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Productivity Enhancement and Popularization of Improved Production Technologies in Pulses through Frontline Demonstrations in Dryland Systems

Vijay Kumar[1], Vivek Sharma[2], Manmohanjit Singh[1] and S.C. Sharma[1]

[1]Regional Research Station (Punjab Agricultural University), Ballowal Saunkhri, Takrala, Balachaur, S.B.S. Nagar - 144521, Punjab, India

[2]Punjab Agricultural University, Ludhiana-141004, Punjab, India

Email: vijaypau@pau.edu

ABSTRACT: Frontline demonstration (FLD) technology is a noble initiative for encouraging adoption of the technology and reducing the yield gaps of different crops. The FLDs/on farm trials on pulses were conducted in 126 farmers' fields in the Shiwalik foothills of North-western Himalayas, India to demonstrate the impact of improved production practices on productivity and the economics during 2012-2016 under rainfed conditions. The improved production technologies recorded 34.7% additional yield of mash (*Vigna mungo* (L.) Hepper) and 40.2% additional yield of chickpea (*Cicer arietinum* L.) over farmers' practices. Thus, productivity of pulses could be increased by adopting recommended improved management practices under rainfed conditions. There is a need to bridge the gap between technology generated and technology transferred through effective extension techniques for the benefit of the farming community.

Keywords: Pulse productivity, frontline demonstrations, dryland systems, constraints

Introduction

Dryland regions are home to roughly 1/3rd of the world's population and cover 41% of the earth's surface spanning over 100 countries. Drylands include about 44% of the total cultivated lands and are home to 50% of the livestock in the world (CRP Dryland Systems 2018). Three-quarters of the additional food that the global population needs over the next several decades could be met by bringing the production level of the world's low-yield farmers up to 80% of that which high-yield farmers obtain from comparable lands (CAWMA, 2007). The greatest potential to increase in yield are in rainfed areas and efficient water management is the key to such increases (CAWMA, 2007). In India, dryland ecosystems cover 83 m ha of the area, contribute about 40% of the total food grain production and support two-thirds of the livestock population (CRIDA, 2011; Chander *et al*., 2019). Shivalik region is sandwiched between Himalayan ecosystem and Indo-Gangetic plains in north-western India and its area ranges from 2.14 to 8.00 mha as reported by different workers. Based on geology and physiography, Yadav *et al.* (2015) demarcated the Shivalik region (3.33 mha), covering hills (1.79 mha) and its piedmont plains or foothills (1.54 mha) in the states of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Punjab, Haryana, Uttar Pradesh and union territory of Chandigarh at an elevation ranging from 217 to 2332 m above MSL and locally known as Kandi region. The Kandi region of Punjab has been declared as backward area by Punjab Government because most of the population in the area depends upon agriculture or works as agricultural laborers. The size of the landholdings is very small and fragmented - merely 1-2 ha (Bala, 2014). The area receives average annual rainfall of 800-1500 mm with a very high coefficient of variation. The agriculture in the region is mostly rain dependent and a declining trend in the *kharif* rainfall over the years has been reported by Sharma *et al*. (2017). The people living in drylands are projected to be affected the most by climate change (Kesava Rao and Wani, 2016).

Pulses are the best source of protein and are the only source of dietary protein for the majority of the population in India. India is the largest producer, consumer and importer of pulses in the world. During 2018, area under pulses in India was 36.4 mha with production of 25.4 m tons and productivity of 6.97 q/ha, which is much lower than the global productivity of 9.64 q/ha (FAO, 2020). Stagnant pulse production in India compared to population growth rate of 1.44% has further led to steady decline in per capita pulse availability over the past two decades (IIPR, 2011). Thus, there is an enormous collective challenge for agricultural scientists, policy planners, extension workers, and the farming community to enhance and sustain pulse productivity with major focus on bridging the yield gaps, besides area expansion and diversified production systems well equipped with appropriate pulses production technology already generated by the research institutions, so as to break the yield plateau through appropriate technology transfer programs. The lower productivity and low net returns to the farmers have resulted in area reduction under pulses in Punjab. The pulse crops are generally cultivated on marginal lands having low soil fertility and under rainfed conditions (Choudhary and Suri, 2014). Moreover, poor agronomic practices, selection of unsuitable variety, poor nutrient management, weed management and irrigation management, etc. are responsible for low productivity of pulses in the state. The improved production technologies are available but they do not serve the purpose until it is adopted by its ultimate users the farmers. The extent of adoption of improved agricultural technologies is a crucial aspect under innovation diffusion process and most important is the rate of enhancing agricultural production. Many of the technologies evolved in the field of agriculture are not being accepted and adopted to fullest extent by the farmers. The gap between recommendations made by the scientists and actual use by farmers is frequently observed (Choudhary and Suri, 2014). Frontline demonstration is the concept evolved by the Indian Council of Agriculture Research (ICAR) with main objective to demonstrate newly released crops, production and protection technologies and its management practices in the farmers' fields under different farming situations & different agro-climatic regions of the country. While demonstrating the technologies in the farmer's fields, the main objective is to study the factors contributing higher crop production, field constraints of production and thereby generate production data and feedback information. Taking all the above into consideration, the present investigation was undertaken to demonstrate and transfer the generated farm technology through frontline demonstrations in pulses under rainfed systems with the objectives of enhancing productivity and reducing yield gaps for sustainable production of pulses in Kandi region.

Materials and Methods

Location and biophysical characteristics of study sites

Hoshiarpur district in Punjab, India is having highest rainfed area in the Kandi region of Punjab. Two villages, Achalpur and Nainwan, block Garshankar, District Hoshiarpur were selected as these villages represent the typical rainfed ecosystem of Kandi region. The action site villages in Achalpur and Nainwan receive about 1100 mm of annual rainfall, 80 per cent of which is received during two and half months of South-West monsoon period (July-September). Similarly, the time and amount of rain during withdrawal of monsoon in September are quite uncertain. Early withdrawal of monsoon is common in this region, resulting in severe drought during late part of *kharif* season. It also affects the establishment of subsequent *rabi* crop as upper soil layer dries up by the sowing time. Sometimes, it becomes impossible to sow a *rabi* crop on residual moisture due to inadequate soil moisture in seed zone (Sharma *et al.,* 2014). The mean monthly minimum and maximum air temperature range from 5.2 to 25.0 and 19.3 to 38.5 °C during the year with their respective plateau in the month of January and May, respectively. The major soil types are silt loam (silty clay loam). The soils are generally non-saline (0.05-0.23 dS m^{-1}), neutral to slightly alkaline (pH 7.5-8.2), low in organic carbon (0.16-0.37%) and available nitrogen, low to medium in available phosphorus and medium in available potassium. Cation exchange capacity and calcium carbonate equivalent vary from 4.8 to 10.3 Cmol kg^{-1} and 2.6 to 5.6%, respectively (Kumar *et al.,* 2019).

Identification of the constraints

The constraints in pulses production were identified through participatory approach to popularize the improved varieties and crop management practices (Table 2). Preferential ranking technique was utilized to identify the constraints faced by the respondent farmers in chickpea production. Farmers were also asked to rank the constraints they perceive as limiting factors for cultivation of pulses in order of preference.

Frontline demonstrations on pulse crops

Based on preferential ranking, farmer's problems were identified for pulse production in the area and front line demonstrations were planned on the basis of the constraints identified for the reduction in the area and productivity of the pulses in the region. 126 Frontline demonstrations were conducted by Regional Research Station, Punjab Agricultural University, Ballowal Saunkhri, Punjab, India to demonstrate the effect of improved crop management practices on production and productivity of mash & chickpea (Table 1) under rainfed conditions during 2012-2016. In FLDs' plot, the full package of agronomic practices recommended by Punjab Agricultural University, Ludhiana for the respective crops was adopted with emphasis on improved cultivars, nutrient-management and weed control, which are major production constraints in the region (Table 2). Each demonstration was conducted on an area of

Table 1: Details of chickpea and mash grown under FLD and farmer practices

S. No.	Technology	Chickpea		Mash	
		Farmers Practice	Improved practices	Farmers Practice	Improved practices
1	Variety	Local/unknown variety from local market	PBG 1, PBG 5 and PBG 7	Local/unknown variety from local market	Mash 114 and Mash 338
2	Spacing	Broadcasting of seed	Line sowing with row spacing of 30 cm.	Broadcasting of seed	Line sowing with row spacing of 30 cm.
3	Seed rate	50-60 kg ha^{-1}	45 kg ha^{-1}	25-30 kg ha^{-1}	15-20 kg ha^{-1}
4	Fertilizers	Only Farm Yard Manure 4-5 tonnes/ha	15 kg N and 20 kg P_2O_5 per hectare as basal dose at the time of sowing	Only farm yard manure 4-5 tonnes/ha	12.5 kg N and 25 kg P_2O_5 per hectare as basal dose at the time of sowing
5	Crop production and protection		All the other crop management practices as per the package of practices *rabi* crops by Punjab Agricultural University, Ludhiana.		All the other crop management practices as per the package of practices for *kharif* crops by Punjab Agricultural University, Ludhiana.

0.1 ha and adjacent plot to the demonstration plot was kept as control (farmers' practices) plot.

Table 2: Ranks given by farmers for different constraints (n=100)

S. No.	Constraints	Percentage	Rank
1	Availability of improved variety seed	69	II
2	Low productivity	78	I
3	Low technical knowledge	42	VI
4	Damage by wild animals/birds	60	III
5	Uncertainty of rains/drought	52	V
6	Disease/pest incidence	55	IV
7	Post harvest management	36	VII

Estimation of crop productivity and yield enhancements

The crop yield was recorded at maturity from 3 plots of 5 m × 5 m, *i.e.,* total 75 m^2 in each FLD for calculation of final yield per ha. Thus, in all FLDs conducted in farmer's fields, the improved practice was compared with the farmers' practice in either the same farmer's or a nearby farmer's field. One-way analysis of variance (ANOVA) of the data collected on improved and farmers' practice was done and a least significant difference, (LSD) was computed using Fisher's method to statistically compare the difference between mean yields of improved and farmers' practice (Choudhary *et al*., 2009).

Rainwater use efficiency

The total rainfall received during the growth period was used for the estimation of rainwater use efficiency in each demonstration. The following formula was used for the calculation of rain water use efficiency:

Rain water use efficiency (kg/ha-mm) = (Economic yield/total rainfall) x 100

Mini Agrometeorological Observatory was established at the study area for recording the daily rainfall and temperature data.

Economic analysis of FLDs

The cost of cultivation of pulse crops includes cost of farm inputs (seed, fertilizers, pesticides etc.) purchased by the farmers (in farmers' practice)/supplied for the FLDs as well as labour (hired/family), sowing charges, and harvesting operation charges. The gross and net returns were worked out accordingly by taking cost of cultivation and price of grain yield into consideration (Table 3). Similarly, the benefit-cost ratio (BCR) was worked out as a ratio of gross returns and cost of cultivation (Table 3).

Results and Discussion

Constraints in production of pulse crops

The problems faced by the farmer's in pulse crops cultivation were documented and preferential ranking technique was utilized to identify the constraints faced by the respondent farmers in pulse production. The rankings given by the farmers to different constraints are given in Table 2. A perusal of table indicates that low productivity (78%), availability of improved variety seed (69%), wild animal/birds damage (60%), disease incidence (55%) and uncertainty of rains/drought (52%) were the major constraints to pulse production. Sharma *et al.* (2016) and Kumar *et al.* (2017) have also reported similar problems in other crops and the results also indicated similar constraints in the present study.

Crop productivity and yield enhancement

Yield of the pulses recorded under improved crop management practices (IP) was significantly higher than the yield with farmers' practice (FP) (Table 3). It was observed that the average productivity of mash in the improved practice over the years ranged between 622-880 kg/ha, with overall average of 698 kg/ha and 34.7% increase over farmers' practice (Table 3). The average productivity of chickpea over the years was 989 kg/ha with 40.2% increase in productivity over the farmers' practice. The variation in the productivity was caused mainly due to sowing under rainfed conditions, delay in sowing due to late winter rains and prolonged dry spell during the early growth period in the month of October to December (chickpea). Similar, enhancement in productivity of pulse and other crops through front line demonstrations has been documented by Chaudhary and Suri (2014), Yadav *et al.* (2016), Kumar *et al.* (2014) and Mishra and Khare (2017). The results indicated that performance of improved technologies was better than the farmers' practices. The farmers were motivated through the FLDs which will result in adoption of these improved technologies.

Economic analysis

The economics of the improved dryland technologies over farmer's practices was calculated depending on the prevailing market prices of inputs and outputs (Table 3). The net returns varied from ₹ 5,774 to 17,969 and ₹ 19,864 to 36,091 with mean net returns of ₹ 12,921 and ₹ 26,598, respectively for mash and chickpea. The mean additional returns to the tune of ₹ 8,685 and ₹ 14,092 per hectare were realized in general by the farmers under mash and chickpea, respectively suggesting higher profitability and economic viability of the FLDs which are in line with the results of Sharma *et al.* (2016) and Kumar *et al.* (2017). Higher BCR of 1.69 and 2.30 with improved practices in comparison to 1.16 and 1.65 from farmers' practices was also recorded, for mash and chickpea. These results are in line with the findings of Chaudhary and Suri (2014), Yadav *et al.* (2016), Kumar *et al.* (2017) and Sharma *et al.* (2017) who also reported

Table 3: Effect of improved crop management practices on yield, economics and rain water-use efficiency of pulses under rainfed condition

Year	Yield (kg/ha)		LSD (5%)	% Increase in yield	RWUE (kg/hamm)		Net returns (₹ /ha)		Additional returns/ha (₹)	B:C ratio	
	IP	FP			IP	FP	IP	FP		IP	FP
Mash											
2012-13	694	540	89.5	28.5	1.19	0.93	14,242	4,812	9,430	1.95	1.18
2013-14	663	480	124.6	38.1	1.08	0.78	16,691	4,216	12,475	1.98	1.14
2014-15	622	520	78.4	19.6	0.99	0.83	5,774	4,684	1,090	1.28	1.15
2015-16	880	585	185.4	50.4	1.36	0.85	17,969	5,319	12,650	1.80	1.24
2016-17	630	460	112.6	37.0	1.05	0.66	9,927	2,151	7,776	1.44	1.10
Mean	698	517		34.7	1.13	0.81	12,921	4,236	8,685	1.69	1.16
Chickpea											
2012-13	1020	720	226.8	41.7	6.76	4.77	21,509	10,754	10,755	2.12	1.60
2013-14	1335	910	240.7	46.7	4.73	3.23	36,091	20,336	15,755	3.08	2.27
2014-15	850	633	186.5	34.3	1.98	1.47	20,146	9,296	10,850	1.90	1.42
2015-16	840	608	162.4	38.2	9.43	6.82	19,864	8,862	11,002	1.89	1.40
2016-17	900	560	214.4	61.1	4.80	3.00	35,381	13,281	22,100	2.53	1.57
Mean	989	686		40.2	5.54	3.86	26,598	12,506	14,092	2.30	1.65

higher net returns and BCR in the FLDs compared to farmers' practices. The results from the present study clearly brought out the potential of improved production technologies in enhancing the pulse production and net returns under dryland farming situations.

Rainwater use efficiency

Total mean annual rainfall during the study period was 1081 mm with 903.7 mm during *kharif* season (June-September) and remaining during the *rabi* season. Rainwater use efficiency (RWUE) in pulses from demonstrations on improved practices varied between 0.99 - 1.36 kg/ha mm in mash and 1.98 - 9.43 kg/ ha mm in chickpea with an average of 1.13 and 5.54 kg/ha mm in comparison to 0.81 and 3.86 kg/ha mm from farmers' practices for the respective crops. Average annual rainfall in the region is about 1084.4 mm with comparatively low precipitation in *rabi* season (Sharma *et al*., 2014). Thus, RWUE in *rabi* pulse was greater than their *kharif* counterpart in demonstration plots as well as in farmer's plots, owing to low rainfall, but better plant nutrition (Chaudhary and Suri, 2014). From the present study, it is evident that use of improved technologies greatly improved the RWUE in pulses over farmers' practices. This can be attributed mainly to improved yields of pulses in demonstrations due to adoption of the better crop management practices, resulting in higher RWUE with the same amount of water (Chaudhary and Suri, 2014).

Conclusion

Front line demonstrations conducted at the farmers' fields revealed that the adoption of improved technologies significantly increased the yield and net returns of pulse crops. So, there is urgent need to disseminate the improved technologies among the farmers with effective extension methods. The non-availability of improved varieties was major constraint for the low productivity of pulses crops followed by wild animal damage, disease/pest incidence and uncertainty of rains/drought. The present study indicated that there was a wide gap among potential crop yields, demonstration yields, and farmers' plot yields in pulse crops. This suggests further refinement in technology generated with special attention on cultivation under dryland conditions. Thus, location specific technologies should be developed and disseminated effectively to the farmers for the increasing yields and economic benefits.

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