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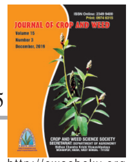

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Enhancing profitability and sustainability through increased pulses production in Assam

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ABSTRACT

Improved pulse production is a way to increase the farm income and profitability of farmers along with sustaining soil health for enhancing the productivity in long run. The study was taken up in Nagaon district which falls under Central Brahmaputra valley zone of Assam. A total of 21 villages were covered under cluster frontline demonstration on pulses with 60 ha on Lentil, 70 ha under Lathyrus, 100 ha under Field pea, and 80 ha under Greengram during 2016-17, 2017-18, 2018-19 and 2019-20. The demonstrations were conducted as per recommendation in package along with full farmers' participation. The results of the demonstration conducted for Lentil, Lathyrus, Field pea and Greengram showed average yield range of 7.80, 7.71, 9.00 and 8.79 q ha $^{-1}$ and average yield increase of 28.22, 13.71, 36.94 and 23.95 per cent in Lentil, Lathyrus, Field pea and Greengram , respectively over the farmers practice followed. The variation seen in demonstartion plots and farmers plot could be considered as a gap between adoptions of recommended package of practices. The average extension gap, technology gap and technology index of Lentil (1.71 q ha $^{-1}$, 2.21 q ha $^{-1}$ and 22.05%), Lathyrus (0.93 q ha $^{-1}$, 2.29 q ha $^{-1}$, 22.93 %), Field pea (2.41 q ha $^{-1}$, 1.00 q ha $^{-1}$ and 10 %) and Greengram (1.58 q ha $^{-1}$, 1.21 q ha $^{-1}$ and 12.08 %) were found during 2016-17, 2017-18, 2018-19 and 2019-20. The economic returns and benefit cost ratio of demonstration plot of Lentil, Field pea, Lathyrus and Greengram were Rs. 46,785 ha $^{-1}$, 4.00:1, Rs. 24,188 ha $^{-1}$, 2.69:1, Rs. 30,365 ha $^{-1}$, 3.07:1, Rs. 38,130 ha $^{-1}$, 3.61:1 as compared to farmers' practice of Rs. 36,243 ha $^{-1}$, 3.91:1, Rs. 20,875 ha $^{-1}$, 2.60:1, Rs. 22,580 ha $^{-1}$, 2.70:1 and Rs. 33,350 ha $^{-1}$, 3.65:1, respectively. The above results confirm that the adoption of scientifically improved technologies over farmers practice will improve the productivity of pulses in the state as well as in country which can help in minimize the pulse production and consumption gaps.

Keywords: Pulses, technology adoption gaps, extension gaps, sustainability, soil health

Pulses are one of the most important parts of Indian diet and being considered as a major source of protein. Apart from being used for human consumption, it also possesses an important dietary supplement of cattle's for milk production and also a supplement towards soil health in form of green manure. Due to population explosion and growing health issues among the people, the demand towards consumption of pulses is increasing leading to high export of pulses to address the country's deficit. According to reports by Sharma *et al*. (2016), out of 24% of undernourished people over the world, 15.6% are found in India which also gives a sign that how important our pulses are for food and nutrition security to Indians. In 1956, the pulses availability per capita was 70.3 g day $^{-1}$capita $^{-1}$ and by 1981 it reduced to 37.5 g day $^{-1}$capita $^{-1}$ and as on 2003, it further reduced to 29.1 g day $^{-1}$capita $^{-1}$ (Tomar *et al*., 2021). Apart from this, pulses should also be included in a cropping system as they help in fixing of atmospheric nitrogen in their roots to meet the nitrogen requirement. They are also a major protector from global warming as they have low carbon footprint as compared to animal protein. Pulses also play a pivotal role in soil amelioration by enhancing soil health, reducing soil erosion, enhancing soil biomass and balancing the nutrient content in soil when grown in cropping system (Singh *et al*., 2019). Around the world, India has been demarcated as one of the largest consumer and producer of pulses contributing to 25-28% of world's total production with an average productivity of 8.06 q ha $^{-1}$ in 2018-19 from an area of 29.03 m ha (https/apps.iasri.res.in) against the global productivity of 10.23 q ha $^{-1}$. Despite being the major producer, the country is unable to increase the yield even with the advanced technological achievements. There are many setbacks and constraints towards pulse production in India and especially in Assam. The farmers are opting for high value crops instead of pulses and also monocropping with major cereals are one of the major concerns towards the fall in pulse production in Assam.

Looking into the depth of concern about the issue, Department of Agriculture, Cooperation & Farmers welfare (DAC&FW), GoI started a project titled "Cluster Frontline Demonstrations on Pulses" funded by National Food Security Mission (NFSM) to showcase the recently

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developed technologies which give higher productivity and profitability as well as increase the in-house production of pulses within the country. Krishi Vigyan Kendras (KVKs)or Farm Science Centres are established in different districts of the country with an objective to implement the innovative agricultural technologies at farmer's field in participatory mode. Among all the mandated activities assigned to KVKs by ICAR, conducting demonstration in larger scale under minute supervision of scientist of KVK helps in proper implementation of agricultural technologies as well as adoption rate is higher. In order to reach the goal of supressed pulse production, an initiative was taken by KrishiVigyan Kendra, Nagaon under the aegis of Assam Agricultural University, Jorhat, Assam along with ATARI Guwahati, Zone VI, to conduct Cluster Frontline Demonstration of pulses to lift the pulse availability as well as production in Nagaon district.

Krishi Vigyan Kendra, Nagaon situated at Central Brahmaputra Valley zone of Assam conducted large scale demos termed as cluster frontline demonstration for pulse crops *i.e.* Lentil (*Lens culinaris* L.), Field pea (*Pisum sativum*), Lathyrus (*Lathyrus sativus* L.*)* and Greengram (*Vigna radiata*) with improved scientific technologies during 2016-17, 2017-18, 2018-19 and 2019-20 in 21 villages of6 blocks *viz* Khagorijan, Dolonghat, Kathiatoli, Kaliabar, Brahampur and Raha in 310 ha area of district Nagaon covering 890 number of farmers. In demonstration plots, recommended packages of practice were followed while farmers practice was followed in control plot crop as mentioned in Table 2. Assam has subtropical climate and during summer high monsoon showers are observed followed by dry winter. The rainfall pattern was erratic and during *rabi* period, a short dry spell is seen in all four years (Table 1). The physico-chemical properties of soils under monocropping (rice-rice) cropping systems are presented in Table 3. The texture of soil was in between from sandy loam to clayey with strongly acidic pH to near neutral pH. Organic carbon content in demonstrated areas ranged from medium to high while cation exchange capacity (CEC) of soil range was 5.5 to 7.6.

The experiments were conducted in farmer's field and the data were recorded statistically. All the data collected were evaluated with the following formulae as given below. These formulae were used to calculate the different parameters associated to yield and returns received from

$$\text{Yield increase (\%)} = \frac{\text{Demonstration yield (q ha-1)}}{\text{Farmers yield (q ha-1)}} \times 100$$

To estimate the additional net return, benefit cost ratio (BCR) and Incremental Cost benefit ratio (ICBR) of the demonstration, partial budgeting technique by Birthal (2003) was used. The results of demonstration plot was compared to farmer's plot which is represented below:

TRt (Demo)-TR (FP) > TC (Demo) - TC (FP)

DR (Demo) > DC (FP); TR = ΣRz. Qz

TC = ΣRk. Sk

Where, TRt (Demo) = Total return from demonstration plots

TR (FP) = Total return from Farmers plots

TC (Demo) = Total cost of cultivation from demonstration plots

TC (FP) = Total cost of cultivation from Farmers plots

DR (Demo) = Change in income due to scientific interventions

DC (FP) = Change in incomedue to farmers practice

Rz = Price of zth output (z =1…..n)

Qz = Quantity of zth output (z =1…..n)

Rk = Price of kth input (k =1…..n)

Sk = Quantity of kth input (k =1…..n)

The calculation of extension and technology gap, technology index are done as per following formulas given below (Dayanand and Mehta, 2012 and Samui *et al.,* 2000)

Technology gap (TG) = Potential yield of crop - Yield from demonstrated plot

Extension gap(EG) = Yield from demonstrated technology - yield from Farmers practice

$$\text{Technology index (\%)} = \frac{\text{Potential yield of crop - Yield from demonstrated plot}}{\text{Potential yield of crop}} \times 100$$

Additional cost in Demo (Rs.ha^{-1}) = Cost of production in demo plots- cost of production in Farmers practice

Additional Net Income (Rs. ha^{-1}) = Net income from demo plot- Net income from farmers plot

Effective gain (Rs. ha^{-1}) = Additional Net Income from demo plot- Additional cost in Demo

Benefit cost ratio= Gross income (Rs. ha^{-1}) /Total cost of cultivation (Rs. ha^{-1})

Incremental cost benefit ratio= Additional Net Income (Rs. ha^{-1}) - Additional cost of demo plots (Rs. ha^{-1})

***Technology Adoption gaps*:** Use of improved technology will give a sustainable yield and income but there was a huge gap in adoption of those technologies by the farmers (Table 4). The gaps were mainly noticed in improved variety, fertilizer use and also crop management practices. Due to this, a decline in crop

Table 1: Deviation in of rainfall (mm) pattern in Nagaon district from 2016 to 2020 as compared to normal rainfall

Month	Normal (mm)	Year				
		2016	2017	2018	2019	2020
Jan	11.7	33.9	0.0	0.0	4.2	18.0
Feb	18	0.4	13.2	8.4	17.2	39.3
March	39.4	60.4	66.0	24.4	46.0	4.7
April	147.7	262.0	134.0	114.7	181.8	67.9
May	203.2	157.2	309.4	160.2	334.6	282.5
June	277.0	227.4	322.2	245.2	64.4	309.6
July	383.0	495.9	336.2	348.0	394.2	271.0
Aug	327.4	146.6	502	235.8	125.4	208.0
Sep	237.3	249.4	234.6	120.6	256.2	300.8
Oct	110.8	84.9	166.8	85.6	201.8	266.2
Nov	16.7	4.2	9.8	12.2	4.0	0.0
Dec	8.0	4.4	0.0	28.2	1.0	22.4
Total	**1780.2**	**1726.7**	**2094.2**	**1383.3**	**1630.8**	**1790.4**

productivity was mainly noticed (Yadav, 2021) which not only have a huge impact on monetary loss but also resource utilization is also hindered. There are various hurdles in pulse production as very less preference is given to them which is a major cause of decline in pulse area and increased area is noticed under high value crops. Irrigation is also one of the factor which is one of the major constraint of pulse crop production in rainfed and dryland areas.

Yield gap, Technology gap and Extension gap **:** The technology demonstrated and the farmers practice for respective pulses *viz.*Lentil, Lathyrus, Field pea and Greengram, was evaluated by taking the yield of all the crops and those results were categorized into technology and extension gaps. The technologies adopted by the farmers while conducting the demonstrations were evaluated using technology index which indicates the sustainability of the improved technology given to farmers. Feasibility of technology index can be seen if the value is lower which means the technology given to farmers is more suitable over the farmers used technology.

Crop yield impact: Crop yield is considered as one of the major component to justify the sustainability of any variety in farmer's field. The average yield of the demonstrated plots of Lentil, Lathyrus, Field pea and Greengram, were 7.80 q ha^{-1}, 7.71 q ha^{-1}, 9.00 q $ha^{-1}$and 8.79 q ha^{-1}respectively while comparing with the farmers practice where the yield was 6.09 q ha^{-1}, 7.34 q ha^{-1}, 6.59 q ha^{-1} and 7.22 q ha^{-1}, respectively. The above results indicates that there was an increase in yield of Lentil, Lathyrus, Field pea and Greengram by 28.22 %, 13.71 %, 36.94 % and 23.95 % respectively (Table 4) which clearly shows the positive effect of demonstrated technologies to be superior over the farmers traditional practice and these results were similar as reported by Yadav (2021) and Shakti *et al.*(2016). The cluster frontline demonstration of pulse crop have been similarly reported by Singh *et al.* (2020).

Analysis of Extension gaps **:** Extension gap was the calculated as the variation between the yield of demonstrated plot and farmers plot which was observed to be 1.71%, 0.93%, 2.41 % and 1.58% for Lentil, Lathyrus, Field pea and Greengram, respectively (Table 4). This gap signifies the importance of various extension tools for proper dissemination of advanced agricultural technologies to the grass-root level. The farmers need to be made aware about the agricultural technologies through training, awareness programme, using of print and electronic media, village level extension workers. Advanced mobile technologies towards proper knowledge transmission is a great tool to amplify the scientific technology to various levels. Conducting large scale demonstration is such a tool which make farmers observe the results in their own fields (Singh *et al.,* 2019).

Analysis of Technology gaps**:** The difference between the potential yields of a crop variety when to the yield of farmer's variety is the technology gap. As shown in Table 4, it can be seen that the technology gap of 2.21%, 2.29%, 1.00 % and 1.21% for Lentil, Lathyrus, Field pea and Greengram, respectively which indicates that the technology demonstrated in the farmers field still possess some lapse which could be due to fertility gradient, weather vagaries and erroneous agricultural practices applied in the demonstration plot. The findings are very similar with Singh *et al.* (2019) and Yadav (2021).

Table 2: List of technological interventions and farmers practices under cluster frontline demonstration

Sl no	Particulars	Scientific interventions				Farmers practice	Technological gap
		Lentil	Lathyrus	Fieldpea	Greengram		
1	Sowing time	15th October to 15th November	15th October to 15th November	15th October to 15th November	15th March to 15th April	As recommended	No gap
2	Variety	Moitree	Ratan	Prakash	IPM 02-3	Unknown varieties	100% gap
3	Seed rate (kg ha^{-1})	40	60	50	25	High seed quantity used	100% gap
4	Method of sowing	Line sowing (30 cm)	Line sowing (30 cm)	Line sowing (30 cm)	Line sowing (30 cm)	Broadcasting	100% gap
5	Seed treatment	Seed treatment with biofertilizer Rhizobium and PSB @ 50 g kg^{-1} of seed + Carbendazim@ 3 g kg^{-1} of seed	Seed treatment with biofertilizer Rhizobium and PSB @ 50 g kg^{-1} of seed + Carbendazim@ 3 g kg^{-1} of seed	Seed treatment with biofertilizer Rhizobium and PSB @ 50 g kg^{-1} of seed + Carbendazim @ 3 g kg^{-1} of seed	Seed treatment with biofertilizer Rhizobium and PSB @ 50 g kg^{-1} of seed + Carbendazim @ 3 g kg^{-1} of seed	Not followed	100% gap
6	Fertilizer dose	15:20:15 N:P:K	20:46:0 N:P:K	15:35:15 N:P:K	15:35:10 N:P:K	Irrational use of fertilizer	Partial gap
7	Pest management	Weed management, need based plant protection measures	Weed management, need based plant protection measures	Weed management, need based plant protection measures	Weed management, need based plant protection measures	Indiscriminate use of pesticides without technical knowledge	Partial gap
8	Irrigation	During flowering and pod formation if rainfall doesn't occur	During flowering and pod formation if rainfall doesn't occur	During flowering and pod formation if rainfall doesn't occur	During flowering and pod formation if rainfall doesn't occur	Critical stages are non-identified before irrigation	Partial gap

***Technology Index*:** This index is the assessment of feasibility of the technology at farmers field which could be analysed from the ratio of technology gap and potential yield expressed as percentage. Higher the technology index, greater is the gap in transmission of proper technology to the farmer's field and lower index shows good efficacy in the farmer's field. From table 4, the results of average technology index was found to be 22.05% in Lentil, 22.93% in Lathyrus, 10.00 % in Field pea and 12.08 % in Greengram. The variation could be due to various technology gaps like soil fertility gradient, agronomic practices followed in participation and also weather parameters which plays a vitalrole in crop growth and productivity. Similar results were reported by Singh *et al.* (2019) and Yadav (2021) which support the observation in this study too.

***Impact of scientific interventions on pulses productivity*:** While conducting the demonstrations, various technological interventions like quality seed, high yielding variety, optimum time and method of sowing as well as various scientific management practices for crops were followed as per recommendations (Table 2). The impact of using these interventions in the demonstration was compared with the district, state and national average data which is shown in Table 5. The average productivity of Lentil was recorded to be 7.80 q ha^{-1} from demonstrated plot. The results recorded clearly indicates that the average productivity of Lentil recorded to be 11.35, 49.94 and 15.06 per cent higher over the district, state and nationalyield data (Table 5). The average productivity of Lathyrus was recorded to be 7.71 q ha^{-1} from demonstrated plot which signifies that the average productivity of Lathyrus was recorded to be 14.14 and 9.82 per cent higher over the state and national yield data. The average productivity of Field pea was recorded to be 9.00 q ha^{-1} from demonstrated plot which signifies that the average productivity of Field pea was 38.12, 45.24 and 4.50 per cent higher over the district, state and national yield data. Similarly, the crop Greengram also got an average yield of 8.79 q ha^{-1} which was found to be 37.89, 90.54 and 83.21 per cent supplemented yield over the district, state and national yield average (Table 5). The results are found to be similar with Kumar *et al.* (2020)

***Economic performance analysis*:** The economic performance of pulse crop is estimated and shown in Table 6. Different variables like quality seeds, improved variety, seed treatment, manures and fertilizer application, and crop pest and disease management were carried out while conducting the demonstrations in participatory mode. An additional cost of Rs. 3,138 ha^{-1}in Lentil, Rs.1, 275 ha^{-1} in Lathyrus, Rs. 1,390 ha^{-1} inField pea and Rs. 2,060 ha^{-1}in Greengram was incurred.

Table 3: Details of physico-chemical properties under of Nagaon district

Sample No.	pH	EC(dS m^{1-})	OC%	CEC [cmol(p+) kg^{-1}]	Sand%	Silt%	Clay%	Soil Texture	Available nutrients (kg ha^{-1})		
									N	P_2O_5	K_2O
1	4.94	0.03	0.95	5.50	44.16	33.00	22.84	l	533.12	57.96	189.91
2	4.78	0.02	0.71	6.20	64.88	15.00	20.12	sc	407.40	29.23	153.08
3	4.72	0.01	0.68	5.80	64.56	18.00	17.44	sl	376.32	25.39	177.54
4	4.43	0.04	0.62	5.60	63.16	17.00	19.84	sl	282.24	24.78	161.95
5	4.43	0.02	0.64	7.60	66.16	18.00	15.84	sl	313.60	28.72	146.76
6	4.68	0.01	0.68	6.50	61.16	21.00	17.84	sl	344.96	29.23	185.60
7	4.83	0.02	0.65	6.20	63.88	18.00	18.16	sl	313.60	28.72	203.21
8	5.12	0.03	0.62	5.80	57.16	24.00	18.84	sl	282.24	23.33	123.91
9	5.29	0.05	0.62	7.50	62.16	15.00	22.84	scl	282.24	23.59	149.45
10	4.81	0.02	0.68	7.00	57.16	22.00	20.84	scl	344.96	25.39	136.41
11	4.49	0.02	0.86	7.10	28.20	22.40	49.40	c	501.76	48.73	229.95
12	4.17	0.01	0.72	6.60	36.30	25.00	38.70	c	407.68	32.06	212.62
13	4.47	0.01	0.72	6.40	36.80	28.00	35.20	cl	407.68	32.06	138.96
14	4.45	0.02	0.74	7.60	54.88	27.32	17.80	scl	376.32	31.29	141.26
15	5.14	0.02	0.75	6.20	52.16	28.00	19.84	sl	439.04	34.36	176.19
16	4.95	0.01	0.71	6.90	44.32	30.16	25.52	sil	407.40	29.23	181.31
17	4.82	0.03	0.57	7.40	64.56	17.00	18.44	sl	250.88	22.05	171.62
18	4.87	0.02	0.51	6.20	52.16	28.00	19.84	sl	219.52	21.54	105.36
19	6.94	0.03	0.83	7.00	62.88	19.00	18.12	sl	501.76	48.73	176.20
20	4.67	0.01	0.76	6.50	53.16	29.00	17.84	sl	439.04	33.08	201.86
21	4.41	0.02	0.94	6.70	56.16	26.00	17.84	sl	501.76	57.45	175.66
22	4.20	0.01	0.91	7.60	51.88	22.00	26.12	scl	470.40	53.86	190.31
23	4.23	0.03	0.75	6.90	62.56	18.00	19.44	sl	407.68	32.82	166.79
24	4.38	0.02	0.70	6.40	54.20	18.28	27.52	scl	344.96	30.52	122.57
25	4.41	0.04	0.73	6.10	52.16	29.00	18.84	sl	376.32	34.36	165.58
Mean	**4.75**	**0.02**	**0.72**	**6.61**	**54.67**	**22.73**	**22.60**		**381.32**	**33.54**	**167.36**
Range	**4.17-6.94**	**0.01-0.05**	**0.51-0.95**	**5.50-7.60**	**28.20-66.16**	**15.00-33.00**	**15.84-49.40**		**219.52-533.12**	**21.54-57.96**	**105.36-229.95**

*** l- Loam, sc- Sandy Clay, sl- Sandy Loam, scl- Sandy Clay Loam, c- Clay Soil, sil-Silty Loam

Table 4: Yield performance of lentil, lathyrus, fieldpea and greengram in demonstrated and farmers field

Crop/Years	Yield (q ha^{-1}) Potential	Demonstrated	Control	Yield enhancement (%)	Extension gap (q/ha)	Technology gap (q/ha)	Technology index (%)
Lentil							
2016-17	10	7.11	5.98	18.90	1.13	2.89	28.90
2017-18	10	7.90	6.45	22.48	1.45	2.10	21.00
2018-19	10	7.87	5.86	34.30	2.01	2.13	21.30
2019-20	10	8.30	6.05	37.19	2.25	1.70	17.00
Average	10	7.80	6.09	28.22	1.71	2.21	22.05
Lathyrus							
2016-17	10	8.13	6.87	18.34	1.26	1.87	18.70
2017-18	10	7.73	6.90	12.03	0.83	2.27	22.70
2018-19	10	7.96	6.60	20.61	1.36	2.04	20.40
2019-20	10	7.01	6.75	3.85	0.26	2.99	29.90
Average	10	7.71	7.34	13.71	0.93	2.29	22.93
Fieldpea							
2016-17	10	8.10	6.23	30.02	1.87	1.90	19.00
2017-18	10	9.20	7.08	29.94	2.12	0.80	8.00
2018-19	10	9.40	7.01	34.09	2.39	0.60	6.00
2019-20	10	9.30	6.05	53.72	3.25	0.70	7.00
Average	10	9.00	6.59	36.94	2.41	1.00	10.00
Greengram							
2016-17	10	7.76	6.30	23.17	1.46	2.24	22.40
2017-18	10	8.32	7.56	10.05	0.76	1.68	16.80
2018-19	10	9.89	8.95	10.50	0.94	0.11	1.10
2019-20	10	9.20	6.05	52.07	3.15	0.80	8.00
Average	10	8.79	7.22	23.95	1.58	1.21	12.08

The average cost of crop cultivation was also found to be increased by 25.23, 9.84, 10.49 and 16.39 per cent in Lentil, Lathyrus, Field pea and Greengram, respectively in the demonstrated plot. While calculating the comparative profitability, it was found that Lentil recorded highest average gross monetary return (Rs. 62,360 ha^{-1}) followed by Greengram (Rs. 52,755 ha^{-1}), Field pea (Rs. 45,000 ha^{-1}) and Lathyrus (Rs. 38,538 ha^{-1}).

The average net returns of demonstration for Lentil recorded the highest from demonstrated plot which was Rs. 46,785 ha^{-1} as compared to control plotRs. 36,243 ha^{-1}, Lathyrus average return was Rs. 24,188 ha^{-1}as compared to farmers plot Rs. 20,875ha^{-1}, Fieldpea average return was Rs. 30,365 ha^{-1}as compared to farmers plot Rs. 22,580 ha^{-1} andGreengram average return was Rs. 38,130 ha^{-1} as compared to farmer's plotRs. 33,350 ha^{-1} which could be due to the difference in market price of the pulses.

On an average, a similar trend is also seen with the average gross monetary income which was increased by 28.10, 13.68, 25.61 and 14.90 percent for Lentil, Lathyrus, Field pea and Greengram, respectively. This result signifies that higher the monetary income, more feasible the technology in farmers field. Though it can be observed from Table 6 that the cost of cultivation is higher from the demonstrated technology over farmers practice but yield and monetary benefits are also on a higher range when compared with farmers practice.

The effective monetary gain was obtained as Rs. 7,405 ha^{-1}, Rs. 2,088 ha^{-1}, Rs. 6,395 ha^{-1} and Rs. 2,720 ha^{-1}from Lentil, Lathyrus, Field pea and Greengram, respectively but average benefit cost ratio was4.00, 2.69, 3.07 and 3.61 in Lentil, Lathyrus, Field pea and Greengram, respectively as compared to farmers practice which is 3.91, 2.60, 2.70 and 3.65 from Lentil, Lathyrus, Field pea and Greengram, respectively. The average incremental cost benefit ratio was 3.36, 2.50, 5.60 and 2.32 from Lentil, Lathyrus, Field pea and Greengram, respectively indicating a profitable return of each rupee invested on demonstrated technology in all the pulses crop. Similar outcomes were also founded by Singh *et al.* (2019), Singh *et al.* (2019) and Yadav (2021).

Table 5: Impact of scientific interventions in terms of productivity enhancement in pulses crops of Nagaon district

Crop	Year	Average Yield ($q\ ha^{-1}$) Demo plot (DP)	Average Yield ($q\ ha^{-1}$) Farmer's plot (FP)	District yield (DY) $q\ ha^{-1}$	State yield (DY) $q\ ha^{-1}$	National yield (DY) $q\ ha^{-1}$	Impact (% change over EP)	Impact (% change over DY)	Impact (% change over SY)	Impact (% change over NY)
Lentil	2016-17	7.11	5.98	6.64	5.05	6.67	18.90	7.08	40.79	6.60
	2017-18	7.90	6.45	7.11	4.94	6.79	22.48	11.11	59.92	16.35
	2018-19	7.87	5.86	7.03	5.00	5.91	34.30	11.95	57.40	33.16
	2019-20	8.30	6.05	7.20	5.86	7.97	37.19	15.28	41.64	4.14
	Average	7.80	6.09	7.00	5.21	6.84	28.22	11.35	49.94	15.06
Lathyrus	2016-17	8.13	6.87	NA	6.98	7.74	18.34	NA	16.48	5.04
	2017-18	7.73	6.90	NA	6.75	6.67	12.03	NA	14.52	15.89
	2018-19	7.96	6.60	NA	6.67	6.75	20.61	NA	19.34	17.93
	2019-20	7.01	6.75	NA	6.60	6.98	3.85	NA	6.21	0.43
	Average	7.71	6.78	NA	6.75	7.04	13.71	NA	14.14	9.82
Fieldpea	2016-17	8.10	6.23	5.69	6.15	7.93	30.02	42.36	31.71	2.14
	2017-18	9.20	7.08	7.69	6.14	8.14	29.94	19.64	49.84	13.02
	2018-19	9.40	7.73	7.40	6.10	9.34	21.60	27.03	54.10	0.64
	2019-20	9.30	7.62	5.69	6.40	9.10	22.05	63.44	45.31	2.20
	Average	9.00	7.17	6.62	6.20	8.63	25.90	38.12	45.24	4.50
Greengram	2016-17	7.76	6.30	5.67	4.63	4.74	23.17	36.86	67.60	63.71
	2017-18	8.32	7.56	6.48	4.59	4.36	10.05	28.40	81.26	90.83
	2018-19	9.89	8.95	8.00	4.60	4.98	10.50	23.63	115.00	98.59
	2019-20	9.20	7.80	5.67	4.64	5.12	17.95	62.26	98.28	79.69
	Average	8.79	7.65	6.46	4.62	4.80	15.42	37.78	90.54	83.21

Table 6: Economic performance of Lentil, Lathyrus, Fieldpea and Greengram in demonstrated and farmers field

Crop	Year	Cost of cultivation (Rs. ha^{-1})		% increase in cost over FP	Gross Income (GI) (Rs. ha^{-1})		% increase on GI over FP	Net returns (NR) (Rs. ha^{-1})		% increase on NR over FP	Additional cost in Demo (Rs. ha^{-1})	Additional Net Income (Rs. ha^{-1})	Benefit cost ratio		Incremental Cost Benefit ratio	Effective gain (Rs. ha^{-1})
		Demo	FP		Demo	FP		Demo	FP				Demo	FP		
Lentil	2016-17	14,800	12,000	23.33	56,880	47,840	18.90	42,080	35,840	17.41	2,800	6,240	3.84	3.99	2.23	3,440
	2017-18	15,500	12,350	25.51	63,200	51,600	22.48	47,700	39,250	21.53	3,150	8,450	4.08	4.18	2.68	5,300
	2018-19	15,900	12,500	27.20	62,960	46,880	34.30	47,060	34,380	36.88	3,400	12,680	3.96	3.75	3.73	9,280
	2019-20	16,100	12,900	24.81	66,400	48,400	37.19	50,300	35,500	41.69	3,200	14,800	4.12	3.75	4.63	11,600
	Average	15,575	12,438	25.23	62,360	48,680	28.10	46,785	36,243	29.09	3,138	10,543	4.00	3.91	3.36	7,405
Lathyrus	2016-17	13,800	12,500	10.40	40,650	34,350	18.34	26,850	21,850	22.88	1,300	5,000	2.95	2.75	3.85	3,700
	2017-18	14,450	12,900	12.02	38,650	34,500	12.03	24,200	21,600	12.04	1,550	2,600	2.67	2.67	1.68	1,050
	2018-19	14,800	13,100	12.98	39,800	33,000	20.61	25,000	19,900	25.63	1,700	5,100	2.69	2.52	3.00	3,400
	2019-20	14,350	13,800	3.99	35,050	33,750	3.85	20,700	19,950	3.76	550	750	2.44	2.45	1.36	200
	Average	14,350	13,075	9.84	38,538	33,900	13.68	24,188	20,825	16.15	1,275	3,363	2.69	2.59	2.64	2,088
Fieldpea	2016-17	14,250	12,500	14.00	40,500	31,150	30.02	26,250	18,650	40.75	1,750	7,600	2.84	2.49	4.34	5,850
	2017-18	14,390	12,580	14.39	46,000	35,400	29.94	31,610	22,820	38.52	1,810	8,790	3.20	2.81	4.86	6,980
	2018-19	14,500	13,300	9.02	47,000	38,650	21.60	32,500	25,350	28.21	1,200	7,150	3.24	2.91	5.96	5,950
	2019-20	15,400	14,600	5.48	46,500	38,100	22.05	31,100	23,500	32.34	800	7,600	3.02	2.61	9.50	6,800
	Average	14,635	13,245	10.49	45,000	35,825	25.61	30,365	22,580	34.48	1,390	7,785	3.07	2.70	5.60	6,395
Greengram	2016-17	12,600	10,200	23.53	46,560	37,800	23.17	33,960	27,600	23.04	2,400	6,360	3.70	3.71	2.65	3,960
	2017-18	14,400	12,400	16.13	49,920	45,360	10.05	35,520	32,960	7.77	2,000	2,560	3.47	3.66	1.28	560
	2018-19	14,900	13,960	6.73	59,340	53,700	10.50	44,440	39,740	11.83	940	4,700	3.98	3.85	5.00	3,760
	2019-20	16,600	13,700	21.17	55,200	46,800	17.95	38,600	33,100	16.62	2,900	5,500	3.33	3.42	1.90	2,600
	Average	14,625	12,565	16.39	52,755	45,915	14.90	38,130	33,350	14.33	2,060	4,780	3.61	3.65	2.32	2,720

CONCLUSION

From the above results and discussion, it was found that the demonstrated technologies were superior when compared with the farmers practice. The feedback collected from farmers gave a positive prospects of conducting cluster demonstration. The farmers of nearby villages were attracted by showing the crops by conducting field days and media also played a vital role in dissemination of the success achieved in Nagaon district through pulse cultivation. The technology and extension gap showed that though there are many advanced technology released but a wide gap is there which can only be minimized using extension methodologies in a greater way. Lower the technology index, higher is the feasibility which concludes that the technology needs to be promoted to lower down the gaps found in extension and technology dissemination, adoption gaps and technology index so that farmers a good return over the existing traditional practice. Thus it can be underlined that improved package of practices can enhance the productivity per unit area.

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