Annals of Arid Zone 62(2): 175-180, 2023

Yield Enhancement and Gap Minimization of Rainfed Pearl Millet by Front Line Demonstration in Churu District of Rajasthan

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Received: March 2023

Abstract: KVK, Chandgothi conducted 175 Front Line Demonstrations on pearl millet at farmers field in Dingli, Thirpali, Chotti, Thirpali Badi, Chandgothi, Sulkhania Chota, Sulkhania Bada, Bas Mamraj, Norangpa villages of Rajgarh tehshil in Churu district during five consecutive *Kharif* seasons from 2018 to 2022. The farming situation was rainfed and soils were sandy loam, low in nitrogen, medium in phosphorus and medium to high in potash. Yield gap was defined as yield difference between demonstrated improved recommended technologies of pearl millet cultivation against conventional practice. Five years average of grain yield was 1349 kg ha^{-1} under demonstration plot against 1081 kg ha^{-1} in farmer's practices which showed an improvement of 24.79%. The higher extension gap (267 kg ha^{-1}), technology gap (3351 kg ha^{-1}) and lower technology index (19.77%) was recorded because of adoption of improved recommended technology in demonstrations. An additional investment of Rs. 1240 ha^{-1} towards scientific monitoring of demonstration and non–monetary factors resulted in additional return of Rs. 6597 ha^{-1} with an effective gain of Rs. 5357 ha^{-1}. On five year average basis, 5.65 Incremental Benefit:Cost ratio (IBCR) was recorded.

Key words: Pearl millet, extension gap, economics, grain yield, straw yield, technology gap.

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Citation

Ali, S., Shivran, R.K., Chandra, S. and Gupta, A. 2023. Yield enhancement and gap minimization of rainfed pearl millet by front line demonstration in Churu district of Rajasthan. Annals of Arid Zone 62(2): 175-180

https://doi.org/10.59512/aaz.2023.62.2.12

https://epubs.icar.org.in/index.php/AAZ/article/view/134653

Pearl millet [(*Pennisetum glaucum* (L) R. Br.] is a nutritious coarse grain millet grown as rainfed and is a staple food for majority of peoples in dry tracts of country (Jain *et al.*, 2022). It is the most drought and heat tolerant among cereals or millets and has the highest water use efficiency under drought stress. It is the only major crop that has high levels of tolerance to both acid and saline conditions in soils. It can be cultivated even in the low fertility sandy soils and drought environments where no other cereal crop can survive. Pearl millet can produce about 300-400 kg ha^{-1}of grain yield (Kumar *et al.*, 2010). The western Rajasthan faces frequent droughts, making arable cropping difficult and uncertain. The adaptive and nutritional features combined with yield potential make pearl millet an important nutri-cereal crop to address the emerging challenges of global warming, water shortages, land degradation and food related health issues (Jain, 2018). Pearl

Table 1. Area, Production and Productivity of pearlmillet (Kharif 2018 to Kharif 2021)

Year	Particular	Area (000′ ha)	Production (000′ t)	Productivity (kg ha^{-1})
2018	India*	7110.0	8660.0	1219
	Rajasthan**	4154.3	3764.6	906
	Churu**	265.8	117.8	443
2019	India*	7540.0	10360.0	1374
	Rajasthan**	4287.1	5086.6	1186
	Churu**	257.1	142.6	555
2020	India*	7570.0	10860.0	1436
	Rajasthan**	4319.4	5773.7	1337
	Churu**	232.6	167.5	720
2021	India***	7050.0	9220.0	1307
	Rajasthan**	4300.7	4303.2	1001
	Churu**	181.0	121.8	673

*(Anonymous 2021a, 2021b); ** (Anonymous 2018-19, 2020-21); ***(Anonymous 2022)

millet contributes significantly towards food and nutritional security of the rural and urban poor in the arid and semi-arid areas of the India and it is valued equally both for its grain and fodder (Parmar *et al.,* 2016). The national productivity of pearl millet was recorded to be 1307 kg ha^{-1} during 2021 (Anonymous, 2022). Total area under pearl millet cultivation is 4.30 mha with production of 4.303 mt in Rajasthan state. The average productivity of pearl millet in Rajasthan is 1001 kg ha^{-1}. As far as Churu district of Rajasthan is concerned total area under pearl millet cultivation 0.181 mha with productivity of 673 kg ha^{-1} recorded during year 2021 (Anonymous, 2021), which is lower than it's potential of production (Table 1). Churu district of western Rajasthan is highly vulnerable to extreme climate and drought events, hence pearl millet, being drought tolerant, is more preferred crop for agriculture under prevailing conditions (Rao *et al.,* 2007).

Low productivity of pearl millet is due to several biotic and abiotic stresses besides unavailability of quality seeds of improved varieties in time and poor crop management practices. Unawareness and non-adoption of recommended production and plant protection technologies also plays a major role. There is a considerable scope for increasing the productivity of pearl millet by using improved practices (Jangid *et al.,* 2006). Large number of technologies for the pearl millet crop improvement has been generated by the Research Institutes and Agricultural Universities, but only few of them have been adopted by the farmers. Therefore, Front Line Demonstration (FLD) on pearl millet at farmer's field may be helpful to establish the technology at farming community. The basic objective of this program was to demonstrate recently released improved technologies mainly short duration hybrid varieties in compact blocks with Integrated Nutrient Management (INM), Integrated Weed Management (IWM) and Integrated Pest Management (IPM) package at farmer's field (Table 2) through Krishi Vigyan Kendra to enhance adoption of modern technologies and to receive farmers' feedback. Keeping this in view, KVK, *Chandgothi, Churu* conducted 175 demonstrations on pearl millet crop at farmer's field during *Kharif* 2018 to *Kharif* 2022.

Materials and Methods

175 Front Line Demonstrations on pearl millet varieties i.e. RHB 177, MPMH 17, MPMH 21 and HHB 299 at selected farmer's field in Dingli, Thirpali Chotti, Thirpali Badi, Chandgothi, Sulkhania Chota, Sulkhania Bada, Bas Mamraj, Norangpura villages of Rajgarh tehshil in Churu district of Rajasthan were conducted by KVK, Chandgothi, Churu (Rajasthan) for five consecutive *Kharif* seasons from 2018 to 2022. Villages were selected on basis of non-adoption of improved and recommended varieties (RHB 177, MPMH 17, MPMH 21 and HHB 299) and improved package of pearl millet cultivation. After the selection of villages, most approachable side of farmer's field was selected, so that the performance of demonstrated technology can be seen by other farmers. The farming situation was rainfed

Table 2. Particulars showing the details of pearl millet growing under front line demonstration and existing farmer's practices

Particulars	Technological Intervention (Demonstration Practices)	Farmers Practices (Local Check)	Technological Gap
Farming Situation	Rainfed	Rainfed	No Gap
Variety	Improved varieties RHB 177, MPMH 17, MPMH 21 and HHB 299	Locally available	Full Gap (100%)
Seed Rate	4 kg ha^{-1}	6 kg ha^{-1}	2 kg higher than recommended
Seed inoculation	Azotobactor & PSB	No Seed Inoculation	Full Gap (100%)
Sowing Method	Line Sowing (30 x 10 cm)	Line sowing (30 x 10 cm)	No Gap
Gypsum	250 kg ha^{-1}	No Use	Full Gap (100%)
Fertilizer	40 kg N, 20 kg P_2O_5	23 kg N and 16 kg P_2O_5	N 42.5%, P_2O_5 20%
Micro-nutrients	25 kg $ZnSo_4$	No use of Micronutrients	Full Gap (100%)
Weed Control	Herbicide application	Hand weeding	No herbicide use Full Gap (100%)
Plant protection	Need based spray of Insecticides and fungicides	No spray	Full Gap (100%)

and soils were sandy loam, low in available nitrogen, medium in phosphorus and medium to high in potash. The area for demonstration was 0.4 ha each and recommended package of practices were followed. The KVK provided high quality seed of pearl millet varieties *i.e.*, RHB 177, MPMH 17, MPMH 21 and HHB 299 @ 4 kg ha^{-1}, gypsum @ 250 kg ha^{-1}, herbicide (Atrazin), micro-nutrients mixture, zinc sulphate, bio-fertilizers (Azotobacter & phosphorus solubilizing bacteria (PSB)), bio-pesticide (Trichoderma) and pesticides (Quanalphos & Imidachloprid). Other critical inputs like urea and single super phosphate (SSP) were purchased by the farmers and used (Table 3) under the guidance of KVK during all the years. The crop was sown in July and harvested in September every year. Scientists of KVK, *Chandgothi, Churu* regularly visited and monitored demonstrations on farmers' fields from sowing to harvesting. The grain yield of demonstrations and of local checks were recorded and analyzed. Other parameters as suggested by Verma *et al*. (2014) were used for calculating gap analysis, cost and returns. The details of different parameters are as follows:

Extension gap = Demonstration yield (D_1) - Farmers practices yield (F_1)

Technology gap = Potential yield (P_1) - Demonstration yield (D_1)

Technology index = [Potential yield (P_1) - Demonstration yield (D_1)/Potential yield (P_1)] x 100

Additional return = Demonstration return (D_r) - Farmers practices return (F_r)

Effective gain = Additional return (A_r) - Additional cost (D_c)

Incremental B:C ratio = Additional return (A_r) - Additional cost (D_c)

Results and Discussion

Grain yield

The grain yield of pearl millet under demonstration plots ranged from 1114 kg ha^{-1} to 1488 kg ha^{-1} with an average of 1349 kg ha^{-1} during 2018 to 2022, while, in farmer's local practices plot it ranged from 908 kg ha^{-1}

Table 3. Critical inputs used to demonstrate the technologies in demonstration plot

Input	Quantity	
	Demonstrated by the KVK	Used by the farmer
Seed	4 kg ha^{-1}	-
Urea SSP	- -	87 kg ha^{-1} 125 kg ha^{-1}
Micro nutrients	5 g l^{-1} water	-
Biofertilizer	Azotobacter and PSB @ 600 g ha^{-1}	-
Gypsum	250 kg ha^{-1}	-
Herbicide	Atrazin @ 500 g ha^{-1}	-
Pesticides	Quanalphos @ 25 kgha^{-1} Imidachloprid@ 300 ml ha^{-1}	-
Bio Pesticide	Trichoderma @ 4 li ha^{-1}	-

Table 4. Grain yield and gap analysis and technology index of front line demonstration on pearl millet at farmer's field.

Year of demo	No. of Demo	Variety	Potential Yield (kg ha^{-1})	Grain Yield (kg ha^{-1})		Increased over FP (%)	Extension gap (kg ha^{-1})	Technology gap (kg ha^{-1})	Technology index (%)
				Demo	FP				
Kharif 2018	25	RHB 177	4500	1114	908	22.69	206	3386	18.49
Kharif 2019	25	MPMH 17	4800	1409	1088	29.50	321	3391	22.78
Kharif 2020	50	RHB 177	4500	1488	1166	27.62	322	3012	21.64
Kharif 2021	50	MPMH 21	4800	1277	1026	24.46	251	3523	19.66
Kharif 2022	25	HHB 299	4900	1455	1218	19.46	237	3445	16.29
Average	175	-	4700	1349	1081	24.75	267	3351	19.77

to 1218 kg ha^{-1} with an average of 1081 kg ha^{-1} over the same period (Table 4 and Fig. 1). The grain yield increased from 19.46 to 29.50% over farmer's practices (local check) during all the five years. On average basis, 24.75% increase in yield was recorded under demonstration plot as compared to farmer's local cultivation practices of pearl millet. The results confirm with the finding of Front Line Demonstration by Kumar *et al.* (2010), Parmar *et al*. (2016), Jain (2018) and Jain *et al.* (2022) in pearl millet as well as with that of Ali *et al*. (2020b) in barley and Ali *et al*. (2020a) in clusterbean crop in *Churu* district of Rajasthan.

Straw yield

The straw yield of pearl millet under demonstration plot ranged from 2175 kg ha^{-1} to 2960 kg ha^{-1} with an average of 2580 kg ha^{-1} (Year 2018 to 2022), while, in farmer's local practices plot it ranged from 1783 kg ha^{-1} to 2277 kg ha^{-1} with an average of 2046 kg ha^{-1} (Table 5). On the five year average basis the straw yield was recorded 26.11% higher than farmer's practices.

Table 5. Economics analysis of front line demonstration on pearl millet at farmer's field

Year of demo	Straw Yield (kg ha^{-1})		Cost of Cultivation (Rs. ha^{-1})		Additional cost in demo (Rs. ha^{-1})	Sale Price of grain (Rs. kg^{-1})		Total return (Rs. ha^{-1})		Additional return in demo (Rs. ha^{-1})	Effective gain (Rs. ha^{-1})	Incremental B:C ratio (IBCR)
	Demo	FP	Demo	FP		Grain	Straw	Demo	FP			
Kharif 2018	2175	1783	7000	6000	1000	15	2.5	22148	18078	4070	3070	4.07
Kharif 2019	2753	2136	9500	8500	1000	18	2.5	32245	24924	7321	6321	7.32
Kharif 2020	2906	2203	10000	9000	1000	18.5	2.5	34793	27079	7715	6715	7.71
Kharif 2021	2361	1830	11000	9000	2000	22.5	3.0	35816	28575	7241	5241	3.62
Kharif 2022	2704	2277	16000	14800	1200	23.5	2.5	40953	34316	6637	5437	5.53
Average	2580	2046	10700	9460	1240	19.50	2.60	33191	26594	6597	5357	5.65

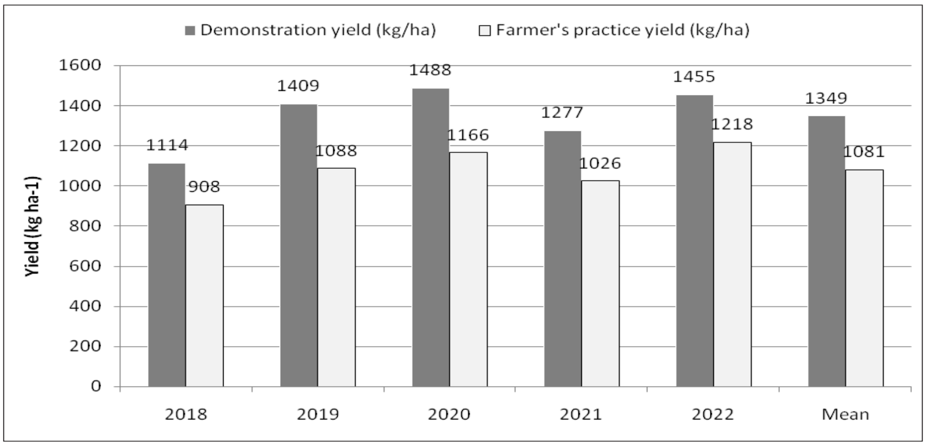

Fig. 1. Grain yield of pearl millet in demonstration and farmer's practices plot.

Gap analysis

An extension gap between demonstrated technology and farmer's practices of total 175 demonstrations ranged between 206 to 322 kg ha^{-1} while overall five year average basis it was observed to be 267 kg ha^{-1} (Table 4). The recorded gap might be attributed to adoption of improved technology in demonstration which resulted in higher grain yield than the traditional farmer's practices. Wide technology gap from 3012 to 3523 kg ha^{-1} in yield was observed during the five demonstration years; the average technology gap was found to be 3351 kg ha^{-1}. The technology gap during all the years indicated more feasibility of recommended technologies during study periods. Similarly, the technology index for all the demonstrations during the study period were in accordance with technology gap. Technology index ranged from 16.29% to 22.78% with an average of five years as 19.77%. Lower technology index reflected the adequateness of proven technology for transferring to farmers. The results confirm with the finding of Front Line Demonstration by Parmar *et al*. (2016), Jain (2018) and Jain *et al.* (2022) in pearl millet and Ali *et al*. (2020b) in barley and Ali *et al.* (2020c) in cowpea.

Economics analysis

Improved variety seed, fertilizers, gypsum, bio pesticide, herbicides and pesticides were considered as cash inputs for the demonstrations as well as farmers practices. On an average additional investment of Rs. 1240 ha^{-1} was made under demonstration which resulted in additional return of Rs. 6597 ha^{-1}. Economics returns as a function of grain and straw yield and selling price varied during all the years. The average total return under demonstration plot was recorded Rs. 33191 ha^{-1} (Table 5). The higher effective gain of Rs. 5357 ha^{-1} was obtained under demonstration. The higher additional returns and effective gain under demonstration could be due to improved technology, non-monetary factors, timely operations of crop cultivation and scientific monitoring. Big difference in incremental B:C ratio (IBCR) was found during all five years which was 4.07 to 7.71 while, on the average of five year basis, IBCR was found 5.65 which was higher enough. Higher IBCR could be due to higher additional return with low additional cost in demonstration and also correlated with selling price. The results confirm with the finding of Front Line Demonstration by Parmar *et al*. (2016), Jain (2018) and Jain *et al.* (2022) in pearl millet; Hussain *et al.* (2018) in wheat; Hussain *et al.* (2019) and Ali *et al*. (2020a) in barley; Ali *et al*. (2020d) in chickpea and Ali *et al*. (2022) in groundnut.

Conclusions

On the basis of five years of Front Line Demonstration it can be concluded that by adopting recommended package of practices pearl millet yield can be increased to 24.75% over farmer's practices. The increase was recorded with little extra spending of Rs. 1240 ha^{-1}, which is an affordable amount for small and marginal farmers. The adoption of improved technology not affected by the additional cost but the ignorance and unawareness was seen to be the primary reason and it is quite appropriate to call such yield gap as extension gap. Moreover, extension gap can be also be minimized by adopting such technology under FLD. The IBCR (5.65) recorded was much high to motivate the farmers for adoption of the technology package. Therefore, Front Line Demonstration of pearl millet was found effective for farmers in changing mind sate, attitude, skill and knowledge of improved practices of pearl millet cultivation including adaption. Farmers and scientist relationship has also improved by conduct of the FLDs, technology effectiveness helped in building confidence over the scientific efforts placed for developing the technology and also its dissemination by KVKs. The farmers selected for conduct of the demonstrations have become a primary source of knowledge and information on improved practices of pearl millet cultivation for its lateral dissemination among the farming community.

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Printed in June 2023