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Enhancing pulses production in India through improving seed and variety replacement rates

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Abstract

India is the largest producer, consumer and importer of pulses in the world. Pulses are important for the nutritional security of the cereal based vegetarian diet of large population of India. Due to ever increasing population, rising income of people and pulses being the major source of protein in Indian diet, the demand for pulses continues to grow at 2.8% per annum. It is estimated that 27.5 million tonnes of pulses would be required by 2025. Since more than 80% of the area under pulses is under stressed rainfed environment, the quality seed of improved varieties has emerged as the most vital input for enhancing pulses production in India. For ensuring availability of quality seed it was estimated that 39.38 lakh q and 46.87 lakh q quality seed of improved varieties would be required in 2020 and 2025, respectively, at increased seed replacement rate (SRR). The SRR of all the pulses under study showed an increasing trend during the last decade. This could be further increased with vibrant formal and informal seed system involving public and private seed industries and promotion of participatory seed production programmes. Since pulses are grown in diverse agro-climatic situations under severe biotic and abiotic stresses, the varietal diversity in seed chain also assumes greater importance. Seed chain is currently being maintained with 236 improved varieties of six major pulses. However, only 44 of them occupied prominence in seed chain and could contribute significantly to increased pulse production in recent times. There is further need to bring sufficient number of high yielding and disease resistant varieties in seed chain which should adequately represent all pulse growing areas in the country. The present paper discusses the options of yield enhancement in pulses through increased availability of quality seed and strategy for enhancing variety replacement, rate (VRR) and seed replacement rate (SRR) of major pulses, *viz*., chickpea (*Cicer arietinum* L.), pigeonpea (*Cajanus cajan* L.), mungbean (*Vigna radiata* L. Wilczek), urdbean (*Vigna mungo* L. Hepper), lentil (*Lens culinaris* L.) and fieldpea (*Pisum sativum* L.)

Key words: Pulses, seed systems, seed chain, variety replacement rate, seed replacement rate, breeder seed, quality seed

Introduction

Current scenario

Pulses are unique for high protein content (20 to 25%), ability to fix atmospheric nitrogen (ca 30-150 kg/ha) and consistent source of income and employment to small and marginal farmers; and thus hold a premier position in the global agriculture (Ali and Gupta 2012). Recognizing their important role in nutritional security and sustainability of global agriculture production systems, the United Nations declared 2016 as International Year of pulses with the objectives of increasing production and consumption of pulses by 10% by 2020 and creating awareness of benefits of pulses by utilizing social media. In India, pulses constitute a group of 12 crops that include mainly chickpea (*Cicer arietinum* L.), pigeonpea (*Cajanus cajan* L.), mungbean (*Vigna radiata* L. Wilczek), urdbean (*Vigna mungo* L. Hepper), lentil (*Lens culinaris* L.) and fieldpea (*Pisum sativum* L.). India is the largest producer of pulses contributing 25.7% to the global production (FAOSTAT 2015). It is also the biggest consumer of pulses with a domestic consumption of about 220 lakh tonnes/annum leaving an annual deficit of more than 50 lakh tonnes necessitating import of 53.35 lakh tonnes worth Rs. 22, 301 crores during 2015-16, registering an increase of 148% in import bill with concomitant rise of 58.6% in quantity of imported pulses over that of 2011-12 (Table 1). Nevertheless during the same period, export of pulses also increased

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Table 1. Recent trends in export and import of pulses in India

Year	Export		Import	
	Qty (lakh tonnes)	Value (Rs in crores)	Qty (lakh tonnes)	Value (Rs in crores)
2011-12	1.74	1,067.9	33.64	8,991.2
2012-13	2.03	1,285.0	38.40	12,738.6
2013-14	3.46	1,748.8	31.78	11,038.2
2014-15	2.22	1,218.1	40.02	14,395.5
2015-16	2.56	1,655.4	53.35	22,301.0

from 1.74 lakh tonnes to 2.56 lakh tonnes worth Rs. 1,655.4 crores (Table 1) enhancing export earnings by 55%. In the current financial year (2016-17), 69,870 tonnes of pulses have been exported until August 2016 worth Rs. 618.8 crores (Anonymous 2016a).

India has made a significant progress in pulses production during past 65 years. The area and production has increased substantially from 19.09 (1950-51) to 25.26 million ha (2015-16) and 8.41 (1950-51) to 16.47 million tonnes (2015-16) registering an increase of 32.3% and 95.8%, respectively (Anonymous 2016b). The yield (kg/ha), nevertheless, showed variable and inconsistent trend during this period ranging from 441 (1950-51) to 652 (2015-16) but attained an overall enhancement of 47.8 % (Fig. 1). Despite the fact that these are vital food crops; they continue to grow predominantly in stressed rainfed environment as only 16.1% area was irrigated during 2011-12 as compared to 9.4% during 1950-51 (Anonymous 2016b). In recent times, especially during the last ten years, due to the concerted and sustained research and development efforts, pulses production

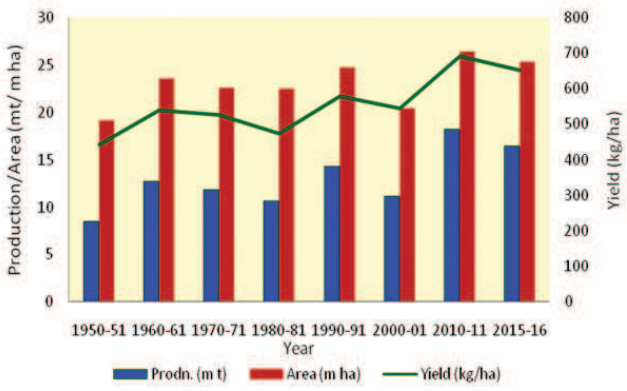

Fig. 1. Trends of area, production and yield of pulses since 1950-51

showed a spectacular increase from 14.76 million tonnes (2006-07) to a record level of 19.25 million tonnes (2013-14). However, due to inclement weather pulse production declined substantially during the last two years (Fig. 2). The increase in total production of pulses has been on account of improvement in yield (kg/ha) which has increased from 612 kg in 2006-07 to 785 in 2012-13. Although, the yield/ha since then declined, yet higher by 6.5% during 2015-16 as compared to that of 2006-07 (Fig. 2).

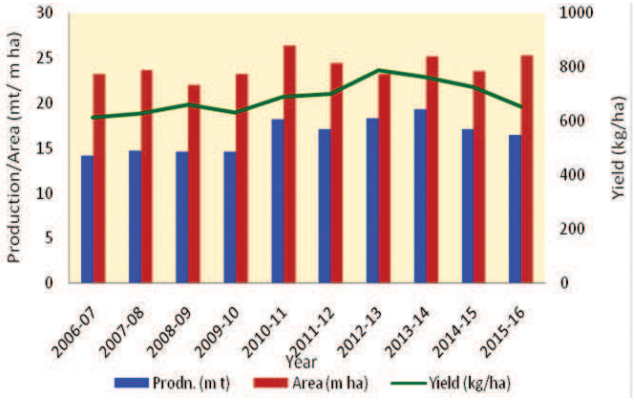

Fig. 2. Area, production and yield of pulses during 2006-2016

In fact, the annual compound growth rate in pulse production (2.61%) during this decade (Anonymous 2016 a,b) was even higher than that of rice (1.59%), wheat (1.89%) and all the cereals (1.88%). But demand of pulses is also increasing at 2.8% per annum. Due to ever increasing population, rising income of people and pulses being the major source of protein in Indian diet, the demand for pulses continues to grow obviously. Therefore, there is a need for developing technologies including varieties for sustainable high production of pulses to meet the demand. The present paper discusses the options of yield enhancement through increasing availability of quality seed by narrowing the yield gaps in major pulses. The paper also presents the seed systems, seed chain, varietal diversity in seed chain, availability of quality seed and strategy for enhancing variety replacement rate (VRR) and seed replacement rate (SRR) in major pulses.

Seed systems

Seed system can be defined as framework of institutions/farmers' group organized together by their involvement or influence on the seed multiplication, processing, quality assurance and marketing. Three

major seed systems: informal, formal and integrated are being followed in India. Guiding principles in the formal system are notification of varieties as per seed Act 1966 and to maintain varietal identity and purity to produce seed of optimal physical, physiological and sanitary quality (Reddy et al. 2007). Informal seed system is characterized by small scale supply of locally known varieties without any government interference in quality control. Activities tend to be integrated and locally organized and it embraces most of the other ways in which farmers themselves produce, disseminate and access seed: directly from their own harvest; through exchange/barter among friends, neighbours, relatives and through local grain markets. In many cases, however, a farmer will use the formal system for some crops and informal system for others. He may buy seed from the formal system once in order to obtain a particular variety, produce own seed from there onwards and share the new variety with neighbours and relatives.

Varietal improvement

With the launch of All India Coordinated Pulse Improvement Project (AICPIP) in 1966, focused and coordinated programme on crop improvement was intensified (Singh and Singh 2016). A large number of high yielding varieties (793) in pulses having resistance/ tolerance to one or more major diseases (Chauhan et al. 2016) have been developed in the country until 2015. Further, 43 varieties were released during 2016 thus bringing the total number to 836. Of these, 171 varieties of six major pulses were released during the last 10 years, the highest being in chickpea followed by mungbean, pigeonpea and urdbean (Table 2). Limited success, however, has been achieved for the development of varieties with resistance to insect-pests and abiotic stresses. Most of these varieties are increasingly being popular among farmers. The front-line demonstrations on pulses conducted with improved varieties during 2007-13 showed yield increase from 19% in chickpea to 28% in lentil (Anonymous 2014). This clearly indicated the need of improved varieties for further increasing productivity of each pulse crop.

Varietal diversity in seed chain

Ensuring availability of quality seed in adequate quantity itself is not enough to trigger the production if it is not coupled with achieving sufficient varietal diversity in seed chain. Since pulses are grown in diverse agro-climatic conditions, it is imperative to produce quality seeds of agro-climatic condition-specific-variety (ies). The seed chain involves multiple stakeholders both from public and private sectors also including NGOs and farmers. Seed chain of pulses at present is being maintained with 73 varieties of chickpea, 33 of pigeonpea, 41 of mungbean, 35 of urdbean, 33 of lentil and 21 of fieldpea. Over the years, there has been declining trend of number of varieties included in seed chain. During the last five years, the total number varieties in the seed chain declined consistently from 315 to 236 (Table 3). This may be due to more emphasis on inclusion of recently released varieties in seed chain under various programmes of the Government of India and specifically, under National Food Security Mission (Pulses). The seed subsidy component is given for the varieties released during the last 10 years only and in some specific cases for 15 years. There is need to bring sufficient number of recently released varieties in seed chain which should adequately represent all pulse growing areas in the country.

Table 2. Varieties of major pulses released during the last 10 years

Crop	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016*	Total
Chickpea	10	4	3	7	2	4	3	1	3	10	47
Pigeonpea	7	2	3	1	1	2	3	2	0	6	27
Mungbean	4	2	7	3	1	3	1	3	2	11	37
Urdbean	1	4	3	4	2	5	1	1	1	3	25
Lentil	1	3	3	2	3	1	0	1	1	4	19
Fieldpea	2	0	0	3	2	2	0	2	1	4	16
Total	25	15	19	20	11	17	8	10	8	38	171

*Until 75th meeting of Central Sub-committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops held on August 12, 2016

Table 3. Varieties (number) in the seed chain and breeder seed indent (q) during the last five years

Crop	2011-12		2012-13		2013-14		2014-15		2015-16	
	Number	Indent	Number	Indent	Number	Indent	Number	Indent	Number	Indent
Chickpea	90	9915	92	9943	76	9433	75	7434	73	7184
Pigeonpea	50	537	45	646	48	391	45	488	33	266
Mungbean	64	1244	60	1168	54	799	49	1053	41	702
Urdbean	46	846	41	798	47	518	39	485	35	424
Lentil	38	644	32	622	41	470	33	286	33	449
Fieldpea	27	838	30	774	27	559	21	529	21	1215
Total	315	14,024	300	13,951	293	12,170	262	10,275	236	10,240

High yielding varieties, JAKI 9218, GNG 1581, JG 11, JG 63, JG 130, Vijay and JG 14 of chickpea; BSMR 736, Maruti, Bahar, Narendra Arhar 1, Asha and TJT 501 of pigeonpea; SML 668, IPM 02-3, GM 4, HUM 16, IPM 2-14, Samrat and Pant Mung 5 of mungbean; Pant U 31, IPU 02-43, KU 96-3, TAU 1, LBG 752, KU 300 and Uttara of urdbean; HUL 57, Pant L 8, JL 3, Pant L7, Pant L6, WBL 77 and K 75 of lentil and HUDP 15, Prakash, KPMR 400, Vikas, KPMR 522, Aman and Adarsh of fieldpea (Table 4) JG 6 during 2013-14. BSMR 736, TJT 501 and Maruthi were the leading pigeonpea varieties with 7.5-12%, 8.3-10.1% and 6.6-10.8% share of indented breeder seed, respectively. The contribution of the topmost 10 varieties to total breeder seed indent varied from 57.3% (2015-16) to 69.8% (2014-15). In mungbean, SML 668 was the leading variety until 2014-15 accounting for 22.6-31.4% of the indented breeder seed.

Table 4. Share of top ten indenting varieties of major pulses during 2010-15

Crop	Share (%)	Prominent varieties in seed chain
Chickpea	50.9 (2011-12)-66.6 (2015-16)	JAKI 9218, GNG 1581, JG 11, JG 63, JG 130, Vijay, JG 14
Pigeonpea	57.3 (2015-16)-69.8 (2014-15)	BSMR 736, Maruti, Bahar, Narendra Arhar 1, Asha, TJT 501, Malviya Chmatkar
Mungbean	65.3 (2011-12)-79.8 (2015-16)	SML 668, IPM 02-3, GM 4, HUM 16, IPM 2-14, Samrat, Pant Mung 5
Urdbean	58.5 (2011-12)-81.5 (2015-16)	Pant U 31, IPU 02-43, KU 96-3, TAU 1, LBG 752, KU 300, Uttara
Lentil	57.4 (2012-13)-84.6 (2014-15)	HUL 57, Pant L8, JL 3, Pant L7, Pant L6, WBL 77, K 75
Fieldpea	76.5 (2012-13)-90.8 (2015-16)	HUDP 15, Prakash, KPMR 400, Vikas, KPMR 522, Aman, Adarsh

which occupied prominence in seed chain have also contributed significantly to increased pulse production in recent times. In chickpea, JG 11 occupied the top position for the breeder seed indent for the first two years; JG 6, and JAKI 9218 occupied the top position in 2013-14 and 2014-15, respectively, and presently GNG 1581 is the leading variety with 13% share of total breeder seed indent. Of the total chickpea varieties indented, the contribution of first top 10 varieties ranged from 50.9% during 2011-12 to 66.6% during 2015-16 (Table 4). Invariably, JAKI 9218, JG 11 and GNG 1581 were always among the top most three varieties in all the five years except GNG 1581 replaced by Vijay in 2012-13 and JG 11 replaced by SML668 was replaced by IPM 02-3 at the top with a share of 26.9% during 2015-16. Except the first two varieties, the remaining topmost varieties contributed 2.0-4.3%, 2.9-6.8%, 2.2-10.5%,2.2-7.8% and 2.9-8.8%, respectively, during 2011-12, 2012-13, 2013-14, 2014-15 and 2015-16 to the breeder seed indent. In urdbean, contribution of topmost 10 varieties to breeder seed was lowest (58.5%) in the year 2011-12 which rose to 81.5% in 2015-16. The topmost variety was TAU 1 (14.7%) in 2011-12 and Pant Urd 31 in rest of the four years accounting for 8.3% (2012-13), 17.9% (2013-14), 18.1% (2014-15) and 32.5% (2015-16) of the indented breeder seed. The other leading varieties of urdbean in the seed chain were Uttara, IPU 02-43

and KU 96-3. The contribution of ten topmost varieties of lentil showed a range of 57.4% (2012-13)-84.6% (2014-15). Narendra Masoor 1 was the top most variety during 2011-12 and 2013-14 with 11.0% and 10.4% contribution to breeder seed, respectively; HUL 57 was on the top for the three years contributing 10.4 %, 17.7% and 16.3% to the breeder seed indent during 2012-13, 2014-15 and 2015-16, respectively. The other leading varieties each were having more than 8% contribution were Azad Masoor 1, JKL 3, K 75, DPL 62, Pant Lentil 7, KLS 218, Pant Lentil 8 and Jawahar Lentil 3. The leading 10 fieldpea varieties contributed 76.5% (2012-13) and 90.8% (2015-16) to the breeder seed. The varieties contributing at least 10% to the breeder seed were KPMR 400, KPMR 522, HUDP 15, Pusa Prabhat, Prakash and Vikas. There is need to have extensive efforts in popularizing new and improved varieties and increase seed multiplication for enhancing availability of quality seed for triggering pulse production in the country.

Breeder seed

To initiate effective seed chain, the production of adequate quantity of breeder seed is foremost and vital. The National Agriculture Research System (NARS) comprising ICAR institutes, State / Central Agricultural Universities and other public sector organizations is mandated to produce breeder seed, which is demand driven and as per the indent of Department of Agriculture, Cooperation and Farmers' Welfare, Government of India for further use by stakeholders both in public as well as private sector for production of foundation, certified/truthfully labeled seed to maintain the effective seed chain for making timely availability of quality seeds to the farmers'. Breeder seed indent for pulse crops consistently increased from 5,536 q (2005-06) to 14, 155 q (2012-13) except the year 2009-10 (Anonymous 2016c). The increase was 155.7% in 2012-13 over the base year, 2005-06. Since 2012-13, indent declined by 44.7% and was 10,488 q during 2015-16. The indents peaked twice in 2008-09 and 2011-12 during the last 11 years (Fig. 3).

The chickpea, pigeonpea, mungbean, urdbean, lentil and fieldpea together account for 97.6.0-98.6% of the total indent during 2011-12 to 2015-16 (Table 2). Among these crops, the share of chickpea in the total indent ranged from 68.5% (2015-16)-76.4% (2013-14). The contribution of mungbean was next highest, varying from 6.5 % (2013-14) to 10.1 % (2014-15). Urdbean, pigeonpea and lentil contributed 4.0% (2015-16)-5.9% (2011-12); 2.5% (2015-16)-4.7% (2014-15) and 2.5% (2014-15)-4.5% (2011-12), respectively. The indent for fieldpea showed a remarkable enhancement and its share was 11.6% in the total seed indent for pulses during 2015-16, otherwise its contribution showed a range of 4.8% (2013-14)-5.9% (2011-12). Currently (2015-16), chickpea, pigeonpea, mungbean, urdbean, lentil and fieldpea contributed, 68.5%, 2.5%, 6.7%, 4.0%,4.3% and 11.6 %, respectively, to the total pulse seed indent. Declining trend of breeder seeds in recent years will have adverse effect in maintenance of seed chain and availability of quality seed for pulses production. However, the production of breeder seed was always higher than the indents barring some varietal mis-match.

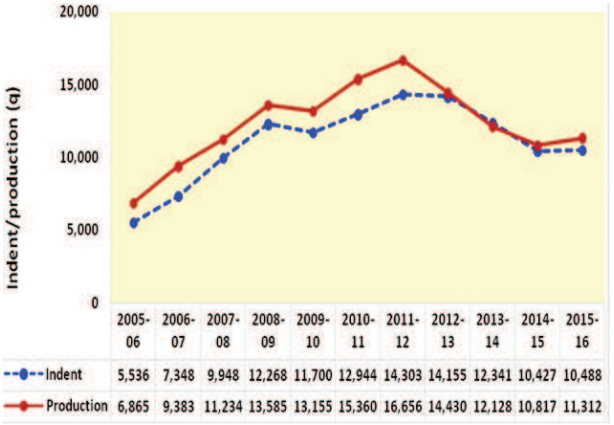

Fig. 3. Breeder seed indent and production from 2005-06 to 2015-16

Quality seed

In pulses, low availability of quality seeds has been one of the major constraints in improving productivity. The total availability of quality seed of pulses in India is around 28 lakh quintals against requirement of 33 lakh q at 30% seed replacement rate (Ali et al. 2016). Significant progress has been made in distribution of certified/quality seed of pulses from 7.18 lakh quintal in 2005-06 to 23.48 lakh quintal in 2014-15 (Table 5). During this period, the supply of certified/quality seed to the stakeholders, invariably increased but no definite pattern was discernable for mungbean, urdbean, lentil and fieldpea. However, consistent increase in seed supply was observed for chickpea and pigeonpea (barring year 2008-09) until 2013-14 (Table 5). Thereafter, except for mungbean and urdbean, the distribution of quality seed declined for rest of the crops. In general, the seed supply during 2014-15, increased by 327.0%, 119.5%, 159.7%,100.0%,164.4% and

Table 5. Distribution of certified/quality seeds (lakh q) of major pulses during the last decade

Crops	Chick-pea	Pigeon-pea	Mung-bean	Urd-bean	Lentil	Field-pea	Total
2005-06	3.45	0.77	0.77	0.92	0.45	0.82	7.18
2006-07	5.08	0.85	0.23	0.80	0.54	0.93	8.43
2007-08	6.73	1.18	1.34	1.40	0.56	1.10	12.31
2008-09	8.60	1.09	1.23	1.37	0.59	1.29	14.17
2009-10	12.32	1.37	1.29	1.61	0.55	2.07	19.21
2010-11	12.5	1.52	1.76	1.96	0.74	1.47	19.95
2011-12	13.16	1.92	2.00	2.31	0.66	1.36	21.41
2012-13	14.83	1.80	2.13	2.33	0.70	1.79	23.58
2013-14	17.48	1.73	1.95	1.64	1.28	3.17	27.25
2014-15	14.73	1.69	2.00	1.84	1.19	2.03	23.48

of quality seed of *kharif* pulses like pigeonpea, mungbean and urdbean was always higher than the requirement while in *rabi* pulses such as chickpea, lentil and fieldpea it has been lower than the requirement (Table 6). The seed requirement for chickpea consistently increased from 2005-06 to 2015-16 except for the year 2014-15.The seed requirement during this period surged by 475.9%, from 3.15 to 18.14 lakh q. However, availability of seed was lower than the requirement during the year 2005-06, 2012-13, 2014-15 and 2015-16 by 6.0%, 7.2%, 2.5% and 19.3%, respectively (Table 6).

Seed requirement increased gradually up to 2008-09 but, thereafter, no consistent pattern of increase or decrease was discernable for pigeonpea, urdbean and fieldpea. But during 2015-16, the change in seed

Table 6. Requirement and availability of seeds (lakh q) of major pulses during 2005-06 to 2015-16

Year		Chickpea	Pigeonpea	Mungbean	Urdbean	Lentil	Fieldpea
2005-06	Requirement	3.15	0.87	0.92	1.28	0.20	0.37
	Availability	2.96	0.99	1.90	2.07	0.41	0.34
2006-07	Requirement	3.65	1.08	1.17	1.35	0.28	0.49
	Availability	5.70	1.19	1.63	1.46	0.26	0.44
2007-08	Requirement	5.85	1.47	1.85	1.63	0.71	1.27
	Availability	6.08	1.67	1.69	1.79	0.63	1.15
2008-09	Requirement	8.35	1.56	2.16	2.65	0.67	1.38
	Availability	8.35	1.75	2.48	3.14	0.59	1.30
2009-10	Requirement	10.91	1.42	1.77	2.02	0.82	1.71
	Availability	12.66	1.65	2.29	2.46	0.8	1.71
2010-11	Requirement	12.56	2.04	2.36	2.09	0.92	1.79
	Availability	15.33	2.33	2.48	2.30	0.92	1.72
2011-12	Requirement	14.22	2.71	2.20	2.44	1.13	1.50
	Availability	16.63	3.55	2.30	3.37	0.95	1.36
2012-13	Requirement	16.32	2.16	2.24	2.41	1.04	1.83
	Availability	15.14	2.27	2.53	3.33	0.74	1.60
2013-14	Requirement	17.06	2.58	1.93	2.47	1.37	1.55
	Availability	20.10	2.52	2.65	3.81	1.33	1.39
2014-15	Requirement	16.11	2.64	2.79	2.68	1.79	1.96
	Availability	15.72	2.78	3.31	3.31	1.38	1.57
2015-16	Requirement	18.14	2.51	2.87	2.62	1.30	2.12
	Availability	14.86	2.72	3.23	2.71	1.06	1.83

147.6% over that of 2005-06, respectively, for chickpea, pigeonpea, mungbean, urdbean, lentil and fieldpea.

The seed requirement for major pulses has increased significantly over the years. The availability

requirement over that of 2005-06 was 188.5%, 104.6% and 473.0%, respectively, for pigeonpea, urdbean and fieldpea (Table 6). Mungbean seed requirement increased up to 2008-09 but showed a variable trend since 2009-10. The seed requirement rose by 212.0% during 2015-16 over that of 2005-06. Lentil seed

requirement increased gradually from 0.20 lakh q during 2005-06 to 1.13 lakh q during 2011-12 except decline in 2008-09 and 2009-10. The requirement declined by 27.4% during 2015-16 as compared to that of 2014-15 but registered an overall increase of 550% since 2005-06. Overall, during the last 11 years, the seed requirement increased considerably for all the pulses except urdbean. Except for the years 2005-06 and 2010-11, the availability of lentil seed was always less than the requirement by 2.4%-28.8%. Availability of fieldpea seed was lower than the requirement during 2008-09 to 2015-16 except the year 2009-10, by 5.8% -19.9%.

Increased seed replacement rate for higher productivity

Seed replacement rate (SRR) is a criterion to assess the use of certified and/or quality seed of a crop and gives an indication of area under quality seeds. Improving SRR helps in enhancing productivity of the crop. The SRR of all the pulses under study showed an increasing trend during the last decade. Nevertheless, no consistent trend was observed except for mungbean where SRR gradually increased since 2005-06 up to 2013-14. During the last decade, SRR peaked twice, once during 2009-10 (except for lentil where it was in 2008-09) and again in 2013-14 (*seednet.gov.in 29.09.2016*) and personal communication DAC&FW). Thereafter, SRR in all the pulses declined (Fig. 4) as 2014-15 was a rainfall

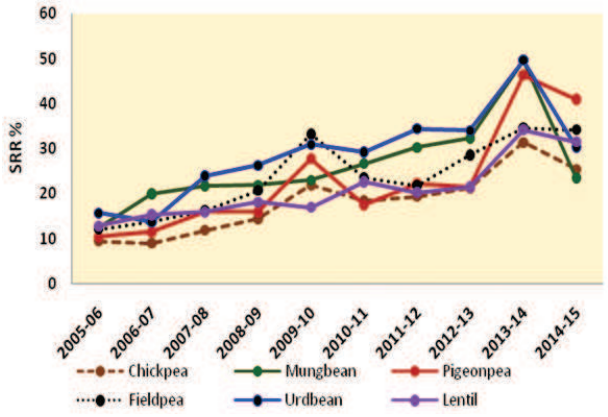

Fig. 4. Seed replacement rate (%) of major pulses during the last decade

deficient year and area under pulses reduced by about 7% (1.68 million ha) and most of the farmers preferred to use saved seeds. Despite the fact that SRR declined during 2014-15, overall, there has been a considerable increase from 9.4% to 25.4% for chickpea; 10.5% to 41.0% for pigeonpea; 12.5%-23.6% for mungbean; 15.7%-30.3% for urdbean; 12.8%-31.5% for lentil and 12.1% to 34.1% for fieldpea, from 2005-06 to 2014-15. Nevertheless, highest SRR was achieved during 2013-14, 31.4%; 46.3%; 49.6%; 49.6 % and 34.1% for chickpea, pigeonpea, mungbean, urdbean and lentil, respectively. The SRR during 2014-15 was still lower than the recommended level of 33% for chickpea, mungbean, urdbean, lentil, fieldpea and 50% for pigeonpea. The SRR, as expected, was closely related to certified/quality seed distribution. The increased SRR contributed to enhanced yield/ ha. However, there was no definite trend of change in yield during the last decade. The yield/ha enhanced from 808 kg (2005-06) to 889 kg (2014-15) for chickpea; 304 kg (2005-06) to 498 kg (2014-15) for mungbean; 417 kg (2005-06) to 604 kg (2014-15) for urdbean; 629 kg (2005-06) to 705 kg (2014-15) for lentil. But it declined from 765 kg (2005-06) to 729 kg (2014-15) for pigeonpea and 920 kg (2005-06) to 912 kg (2014-15) for fieldpea. The yield peaked in 2012-13 for chickpea (1036 kg/ha), lentil (797 kg/ha) and fieldpea (1100 kg/ha) while in 2010-11 for mungbean (512 kg/ha), 2013-14 for pigeonpea (849 kg/ha) and 2014-15 for urdbean (604 kg/ha). This trend was expected due to aberrant monsoon in *kharif* and unusual heavy rains during *rabi* since 2012-13, coinciding with maturity/ harvest of the crops. Despite these odds, yield increased to the extent of 10.0%, 63.8%, 44.8% and 12%, respectively, for chickpea, mungbean, urdean and lentil during 2014-15 as compared to that of 2005-06 but yields of pigeonpea and fieldpea declined marginally by 4.9% and 1%. Since, pulses are rainfed crops and seed is only input used by the farmers, it becomes imperative to increase SRR further in each crop. It has been suggested that 40% SRR would be appropriate for achieving higher productivity in pulses and accordingly state wise seed plans must be developed for each crop by various stakeholders both in public and private seed sectors.

Perspectives

The present per capita availability in the country is 41.9 g/day (15.3 kg/year) against the recommendation of World Health Organization (Anonymous 2012) for 53 g/day (19.3 kg/year), is a cause of concern. Further, considering the population (1.41 billion), per capita consumption (16.42 kg/annum) as well as other usages of pulses, it is estimated that 27.5 million tonnes pulses would be required by 2025 (Anonymous 2012), a daunting but achievable target, through adopting

existing and emerging technological advances. There could be multi-pronged strategy for enhancing pulse production in the country, *viz.*, vertical growth in yield through genetic enhancement raising yield ceiling; productivity enhancement and horizontal expansion of the crop to new niches. A strategy paper of Indian Council of Agricultural Research, New Delhi (Anonymous 2014) envisions bringing 3.58 million ha additional area under crops by intercropping, extending crops to new niches like rice fallow, *kharif* fallow and as catch crop to achieve 9.65 million tonnes of additional pulses by 2025 (Table 7).

it was estimated that 39.38 lakh q and 46.87 lakh q quality seed would be required in 2020 and 2025, higher by 67.7% and 99.6%, respectively, over that of 2014-15 (Table 8). This needs concerted, systematic and organized efforts of all the stakeholders involved in the seed chain. India has a robust seed system comprising public sector institutions as well as private seed companies. Private sector contributed 58.8% to the total seed availability (Chauhan et al. 2016) and is largely involved in low volume, high value crops or hybrids in certain field crops. Pulses being large volume and low value crops, private sector is still to make

Table 7. Current and targeted area (million ha), production (million tonnes) and yield (kg/ha) of major pulses for the next 10 years

Crop	2014-15			2020			2025		
	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
Chickpea	8.25	7.33	889	9.15	10.65	1136	9.50	12.63	1330
Pigeonpea	3.85	2.81	729	4.11	3.78	920	4.20	4.32	1028
Mungbean	3.02	1.50	498	3.85	1.96	510	4.25	2.46	580
Urdbean	3.24	1.96	604	3.39	2.31	682	3.50	2.55	730
Lentil	1.47	1.04	705	1.72	1.57	915	2.07	2.02	980
Fieldpea	0.98	0.89	912	0.81	1.02	1265	0.86	1.20	1400
Total	20.80	15.53		23.03	21.29		24.38	25.18	

Productivity enhancement includes seed replacement rate, providing life-saving irrigation to crops, ensuring timely availability of critical inputs and mechanization for production. This approach would require additional quality seed for increasing SRR and area expansion. For ensuring availability of quality seed any impact on seed production of these crops, so primarily; it is the responsibility of different public sector organizations in central or state government to produce the requisite seed to meet the demand. Government of India made special efforts in ensuring availability of quality seeds of pulses through various schemes such

Table 8. Current seed production, SRR and quality seed requirement for the next 10 years

Crop	Seed produced during 2014-15		SRR (%)					Quality seed (' 000 q)					
								2020-21			2025-26		
	Breeder (q)	Quality (lakh q)	2014-15	2020-21	2025-26	SMR*	Seed rate (kg/ha)	Breeder	Foundation	Certified	Breeder	Foundation	Certified
Chickpea	7,703	14.73	25.4	35.0	40.0	15	80	11.40	170.8	2562.0	13.51	202.7	3040.0
Pigeonpea	670	1.69	41.0	45.0	50.0	40	20	0.23	9.2	368.0	0.26	10.5	420.0
Mungbean	1,038	2.00	23.6	35.0	40.0	30	20	0.30	9.0	270.0	0.38	11.4	342.0
Urdbean	402	1.84	30.3	35.0	40.0	30	20	0.26	7.9	237.0	0.31	9.3	279.0
Lentil	312	1.19	31.5	35.0	40.0	15	40	1.07	16.1	241.5	1.47	22.1	331.5
Fieldpea	637	2.03	34.1	40.0	40.0	15	80	1.15	17.3	259.5	1.22	18.3	274.5
Total	10,152	23.48						14.41	230.3	3938.0	17.152	274.3	4687.0

***Seed Multiplication Ratio**

as Integrated Scheme on Oilseeds, Pulses, Oil palm and Maize (ISOPOM), National Food Security Mission (NFSM), Seed Village Programme (SVP), etc. To augment seed production, ICAR launched a mega seed project 'Seed Production in Agricultural Crops and Fisheries' during X plan which is extended to XII plan also. Similarly, the AICRP-NSP (Crops) has 41 collaborating centres for breeder seed production. Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India launched a National Mission on Agricultural Extension and Technology including sub-mission on seed and planting material during XII plan (Chauhan et al. 2016) covering entire gamut of seed chain from nucleus seed to supply to farmers and also to the major stakeholders in the seed chain. It provides support for infrastructure to create enabling environment for development of seed sector. The Government of India attached highest priority to seed component under NFSM during XI Plan (2007-12). An amount of Rs. 10 crores was allocated to ICAR under NFSM for enhancing production of breeder seed by supporting production and distribution of seeds of pulses. During XII plan also, assistance continued as Rs. 25/kg for distribution of certified seeds in all 622 NFSM-Pulse districts in 27 states, however, there is no assistance on production. To achieve the targeted SRR, it is imperative to continue the assistance on production so as to attract more seed growers in this programme.

Recently, Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India has taken initiatives to ensure availability of quality seeds of pulses through creation of seed hubs, enhancing breeder seed production and maintenance of seed chain of newly released varieties of pulses. A total of 150 seed hubs are being created during 2016-17 with a target of 2, 31, 955 q quality seed. Under National Food Security Mission, 12 centres have been strengthened in major pulse growing states to enhance the availability of breeder seed. Breeder seed indent has enhanced from 10, 488 q in 2015-16 to 16, 378 q in 2016-17, an increase of 56.2%, which would have greater impact on quality seed production, if utilized effectively. To ensure that only high yielding and disease resistant varieties are propagated, the old and obsolete varieties should be replaced gradually with new varieties in a time bound manner.

The seed chain has very well defined role for all the stakeholders. Keeping in view the federal structure of the country, the central government frame rules and regulations to regulate the quality of seeds and State Governments have powers to implement them. The NARS has the responsibility of producing the breeder seed, which forms the backbone of the quality seed programme. The responsibility of conversion of breeder seed to quality seed is of National Seed Corporation, Government of India and State Government agencies. Our earlier analysis of trends of breeder seed indent/production and conversion revealed weak seed chain in conversion of breeder seed to other classes of seed (Chauhan et al. 2016). Despite production of abundant breeder seed, barring a few varietal mismatches, in most of the crops, the SRR is lower than the expected.

The leading pulse production states like Madhya Pradesh, Uttar Pradesh and Rajasthan are not placing appropriate indents. Moreover, on many occasions relevant varieties were not indented by the states. Unrealistic demand for breeder seed, non-lifting of breeder seed, weak seed chain, climate change along with lack of adequate qualified human resources to enforce the quality regime in seed production, lack of modernization of seed processing units and inadequate storage capacity are the major issues to be addressed to meet the challenging task of nearly doubling the quality seed production of pulses. The unrealistic indents more often in lentil, fieldpea and chickpea create difficulty in maintenance of seed chain. In some cases, the non-lifting of indented quantity of breeder seed also discouraged the seed producing organizations. There is a need for convergence of various schemes on seed as well as stakeholders to synergize the efforts for better output and outcome. Since agriculture is a state subject, therefore, State Seed Agencies/Corporations and Department of Agriculture will have to play an important pro-active role in planning and implementation of seed rolling plans for pulses. Time frame work for replacing old and obsolete varieties in consultation with research organizations and gradual increase in SRR should be clearly delineated. Various stakeholders should timely place realistic indent for breeder seed with firm commitment of lifting through memorandum of understanding at the time of indenting. In fact, there is a need to incentivize quality seed production especially breeder seed of new varieties of pulses. This will help in quick spread of new varieties and improved varietal replacement. To mitigate the adverse effects of climate change, search for suitable alternate areas for seed production in non-traditional area/season should be systematically pursued for different pulse crops. Capacity building of various stake-holders in

seed chain with focus on enhancing farmers' participation in seed production, processing, marketing, development of seed villages and seed banks and creation of farmer producer organizations is foremost for making seed chain efficient and effective in accelerating pulse seed production.

Declaration

The authors declare no conflict of interest.

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