Enhancing Pulse Productivity through Agro-Technologies under Clustered Frontline Demonstration Programme

(Bihar, Jharkhand and West Bengal)

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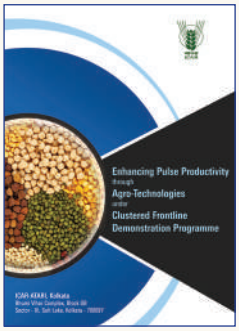

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Foreword

I have great contentment in writing this foreword to the monograph titled "**Enhancing Pulse Productivity through Agro-Technologies under Clustered Frontline Demonstration Programme** (Bihar, Jharkhand and West Bengal)" authored by the Principal Scientists of ATARI, Kolkata which is in coherence with the celebration of International Pulses year-2016.

It is noted that India is the largest producer and consumer of pulses. Pulses are rich source of protein and occupy a unique place in the world of agriculture by its high protein content, which is almost double than that of cereal. India though is the biggest producer and largest consumer of pulses, substantial expenditure is incurred from the state exchequer to import pulses every year to meet the requirement. The Government of India is striving to increase the pulses production schemes; ICAR has taken initiatives in from of a collaborative project **"Cluster Frontline Demonstration on Pulses (CFLD)"** since 2015 under NFSM with financial assistant of Department of Agriculture, Co-operation & Farmers Welfare, to augment pulses production and productivity.

CFLD on pulses production technology were implemented through a network of KVKs in Bihar (38 KVKs), Jharkhand (24 KVKs) and West Bengal (18 KVKs) with the mission objectives to increase pulses production through area expansion & productivity enhancement. About 1956 ha of area was brought under pulses during kharif, 2016; CFLD on pigeon pea, black gram, green gram, horse gram in Bihar, Jharkhand and West Bengal. In rabi season, a total area of 3046.25 ha was under CFLD pulses namely lentil, chick pea and field pea. Summer pulses green gram and black gram acreage was 1340 ha. The technology adopted for CFLD by farmers of this zone is seed treatment with *Rhizobium,* varietal trial application of weedicides, Recommended Dose of Fertilizer (RDF), Integrated Nutrient Management (INM) and Integrated Pest Management (IPM). The varietal performance was assessed for varieties of pigeon pea, black gram, green gram, lentil, chick pea, field pea in Bihar, Jharkhand and West Bengal. The yield increase percentage of CFLD in compared to farmers' practice ranges from 30% to 58 % in kharif pulses, 30 % to 46 % under rabi pulses and 32% to 43 % in summer pulses.

This monograph also gives a brief description of technology applied through cluster frontline demonstration in Bihar, Jharkhand and West Bengal. The compilation will help all the stakeholders in planning their pulse production programme in a desired way.

(S. S. Singh)
Director

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1. An overview of pulse production

Pulses are an important commodity group of crops that provide high quality protein complementing cereal protein for the substantial vegetarian population of this country. Pulses and cereals provide balance protein diet comparable to meat and dairy food. The cultivation of pulses builds up a mechanism to fix atmospheric nitrogen in their root nodules to meet their nitrogen requirement to a great extent. Pulses production has lower carbon footprint than most animal source of protein. Thus protects environment from global warming. In India, pulses are produce with minimum use of resource and hence, becomes less costly even than animal protein. In India, pulses are mostly grown under rain fed condition and do not require intensive irrigation facility also. This is the reason for growing pulses in areas left after satisfying the demand for cereals and cash crops. Besides being rich in protein, it improves soil fertility and physical structure, fits in mixed/ inter cropping systems, helps in crop rotation and provides green pods for vegetables and nutritious fodder for cattle as well. In the marginalized land also, pulses give better returns than other conventional crops.

India though is the biggest producer and largest consumer of pulses, substantial expenditure is incurred from the state exchequer to import pulses every year to meet the requirement. The country has not been able to increase the productivity in spite of technological advancement in pulse cultivation. In the year 2013-14, India produces 19.25 million tonnes of pulses, which a year later came down to 17.3 million tonnes, necessitating more imports. A close look at the pulse production scenario reveals that for several decades after independence, more or less unlit 2008 production of pulses remained almost static- in the range of 14 million tonnes. The present low productivity of pulses can be attributed to decrease in farm area, as farmers opt for high yielding crops with higher MSP, such as paddy and wheat. This has resulted in pulse getting pushed to being grown in marginal, poorly irrigated and low quality soil resulting in lower yield. Moreover, pulses in India are mostly grown in rain fed areas with unstable and uncertain rain fall condition increasing the risk of crop failure. Poor access to storage and milling facilities causes further risk to farmers, as unshelled pulses have a low shelf life. Additionally, poor market linkages cause constraints in meeting market demand. The present high demand and deficit in local supply has increase India's dependence on import from countries like Canada, Myanmar and Australia.

As an incentive, procurement prices of pulses are announced every year but actual procurement hardly takes place. This becomes a disincentive for farmers to grow pulses. Procurement prices have been increase recently, which has helped in growing up production of some pulse crops. However, only announcement of higher MSP is not enough, the government should commit itself to procuring pulses at the announced MSP, as it does for wheat. Pulses are grown mainly in marginal lands prone to moisture stress. Offering remunerative prices would not only help the less well-off producers but may induce farmers in irrigated areas to switch from water- guzzling paddy and sugarcane to pigeon pea or from wheat to chick pea. In fact, the recent announcement by the NITI Aayog to create a buffer stock for pulses is a welcome thought. Alongside buffer stock, if pulses are included in PDS, it will go a long way to improve food and nutrition security of the country.

India's production and import of pulses in recent past

Major pulses	2010-11	2011-12	2012-13	2013-14	2014-15
Production (million tonne)	18.2	17.1	18.3	19.8	17.3
Import (million tonne)	2.8	3.5	4.0	3.5	4.64
Imports as % of domestic supply	13.4	17.1	18.1	15.2	21.2
Source: Ministry of Agriculture and Farmers' Welfare, GoI and other sources					

India's production and import of major pulses

	Imports		% change in imports
	2013-14	2014-15	
Peas	13.30	19.41	45.93
Chick pea	06.97	04.18	-40
Tur	04.65	05.75	23.65
Lentils	07.08	08.16	15.25
Total	36.54	45.84	25.45

2. Pulse production scenario in Bihar, Jharkhand and West Bengal

(I) Kharif pulses

In the eastern states of India, like Bihar, Jharkhand, and West Bengal pulses are grown in kharif, rabi and rabi-summer season. The total area under kharif pulses in Bihar is 37377 ha with average productivity of 1286.5kg/ha and production of 50601MT. The major pulses are pigeon pea 21874 ha followed by black gram 15503ha. In Jharkhand, area under pulses is about 324090 ha with productivity of 816.75 kg/ha with production of 314720 MT. Pigeon pea 196806 ha occupies major portion followed by black gram 94206 ha, green gram 16137 ha and horse gram 16941 ha. West Bengal is having 77478 ha under kharif pulse with average productivity of 923kg/ha and production of 59209 MT; black gram 60427 ha occupies maximum area, followed by pigeon pea 1483 ha and green gram 976 ha. The average productivity of the major pulses in these states is given below.

Bihar

Crops	Area (ha)	Production (MT)	Productivity (kg/ha)
Pigeon Pea	21874	36459	1667
Black gram	15503	14142	879

Jharkhand

Crops	Area (ha)	Production (MT)	Productivity (kg/ha)
Pigeon Pea	196806	205153	1042
Black gram	94206	88251	937
Green gram	16137	10283	637
Horse gram	16941	11033	651

West Bengal

Crops	Area (ha)	Production (MT)	Productivity (kg/ha)
Pigeon Pea	1483	2124	1432
Black gram	60427	40267	666
Green gram	976	823	843

Area in hectare, production in metric tonnes, productivity in kg per ha
Source: Fertilizer and Agriculture Statistics Eastern Region, Edition-39, 2014-15

(a) Pigeon Pea:

Pigeon pea is one of the most preferred pulses consumed in Bihar. The productivity of pigeon pea in the state is always more than the

national average (813kg /ha) with highest yield in 2013-14 of 1667 kg/ha. In Bihar traditionally long duration varieties (>200 days) of pigeon pea are grown which are highly photoperiod-sensitive taking about 40 weeks to mature exposing the crop to terminal drought stress and frosts. Pigeon pea production of Bihar mainly comes from the districts of Samastipur (1836 ha), Kaimur (1791 ha), E. Champaran (1673ha), Gaya (1535 ha). The productivity of pigeon pea is highest in Lakhisarai district (3393 kg/ha) of Bihar. Major varieties under cultivation are *Malaviya -13, NDA-2, LRG-41, BSMR 736 etc.*

In Jharkhand pigeon pea production comes mainly from the districts of Palamu (27256 ha), Latehar (25986 ha), Garhwa (23455 ha) and Ranchi (10764 ha) and productivity is highest in district of Simdega (1930 kg/ha). Jharkhand's major pigeon pea varieties under cultivation are *NDA-2, Malviya -13, ICPL-87119, 85063, UPAS 120 etc.*

In West Bengal, maximum productivity of 1567 kg/ha comes from West Midnapore district. Major varieties under cultivation are *UPAS-120, Laxmi (ICPL 85063) etc.*Pigeon pea is mainly grown in South 24 pgs (437 ha), Purulia (332 ha), and West Midnapore (164 ha) districts of West Bengal.

(b) Black gram (Urd Bean):

Urd bean is grown mostly during rainy season; however, being a short duration urd bean fits well in multiple cropping systems and can provide desired sustainability to cereal based cropping systems. Black gram is grown in 15503 ha in kharif season in Bihar and production is 14142 MT with average productivity of 912kg/ha. The leading districts in black gram production in Bihar are Katihar (3107 ha), Khagaria (2602 ha), Lakhisarai (2244 ha), and Bhagalpur (1981 ha). The highest productivity is recorded in Katihar district (3107 kg/ha).

In Jharkhand, crop is grown in 94206 ha with production of 88251 MT and productivity of 937kg/ha, leading black gram producing districts are Simdega (20687 ha), Palamau (10232 ha), and Ranchi (8600 ha). The highest productivity (1610 kg/ha) comes from Simdega district.

In West Bengal, black gram is grown in 60427 ha and total production is 40267 MT. Murshidabad is leading district in black gram production with 14039 ha acreage which is followed by Nadia (12384 ha), and Purulia (12986 ha). The productivity of Malda district (931 kg/ha) is highest in black gram.

(c) Green gram:

Green gram production of Jharkhand primarily comes from the districts of Sariekela (4514 ha), West Singhbhum (2612 ha) and E. Singhbhum (1028 ha). The productivity of green gram is highest in Dumka district (1150 kg/ha) followed by Lohardaga (1100 kg/ha). Major varieties under cultivation are *IPM 2-3, SML-66 etc*. In West Bengal, the total area of kharif moong (green gram) is 976 ha with highest productivity of 1205 kg/ha in North Dinajpur district.

(d) Horse gram:

Horse gram is an underutilized pulse crop grown in wide range of adverse climatic conditions. Horse gram is grown in 16941 ha in Jharkhand and production is 11033 MT with average productivity of 651 kg/ha. The leading districts in horse gram production are Simdega (3226 MT), Dumka (1492 MT), and Lohardaga (882 MT). The productivity is highest in Lohardaga, Dumka and Latehar districts (900 kg/ha each). The best yielding varieties are *Birsa Kulthi-1 and Payur-1, 2.*

(II) Rabi Pulses:

Bihar has significant area under rabi pulse which is about 448465 ha and it compete with other crops. The average productivity of pulses is 818 kg/ha and production is 366695 MT. Major rabi pulses grown in Bihar are summer moong (156699 ha) followed by lentil (152912 ha) and chickpea (60002 ha). In Jharkhand area under rabi pulses is also significant compared to other crops. The area covered is about 79148 ha with

productivity of 1061.67 kg/ha and production of 78175 MT. Major crops are chick pea (160000 ha) followed by lentil (43000 ha). West Bengal is having 170553 ha under rabi pulse with average productivity of 1015 kg/ha and production of 173130 MT. Lentil (65972ha) occupies largest area, followed by summer moong (27994 ha) and field pea (14114 ha). The average productivity of the major pulses in these states is indicated in below.

Bihar

Crops	Area (ha)	Production (MT)	Productivity (q/ha)
Lentil	152912	140063	9.15
Chickpea	60002	57490	9.58
Field pea	17142	17313	10.10
Green gram (rabi summer)	156699	90725	5.78
Black gram	15725	14355	9.12

Jharkhand

Crops	Area (ha)	Production (MT)	Productivity (q/ha)
Lentil	43000	39249	8.96
Chickpea	160000	186374	11.0
Field pea	33000	40364	11.74

West Bengal

Crops	Area (ha)	Production (MT)	Productivity (q/ha)
Lentil	65972	63516	9.63
Chickpea	26177	30844	11.78
Field pea	14114	16778	11.89
Green gram (rabi summer)	27994	19059	6.81
Black gram	9625	8543	8.88

(a) Lentil:

Lentil is most important pulse in rabi season grown mainly in Uttar Pradesh, Madhya Pradesh, Chattishgarh, Bihar and West Bengal. These states all together account for 80-90% of the total area under lentil. In Bihar, lentil production mainly comes from the districts of Patna (27722 ha), Aurangabad (13612 ha), Nalanda (12013ha)and West Champaran (10238 ha). The productivity of lentil is highest in Patna district (1489 kg/ha). Major varieties which are under cultivation in Bihar are *PM-5, Pant L-406, DPL-62, Arun, HUL-57 etc*. Among the major pulse crops in West Bengal, lentil has prime importance. Lentil was grown mainly in Nadia (24135 ha), Murshidabad (16922 ha), North 24 Parganas (7844 ha) and Birbhum (5864 ha) districts of West Bengal. The maximum productivity of 1145 kg/ha comes from Murshidabad district. Major varieties under cultivation are *WBL-58, B-77 etc.*

(b) Chick pea:

Chickpea is grown in about 60002 ha in Bihar with production of 57490 MT and average productivity of 958 kg/ha. The leading districts in chickpea production in Bihar are Aurangabad (7599ha), Patna (6338 ha), Nalanda (5293ha), Gaya (5058 ha) and Bhojpur (4149 ha). The productivity

of chickpea was highest in Patna district (1582 kg/ha). In Jharkhand, chickpea (2013-14) is grown in 155840 ha with production of 181731 MT and productivity of 1166 kg/ha. Leading chickpea producing districts are Latehar (11960 ha), Garwaha (11554 ha), Palamu (10215 ha) and Saraikela (10046 ha). The highest productivity comes from Saraikela district (1880 kg/ha). In West Bengal, chick pea is grown in 26177 ha and total production is 30844 MT. Nadia is leading district in chickpea production with 9906 ha which is followed by Birbhum (6781 ha) and Murshidabad (5462 ha). The productivity of chick pea was highest in Birbhum district (1390 kg/ha) of West Bengal.

(c) Green gram:

Green gram is grown in 156699 ha in rabi season in Bihar and production is 90725 MT with average productivity of 579 kg/ha. It is grown mainly in summer season. The leading districts in green gram production in Bihar are Muzaffarpur (24487 ha), Supual (24108 ha), Saharsa (19277 ha) and Madhepura (18064 ha). The highest productivity recorded in Darbhanga district (1290 kg/ha). In Jharkhand crop is grown in 16137 ha with production of 10283 MT (2013-14). In West Bengal, green gram is grown in 27994 ha and total production is 19059 MT in summer (2014-15). South 24 Parganas is leading district in green gram production with 19457 ha followed by Nadia, Birbhum and Uttar Dinajpur. The productivity was highest in Birbhum (1678 kg/ha).

(d) Field pea:

In Jharkhand, field pea is grown in 31708 ha and production is 37600 MT with average productivity of 1186 kg/ha (2013-14). The leading districts in field pea production in Jharkhand are Gumla (3273 ha), Deoghar (2344 ha), Garwah (2410 ha) and Palamau (2105 ha). The productivity is highest in Lohardaga district (3052 kg/ha).

(e) Black gram:

In West Bengal, black gram is grown in 10038 ha in rabi season and production is 9433 MT with average productivity of 940 kg/ha (2014-15). The leading districts in rabi blackgram production in West Bengal are Murshidabad (4045 ha), Coochbehar (2438 ha), and North 24 Parganas (780 ha). The productivity was highest in Jalpaiguri district (1356 kg /ha).

3. Cluster frontline demonstration on pulses

Cluster Front Line demonstrations (CFLDs) is a unique approach to provide a direct interface between researcher and farmers as the scientists are directly involved in planning, execution and monitoring of the demonstrations for the technologies developed by them and get direct feedback from the farmers' field about pulses production. This enables the scientists to improvise upon the research programme accordingly. In FLDs, the subject matter scientists provide technological inputs to extension scientists to organize the demonstrations. Thus, FLDs provide an opportunity to researchers and extension personnel for understanding the farmer's resources and requirement to fine tune and/or modify the technologies for easy adaptability at farmers' fields. Frontline Demonstration is a form of applied research through ICAR/SAUs system on latest notified/released varieties along with full package of practices on selected farmers' fields with a view to demonstrate the potentiality of the technologies to (a) participating farmers (b) neighbouring farmers and other agencies; (c) to analyze the production (d) performance of the technologies for scientific feedback. The objectives of CFLD were mentioned below:

- To demonstrate improved Crop Production Technologies of Pulses on the farmers' fields;
- To popularize the newly notified and improved varieties/technologies for varietal diversification and efficient management of resources.
- To bring synergy among planers, researchers,

farmers and industry for parable interface through seminars/symposium on emerging themes of importance in the field of pulses production for deciding strategies for development of pulses.

Following the mission objective, ICAR-Agricultural Technology Application Research Institutes Kolkata is implementing Cluster Frontline Demonstration on Pulses for demonstrating production potential of modern technologies through KVKs of Bihar, Jharkhand and West Bengal. Major technologies followed by each KVK includes newly developed varieties, sowing methods, seed treatment, integrated nutrients management (INM), use of micro nutrients, bio fertilizers, integrated pest and diseases management (IPDM) and intercropping etc. The main stress was given to reduce the gap between existing and potentiality to produce more pulses through available technology options, detailed planning, and monitoring of crops by the KVKs at critical stages of ongoing CFLD programme.

3.1 Performance of CFLD on Pulses during 2016-17

During 2016-17, Cluster Frontline Demonstrations (CFLDs) were implemented in 80 KVKs *i.e* 38 KVKs of Bihar, 24 KVKs of Jharkhand and 18 KVKs of West Bengal according to the agro- ecological condition. The target number of demonstration was 16625 of which 15856 number of demonstration was achieved covering a total area of 6342.3 ha in Bihar, Jharkhand and West Bengal. Details of the number of demonstrations and area under CFLD are indicated in table 3.1 (a), (b) & (c).

Table 3.1 (a): Total area covered under CFLD Pulses (kharif) 2016-17

Sl. No	Crops	State	No of Demonstration	Target Area (in ha)	No of Demonstration	Achievement Area (in ha)
Kharif Season						
1	Pigeon pea	Bihar	1650	660.0	1553	621.0
		Jharkhand	1400	560.0	1388	555.0
		West Bengal	200	80.0	200	80.0
2	Black gram	Bihar	125	50.0	0	0
		Jharkhand	500	200.0	525	210.0
		West Bengal	575	230.0	575	230.0
3	Green gram	Bihar	125	50.0	25	10.0
		Jharkhand	275	110.0	275	110.0
		West Bengal	200	80.0	125	50.0
4	Horse gram	Jharkhand	275	110.0	225	90.0
Total Kharif Season			5325	2130.0	4890	1956.0

Table 3.1 (b): Total area covered under CFLD Pulses (rabi) 2016-17

Sl. No	Crops	State	No of Demonstration	Target Area (in ha)	No of Demonstration	Achievement Area (in ha)
Rabi Season						
1	Lentil	Bihar	2650	1060.0	2974	1189.75
		West Bengal	875	350.0	825	330.0

Sl. No	Crops	State	No of Demonstration	Target Area (in ha)	No of Demonstration	Achievement Area (in ha)
2	Chick pea	Bihar	1450	580.0	1316	526.25
		Jharkhand	1175	470.0	1125	450.0
		West Bengal	225	90.0	200	80.0
3	Field pea	Bihar	925	370.0	626	250.25
		Jharkhand	225	90.0	200	80.0
		West Bengal	350	140.0	350	140.0
Total Rabi Season			7875	3150.0	7616	3046.3

Table 3.1 (c): Total area covered under CFLD Pulses (summer) 2016-17

Sl. No	Crops	State	No of Demonstration	Target Area (in ha)	No of Demonstration	Achievement Area (in ha)
Summer						
1	Green gram	Bihar	1225	490.0	1200	480.0
		Jharkhand	950	380.0	900	360.0
		West Bengal	725	290.0	825	330.0
2	Black gram	Bihar	100	40.0	100	40.0
		Jharkhand	350	140.0	300	120.0
		West Bengal	75	30.0	25	10.0
Total Summer Season			3425	1370.0	3350	1340.0
Grand Total (Kharif +Rabi+ Summer)			16625	6650.0	15856	6342.3

3.2 Technologies demonstrated:

Different technologies were adopted by 80 KVKs of Zone II in farmers' field of Bihar, Jharkhand and West Bengal. The various crop wise technologies demonstrated are depicted in table 3.2, kharif pulses (pigeon pea and black gram) in Table 3.2 (a) & 3.2 (b) , rabi pulse crops (lentil & chick pea) in table 3.2 (c) & 3.2 (d) and summer crop in table 3.2 (e). The demonstrations were on newly released varieties/hybrid, biotic & abiotic resistance varieties, method of sowing, integrated nutrient management (INM), integrated pest management (IPM), irrigation, farm machines etc.

Table 3.2(a): Technology demonstration on pigeon pea during kharif 2016-17

Crop	Varieties	Seed treatment	Weed management	Fertilizer Management/ Micronutrients	Insect pest and disease
Pigeon pea	*Malviya-13, NDA-2, BSMR-736 /LRG-41, ICPL-87119 (Asha)*	Carbendazime @2.5g/kg seed+ Chloropyriphos @ 8ml/kg seed+ Rhizobium and PSB 500g/ha	Pendimetalin @3.3L/ha, Flumendamied @80ml/ha, Po.E (20-25 DAS) application of Imezethapyr @40g ai/ha	Integrated Nutrient Management, Sulphur @20kg/ha, Micronutrient Mixture, N25:P250:K25 kg/ ha	IPM/IDM- Neem oil and Chloroporiphos 50% spray

Table 3.2 (b): Technology demonstration on black gram during kharif 2016-17

Crop	Varieties	Seed treatment	Fertilizer Management/ Micronutrients/Bio fertilizer	Insect pest and disease
Black gram	*Pant Urd-31, Uttra, Shekhar – 2, WBL-109, WBU 108*	*Trichderma viride* @ 200gm/ha and *Pseudomonas* @ 200gm/ha	Integrated Nutrient Management, Application of sulphur @20 kg/ha Foliar application of boron, soil application of Boron (Borex 10.5% @ 10 kg/ha), *Rhizobium* @2kg/ha; and PSB @ 2kg/ha; 20:40:20:: NPK	IPM (Pheromone trap and Lure), Need based management of insect pest and diseases

Table 3.2 (c): Technology demonstration on lentil during rabi 2017

Crop	Varieties	Seed treatment	Weed management	Fertilizer Management/ Micronutrients/Bio fertilizer	Insect pest and disease
Lentil	*HUL 57, KLS-218, Pant Moong-5, WBL-77*	Inoculation of seed with *Rhizobium* @ 0.75 kg / 30 kg of seed	Pre emergence-Oxyfluorfen 23.5 EC @ 3 ml / L of water at 3 DAS.	Integrated Nutrient Management, Application of micronutrient MOBOMIN @ 1.0 kg / ha, Foliar spray of micronutrient Borax (Boron) as 0.5 % solution of at 15, 40 DAS and at flower initiation stage, Application of Sulphur @20 kg/ ha	Application of Carbedazin @ 0.75 kg / ha, Spraying of Mancozeb @ 2.5g/L, Spraying of Copper oxychloride 50% WP @ 4 g/L

Table 3.2 (d): Technology demonstration on chick pea during rabi 2017

Crop	Varieties	Seed treatment	Weed management	Fertilizer Management/ Micronutrients/Bio fertilizer	Insect pest and disease
Chick pea	*BGM-547, GNG-1581, JAKI-9218*	Bavistin & *Rhizobium*, and PSB 500g/ha, *Trichoderma viride* @ 200gm/ha & *Pseudomonas* @ 200g/ha	Pre emergence-Pendimetalin @ 3.3L/ha	Integrated Nutrient Management, Foliar application of Borax @ 0.2%, 25:50:25::N:P:K, 30kg N &100kg P2O5/ha, Zn @ 25 kg/ha	Foliar spray with Chloropyriphos, IPM (Pheromone trap & Lure), Triazophos 40 EC @ 2.5 ml/ L

Table 3.2 (e): Technology demonstration on green gram during summer 2017

Crop	Varieties	Seed treatment	Weed management	Fertilizer Management/ Micronutrients/Bio fertilizer	Insect pest and disease
Green gram	*IPM-2-3, HUM 16, PDM 139, SML-668*	*Rhizobium* culture, Carbendazim and Chloro-pyriphos, PSB and *Azotobactor*	Pre emergence-Pendimetalin @3.3L/ha	Integrated Nutrient Management, Phosphogypsum, Sulphur@20 kg/ha, Zinc Zn @25 kg/ha, Soil application Borex 10.5% @ 10 kg/ha	Foliar application of Borax @0.2%, IPM (Pheromone trap & Lure), Use of liquid bio pesticides (Dasparni), Neem oil on every 15 days interval. Yellow sticky trap was used @ 20 sticky trap per ha.

4. Performance of clustered pulse demonstration in kharif 2016-17

A total of 5325 number of demonstration was allotted to ATARI-ICAR, Zone-II against which 4890 number of demonstrations to an area of 1956 ha was covered throughout Bihar, Jharkhand and West Bengal. The details of state-wise and crop wise breakup of demonstrations are provided in Table 4(a).

West Bengal. The acreage of CFLD on black gram in Jharkhand was 210 ha involving 525 numbers of demonstrations. In West Bengal total area of 230 ha on black gram and 50 ha under green gram was covered during kharif, 2016. CFLD on green gram was demonstrated in 110 ha through 275 demonstrations in Jharkhand.

The average state wise and crop wise yield performance of kharif pulses in farmers existing

Table 4 (a): State-wise demonstration conducted in CFLD kharif 2016-17

Crop/State	Area (ha)	No of Demonstration
Pigeon pea		
Bihar	621	1553
Jharkhand	555	1387
West Bengal	80	200
Total	1256	3140
Black gram		
Jharkhand	210	525
West Bengal	230	575
Total	440	1100
Green gram		
Bihar	10	25
Jharkhand	110	275
West Bengal	50	125
Total	170	425
Horse gram		
Jharkhand	90	225
Total Achievement	1956	4890
Total target	2130	5325

CFLD on Pigeon pea encompasses 621 ha area in Bihar, 555 ha in Jharkhand and 80 ha in

plot and demonstrations plot is shown in Table 4 (b)

Table 4 (b): Performance of pulse demonstration in kharif 2016-17 (in Rs.)

State	No of Demo	Area (ha)	Yield (q/ha)					Farmers Existing plot				Demonstrated Plot			
			Highest	Lowest	Average	Local Check	%	Gross Cost	Gross Return	Net Return	B:C ratio	Gross Cost	Gross Return	Net Return	BC ratio
Pigeon pea															
Bihar	1553	621	18.94	13.97	16.45	12.39	32.77	23068.28	63920.99	40852.71	2.77	24706.5	89868.84	65161.96	3.64
Jharkhand	1387	555	14.82	10.50	12.66	8.88	42.57	17918.92	45634.56	27715.64	2.54	20321.4	69740.99	49419.61	3.43
West Bengal	200	80	11.51	9.59	10.55	7.60	38.81	21437.5	40613.75	19176.3	1.89	28317.1	61396.25	33079.15	2.18
Black gram															
Jharkhand	525	210	11.58	7.74	9.66	6.89	40.20	15117.0	37936.77	22819.77	2.50	17118.5	58436.54	41318.08	3.41
West Bengal	575	230	9.57	7.45	8.51	6.13	38.82	20499.3	37336.67	16837.4	1.82	24197.8	53612.2	294144	2.21
Green gram															
Bihar	25	10	13.7	8.2	10.9	6.9	58	19600	73100	53500	3.71	20200	123800	103600	6.12
Jharkhand	275	110	10.41	6.57	8.49	6.18	37.38	13453.7	36183.3	22729.7	2.69	16651.3	58010	41358.7	3.48
West Bengal	125	50	11.3	8.98	10.1	7.31	38.17	22383.3	47758.3	25375	2.13	27178.3	67833.3	40655	2.48
Horse gram															
Jharkhand	225	90	10.27	6.87	8.57	6.65	28.87	10600	20634	10034	1.95	12198	32021	19823	2.63
Total	4890	1956	12.46	8.87	10.67	7.66	39.29	18230.89	44790.93	26560.06	2.46	21209.9	68302.12	47092.21	3.22

Pigeon pea:

In Bihar, it has been observed from the table 4(b) there is an average increase of 32.7% in yield in demonstration plots over the local check and the BC ratio is 3.6. In Jharkhand and West Bengal, the percentage in yield increase in demonstrations plot was 42.5% and 38.8% respectively.

Black gram:

Yield performance of black gram CFLD in Jharkhand and West Bengal shows an increase of 40.2% and 38.8 % respectively. In Jharkhand, the net return in demonstration plot was about Rs 41000/- against Rs.23000/- in existing plot.

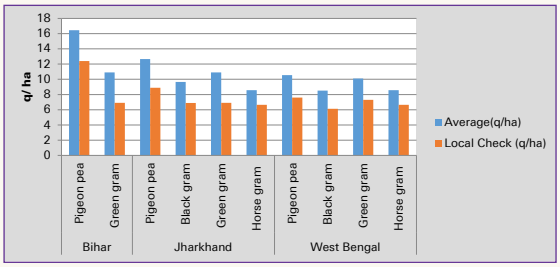

Fig 1: Performance of kharif pulses in comparison with average yield (demonstrated variety) and farmers practices (local check)

Green gram and Horse gram:

The BC ratio of 6.1 under CFLD on green gram was recorded in Bihar. In Jharkhand and West Bengal the net return of green gram demonstration ranges from Rs.40,000/- to Rs. 41,000 as compared to Rs.23,000/- to Rs.25,000/- in existing plot. In Jharkhand, the average CFLD horse gram yield was 8.57 q/ha as to 6.65 q/ha in check plot and the BC ratio 2.6.

4.1 Varietal performance of Pigeon pea under CFLD

During kharif 2016-17, pigeon pea varieties namely *Malviya 13, NDA-1, LRG-41 and NDA-2* in Bihar, variety *Asha, NDA-2, Malviya-13* in Jharkhand and variety *UPAS 120,* Laxmi and Asha in West Bengal were demonstrated under CFLD to evaluate its yield performance. *Malviya-13,* widely adopted variety of Bihar was brought under CFLD in an area of 210 ha. The variety is highly resistant to wilt, SMD and tolerant to *Phytophthora* and pod fly infestation. The average demonstrated yield is 17.59 q/ha. The percentage of yield increase over the existing yield is 36.44% [Table 4.1(a)]. *NDA 2* covered 100 ha of area in CFLD in Jharkand with average yield of 14.63 q/ha. The high-yielding pigeon pea variety, *Asha* was grown in 230ha under CFLD pulses. The variety is resistant to *fusarium* wilt and sterility mosaic diseases which gave an average yield of 12.38q/ha. In West Bengal, among the three varieties *UPAS 120* performed best with an average yield of 14.37q/ha and *Laxmi* variety covered 40 ha area with average yield of 10.37q/ha.

Table: 4.1(a). Performance of major varieties of pigeon pea

Variety	Area (ha)	No. of demonstration	Demonstrated yield (q/ha)	Check yield (q/ha)	% of yield increase	Yield gap (%)
Bihar						
Malviya 13	210	525	17.59	12.89	36.44	26.72
NDA -1	130	325	17.35	12.35	40.48	28.82
LRG-41	90	225	16.69	13.00	28.38	22.11
NDA-2	50	125	16.72	11.95	39.92	28.53
Jharkhand						
Asha	230	575	12.38	8.22	50.60	33.60
NDA 2	100	250	14.63	10.34	41.48	29.32
Malviya 13	60	150	13.26	9.90	34.00	25.34
West Bengal						
UPAS 120	20	50	14.37	13.40	7.23	6.75

The yield in the demonstration plot shows higher than the check yield it ranges from 12.38 to 17.59 q/ha. The maximum percentage of yield increase was noticed in the variety *NDA-1* in the state of Bihar 40.48% whereas in Jharkhand *Asha* variety has recorded 50.60% yield increase over the check yield. In West Bengal, *UPAS 120* has shown percentage yield increase of 7.3 over the check yield. The yield gaps (%) are almost similar in all varieties in the state of Bihar and Jharkhand. In West Bengal yield gap (%) of 6.75 was recorded in the variety *UPAS 120*. Hence it indicates that the existing varieties of pigeon pea can give better yield if proper agro-technologies and practices are adopted.

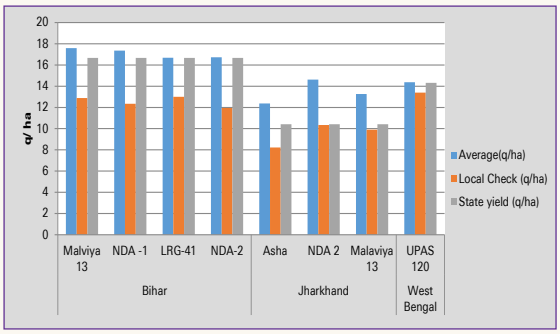

Fig 2: Performance of different varieties of pigeon pea under CFLD Pulses 2016-17 of three states

4.2 Varietal performance of green gram (kharif) under CFLD

CFLD on green gram (kharif) was demonstrated in the states of Jharkhand and West Bengal. Green gram varieties *HUM 16, Pant Moong 5, IPM 2-3 and SML 668* were demonstrated in the state of Jharkhand and variety *Samrat* was demonstrated in West Bengal during kharif 2016-17. In Jharkhand, total coverage of area was 110 ha and number of demonstrations was 275. Demonstrated yield was highest with the variety *SML 668* which was 10.23 q/ha. (Fig 3). In West Bengal, green gram variety *Samrat* was covered 50ha area comprising of 125 demonstrations.

From the table [4.1(b)], the yield in the demonstrations plot clearly shows and increase over the check plot. In Jharkhand, *HUM 16* variety recorded highest percentage of yield increase (53.30 %) over the check yield and *SML 668* recorded minimum percentage (35.35 %) of yield increase over the check yield. In West Bengal, yield of *Samrat* variety was 10.10 q/ha in CFLD whereas check yield was 7.31 q/ha showing a yield increase of

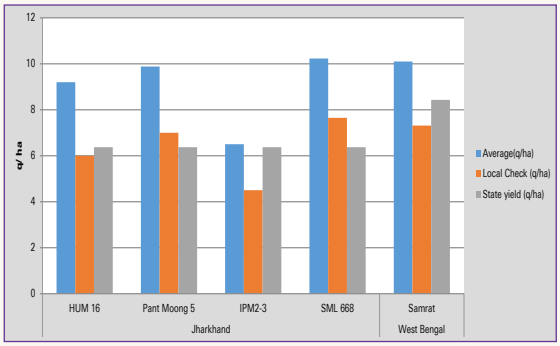

Fig 3: Performance of different varieties of green gram (kharif) under CFLD Pulses 2016-17 of two states

Table 4.1(b): Performance of major varieties of green gram (kharif)

Variety	Area (ha)	No. of demonstration	Demonstrated yield (q/ha)	Check yield (q/ha)	% of yield increase	Yield gap (%)
Jharkhand						
HUM 16	10	25	9.20	6.00	53.30	34.78
Pant Moong 5	40	100	9.88	7.00	41.15	29.15
IPM2-3	20	50	6.50	4.50	44.40	30.77
SML 668	40	100	10.23	7.65	35.35	25.22
West Bengal						
Samrat	50	125	10.10	7.31	38.16	27.62

38.16 %. Thus by adopting new agro-techniques and recommended package of practices farmers' can enhance the yield of the existing varieties.

4.3 Varietal performance of black gram (kharif) under CFLD

Variety *PU 31* was demonstrated in 80 ha. The total number of demonstrations was 200. The average yield in the demonstration plot was 9.67 q/ha and in check plot 6.78 q/ha *Uttar* variety of black gram covered 50 ha and the maximum yield ranges from 10.45-13.6 q/ha. Other varieties under black gram cluster frontline demonstration are *Azad Urd -2, Meha, Birsa Urad 1, Shekhar-2*.

In West Bengal, *Sharda (WBU 108) & Sulata (WBU 109)* was demonstrated in 210 ha through 525 demonstrations. The demonstrated yield of 8.57q/ha over the existing average of 6.06 q/ha. The percentage of yield increase of these varieties is similar which ranges from 34.20 to 44.23 [Table4.1(c)]. The highest percentage of yield increase was shown by the variety *WB 108 (Sharda)*. The yield gap percentage clearly shows that adopting various technologies like seed treatment, use of bio fertilizers, micronutrients and integrated crop management can increase the yield of existing varieties.

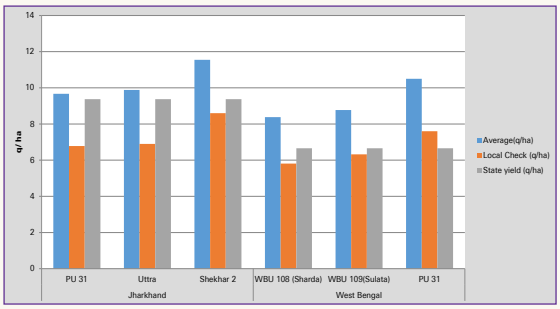

Fig 4: Performance of different varieties of black gram (kharif) under CFLD Pulses 2016-17 of two states

4.4 Varietal performance of horse gram under CFLD

Horse gram variety *Birsa Kulthi 1* was demonstrated in 40 ha through 100 demonstrations. The average yield of 8.7q/ha in demonstration plot was 52.45% higher than the local check. Another promising varieties of this region are *Payur 2, Indra Kulthi -1* with average demonstrated yield of 7.14 q/ha [Table 4.1(d)]. The variety *Payur 2* recorded 59.52 % of yield increase in demonstration plot over check and variety *Birsa Kulthi 1* by 52.45% indicating that the existing varieties can perform better if farmers' adopt various technologies like seed treatment, use of bio fertilizers and micronutrients along with integrated nutrient management and effective management of pest and diseases.

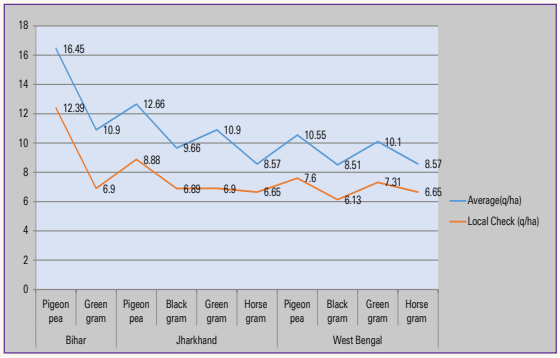

Fig 5: Overall performance of kharif pulse under CFLD Pulses 2016-17 of three states

Table 4.1(c): Performance of major varieties of black gram (kharif)

Variety	Area (ha)	No. of demonstration	Demonstrated yield (q/ha)	Check yield (q/ha)	% of yield increase	Yield gap (%)
Jharkhand						
PU 31	80	200	9.67	6.78	42.62	29.89
Uttara	50	125	9.88	6.90	43.18	30.16
Shekhar 2	20	50	11.55	8.60	34.3	25.54
West Bengal						
WBU 108 (Sharda)	120	300	8.38	5.81	44.23	30.67
WBU 109(Sulata)	90	225	8.77	6.32	38.78	27.94
PU 31	20	50	10.50	7.60	34.20	27.62

Table 4.1(d): Performance of major varieties of horse gram

Variety	Area (ha)	No. of demonstration	Demonstrated yield (q/ha)	Check yield (q/ha)	% of yield increase	Yield gap (%)
Jharkhand						
Birsa Kulthi 1	40	100	8.69	5.70	52.45	34.41
Payur 2	20	50	6.70	4.20	59.52	37.31
Indra Kulthi 1	20	50	7.59	6.17	23.01	18.71

5. Performance of clustered pulse demonstration in rabi and rabi-summer 2016-17

Chickpea, lentil, green gram, field pea and black gram are the major rabi and summer pulses in the states of Bihar, Jharkhand and West Bengal. Clustered demonstration was organized in 4456.25 ha covering the three states. The details of state-wise and crop wise breakup is given in Table 5.1.

Table 5. 1: State-wise demonstration conducted in rabi and summer 2016-17

Crop/State	Area (ha)	No. of demonstration
Lentil		
Bihar	1189.75	2974
West Bengal	330.00	825
Total	1519.75	3799
Chickpea		
Bihar	526.25	1316
Jharkhand	450.00	1125
West Bengal	80.00	200
Total	1056.25	2641
Field pea		
Bihar	250.25	626
Jharkhand	80.00	200
West Bengal	140.00	350
Total	470.25	1176
Green gram		
Bihar	480.00	1200
Jharkhand	360.00	900
West Bengal	330.00	825
Total	1170.00	2925
Black gram		
Bihar	40.00	100
Jharkhand	120.00	300
West Bengal	10.00	25
Total	170.00	425
Total	4386.25	10966
Allotment	4520	11300

In Bihar an area of 1189.75 ha was brought under CFLD on lentil and 330 ha in West Bengal. The acreage of CFLD on chickpea in Jharkhand was 450 ha involving 1125 number of demonstrations and in Bihar and West Bengal an area of 526.25 ha and 80 ha were covered respectively. In Bihar and Jharkhand total area of 250.25 ha and 80 ha were under field pea demonstrations during rabi 2016-17. CFLD on green gram was demonstrated in 480 ha, 360 ha and 330 ha in Bihar, Jharkhand and West Bengal respectively. Demonstrations on black gram in Jharkhand were in 120 ha during rabi 2016-17.

The average state wise and crop wise yield performance of rabi pulses in farmers existing plot and demonstrations plot is shown in Table 5.2

Table 5.2: Performance of pulse demonstration in rabi 2016-17

(in Rs.)

State	Area (ha)	No of demo	Yield (q/ha)					Demonstrated Plot				Farmers Existing plot			
			Highest	Lowest	Average	Local Check	% increase	Gross Cost	Gross Return	Net Return	B:C ratio	Gross Cost	Gross Return	Net Return	BC ratio
Lentil															
Bihar	1189.70	2974	14.92	10.83	13.11	9.36	40.02	20776.37	62847.3	42070.92	3.02	18531.42	44465.51	25934.09	2.40
West Bengal	330.00	825	10.72	8.42	9.72	7.50	30.76	21427.77	51877.01	30449.24	2.42	19126.4	38846.5	19720.1	2.03
Chickpea															
Bihar	526.25	1316	15.03	10.76	12.15	9.18	32.33	22369.46	102629.2	80259.71	4.59	19419.42	51213.92	31794.5	2.64
Jharkhand	450	1125	13.15	8.97	11.06	8.33	32.77	16873.38	58631.6	41758.22	3.47	14651.56	36911.95	22260.39	2.52
West Bengal	80	200	11.43	8.03	9.65	6.61	45.93	19902.4	48330	28427.6	2.43	17862	33900	16038	1.90
Field Pea															
Bihar	250.3	626	15.78	11.20	15.06	10.96	37.33	23708.71	60809.62	37100.9	2.56	21734.69	45792.69	24058	2.11
Jharkhand	80	200	15.17	10.82	13.29	9.42	41.09	16104.64	45949.64	29845	2.85	15021.07	32590	17568.93	2.17
West Bengal	140	350	13.75	10.24	12.15	7.11	70.80	20163.57	47421.71	27258.14	2.35	16299.29	27863.71	11564.43	1.71
Green gram															
Bihar	480	1200	11.49	8.46	9.98	6.97	43.19	20815	54746	33931	2.63	18581	38363	19782	2.06
Jharkhand	360	900	10.5	7.40	8.95	6.55	36.64	20318	57263	36944	2.82	16802	35784	18981	2.13
West Bengal	330	825	10.46	7.50	8.98	6.82	31.19	29331	64293	34962	2.32	26182	47070	20894	1.87
Black gram															
Bihar	40	100	11.03	7.69	9.36	6.94	34.87	15300	41400	26100	2.70	16119	32730	16611	2.03
Jharkhand	120	300	11.57	8.16	9.86	7.18	37.33	18985	60212	41227	3.17	17233	37722	20489	2.19
West Bengal	10	25	10.13	7.88	9.01	8.25	9.2	24750	58500	33750	2.36	21750	45000	23250	2.06
Total	4386.25	10966	13.74	9.91	11.83	8.56	38.20	20165.79	59812.01	39646.22	2.96	17830.73	38948.04	21117.30	2.18

Lentil:

It has been observed from the table 5.2 that yield performance of lentil CFLD in Bihar and West Bengal shows an increase of 40.2% and 30.7 % respectively. In Bihar, the average net return in demonstration plot was about Rs 42071/- against Rs.26000/- in existing plot.

Chick pea:

In Bihar, there is an average increase of 32.3% in yield of demonstration plots over the local check and the BC ratio in demonstration plot 4.6. In Jharkhand and West Bengal, the percentage in yield increase in demonstrations plot was 32.77% and 45.93% respectively. The BC ratio of existing and demonstration plot in Bihar was 2.6 and 4.5 respectively, which in Jharkhand it was 2.5 and 3.4 and in West Bengal it was 1.9 and 2.4

Field pea:

In Bihar, the average CFLD horse gram yield was 15.06 q/ha as to 10.96 q/ha in check plot and the BC ratio 2.5:2.1. The percentage in yield increase in demonstrations plot was 41.0% in Jharkhand. In West Bengal BC ratio of existing to demonstration plot was 1.7 and 2.3 respectively

Green gram and Black gram:

The BC ratio of 2.63 under CFLD on green gram was recorded in Bihar. In Jharkhand and West Bengal the net return of green gram demonstration ranges from Rs.34,000/- to Rs. 36,000 as compared to Rs.19,000/- to Rs. 20,000/- in existing plot. In Jharkhand, the average CFLD black gram yield was 9.86 q/ha as to 7.18 q/ha in check plot. In Bihar and West Bengal, the percentage in yield increase in demonstrations plot was 34.87 % and 9.2 % respectively.

5.1 Varietal performance of chick pea under CFLD

Varietal performance by adopting new agro-technologies of chick pea varieties *BGM 547, GNG 158, JAKI 9218* in Bihar, varieties *JAKI 9218, JG 14 and BGM 547* in Jharkhand and variety *JAKI 9218* in West Bengal were conducted under CFLD during rabi 2016-17. In Bihar, most area covered in chickpea was through variety BGM 547. This variety is found suitable for cultivation in late sown conditions and also yields well under both irrigated and rain fed conditions. The coverage area was 260 ha with 650 number of demonstration. The highest demonstrated yield was 15.43 q/ha, which are about 43.5% increases over the existing yield 10.75 q/ha [Table5.1 (a)]. *GNG-1581* variety demonstrated a yield of 14 q/ha with 348 number of demonstrations which is recommended for North Western Plain Zone (NWPZ) and resistant to water logging condition. The *JAKI-9218* variety was trial in three states has performed better and highest demonstrated yield of 15.36 q/ha was recorded in Bihar. In Jharkhand, *JAKI-9218* was demonstrated in 285 ha and in Bihar and West Bengal 60 ha each. The variety has shown percentage of yield increase of 49.36 % in Jharkhand, 32.06 % in Bihar and 38.44 % in West Bengal. The *JAKI-9218* variety was widely adopted due to resistant of wilt, root rot and collar rot. The demonstration of *JAKI -9218* variety yield was 11.8 to 15.36 q/ha in these states. The yield gap percentage has shown that *JAKI 9218* is most suitable chick pea variety for these three states. Other varieties like *JG14, Anuradha, Mahamaya, and CSJ 515* were also demonstrated.

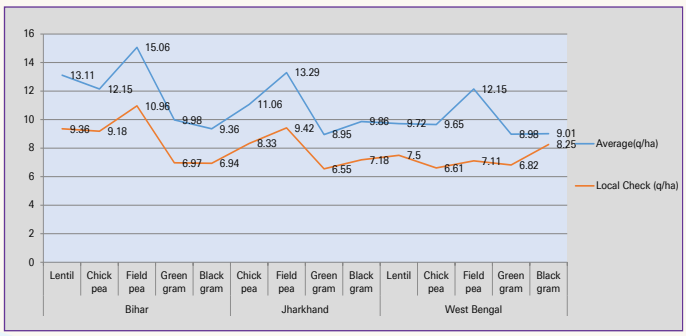

Fig 6: Overall performance of rabi & summer pulse under CFLD Pulses 2016-17 of three states

Table 5.1(a): Performance of major varieties of chickpea

Variety	Area (ha)	No. of demonstration	Demonstrated yield (q/ha)	Check yield (q/ha)	% of yield increase	Yield gap (%)
Bihar						
BGM 547	260	650	15.43	10.75	43.5	30.33
GNG-1581	139	348	14.00	11.66	20.11	16.71
JAKI-9218	60	150	15.36	11.63	32.06	24.28
Jharkhand						
JAKI – 9218	285	713	14.00	9.36	49.36	33.14
JG 14	40	100	13.65	11.81	15.53	13.48
BGM 547	40	100	15.20	11.8	28.81	22.37
West Bengal						
JAKI-9218	61	153	11.80	8.52	38.44	27.80

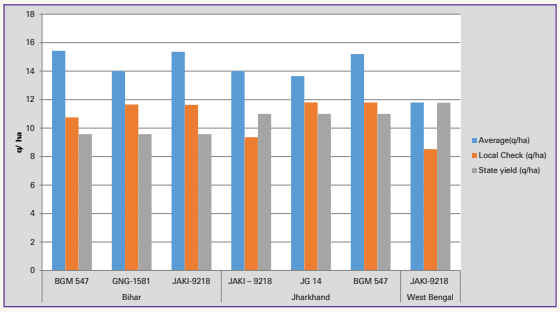

Fig 7: Performance of different varieties of chick pea under CFLD Pulses 2016-17 of three states

5.2 Varietal performance of lentil under CFLD

The variety *HUL-57* was demonstrated in 815.45 ha in Bihar. The total number of demonstrations was 2039. It gave an average demonstrated yield of 13.9q/ha. The variety *KLS-218* was demonstrated in 134.3 ha through 336 demonstrations. The average yield in the demonstrations was 13.4 q/ha compared to local check average of 8.36 q/ha. Other varieties like *Pant L 406, PM- 5, Arun* are demonstrated in an area of 20 to 40 ha with average yield of 8.5-11.0 q/ha which has yield advantage of 10-36% over the local check average [Table 5.1(b)]. In West Bengal, *WBL-77(Moitree)* variety of lentil was predominantly demonstrated in 330 ha through 825 demonstrations to harvest demonstrated yield of 9.74 q/ha over the existing average of 7.5q/ha.

The variety *KLS 218* has recorded 60.17% of yield increase whereas *HUL 57* has shown 37.08 % over check yield in Bihar. The yield gap percentage has reflected that if farmers' adopt new agro-technologies like selection of improved varieties, seed treatment, use of weedicide, integrated nutrient management, integrated pest management etc. can increase yield of existing varieties to its maximum.

Table 5.1(b): Performance of major varieties of Lentil

Variety	Area (ha)	No. of demonstration	Demonstrated yield (q/ha)	Check yield (q/ha)	% of yield increase	Yield gap (%)
Bihar						
HUL-57	815.45	2039	13.90	10.14	37.08	27.05
KLS-218	134.3	336	13.40	8.36	60.17	37.61
West Bengal						
Moitree (WBL 77)	330	825	9.74	7.50	30.76	23.00

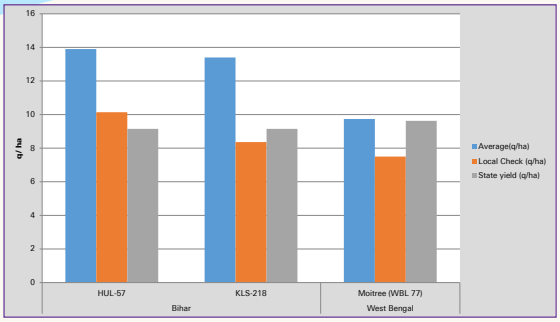

Fig 8: Performance of different varieties of lentil under CFLD Pulses 2016-17 of three states

5.3 Varietal performance of field pea under CFLD

The yield performance *HUDP 15* variety of field pea under CFLD in state of Bihar, Jharkhand and West Bengal has shown tremendous yield increase percentage over check. The percentage of yield increase of this variety was recorded highest in West Bengal (61.0%) [Table 5.1(c)]. Other varieties such as *Prakash* (Jharkhand) and *Vikash* (West Bengal) has shown an increase in yield by adopting different agro-technologies. The yield gap percentage figures from the table clearly show that if farmers' adopt the proper cultivation practices, the yield potential of the existing varieties can be enhanced.

Table 5.1(c): Performance of major varieties of field pea

Variety	Area (ha)	No. of demonstration	Demonstrated yield (q/ha)	Check yield (q/ha)	% of yield increase	Yield gap (%)
Bihar						
HUDP 15 (Malviya matar 15)	250.25	626	15.0	10.96	36.86	26.93
Jharkhand						
HUDP – 15 (Malviya matar 15)	40	100	15.79	11.27	40.10	28.63
Prakash	20	50	13.50	8.60	57.00	36.30
West Bengal						
Vikash	40	100	12.00	9.94	20.72	17.17
HUDP-15	20	50	15.30	9.50	61.05	37.91

5.4 Varietal performance of black gram under CFLD

Black gram variety *PU 31* was demonstrated in 120 ha through 300 demonstrations during summer in states of Bihar and Jharkhand. The yield of *PU 31* was 9.76 in demonstrated plot whereas in the check plot it was 6.79 q/ha and yield increase percentage was 43.66 [Table 5.1(d)]. Farmers' adopting agro-technologies like good quality seed, seed treatment, use of bio-fertilizers and micronutrients along with integrated approach of nutrient and pest management can improve the yield of the existing variety.

Table 5.1(d): Performance of major varieties of black gram

Variety	Area (ha)	No. of demonstration	Demonstrated yield (q/ha)	Check yield (q/ha)	% of yield increase	Yield gap (%)
Bihar & Jharkhand						
PU 31	120	300	9.76	6.79	43.66	30.43

5.5 Varietal performance of green gram under CFLD

Green gram was demonstrated during rabi-summer. In Bihar and Jharkhand, maximum area is covered by the variety *IPM 02-03* under CFLD. In Bihar, the average demonstrated yield is around 9 q/ha whereas in Jharkhand it is 8.66 q/ha. In Jharkhand, variety *HUM 16* covered 100 ha area with demonstrated yield of 9.67 q/ha. The percentage of yield increase was recorded to the extent of 55.22 against the existing yield.

In West Bengal, variety *Samrat* covered 100 ha area and recorded an average demonstration yield of 10.22 q/ha compared to existing yield of 6.97 q/ha while *SML 668* gave demonstrated yield of 10.65 q/ha compared to existing yield of 8.6 q/ha[Table 5.1(e)]. In percentile terms, the increase was 32.8 percent compared to check yield. Varietal evaluation in summer green gram conducted with *IPM 02-03*, *HUM-16*, *SML-668* and *Samrat* in Bihar, Jharkhand and West Bengal produce almost identical yield through *Samrat* and *SML-668* produce higher average demonstration yield than other varieties [Table 5.1(e)]. In terms of percentage increase of yield as well as yield gap between demonstrated and existing varieties, it was recorded 55.22% in respect of Jharkhand with *HUM-16* variety but lowest yield gap was observed in respect of West Bengal (*SML-668*) which was 19.25%. It indicates that the existing variety of summer green gram performed better than other states.

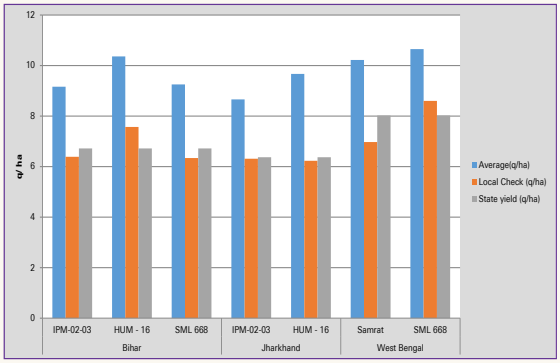

Fig 9: Performance of different varieties of green gram (summer) under CFLD Pulses 2016-17 of three states

Table 5.1(e): Performance of major varieties of green gram

Variety	Area (ha)	No. of demonstration	Demonstrated yield (q/ha)	Check yield (q/ha)	% of yield increase	Yield gap (%)
Bihar						
IPM-02-03	246	615	9.16	6.39	43.34	30.24
HUM - 16	54	135	10.36	7.57	36.85	26.93
SML 668	50	125	9.25	6.34	45.90	31.46
Jharkhand						
IPM-02-03	210	525	8.66	6.31	37.24	27.14
HUM - 16	100	250	9.67	6.23	55.22	35.57
West Bengal						
Samrat	100	250	10.22	6.97	46.63	31.80
SML 668	20	50	10.65	8.60	23.83	19.25

6. Successful technologies identified through clustered frontline demonstrations

6.1 Kharif pulses:

Supual KVK:

The KVK Supaul has developed improved technology to optimize yield of new variety of pigeon pea (*Malviya Arhar-13*). Organic fertilizers, micronutrients and plant protection measures were adopted which enhance the yield by 37.9% in compare to farmers practice.

Variety	Area (ha)	No. of farmers	Yield (q/ha)			Local check (q/ha)	% increase
			Max	Min	Av		
Malviya Arhar-13	20	49	12.8	7.74	10.27	7.45	37.9


Kishanganj KVK:

Kishanganj KVK, introduced variety *Malviya Arhar-13* with seed treatment, bio fertilizer and integrated nutrient management which increase no. of seeds /pod to 6 seeds/pod and test weight to 92 grams per 1000 seeds. Demonstrated yield was 17.8 q/ha which was 48.33 % higher than the local check.

Variety	Area (ha)	No. of farmers	Yield			Local check (q/ha)	% increase
			Max	Min	Av		
Malviya Arhar-13	50	20	19.4	16.2	17.8	12.0	48.33


West Bengal

Hooghly KVK:

Seed treatment is not common among the farmers of Hooghly district. The KVK Hooghly introduced demonstration on use of improved variety of Black gram *Sarada (WBU 108)* along with seed treatment. Seed treatment with Carbandezim @ 2.5 g / kg of seed helped the growth of the plant. As a result of which there is a yield increase of 28% as compared to local check. Thus seed treatment is being popularized by the KVKs.

Variety	Area (ha)	No. of farmers	Yield (q/ha)			Local check (q/ha)	% increase
			Max	Min	Av		
Sarada	20	118	11	8.2	9.6	7.5	28


Narendrapur (South 24 Pgs) KVK:

Variety *WBU 108* of black gram performance was observed with three types of observation. **I.** seed treatment *Rhizobium* and PSB along with 0.2% spray of Boron .**II** Seed treatment with Mancozeb 50% + Carbendazim 25% WS @ 2.5g/kg seed, yellow sticky trap @ 16/ha & need based spot application of insecticides & spraying of wettable sulphur @2g/L as prophylactic measures help to reduce the incidence of powdery mildew and YMV and reduced infestation of pod borer. **III.** Application of Panchagavya and Sanjibani (3%) at flowering and pod formation stage. The application Panchagavya and Sanjibani (3%) enhance the yield by 57.12% in comparison to farmers' practices.

Variety	Area (ha)	No. of farmers	Yield (q/ha)			Local check (q/ha)	% increase
			Max	Min	Av		
WBU 108	10	96	9.1	7.25	8.17	5.2	57.12

Uttar Dinajpur KVK:

Weed management and plant protection measures were important practices in black gram. KVK developed application of Pendimithaline as pre-emergence herbicide and spraying of 20% Boron @ 1.5gm/L of water at 25, 45 and 60 DAS as a part of management practice to increase yield of *WB-109 (Sulata).* The increase in yield was 33.78% higher in comparison to farmers' practice.

Variety	Area (ha)	No. of farmers	Yield (q/ha)			Local check (q/ha)	% increase
			Max	Min	Av		
WB-109	30	84	10.6	9.2	9.9	7.4	33.78


Jharkhand

Ramgarh KVK:

Horse gram is very popular in Jharkhand particularly by the tribal farmers. KVK demonstrated the variety of horse gram- *Birsa Kulthi 1*. Application of Bavistin with *rhizobium* culture as seed treatment with two foliar spray of 19:19:19::NPK at 45 and 60 days old crops @ 4.0 kg/ha along with organic sprays of neem oil (Neemarin) at the time of pod formation @ 2.5 L/ ha increased the yield by 86.67%.

Variety	Area (ha)	No. of farmers	Yield (q/ha)			Local check (q/ha)	% increase
			Max	Min	Av		
Birsa Kulthi 1	20	85	9.5	7.62	8.4	4.5	86.67


6.2 Rabi pulses:

Bihar

Darbhanga KVK:

The *BGM 547* chickpea variety which was released in the North Western Plains Zone (NWPZ) in late sown conditions was adopted by the farmers of KVK Darbhanga. Dharbanga KVK did a varietal trial with *BGM 547* variety of chickpea with seed inoculation of *Rhizobium* culture, basal application of Sulphur, use of micronutrient Boron which helps in formation of healthy pods and bold grain. The increase in yield was 54.6% when compared to farmers' practice. The potential yield of this variety is 1800kg/ha.

Variety	Area (ha)	No. of farmers	Yield(q/ha)			Local check (q/ ha)	% increase
			Max	Min	Av		
BGM 547	10	25	16.7	15	15.85	10.25	54.63


Demonstration of *HUL-57* variety in KVK Darbhanga showed tremendous change in yield level and recorded 75% increases in yield as compared to local check. Farmers got a net return of Rs 89,950/- per hectare. Farmer preferred medium size grain, and wilt resistant variety which has been found in *HUL -57* attribute of this variety.

Variety	Area (ha)	No. of farmers	Yield (q/ha)			Local check (q/ha)	% increase
			Max	Min	Av		
HUL 57	20	50	19.00	16.00	17.50	10.00	75

Rohtas KVK:

Zero tillage method of cultivation was adopted with improved variety of lentil (*HUL 57*) in this KVK. The lentil cultivating farmers associated to Rohtas KVK did seed treatment with *Rhizobium* culture. The post emergence herbicide Imazethapyr @ 500 ml/ha was also used to control weed. The seed size is bold and the farmer fetch a gross profit of Rs.52,500/ha. There is a yield increase of 66.67 % in comparison to local check.

Variety	Area (ha)	No. of farmers	Yield (q/ha)			Local check (q/ ha)	% increase
			Max	Min	Av		
HUL 57	60	106	20.2	17.3	18.75	11.25	66.67


Kaimur KVK:

The *JAKI-9218* variety of chick pea is a short duration of 93-125 days was cultivated by farmers of KVK Kaimur. The variety is resistant to *fusarium* wilt, root rot, and collar rot and yield of demonstrated plot is 14.45q/ha which is 32.93% increase over local check. The benefit cost ratio of demonstrated plot is 2.38, where in case of control or local check plot it is 1.92. Farmers are satisfied with the variety as it performs well in both upland and low land condition. They are interested in multiplication of foundation seeds.

Variety	Area (ha)	No. of farmers	Yield (q/ha)			Local check (q/ha)	% increase
			Max	Min	Av		
JAKI-9218	40	100	17.9	11.00	14.45	10.87	32.93


Saharsa KVK:

Varietal trial of *HUL 57* was conducted in farmers' field of Saharsa KVK. The variety showed good seed germination in comparison to locally identified varieties and preferred by the farmers. The yield increase was 14.79% compared to local check. The BC ratio is 3.35 in demonstrated plot comparison 3.08 in local check plot.

Variety	Area (ha)	No. of farmers	Yield (q/ha)			Local check (q/ha)	% increase
			Max	Min	Av		
HUL 57	30	96	17.5	14.5	16.3	14.2	14.79


Sitamarhi KVK:

The KVK Sitamarhi, demonstrated lentil variety *KLS 218* with soil test based recommended fertilizer nitrogen and phosphorus @ 20:40 kg/ha. The variety increased the yield by 37.5% when compared to local check. Different attributes of *KLS 218* variety like maturity in 115-120 days in rabi season, medium grain size and wilt resistant is preferred by the farmers.

Variety	Area (ha)	No. of farmers	Yield (q/ha)			Local check (q/ha)	% increase
			Max	Min	Av		
KLS 218	60	145	18.0	13.00	16.5	12.0	37.5


Patna KVK:

In Patna district of Bihar, use of improved variety of lentil (*IPL 406)* with recommended package and practices like application of 20:40:20::N,P_2O_5,K_2O kg/ha along with seed treatment with Carbendazim @ 2gm/kg seed and Chlorpyriphos (20%)@ 8ml/kg seed followed by *Rhizobium* culture and timely application of pesticide to keep the pest infestation under control resulted in yield enhancement up to 31.25% as compared to local check variety and observed benefit cost ratio is 2.9 and 2.4 in demonstrated plot and check plot respectively.

Variety	Area (ha)	No. of farmers	Yield (q/ha)			Local check (q/ha)	% increase
			Max	Min	Av		
IPL 406	40	100	15.1	10.1	12.6	9.6	31.25


Field pea variety (*HUDP-15*) along seed treatment with fungicide (Carbendazim@2gm/kg seed) was demonstrated in Patna district of Bihar. The technology helped to increase 50.49% yield over the farmers' practice.

Variety	Area (ha)	No. of farmers	Yield (q/ha)			Local check (q/ha)	% increase
			Max	Min	Av		
HUDP-15	20	50	18.2	12.5	15.35	10.2	50.49


West Bengal

Hooghly KVK:

Moitree (*WBL 77*) variety of lentil was introduced in Hooghly district which has higher yield potential but pod setting was low in many cases. Pod setting increases with the increase boron application @ 0.2 % twice at 30 DAS and at flowering stage and resulted yield increase by 16.67% compared to local check.

Variety	Area (ha)	No. of farmers	Yield (q/ha)			Local check (q/ha)	% increase
			Max	Min	Av		
WBL 77	30	194	11.25	9.0	10.50	9.0	16.67

Howrah KVK:

Lentil is widely grown in Howrah district .Seed treatment with *T.viridae* @ 5 g/kg of seed of *Moitree* variety of lentil and seed inoculation with *Rhizobium* helped to reduced seed borne fungal diseases with increased no. of nodule and fixed nitrogen to the soil. Improved management practices increased in yield by 48.3% over farmers yield.

Variety	Area (ha)	No. of farmers	Yield (q/ha)			Local check (q/ha)	% increase
			Max	Min	Av		
Moitree	10	60	10.1	7.5	8.9	6.01	48.33

South 24 Parganas(Nimpith) KVK:

Bio fertilizers are not used by the farmers in pulses in South 24 parganas. The KVK demonstrated the practice of seed treatment with *Rhizobium* and *Trichoderma viridie*, *Pseudomonas flurosence* & PSB .The variety *Moitree (WBL-77)* showed 5.2% yield increase over farmers practice due to seed treatment.

Variety	Area (ha)	No. of farmers	Yield (q/ha)			Local check (q/ha)	% increase
			Max	Min	Av		
Moitree	20	105	6.64	6.15	6.47	6.15	5.2


Nadia KVK:

The Nadia KVK, conducted 20ha cluster frontline demonstration of lentil *(Moitree)* in rabi 2016-17. Application of micronutrients MOBOMIN @ 1.8 kg / ha as basal and foliar application (2g/L of water) with two sprays one at 21 DAS and 2nd before flowering caused enhancement of yield by 19.68 % over local check. MOBOMIN aids in enzymatic process which in turn required for good harvest.

Variety	Area (ha)	No. of farmers	Yield (q/ha)			Local check (q/ha)	% increase
			Max	Min	Av		
Moitree	20	87	12.75	9.75	11.25	9.4	19.68


7. Constraints in Pulse production

India is the largest producers of pulses in the world, yet there is shortfall for requirements of pulses. On an average, we import three to four million tonnes (MT) of pulses each year. Though our population and demand for pulses steadily increased, production has more or less remained static. There are several constraints in our production process which causes decline in production. They are

I. Agro Ecological Constraints

II. Biological Constraints.

III. Socio Economic Constraints.

IV. Technical Constraints

Agro Ecological

- Largely grown as a rain fed crop and mainly cultivated in marginal and sub-marginal land with poor fertility and low moisture availability
- Poor research base for developing /testing varieties for different agro ecological situations.
- The variety developed by other states is not suitable for eastern states.
- High rainfall and water logging in kharif, lack of irrigation at critical stage in rabi.
- Imbalance use of fertiliser to preceding rice crop.
- Non use of chemical organics with chemical fertiliser.
- Nitrogen fixing bacteria are killed during water logged in rice field.
- Rice stubbles are having allelepathic effect on germination & growth of pulse crop in rice fallow system.
- Non availability of effective *Rhizobium* culture.

Biological

- Non-availability of quality seeds, low seed replacement rate
- Heavy infestation of weeds
- High infestation of insect pests and diseases.
- Poor storability due to store grain pests
- Lack of suitable variety for paira cropping.
- Indeterminate growth habit of most pulse crop leads to poor harvest index.
- Pulse crop is prone to damage during storage.

Socio-Economic

- Cereals are staple food & highly productive.
- Relatively less remunerative.
- Reluctance to invest more on costly inputs viz. seed, fertilizer and plant protection chemicals.
- Lack of awareness about improved production technology.
- Stray cattle menace.
- Fluctuating market price.
- High post harvest losses (25-30%) due to non availability of storage facility.
- Lack of social fencing.

Technical

- Non availability of adequate seeds in time.
- Being a low profitable crop needs low cost technology to increase production.
- Poor land preparation especially in rice fallow.
- Broadcast sowing.
- Low seed rate.
- Low cost plant protection measures are assured.
- Limited use of bacterial inoculums.
- Cultivation as free crop without fertilizer, intercultural, irrigation and plant protection measures.
- Mostly grown as a mixed/ inter crop ignoring crop without compatibility and plant geometry.
- No effective transfer system for pulses to bridge the gap in yield.
- No approach for pulse based cropping system.
- Lack of processing technology

8. Conclusion

India has potential to achieve much higher pulses production. To stabilize prices in the long run, it is needed to increase domestic production by eliminating the risks farmers experience in relation to growing pulses. India can be self sufficient in pulse production through taking following measures:

- **Developing short duration and pest – disease resistant varieties:** Long duration, susceptibility to pests and diseases are a few reasons farmers find it difficult to fit pulses in the usual cropping pattern. Large-scale development of short duration varieties and salt tolerant varieties will help the farmers include pulse crop in their cropping pattern with additional income. Development of high yielding pigeon pea hybrid suitable for irrigated areas by ICRISAT may induce the farmers to take up pulse cultivation in irrigated areas provided remunerative prices are offered.
- **Seed multiplication:** Multiplication of quality seeds is also an important step to popularised pulses cultivation. State Agricultural University, ICAR Institutes and KVK can play pro-achieve role to multiply seeds and make available to farmers.
- **Area expansion:** Substantial additional area can be brought under pulses by adopting cropping system like mung/ urad beans as catch crops in summer under cereal- based cropping system, inter-cropping with short duration pulses (mung, urad and cowpea) in sugarcane, millet, cotton etc. and new cropping system such as pigeon pea and wheat in northern region, rice and lentil in eastern region and urad and rice in southern peninsula. In addition, rice fallow could be utilized in pulse cultivation to bring additional area under pulses.
- Involving large farmers: Large farmers having risk absorbing ability should be targeted to bring under pulse cultivation. They can diversify the cropping system taking the risk to cultivate pulses in their land to motivate others to follow. Such progressive farmers can also be monitored and trained easily.

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