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Yield gap and economics of frontline demonstrations (FLDs) on pulses under rain-fed condition

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Abstract
Pulse crops, also called grain legumes, are plants from the legume family (Leguminosae) that are strictly harvested for their dried seeds. India is the largest producer (25% of global production), consumer (27% of world consumption) and importer (14%) of pulses in the world. Pulses account for around 20% of the area under food grains and contribute around 7-10% of the total food grains production in the country. Though pulses are grown in both Kharif and Rabi seasons, Rabi pulses contribute more than 60% of the total production. Front line demonstration was conducted on pulses during Kharif and Rabi seasons of 2017-22 in Vijayanagar district, Karnataka with the objective to know the extent of adoption of improved practices and to find out the yield gap in pulses production technology. The average extension gap for redgram was calculated 2.25 qtl/ha over five years, greengram was 2.20 qtl/ha, Bengalgram 3.00 qtl/ha and cowpea was 1.60. The average technology index was calculated was 16.07, 18.33, 31.57 and 10.66 in redgram, greengram, Bengalgram and cowpea respectively. The maximum technology gap 3.00 qtl/ha was in Bengalgram crop and lowest 1.60 qtl/ha in cowpea with overall cumulative technology gap ranged from 1.60 to 3.00 t/ha among the different varieties. Lowest cost cultivation was recorded under improved practices in redgram, greengram, Bengalgram and cowpea by of Rs. 30,000/ha, Rs. 18,000/ha, Rs. 18,200/ha and Rs. 19,000/ha respectively compared to farmers practices. Approach of frontline demonstrations was proved to be effective in increasing the yield of farmers which not only increased the yield per unit area but also enhanced the farmers' income.

Keywords: Extension gap, frontline demonstrations, yield, pulses, farming practices

Introduction
The higher protein content of pulses makes them one of the major food crops in the world. Pulses are an important crop in India, where they account for a large portion of exports and have the potential to provide significant financial gains. The main sources of protein in the diet are pulses. For all demographic groups, pulses are an essential component of the Indian diet, contributing much-needed protein to the diet high in carbohydrates. The world's biggest producer and consumer of pulses is India. The protein content of pulses is 20-25% by weight, which is three times more than that of rice and twice that of wheat.

Legumes, or pulses, are considered a poor man's meat, yet they are an essential source of additional protein for vegetarian diets. Since the majority of Indians are vegetarians, pulses provide the majority of the dietary protein needed for human growth and development. In addition to being a staple of the human diet, leguminous pulses have the significant and distinctive ability to preserve and improve the physical qualities of soil due to their deep root system and leaf fall, which leaves behind a reasonable amount of nitrogen in the soil and can add up to 40 kg N/ha. This biological nitrogen fixation helps pulses maintain and restore soil fertility. Due to their deep roots, pulses are incredibly adaptable to the country's dry land areas, which make up a sizable portion of the cropped area and greatly contribute to the total production of pulses. Additionally, a significant portion of concentrates, hay, and green fodder for cattle are made from pulses (Singha *et al.*, 2020) [12].

Pulses and oilseeds provide excellent source of protein to the human diet. Protein energy malnutrition and micronutrient deficiencies can be reduced by increase in consumption of pulses. Because they are excellent providers of high-quality protein and nutrients. As per NIN recommended dietary allowances net daily pulses availability for Indians has increased slightly from 32 gm per capita in 2000 and 37gm per capita in 2009. India needs to focus on both production and consumption of pulses in order to satisfy the 40 gm per day per capita need. Therefore, pulses could provide a significant portion of their protein needs (Anon, 2021-22) [1].

India is the second most populous country in the world with >1/6th of the world's population (Anon, 2021-22) [1]. The total world acreage under pulses is about 93.18 (Mha) with production of 89.82 (Mt) at 964 kg/ha yields level. India, with >28 Mha pulses cultivation area, is the largest pulse producing country in the world. It ranks first in area and production with 31% and 28% respectively. During 2020-21 our productivity at 885 kg/ha, has also increased significantly over last 05 year (Anon, 2021-22) [1].

Pulses are highly flexible in terms of latitude, longitude, and climate. Pulses use less water during production than cereals because of their biological nitrogen fixation action, and their rotation with cereals aids in the management of pests and diseases. One of the main constraints to increase the pulse production is the non-availability improved varieties and high-quality seed and other inputs. Keeping this in view, the present study was conducted on pulses during the year 2017-22 to demonstrate improved crop production technologies of pulses on the farmers' fields and to know the gap between the potential yield and demonstrated yield, extension gap between demonstrated yield and yield under existing practice and technology index.

Materials and Methods

Front Line demonstrations (FLDs) are a novel way to establish a direct line of communication between researchers and farmers. Scientists plan, carry out, and oversee the demonstrations of the technologies they have developed, and they receive direct feedback from farmers about the production of crops like wheat, rice, and pulses in general, and the technology under demonstration in particular. This gives the scientists the flexibility to adjust the research plan as needed. Thus, FLDs provide an opportunity to researchers and extension personnel for understanding the farmer's practices and resources and necessary recommendation to modify the technologies for easy adaptability at farmers' fields.

Front line demonstration was carried out on pulse crop (Pigeon pea, Bengalgram, Greengram and cowpea) during Kharif and Rabi seasons of 2017-22 in selected cluster villages of Vijayanagar district. Frontline demonstrations were carried out through Agricultural Extension Education Centre, Huvinahdagali. The total number of 50 pulses growers (15 Pigeon pea, 15 Chickpea, 10 Greengram and 10 cowpea) were selected for successful demonstration during kharif & rabi season 2017-22 in the 5 blocks of Vijayanagar district *viz*., Nagatibasapura, Hagaribommanahalli, Morigeri, Bavihalli and Kanhalli. The total area of 20 ha was covered for the pulse demonstrations. The improved varieties of Pigeon pea, Greengram, Bengalgram and cow pea that was GRG-811, BSMR-736, TS-3R, BGS-9, JG-11, BGD-103, DGV-2 and IT – 38956-1 respectively, demonstrated with full package of practices. Farmers were advised with proper tillage, proper seed rate and sowing method, balanced dose of fertilizer bio fertilizers, Trichoderma and Rhizobium culture & PSB @ 5 gm/kg of seed as seed treatment, proper irrigation, inter cultivation, weed management and improved plant protection measures were applied (Table 1) at the farmers' fields. Control plot was selected to know the farmers practices. The technology gap, extension gap and technological index were calculated by using Extension Gap= Demonstration – Farmers yield, Technology gap = Potential yield - Demonstrated yield, Technology index = Potential yield - Demonstrated yield / Potential yield X 100 and Percent increase yield = Demonstration yield-farmers yield / Farmers yield X 100.

Results and Discussions

It was observed from the table 1 that farmers use local varieties instead of high yielding varieties, and they use high seed rate during sowing and may not use seed treatment for seeds, which depicts that there was full gap observed between the use of high yielding varieties, seed rate and seed treatment. High incidence of pest and disease (95.56%) to the crop was the major constraint expressed by farmers followed by lack of high yielding varieties (85.34%), lack of knowledge about pest and disease management (76.25%) and high cost labour (72.34%). Similar results reported by Kumar *et al*. (2010) [6] as stated that non availability of high yielding varieties and lack of knowledge about plant protection measures were the major problems as expressed by farmers. Other production problems faced by farmers were marketing linkage (45.50%), lack of knowledge about seed rate (67.34), high cost seed (56.78%), lack of knowledge about weed management (36.25) and labour scarcity (65.45%). Vanishree *et al*. (2018) [16] and Sunitha *et al*. (2020c) [15] reported that problem in marketing and non-availability of high yielding varieties was the major constraint in foxtail millet production.

Table 1: Major constraints faced by farmers in cultivation of pulse crop

Sl. No.	Constraints	Percentages *
1.	Non availability of high yielding varieties	85.34
2.	Problem in marketing	45.50
3.	Lack of knowledge about seed rate	67.34
4.	High incidence of pest and disease	95.56
5.	High cost seed	56.78
6.	Lack of knowledge about seed treatment	45.67
7.	Lack of knowledge about weed management	36.25
8.	Lack of knowledge about pest and disease management	76.25
9.	High cost of labour	72.34
10.	Labour scarcity	65.45

*Multiple answers

Technology gap

The technology gap refers to difference between potential yield and demo yield. In the present study the maximum technology gap 3.00 qtl/ha was in Bengalgram crop and lowest 1.60 qtl/ha in cowpea with overall cumulative technology gap ranged from 1.60 to 3.00 t/ha among the different varieties (Table 2). Similar findings reported by Mukherjee (2003) [8] in Jharkhand maximum technology gap (1.49 t/ha) was recorded in pigeion pea var Rajendra Arhar-1 and lowest (0.46 t/ha) in varieties Birsa Arhar-1. Another effective method for impact analysis is the percent increase in yield over control. It was varied from 4.20 to 8.60% over 5 years among all the crops. Kumar *et al*. (2022) [5] stated that% change in yield over control varied from 22.55 to 71.68% in Bihar.

Table 2: Difference between technological interventions and farmers practices under frontline demonstrations in pulses

Sl. No.	Particulars	Technological intervention				Existing practices
		Pigeon pea	Chickpea	Greengram	Cowpea	
1.	Variety	GRG-811, TS-3R	BGD-103, JG-11	BGS-9	IT – 38956-1	Local
2.	Land preparation	One cultivator ploughing and 3 ploughing	One cultivator ploughing and 2 p ploughing	One cultivator ploughing and 2 p ploughing	One cultivator ploughing and 2 p ploughing	One cultivator ploughing and 2 p ploughing
3.	Seed rate (Kg/ha)	12.50	62.50	12.50	12.50	High seed rate
4.	Sowing method	Line sowing raised bed 60x15 cm (RxP)	30x10 cm (RxP)	30x10 cm (RxP)	30x10 cm (RxP)	Ridge sowing/line sowing/ broadcasting
5.	Seed treatment	Trichoderma powder and Rhizobium culture @ 5 g/kg seed	Trichoderma powder and Rhizobium culture @ 5 g/kg seed	Trichoderma powder and Rhizobium culture @ 5 g/kg seed	Trichoderma powder and Rhizobium culture @ 5 g/kg seed	No seed treatment
6.	Fertilizer dose (Kg/ha)	18 N and 46 P_2O_5	18 N and 46 P_2O_5	18 N and 46 P_2O_5	18 N and 46 P_2O_5	Use imbalance fertilizers
7.	Plant protection	Need based plant protection measure Indoxacarb (15.8% E.C) @ 500 ml/ha	Need based plant protection measure Indoxacarb (15.8% E.C) @ 500 ml/ha	Need based plant protection measure Indoxacarb (15.8% E.C) @ 500 ml/ha	Need based plant protection measure Indoxacarb (15.8% E.C) @ 500 ml/ha	Improper management.

Table 3: Performance of frontline demonstrations on pulses during the year 2017-22 (Average of 5 years)

Name of the crop	Variety	Area (ha)	No of demos	Yield (q/ha)		% increase in yield over local check	TG	EG	TI
				I.P	F.P				
Redgram	GRG-811, TS-3R	20.00	200	11.75	8.30	41.56	2.25	3.45	16.07
Greengram	BGS-9	20.00	200	9.80	6.75	45.18	2.20	3.05	18.33
Bengalgram	BGD-103, JG-11	20.00	200	6.50	4.20	54.76	3.00	2.30	31.57
Cowpea	IT – 38956-1	20.00	200	13.40	8.60	55.81	1.60	4.80	10.66

I.P = Improved practices, F.P = Farmers practices, T.G = Technology Gap, E.G = Extension Gap and TI = Technology Index

Table 4: Economic analysis of demonstrated pulses grown under improved practices and farmers practices (Average 5 years)

Year	Variety	B:C Ratio		% increase in yield	Cost of cultivation (Rs/ha)		Gross returns (Rs. /ha)		Net returns (Rs./ha)	
		I.P.	F.P.		I.P.	F.P.	I.P.	F.P.	I.P.	F.P.
Redgram	GRG-811, TS-3R	1.60	0.61	41.56	30000	35000	79900	56440	49900	21440
Greengram	BGS-9	3.35	1.45	45.18	18000	22000	78400	54000	60400	32000
Bengalgram	BGD-103, JG-11	1.14	0.42	54.76	18200	20400	39000	28200	20800	7800
Cowpea	IT – 38956-1	3.90	1.41	55.81	19000	25000	93800	60200	74800	35200

I.P. = Improved practices, F.P = Farmers practices

Extension gap

Extension gap refers to difference yield between demo plot and control plot. With respect to the extension gap the average extension gap for redgram was calculated 2.25 qtl/ha over five years, greengram was 2.20 qtl/ha, Bengalgram 3.00 qtl/ha and cowpea was 1.60 (Fig. 1). However, Bengalgram yield showed higher extension yield gap that varied from 3.00 qtl/ha. This may due to unawareness about high yielding varieties, increased extension yield gap as a result of farmers' ignorance to adopt better farming practices; this suggests that farmers need to be strongly encouraged to embrace improved farming practices in pulse crop rather than sticking with traditional local methods. These findings in line with findings reported by Kumar *et al*. (2022) [5], Singh *et al*. (2020) [11], Dubey *et al*. (2022) [2] and Sunitha *et al*. (2020c) [15] reported that the highest extension gap was observed in pigeon pea. This extension yield gap may minimized by promoting some extension activities, organizing awareness training programme to the farmers about high yielding varieties and organizing Krishimela's.

Technology index

Another important factor for assessing the adoption and impact of technologies was technology index. The average technology index was quite higher in Bengalgram over five years as indicated in Table 2. The technology index calculated was 16.07, 18.33, 31.57 and 10.66 in redgram, greengram, Bengalgram and cowpea respectively. This depicted that lower value of technology index better performance of technology. In the current study technology index varied from 10.66 to 18.33% in Vijaya Nagar district. From the data it can be seen that the technology index in cowpea is quite lower (10.66%). Results depicts that the demonstrated varieties performed better results. Similar results quoted by Singh *et al*. (2020) [11], Kumar *et al*. (2010) [6] and Sunitha *et al*. (2020b) [14] that higher technology index may be due to incidence of pest and disease, soil fertility condition and climatic conditions. One probable explanation for low yields and a higher technology index in both crops is poor field establishment during the early vegetative stage caused by water stress under rainfed farming with irregular rainfall distribution, a protracted dry spell, and growing pressure from diseases and insect pests.

Economics analysis

The foundation of both adopting and rejecting technology is economics, which is based on a number of variables such as seed yield, cost of labour, input costs, and marker prices. Improved technology interventions decreased the average cost of agriculture by 4.30% when compared to farmers' practices (Table 3). On average basis, lowest cost cultivation was recorded under improved practices in redgram, greengram, Bengalgram and cowpea by of Rs. 30,000/ha, Rs. 18,000/ha, Rs. 18,200/ha and Rs. 19,000/ha respectively compared to farmers practices. Similar results documented by Raghav *et al*. (2021) [9], Sunitha *et al*. (2020a) [13], Meena & Singh (2021) [7], Reager *et al*. (2020) [10] who noted that the exhibited techniques yielded a higher B: C ratio than the check plots.

Demonstration plots, there was a noticeable decline in these parameters, such as lower gross return (Rs.28200/ha to Rs.93, 800 /ha), higher net return (Rs.20,800/ha to Rs.74,800/ha), high benefit cost ratio (3.35 to 3.90) in all the crops (Fig. 2). Additionally, under farmers practice plots, there was a decrease in these parameters as well. The technology's economic feasibility is demonstrated by the farmers' higher gross financial returns.

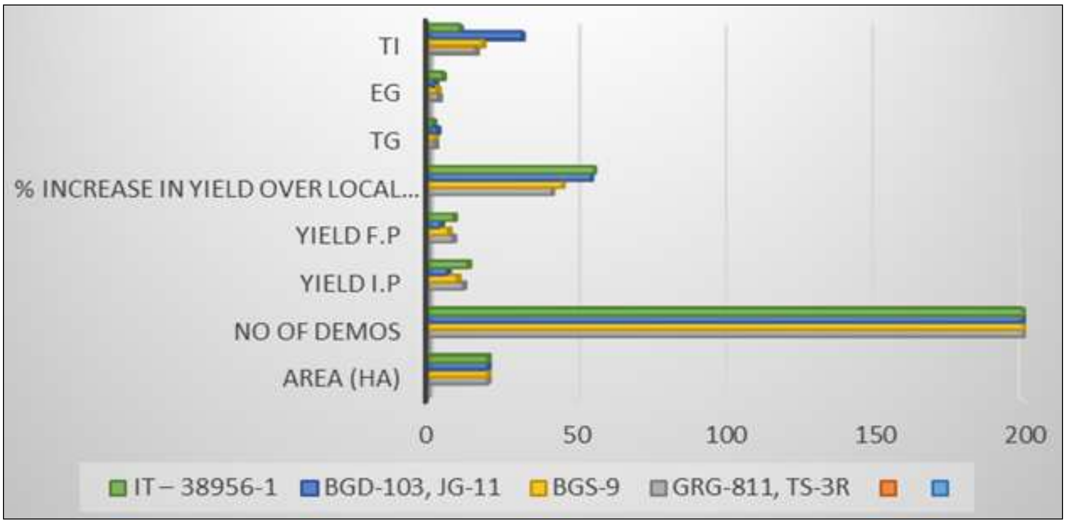

Fig 1: Performance of frontline demonstrations on pulses during the year 2017-22 (Average of 5 years)

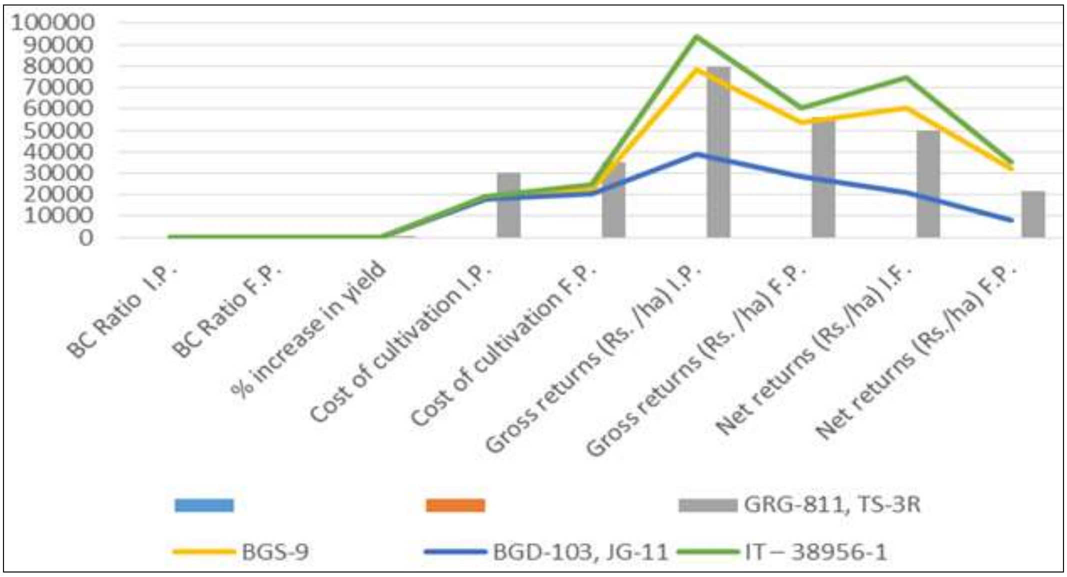

Fig 2: Economic analysis of demonstrated pulses grown under improved practices and farmers practices (Average 5 years)

Conclusion

Approach of frontline demonstrations was proved to be effective in increasing the yield of farmers which not only increased the yield per unit area but also enhanced the farmers' income. However, a wide gap in potential yields, demonstration yields and farmers plot yields under all the crops due to technological and extension gaps indicating that there is a need of proper dissemination of location specific technologies imbedded with high yielding varieties to improve productivity and profitability of pulses in rainfed conditions. Hence there is a need to create awareness regarding consumption of pulses as daily diet. It is also helpful in increasing the nutritional security of the people in the community.

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