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Popularization of mothbean cultivation in Rajasthan

M S Meena[1]*, J P Mishra[1] and H N Meena[1]

[1]*ICAR-Agricultural Technology Application Research Institute, Jodhpur, Rajasthan 342 005*

India experienced pulses revolution during last 10 years due to the concerted efforts of all stakeholders. One of the innovation in frontline extension approach implemented since 2016-17 was FLDs in clusters in place of individual farmers' field. The CFLDs were initiated under ICAR-DAFW collaborative project implemented by frontline extension institutions at districts. This proved an effective tool in educating farmers about improved cultivars and agro-techniques of pulses. Over a dozen pulse crops are grown in one or the other part of the country. One of the most climate resilient and stress adaptive pulse crops in India is mothbean, of which over 94% is produced in arid region of Rajasthan. The farmers harvest very low productivity of this crop due to traditional practices and use of farm saved seeds of old varieties. The CFLDs on mothbean were implemented in 6 districts of western Rajasthan for popularization of improved technologies amongst farmers. The demonstrations proved the merits of improved package of practices and varieties with 34.7% yield advantage over farmer's practices and farm saved seeds of crop varieties. In monetary terms, ₹27.8 lakh additional income was generated from CFLD farmers' fields. The CFLDs have been unique in attracting the farmers and extension personnel for understanding the improved technologies and future requirement to fine tune or modify the technologies for easy adoptability at farmer's fields. Improvements in this approach with continuous and coordinated efforts shall help in developing and deploying high-yielding and climate resilient varieties as well as practices of moth bean for diversified agri-food systems in the arid regions.

Keywords: Arid, CFLDs, Frontline extension, Income, Mothbean, Pulses, Rajasthan

INDIA is a global leader in production and consumption of pulses. It shares about 25% of the global pulse production and consumes nearly 27% of it. While the grains of pulses are the rich source of plant protein to a large vegetarian masses in the country, the intrinsic capacity of pulses to assimilate atmospheric nitrogen through root-rhizobia symbiosis and its biomass once incorporated in the soil adds to sustainability of pulse based production systems. The pulses, in a given cropping system, economises applied nitrogen requirement to subsequent cereals to the tune of 30-40 kg/ha. In India, more than a dozens of pulses such as chickpea, pigeonpea, mungbean, urdbean, lentil, field pea, french bean, horse gram, moth bean, cowpea, lathyrus, etc. are cultivated in different cropping seasons and situations across the country. Mothbean (*Vigna aconitifolia*) is an important pulse crop of arid region due to its-inherent adaptive attributes to withstand against a diverse array of abiotic and biotic stresses that commonly limit the yield of other pulse crops of the *vigna* species. This crop is predominantly grown in the arid region of Rajasthan. The total acreage under moth bean during 2021-22 was 9.93 lakh ha with total harvest of 3.43 lakh tonnes at 346 kg/ha productivity. Of the total production, 94% is produced in Rajasthan (AGRISTAT, 2021). The acreage, production and productivity of mothbean in India is given in Table 1.

Demand and supply of pulses

The working group of NITI Aayog on Demand and Supply projection for agricultural commodities and inputs estimated a consumption demand of 35.23 million tonnes in 2032-33 (Fig. 1). The deficit in demand and supply are met through imports which is about 14% global trade of pulses. Over the years, this deficit has reduced substantially due to significant increase

Table 1. Area, production and productivity of mothbean in India

State	Area ('000 ha)	% Share of India	Production ('000 tonnes)	% Share of India	Productivity (kg/ha)
Rajasthan	972.99	97.9	324.27	94.48	333
Gujarat	14.79	1.5	7.71	2.24	521
Himachal Pradesh	3.35	0.3	10.11	2.94	3014
Jammu & Kashmir	1.09	0.1	0.78	0.22	718
Chhattisgarh	0.54	0.1	0.17	0.04	315
Haryana	0.32	0.03	0.16	0.04	500
India	993.08	100	343.19	100	346

Source: Ministry of Agriculture & Farmers Welfare, GoI, 2021.

in pulses production since 2013-14 onwards. However, being largely rain dependent crop and grown in stressed conditions, the intermittent productivity shocks are not uncommon causing shortfalls in supply and forces for imports to meet the consumption demands. In order to meet the projected demand of 35.23 million tonnes of pulses by 2032-33, a growth of 2.2% per annum is required in pulses production. As the luxury of area expansion under pulses has almost dried up due to similar incentives, price signals and level of productivity in competing and companion crops, the productivity enhancement is the sole option for enhancing pulses production. This requires a paradigm shift in technology development and deployment besides commercialization along with capacity building of the stakeholders. Exploitation of available yield reserves to realise higher production and genetic enhancement for yield and quality would be a critical factor in raising the productivity. The supply projections of NITI Aayog projected availability of 33.95 million tonnes of pulses in 2032-33 which implies a deficit of about 1.28 million tonnes. Given the present trends of growth in pulses production, this seems to be achievable with utilization and exploration of all opportunities to enhance the pulses production. In the follow up, the innovative cluster approach of demonstration in moth bean was initiated in Rajasthan for achieving higher production of pulses in the state.

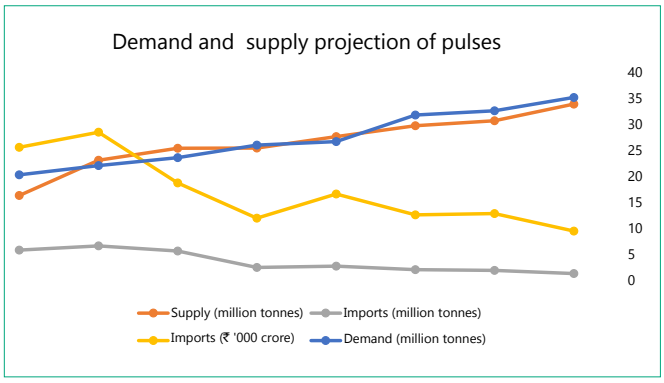

Fig. 1. Demand and supply and imports of pulses during 2015-16 to 2032-33. *Source:* NITI Aayog, 2018

Cluster frontline demonstrations (CFLDs)

A special programme for demonstration of new varieties through Krishi Vigyan Kendra (KVKs) to promote adoption of new varieties of pulses was initiated under National Food Security Mission (NFSM) through a collaborative project of ICAR-DAFW in 2016-17. CFLDs is an innovation over individual and isolated FLDs and technology application research for popularization of the latest notified/released varieties along with full package of practices on a cluster of farmers' fields of a village or more villages. This enables to demonstrate the potentiality of the technologies with scale to participating farmers as well as the farmers of adjacent villages and other agencies. The robustness of precision in outcomes of technology dissemination is enhanced due to economy of scale so is the opportunities for performance analysis and the feedback of practitioners. The frontline extension agencies in Rajasthan under ICAR-ATARI, Jodhpur have been implementing CFLDs on mothbean. During 2022, CFLDs on 340 ha involving 840 farmers were conducted in stressed districts of Bikaner, Barmer, Churu, Jaisalmer, Jodhpur and Nagaur in western Rajasthan. Full packages of practices of mothbean including newly developed varieties, sowing methods, seed treatment, integrated nutrient management (INM), use of micronutrients, bio-fertilizers, integrated pest and diseases management and intercropping, etc. were implemented. The attributes of demonstrated varieties of mothbean are presented in Table 2.

CFLD on Mothbean variety RMO 257 at farmer's field in Nagaur district, Rajasthan

Table 2. Characteristics of HYVs of mothbean under CFLDs in Rajasthan

Variety/Year of release	Developed/ Released by	Avg. yield	Maturity days	Characteristics
RMO-435 (Maru Bahar) 2022	SKRAU, Bikaner	6-6.5 q/ha	65-67 days	• Mutant derived from RMO-40 through 60 Kr gamma radiations. • Suitable for Rajasthan, Gujarat, Maharashtra. • Erect, short duration variety with good fodder value. • High protein (27%) content.
RMO-2251 (Marudhar) 2018	SKRAU, Bikaner	6.0-6.5 q/ha	63-67 days	• Erect with 3 to 5 branches, suitable for mixed cropping, fodder remains green up to maturity. • Good resistance against sucking pest like white fly and jassid. • Escapes terminal drought.
RMO-257 2006	SKRAU, Bikaner	5.0-5.5 q/ha	62-67 days	• Mutant from Jadia moth through 30 Kr + 0.6% EMS for both grain and fodder production (17.4 q/ha). • Flowers in cluster and small petioles and spreading plants. • Moderately tolerant to YMV. • Broad leaves and shallow lobed with 2-3 pod clusters/leaf axil.

Source: https://seednet.gov.in (Accessed on 09.01.2024)

Yield and yield gap

To demonstrate the potential yields of three leading varieties of mothbean viz. RMO-2251, RMO-435 and RMO-257, demonstrations were organised at farmers' fields. Average yield of 551 kg/ha and net return of ₹17516/ha was obtained with improved varieties and packages of practices adopted in CFLDs compared to 414 kg/ha yield and ₹12537/ha net return under farmers' practices. The yield gap between the yields of CFLDs and that of farmers practice was 34.7% (137 kg/ha) (Table 3 and 4).

Table 3. Performance of mothbean varieties during *Kharif* 2022 in Rajasthan (n=794).

Variety	KVKs	Average yield-FP	Average yield-CFLD	Yield gap (%)
RMO-2251	Bikaner-I	2.80	4.40	57.14
	Bikaner- II	4.90	5.71	16.61
	Barmer-I	3.98	5.12	28.64
	Barmer-II	2.60	4.28	64.62
	Churu-I	4.42	5.45	23.30
	Churu-II	4.93	7.20	46.04
	Jaisalmer-I	4.50	7.30	62.22
	Jodhpur-I	4.47	5.92	32.44
	Nagaur-I	4.99	6.25	25.25
	Average	4.18	5.74	39.58
RMO-435	Jaisalmer-II	4.60	5.35	16.30
RMO-257	Jodhpur-II	3.60	4.41	22.50
	Nagaur-II	3.91	4.75	21.48
	Average	3.76	4.58	21.99
Overall average		4.14	5.51	34.71

Table 4. Economics of mothbean CFLDs in Rajasthan in 2022 (n=794).

KVKs	Economics of FP (₹/ha)				Economics of CFLDs (₹/ha)			
	Cost of cultivation	Gross return	Net return	B:C ratio	Cost of cultivation	Gross return	Net return	B:C ratio
Barmer-I	12,850.0	21,890.0	9,040.0	1.70	14,350.0	28,160.0	13,810.0	1.96
Barmer-II	8,500.0	14,300.0	5,800.0	1.68	10,400.0	23,540.0	13,140.0	2.26
Bikaner-I	14,000.0	23,900.0	9,900.0	1.71	14,500.0	29,398.6	14,898.6	2.03
Bikaner-II	17,550.0	37,645.1	20,095.1	2.15	13,900.0	31,426.6	17,526.6	2.26
Churu-I	13,870.0	27,404.0	15,029.0	1.97	17,340.0	39,200.0	18,487.0	2.26
Churu-II	17,000.0	37,090.0	20,090.0	2.18	18,500.0	49,050.0	30,550.0	2.65
Jaisalmer-I	16,600.0	27,300.0	10,700.0	1.64	15,300.0	29,700.0	14,400.0	1.94
Jaisalmer-II	11,270.0	25,300.0	14,030.0	2.24	12,640.0	29,425.0	16,785.0	2.33
Jodhpur-I	14,470.0	24,585.0	10,115.0	1.70	16,185.0	32,560.0	16,375.0	2.01
Jodhpur-II	9,810.0	19,800.0	9,990.0	2.10	10,600.0	24,090.0	13,490.0	2.20
Nagaur-I	22,685.0	27,944.0	5,259.0	1.23	23,725.0	38,756.8	15,031.8	1.63
Nagaur-II	16,300.0	36,701.3	20,401.3	2.25	17,218.6	42,915.3	25,696.6	2.49
Average	14,575.4	26,988.2	12,537.4	1.88	15,388.2	33,185.2	17,515.9	2.17

Intra and Inter variations across district and varieties

Substantial inter- and intra-variety as well as inter- and intra-district variations were observed in the performance of mothbean under farmer practice as well as CFLDs. A much wider intra-variety variation of 12 to 75% in productivity was recorded under farmer practice against the narrow variation of 20 to 32% under CFLDs. The intra-district and intra-variety variations in Barmer, Bikaner and Churu were 20%, 30% and 32% for mothbean variety RMO-2251, respectively. Interestingly, the inter-variety and intra-district variations were also in the same range at 32% for Nagaur, 34% for Jodhpur and 36% for Jaisalmer. This indicated that introduction of HYVs alone cannot help in managing in realizing the potential yields of mothbean in Rajasthan. The management of natural resources and other yield maximizing options shall have to be put in place in the production cycle for realizing the potential harvests from the HYVs. Mothbean variety RMO 2251 proved the best performing which should be promoted by the state department of agriculture. The gap between yields obtained at demonstrations and farmers practices ranged from 16.3 to 64.6%. The narrowest yield gap of 16.3% was recorded under Jaisalmer conditions with 'RMO-435' mothbean and widest gap of 64.6% under Barmer conditions with 'RMO-2251' variety of mothbean (Fig. 2).

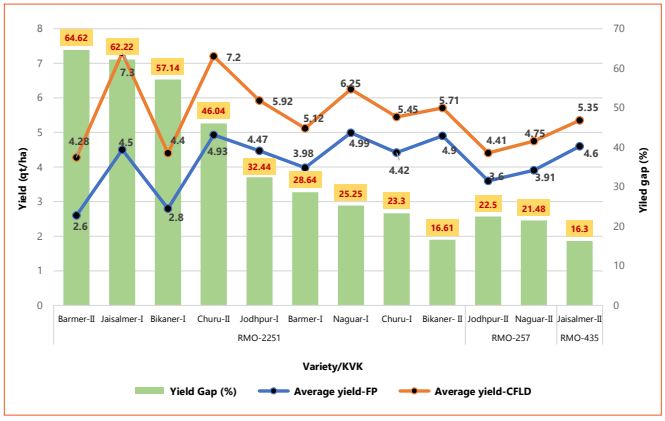

Fig. 2. Yield gap (%) between CFLDs and farmers practice of mothbean in Rajasthan

Income augmentation

Recommended techniques put in practice under CFLDs resulted into higher net return and benefit: cost ratio for mothbean (₹17516/ha and 1:2.17) than farmer practice (₹12537/ha and 1:1.88). On an average, a yield advantage of 137kg/ha was achieved by CFLDs adding to income of the farmers by ₹ 8197/ha. Improved varieties of mothbean under the CFLDs fetched distinct monetary advantage over the farmers' saved seed/ variety. The improved varieties of mothbean proved advantageous in monetary returns by 19.6% with 'RMO-435' at Jaisalmer conditions to 185.8% with mothbean 'RMO-2251' at Nagaur conditions (Fig. 3).

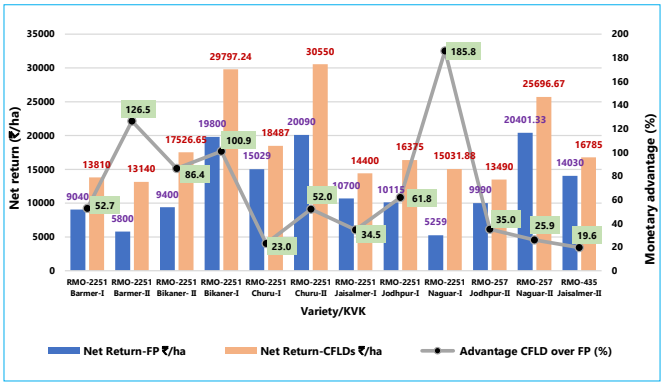

Fig. 3. Monetary advantage of improved varieties of mothbean over farmers saved seed in Rajasthan

Extension activities under CFLDs

The farmers as well as KVKs scientific personnel were broadly capacitated through trainings/workshops and various extension activities viz. organizing field days, field visits by the scientists for crop monitoring and problem solving of farmers, experience sharing etc. In this context, in mothbean CFLDs, a total number of 17 extension activities were conducted with 724 actively involving participants during 2022. Similarly, 330 farmers were trained through 12 mothbean trainings conducted by the KVKs scientists and contributed by forwarding their feedback. CFLDs as an extension approach proved promising for all stakeholders in terms of (i) accessibility, (ii) operability of different interventions and periodic activities/events, and (iii) impacts to farmers of neighbouring villages due to the size of demonstrations and its visibility.

Challenges experienced

- Extreme weather conditions such as abrupt change in minimum and maximum temperatures beyond threshold level of tolerance caused flower abortion, hastened the reproductive period and lowered grain yield.
- The edaphic factors like waterlogging is common feature of monsoon season cropping. Mothbean is sensitive to waterlogging and results in crop failure.
- Lower productivity and low yield potential of mothbean as compared to cereals. Less allocation of resources and sub-optimal nutrition.
- Inadequate availability of seed of improved varieties, vast gap in adoption of agronomic practices and other package of practices.
- Slow growth, long duration, less yields due to poor seed set, and low response to fertilizers. Farmers preferring alternate productive crops resulting into decrease in mothbean area over the years.
- Damage caused by blue bull *(Boselaphus tragocamelus)* and other wild animals.

Future perspectives

- Mothbean is the most suitable and adapted to hot arid and semi-arid agro-climatic conditions, which makes it unique under the climate change and stressed conditions.
- Given its inherent capability of withstanding stresses, mothbean has not been fully exploited for its genetic and genomic resources. Since there are limited number of genetic resources, efforts are

needed for extensive explorations, characterization and evaluation of the collected germplasm. The genetic variability may be employed for higher yield, yield stability, salinity tolerance, multi-disease and pest resistance, higher protein as well as other nutrients.

- Use of advance breeding methods in association with available genetic diversity can help in accelerating domestication in mothbean and expediting its productivity.
- Value-added products and effective marketing strategies can be instrumental in the promotion of mothbean.
- Farmers' participatory varietal development can improve the varietal selection process given that farmers' selection intensity was like that of the breeders.
- Scientific advances coupled with policy signals are required for implementing the innovation and development of high yielding and climate-resilient varieties as well as in mainstreaming of mothbean for diversification of food systems.

SUMMARY

The CFLD approach of frontline extension is an effective tool for increasing the production and productivity of crops as well as motivating the farmers for adoption of improved technologies and package of practices. They have been effective in changing the knowledge, attitude and skills of farmers. Higher yield in demonstration plots over farmers practice created greater awareness and motivation to other farmers to adopt the improved package of practices of mothbean. These demonstrations also built relationship and confidence between farmers and scientists. The beneficiary farmers of CFLDs also play an important role as source of information and quality seeds for farmer-to-farmer dissemination of the high yielding varieties. RMO 2251 mothbean proved the best performing variety which should be promoted through mass extension programme. There is need to augment seed production of farmers preferred varieties at extension farm and farmers' fields in a participatory mode. Efforts may also be augmented for development of high-yielding and climate-resilient varieties of mothbean for diversification of pulses production catering to needs of diversified agri-food systems under diverse agro-climatic conditions.

*Corresponding author email: mohar.meena@icar.gov.in

Impact Evaluation of KVKs

Third Party Evaluation by NITI Aayog Institute - National Institute of Labour Economics Research and Development (2015 & 2018)

- On an average, each KVK covers 43 villages and 4,300 farmers.
- About 80% of villages covered by KVK are over 10 km away from the KVK.
- Of-campus activities are more than On-campus.
- 96% of farmers' requests were attended by KVKs.
- 42% of technologies adopted resulted in higher productivity.
- Enhanced incomes are spent on better education, health, housing etc.
- On an average, each KVK trained about 100 persons annually on agriprenurship.
- About 25% of the persons trained started self-employment venture.
- KVKs reported an edge over other organization providing technology services.

Third Party Impact Evaluation of KVK Scheme by Indian Society of Agribusiness Professionals (2021)

- Impact of On-farm Trials and Frontline demonstrations is excellent.
- Impact of the IFS models is seen manifolds as compared to other extension activities.
- As per the feedback received from the farmers, demonstration of precision agriculture in farmers' fields should also be taken up in good numbers by KVKs.
- It is required to give demonstrations on improved tools and farm implements including drudgery reduction tools by KVKs.
- KVKs should be promoted and fully equipped for the promotion of entrepreneurs for Agri-clinics and supply systems.