.0%	75.0%	75.0%	75.0%	75.0%	75.0%	75.0%	75.0%
Moisture (maximum)	9.0%	9.0%	9.0%	9.0%	9.0%	9.0%	9.0%	9.0%	9.0%	9.0%	9.0%	9.0%
For vapour-proof containers (maximum)	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	7.0%	7.0%	8.0%	8.0%

*Maximum permitted at the final inspection, Indian bean: Seed borne diseases shall be:

Indian bean: Bacterial blight *(Xanthomonas spp.),* Anthrocnose[*Colletotrichum lindamuthianum (*Sacc. and magn) Brr. and Cav.]and Ascochyta blight *(Ascochyta spp.)* for hill areas only; Cowpea: Seed borne diseases shall be Ashby stem blight *(Macrophomina phaseoli (Maub.)Ashby.);* Anthrocnose[*Colletotrichum lindamuthianum (*Sacc.&magn) Brr.& Cav.]; Ascochyta blight *(Ascochyta spp.)* for hill areas only and Cowpea mosaic and Rajmash : Bacterial blight *(Xanthomonas spp.),* Anthrocnose[*Colletotrichum lindamuthianum (*Sacc.&magn) Brr.& Cav.]and Ascochyta blight *(Ascochyta spp.)* for hill areas only and Bean mosaic (*Macrosiphumpisi* Kalt,)

Table 3: Breeder seed indent [I] and production [P] of minor pulses (in quintals) from 2010-11 to 2022-23*.

Year	[I]/[P]	Crop				
		Moth bean	Horsegram	Grasspea	Cowpea	French bean
2010-11	I	221.0	-	-	30.0	-
	P	262.0	-	-	28.0	-
2011-12	I	213.0	12.0	-	54.0	-
	P	95.0	11.0	-	42.0	-
2012-13	I	94.5	5.2	-	32.1	-
	P	62.6	3.2	-	36.6	-
2013-14	I	95.3	8.0	-	38.8	-
	P	40.0	-	-	52.5	-
2014-15	I	95.3	7.6	-	38.8	-
	P	35.7	4.0	-	15.2	-
2015-16	I	59.1	9.7	9.2	163.2	2.0
	P	23.4	1.7	11.5	71.0	7.1
2016-17	I	61.8	16.9	114.6	31.3	3.0
	P	64.5	18.9	166.0	55.1	14.4
2017-18	I	24.9	24.6	131.5	17.1	25.0
	P	42.0	20.6	161.9	31.2	17.6
2018-19	I	29.8	34.9	145.3	20.8	12.0
	P	30.5	22.4	147.5	21.0	4.4
2019-20	I	18.9	11.8	188.0	16.1	6.0
	P	20.2	28.1	56.0	28.3	3.1
2020-21	I	21.5	23.7	132.5	13.2	-
	P	41.3	22.0	112.1	25.2	-
2021-22	I	20.0	10.8	109.0	34.3	-
	P	37.8	13.5	86.5	29.2	-
2022-23	I	15.3	20.8	155.2	30.0	0.1
	P	35.2	22.6	117.0	37.5	70.0

*Source: Anonymous, 2020b, 2021b, 2022c; Yadava *et al*., 2023, 2024.

Seed production

Breeder seed

There were consistent indents for breeder seed for cowpea and moth bean whereas; for French bean and grasspea, the indents were only during 2015-16 to 2019-20 and 2022-23 and 2015-16 to 2022-23, respectively. Except for 2011-12, there was regular indent for horsegram breeder seed until 2022-23.

Moth bean

In moth bean breeder seed indent was the highest in the base year and thereafter declined in the remaining years and reached the lowest, registering a decrease of 93.1% during 2022-23. Breeder seed production was higher than the indents during 2010-11, 2016-17 and thereafter by 2.3% (2018-19) 130.1% (2022-23) but in the remaining years, a deficit ranging from 33.8% (2012-13) to 62.5% (2014-15) was observed (Table 3).

Horsegram

Indent for breeder seed for horsegram did not show a definite pattern during the period under investigation. It declined during 2012-13 from that of the base year (2011-12) but consistently increased from 5.2 q during 2012-13 to 34.9 q during 2018-19, an increase of 571.2%. Thereafter, declined and was only 10.8 q during 2021-22, which was even lower than that of the base year by 10.0% and 69.1% over that of the highest ever attained during 2018-19. But, the indent during 2022-23 was higher by 73.3% over that of the base year (2011-12) but still lower by 40.4% in comparison to 2018-19 (Table 3). Breeder seed production was higher than the indent only during 2016-17, 2019-20, 2021-22 and 2022-23 by 11.8% (2016-17) - 138.1% (2019-20); in rest of the years, it was less than the indents by 7.2% (2020-21) -82.5% (2015-16).

Grasspea

Breeder seed indent for grass pea ranged from 9.2 q (2015-16) to 188.0 q (2019-20). During 2019-20, 2020-21, 2021-22 and 2022-23 (Table 3), production was less than the indents by 70.2%, 15.4%, 20.6% and 24.6%, respectively, whereas; in rest of the years surpassed the indents by 1.5% (2018-19) -44.9% (2016-17).

Cowpea

Cowpea breeder seed indent was lower than that of the base year during 2017-18, 2018-19, 2019-20 and 2020-21 by 53.0%, 30.7%, 46.3% and 56.0%, respectively (Table 3).

In the remaining years, the trend was reversed and it increased over the base year by 4.3% (2016-17) -444.0% (2015-16). It was *at par* during 2022-23 in comparison to the base year (Table 3). Breeder seed production was less than the indent during 2010-11, 2011-12, 2014-15, 2015-16 and 2021-22 by 6.7% (2010-11)-60.8% (2014-15). In other years, the breeder seed production was higher than the indents by from as low as 1.0% during 2018-19 to as high as 90.9% during 2020-21 (Table 3).

French bean

The seed indents for rajmash or French bean were always higher than that of the base year, 2015-16, (2.0q) except 2022-23 (0.1 q), the highest being (25.0 q) during 2017-18, registering an increase of 1150.0%. There was shortage in breeder seed production during 2017-18, 2018-19 and 2019-20 by 29.6%, 63.3% and 48.3%, respectively. In rest of the years of the analysis, breeder seed breeder seed production was more than the indent (Table 3).

Foundation Seed

Foundation seed is produced utilizing breeder seed and its mechanism such as qualified stakeholders to produce, minimum seed standards, monitoring and certification by an appropriate agency has been presented earlier (Trivedi and Gunasekaran, 2013; Chauhan *et al.,* 2016c, 2020). There was no demand for foundation seed during 2019-20 for moth bean, however, foundation seed requirement varied from 34 q during 2010-11 to 1673 q during 2017-18. Nevertheless its availability was always more than the requirement in all the years by varying from as low as 7.6% in 2016-17 to as high as 1311.8% in 2010-11, except 2014-15, when a reduction of 14.7% was observed. During 2022-23, the increase was to the extent of 394.0%. For cowpea, the requirement of foundation seed was inconsistent; ranging between 250 q (2011-12)-1121q (2016-17). It was reduced in 2011-12, 2015-16, 2017-18, 2018-19, 2019-20, 2021-22 and 2022-23 as compared to the base year, 2010-11(552 q) by 54.7%, 9.8%, 54.5%, 5.4%, 10.0%, 19.0% and 18.8%, respectively. In rest of the years, it was higher to the extent of 1030.8% during 2016-17 followed by 67.6% during 2020-21 (Fig 3) except 2012-13, 2014-15, 2017-18 and 2018-19, when seed availability was lower than the requirement by 4.0% (2017-18) - 26.2% (2018-19). In other years, it was higher by 4.5% (2016-17) - 34.1% (2022-23). The foundation seed requirement of other pulses varied from 126 q during 2017-18 to 6283 q during 2022-23. It was lower than that of the base year (1968 q) by up to 93.6% in all the years except during 2016-17 and 2022-23 when it was either *at par* or higher by 219.3%, respectively. It was higher than the availability for other pulses during 2010-11, 2014-15, 2016-17 and 2017-18 by 9.4% (2016-17) - 59.8% (2014-15) but lower in rest of the years by 3.5% during 2022-23 -120.5% during 2018-19 (Fig 3).

Certified/quality seed requirement and availability

Moth bean seed requirement varied from 0.15 lac q (2010-11) to 0.25 lac q (2014-15, 2021-22 and 2022-23), registering an increase of 66.7% against the seed availability of 0.06 lac q (2010-11) to 0.29 lac q (2021-22 and 2022-23) and a surge of 383.3%. Seed availability was higher than the requirement during 2012-13, 2016-17, 2017-18, 2018-19, 2019-20, 2020-21, 2011-22 and 2022-23 by 15.0%, 5.0%, 26.3%, 10.0%, 9.1%, 8.3%, 45.0% and 45.0%, respectively. Seed requirement for horsegram during the period under study was the highest during 2010-11 (0.41 lac q) and declined until 2021-22 (0.20 lac q) but without any specific trend and showing large annual variations when decline was to the extent of 63.4% during 2021-22 (Table 4). Nevertheless, there was negligible requirement for horsegram seed during 2011-12. Seed availability was at par with requirement during 2011-12, 2012-13, 2013-14 and 2018-19; higher during 2014-15 (5.9%), 2016-17 (38.5%), 2019-20 (11.8%), 2020-21(5.6%) and 2021-22 (60.0%). In rest of the years, a seed shortage up to 97.5% during 2010-11 was recorded. Cowpea seed requirement did not show any definite pattern and varied from 0.10 lac q during 2021-22 to 0.37 lac q during 2019-20 that subsequently declined by 40.5%, 73.0% and 10.8%, respectively, during 2020-21, 2021-22 and 2022-23. The increase was to the extent 57.1% during 2022-33 in comparison to the base year; 2010-11.The seed availability for cowpea was either *at par* or higher than the requirement by 3.7% (2017-18) to 70.0% (2021-22). Nevertheless, it was lower than the requirement by 45.0%, 4.8%, 2.7% and 5.4%, 2011-12, 2012-13, 2014-15 and 2019-20, respectively (Table 4).

Seed availability was either *at par* with requirement for French bean during 2010-11, 2012-13, 2013-14, 2015-16, 2018-19, 2020-21, 2021-22 and surpassed during 2016-17 and 2019-20. Shortage of seed was observed by 33.3% and 4.5% respectively, during 2011-12 and 2017-18 (Table 4). Seed availability was just enough to meet the requirement

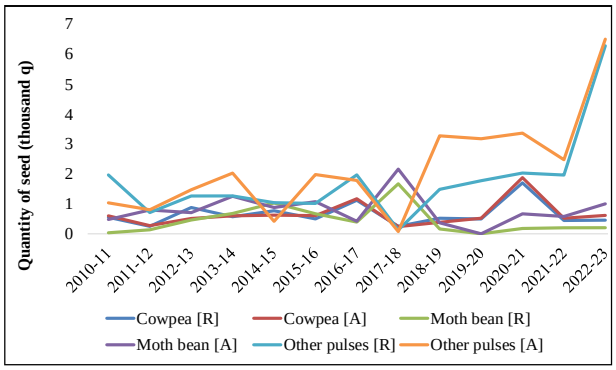

Fig 3: Foundation seed requirement [R] and availability [A] of minor pulses (other pulses include horsegram, grasspea, French bean, Indian bean, faba bean, *etc*.) during 2010-11 to 2022-23.

Table 4: Requirement (R) and availability (A) of certified/quality seeds of minor pulses (lac quintals) from 2010-11 to 2022-23*.

Year	[R]/[A]	Crop				
		Moth bean	Horsegram	Grasspea	Cowpea	French bean
2010-11	R	0.15	0.41	-	0.21	0.01
	A	0.06	0.01	-	0.21	0.01
2011-12	R	0.15	0.009	-	0.20	0.03
	A	0.09	0.009	-	0.11	0.02
2012-13	R	0.20	0.08	0.05	0.21	0.11
	A	0.23	0.08	0.05	0.20	0.11
2013-14	R	0.21	0.17	0.06	0.27	0.05
	A	0.17	0.17	0.06	0.30	0.05
2014-15	R	0.25	0.17	0.01	0.36	-
	A	0.14	0.18	0.01	0.35	-
2015-16	R	0.21	0.24	0.06	0.26	0.06
	A	0.13	0.22	0.06	0.29	0.06
2016-17	R	0.20	0.26	-	0.19	0.02
	A	0.21	0.36	-	0.23	0.04
2017-18	R	0.19	0.20	-	0.27	0.22
	A	0.24	0.17	-	0.28	0.21
2018-19	R	0.20	0.09	0.20	0.25	0.05
	A	0.22	0.09	0.20	0.27	0.05
2019-20	R	0.20	0.17	0.21	0.37	0.05
	A	0.22	0.19	0.21	0.35	0.06
2020-21	R	0.24	0.18	0.35	0.22	0.10
	A	0.26	0.19	0.31	0.24	0.10
2021-22	R	0.20	0.15	0.12	0.10	0.02
	A	0.29	0.24	0.29	0.17	0.02
2022-23	R	0.25	-	-	0.33	1.44**
	A	0.29	-	-	0.36	1.52**

*Source: Selvraj 2013; Anonymous, 2015, 2016, 2020a, 2021a, 2022a,b, 2023b.

**Other pulses include horsegram, grasspea, French bean, Indian bean, faba bean, *etc*.).

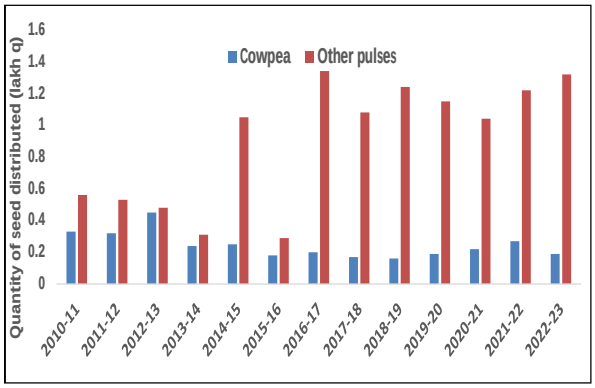

Fig 4: Certified/quality seed of cowpea and other minor pulses (other pulses include horsegram, grasspea, French bean, Indian bean, faba bean, *etc.,*) distributed to the stakeholders during 2010-11 to 2022-23.

of grasspea seed until 2019-20 but showed a decline of 11.4% during 2020-21 but surpassed requirement by 141.7% during 2021-22. During 2022-23, the seed availability for other pulses including horsegram, grasspea and French bean was higher by 5.6% than the requirement.

Certified/quality seed distributed

More than production or availability, the distribution of certified/quality seed to the stakeholders is critical for the commercial production of any crop. Certified/quality seed distribution for cowpea attained the peak during 2012-13 (0.45 lac q), an increase of 36.4% ranging from 0.16 lac q during 2018-19 to 0.33 lac q during 2010-11 (Fig 4). It was lower throughout the period under study in comparison to that of the base year by 3.1% (2011-12) to 51.5% (2018-19). During 2021-22 and 2022-23, 0.27 lac q and 0.19 lac q seed was distributed for cowpea which was about 18.2% and 42.4% lower, respectively, as compared to 2010-11 and 40.0% (2021-22) and 57.8% (2022-23) lower than that of the highest ever distributed during 2012-13 (Anonymous, 2023b). For other minor pulses (horsegram, moth bean, rajmash, grasspea, fsaba bean, indian bean, *etc*.), seed distribution varied widely ranging from 0.29 lac q (2015-16) to 1.34 lac q (2016-17). The increase during 2016-17 over 2010-11(base year) was 139.3% and 117.9% and 135.7% during 2021-22 and 2022-23, respectively (Fig 4). In comparison to the base year, a decline, ranging from 5.4% to 48.2% was observed in the seed distribution during

Table 5: Projected demand for certified (CS), foundation (FS) and breeder (BS) seed for minor pulses in the next five years.

Crop	Cropped area (lac ha)		SMR*	Seed rate (kg/ha)	Targeted SRR (%)	Breeder seed (2022-23)		Requirement of seed (q) to achieve the target SRR by 2027-28		
	Highest ever since 2010-11	Actual (2019-20)				Indent (q)	Production (q)	CS	FS	BS
Moth bean	16.5	9.7	40	15	40	15.3	35.2	99000	2475	61.9
Horsegram	5.1	4.6	40	12.5	40	20.8	22.6	25500	637.5	15.9
Grasspea	5.8	3.1	20	25	40	155.2	117.0	58000	2900	145.0
Cowpea	5.6	0.71	40	15	40	37.9	46.2	33600	840	21.0
Rajmash	0.85	0.18	8	60	40	0.1	70.0	20400	2550	318.8

*Seed multiplication ratio.

2011-12, 2012-13, 2013-14 and 2015-16 (Fig 4). In rest of the years, seed distribution was higher over that of 2010-11 by 87.5% (2014-15); 92.9% (2017-18); 121.4% (2018-19); 105.4% during 2019-20; 85.7% during 2020-21, 117.9% during 2021-22 and 135.7% during 2022-23 (Anonymous, 2023b).

Future strategies

Minor pulses are rich sources of nutrients and minerals, in general, showed large variability in production system owing to the fact they are cultivated largely in nutrient starved soils under fragile agro-ecological conditions mostly by marginal and poor farmers. But for moth bean, horsegram and grasspea no specific trend was evident in area, production and yield. During 2019-20, acreage, production and yield were substantially reduced for moth bean and grasspea but despite decline in acreage of horsegram, its production and seed yield were higher than that of 2010-11. Timely availability of quality seed is an important issue in these crops. The breeder seed indent was irrational and inconsistent for these pulses. Seed requirement of various crops was also assessed considering standard seed multiplication ratio; seed replacement rate (SRR) of 40.0% against 33% for self pollinated crops and the highest ever cropped acreage (Table 5).

Breeder seed production is an issue as it was lower than the indents for horsegram, grasspea and cowpea during the year 2021-22 but situation improved and production of breeder seed was higher than indents during 2022-23 for these crops except grasspea. But, the indents for horsegram, grasspea and cowpea were still more than the envisioned requirement. It was lower than the projected requirement for moth bean and for rajmash breeder seed production (Table 5). Therefore, seed rolling plan should identify appropriate varieties and consider variety wise area to be covered with annual incremental rate in the next five years. It should be specific to region/ preferably district. Then quantity of breeder seed should be assessed considering seed multiplication ratio including contingency then only indents of suitable varieties for breeder seed should be timely placed with the concerned organization and also ensure its effective conversion to foundation and certified seed. Of the 94 varieties released and notified during 2016-24 but only 17 were in the seed chain until 2023-24 suggesting poor varietal replacement. Further, many crops like faba bean, rice bean and winged bean have yet to be inducted in the formal seed chain. Therefore, greater emphasis should be on inducting recently released varieties and several new crops for which many varieties have been notified, in the seed chain. Further, many crops such as cowpea, French bean, rice bean, faba bean, Indian bean and winged bean have multipurpose usage like grain, vegetables and fodder, dual purpose thus coordinated efforts should be made by various AICRPs to address the quality seed production issues. To make timely availability of quality seed, efforts of stakeholders from both public and private sector including farmers' producing organizations need to be synergized backed by regular capacity building and technical back stopping.

CONCLUSION

Major issues impacting productivity and thereby production of minor pulses are lack of varietal diversity and poor varietal replacement in the seed production chain, inadequate production of breeder seed and its conversion to other classes of seed resulting in to shortage of foundation and certified seed availability for cowpea, moth bean and other pulses. Further, many crops like faba bean, rice bean and winged bean have yet to be inducted in the formal seed production chain. Adequacy and timely availability of quality seed of minor pulses of recently released and notified high yielding varieties is foremost for enhancing production. Seed requirement of different minor pulse crops has also been assessed and strategy to sustain high production of these crops is proposed.

Conflict of interest

The authors declare that they have no conflict of interest.

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