Indian J. Dryland Agric. Res. & Dev. 2024 39(1): 39-45 10.5958/2231-6701.2024.00007.3

Assessment of Biofortified Wheat Varieties for Nutritional Security in Eastern India

Anjani Kumar[1], Amrendra Kumar[1]*, D.V. Singh[1], Mohammad Monobrullah[1], Priyanka Kumari[1], Tejaswini Kapil[2], Ramakant Singh[3], Dibyanshu Shekhar[4], P.K. Pankaj[5], Keshava[6] and U.S. Gautam[6]

[1]*ICAR- Agricultural Technology Application Research Institute, Zone IV, Patna-801 506, Bihar*

[2]*KVK East Champaran,* [3]*KVK Rohtash,* [4]*KVK Darbhanga-845 429, Bihar*

[5]*ICAR-Central Research Institute for Dryland Agriculture, Hyderabad-500 059, Telangana*

[6]*ICAR-Division of Agricultural Extension, New Delhi-110 012*

*E-mail: amrendra14d@gmail.com

ABSTRACT: The present study was carried out during the *rabi* seasons of 2021-22 and 2022-23 at farmers' fields under ICAR-ATARI, Patna with the help of 7 KVKs to assess the performance of 4 biofortified wheat varieties for mitigating hidden hunger and malnutrition in pregnant women and preschoolers. Standard norms of frontline demonstration were adopted at 10 sites involving farmers at 100 different locations. Primary data on yield parameters of the demonstration plot and secondary source data of district level, state level and potential yield level of biofortified wheat varieties were collected and statistically analyzed. The highest demonstration yield (55.5 q/ha) was recorded in Muzaffarpur var. DBW 332 under ACZ-I. The state yield was 29.5 q/ha against the potential yield of 48.80 to 78.30 q/ha for different biofortified varieties. The local check yield was highest (43.2 q/ha) in Muzaffarpur district which lies in Bihar ACZ- I. The district level absolute yield gap w.r.t potential yield was highest in Muzaffarpur in DBW 332 variety (56.27 q/ha) followed by Kishanganj in var. HPBW 01 (29.33 q/ha). Maximum technology gap (30.52 q/ha) was recorded in Kishanganj district with highest technology index (59.03 %) while highest extension gap (12.90 q/ha) was recorded in Muzaffarpur district. Higher net returns (32.92%) and B:C ratio (2.81) under demonstration over farmer's practice was recorded in Muzaffarpur.

Keywords: Biofortified varietal assessment, nutritional security, technology gap, wheat, yield

Introduction

Wheat occupies the prime position among the food crops in the world. Nearly 55% of the world population depends on wheat for about 20% of calories intake. In India, wheat is the second important food crop being next to rice and contributes to the total food grain production of the country to the extent of about 25%. The diverse environmental conditions and food habits of people in India supports the cultivation of three types of wheat (bread, durum and dicoccum). Among these, bread wheat is contributing approximately 95% to total production while another 4% comes from durum wheat and close to 1% from dicoccum (Kumar *et al*., 2014). In developing countries, particularly in South and West Asia, about half a billion people are iron deficient having wheat as their staple food. The main objective of biofortifying wheat is to develop nutritionally enhanced wheat to increase people's intake of iron and zinc (Velu *et al*., 2012). Biofortified crops, which are bred to contain higher quantities of nutrients, can be one part of the answer to the problem of rampant nutritional insecurity among India's poorer populations. Biofortified grains help meet the nutritional needs of populations lacking access to naturally nutrient-rich foods due to availability or affordability issues. Introducing biofortified wheat varieties is a key food-based strategy to enhance nutritional security, complementing dietary diversification, supplementation, and commercial fortification. Bihar needs biofortified crops to overcome the problem of malnutrition. The challenge before the state is two-fold: first, it expects to feed its every citizen stomach full, and the next, it should ensure nutrition to all the people. Biofortified crops, particularly wheat, present a viable option. The multiplication and distribution of seeds of biofortified crops is the foremost priority. In Bihar, both the government and privately-owned agencies are involved in the multiplication and distribution of seeds. Considering the nature of the biofortified crops and their popularity, the state agriculture policy and the existing market, it is necessary to identify possible options to promote biofortified varieties.

In this paper, the scope of biofortified iron- and zinc-rich wheat into the diets of people in Bihar and nutritional security as well as yield gap minimization in Indo-Gangetic plain of Eastern region was explored.

Material and Methods

The present study was the part of frontline demonstrations (FLDs) on biofortified wheat varieties conducted by KVKs of the ATARI Zone IV in three agroclimatic zones of Bihar. FLDs on wheat varieties were conducted during *rabi* season of 2021-22 and 2022-23 in 7 districts of Bihar (Muzaffarpur, East Champaran, Darbhanga, Katihar, Kishanganj, Aurangabad and Rohtas) (Table 1). Before conducting the FLDs, training on scientific cultivation and management of biofortified wheat was organized for selected farmers. Under FLDs, all the recommended package of practices of the district were adopted. Demonstration on four biofortified wheat varieties viz. HPBW 01, DBW 18, WB 02 and DBW 332 released from different institutions (Table 1) were conducted and comparative analysis was made with farmer's practices.

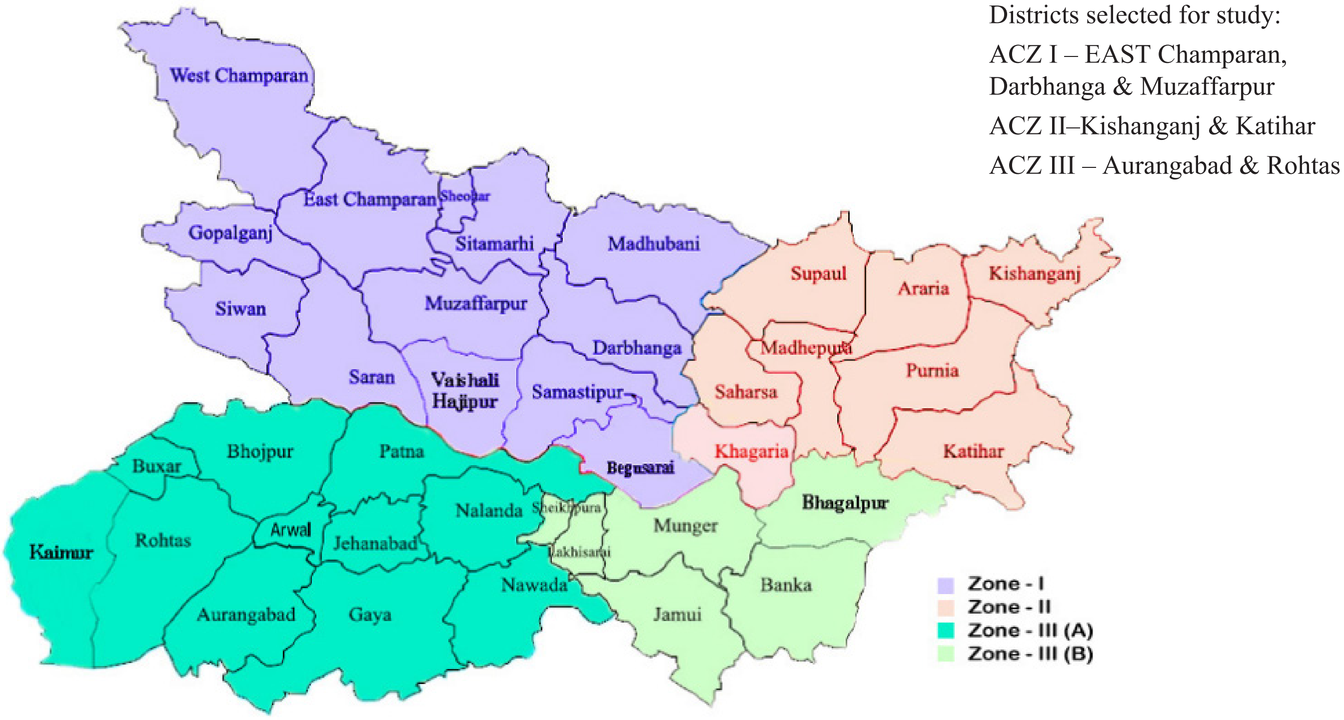

Fig. 1: ACZ-wise districts for demonstration of biofortified wheat varieties in Bihar

Table 1: Details of district, biofortified varieties and nutritional values

Variety	Year of release	Maturity period (days)	District	Nutritional value	Potential yield (q/ha)
HPBW 01	2017	141	Katihar, Aurangabad, Kishanganj, Rohtas	Fe (40 ppm) Zn (40.6 ppm)	51.7
DBW 187	2020	120	Muzaffarpur, East Champaran, Darbhanga	Fe (43.1 ppm)	48.8
WB 02	2017	142	Katihar, East Champaran, Darbhanga	Zn (42 ppm) Fe (40 ppm)	51.6
DBW 332	2021	156	Muzaffarpur	Fe (43.1ppm) Protein (12.2 ppm)	78.3

The demonstrations on farmers' fields were facilitated by KVK scientists in performing field operations like sowing, fertilizer application, water management, weed management, plant protection measures, harvesting etc. However, traditional practices were adopted in case of local checks/ farmer's practices. Necessary steps for selection of site and farmers, layout of demonstration, etc. were followed as suggested by Choudhary (1999). For popularization of demonstrated technology, field day was conducted with support of extension functionaries of district department and local farmers. For the analysis, data of demonstration (demo), local check (farmer's practices), district, state yield and potential yield were collected. The demo yield and net returns data were analyzed. For the estimation of technology gap, extension gap and technology index, the formulae were used as per method of Sagar and Chandra (2004) and Kumar *et al*. (2023).

Yield advantage: Yield advantage was the extent of gain in the reported yield of wheat at district level, state level and farmers' field level as against the average yield obtained in the demonstrations.

$$\text{Yield advantage (\%)} = \sum_{i=1}^{n} \frac{(\text{Pyi} - \text{Ryi})_{\text{DSF}}}{\text{Dyi}}$$

where, Py_i is the Potential yield of ith farmer, Dy_i is the demonstration yield of ith farmer and Ryi is the reported yield for the ith farmer against the district (D), state (S) and farmer (F) yield.

The estimation of technology gap, extension gap and technology index and yield gap minimized were estimated using following formula (Kadian *et al*., 1997, Samui *et al*., 2000, Dwivedi *et al*., 2014):

i) $\text{Percent yield increase} = \frac{\text{Demonstration yield} - \text{Farmer's yield}}{\text{Farmer's yield}}$

ii) Technology gap = Potential yield - Demonstration plot average yield

iii) Extension gap = Demonstration plot average yield - Farmer's plot average yield

iv) $\text{Technology Index} = \frac{Pi - Di}{Pi} \times 100$

where, Pi = Potential yield of i crop and Di =Average demonstration plot yield of i crop.

Results and Discussion

Yield of biofortified wheat varieties

The demonstration yield analysis of biofortified wheat and normal wheat varieties at district level, state level and farmer's level were recorded from different agroclimatic zones (ACZ) of Bihar viz. Zone 1, Zone II and Zone III A. Biofortified wheat varieties yield ranged between 21.18 to 55.50 q/ha in Kishanganj and Muzaffarpur district compared to farmers' practice (19.50 to 43.20 q/ha) (Table 2). Lowest yield was recorded in Kishanganj district (ACZ-II) whereas, highest yield was recorded in Muzaffarpur district (ACZ-I). The yield increase over farmer's practices ranged from 2.27-36.61% and lowest increase was recorded in Aurangabad district and highest in Rohtas district. The yield under farmers' practice (19.50 q/ha) in Kishanganj district was even lower than the district average yield and state average yield. Rana *et al*. (2002) and Kumar *et al.* (2023) concluded that field demonstrations are quite effective in bridging the production gaps between improved and farmer practices in cereals and pulses. The results also indicated that maximum increase in yield (36.61%) was observed in Rohtas district followed by Muzaffarpur district (30.28%). While lowest value (2.27%) was recorded in Aurangabad district. There was major yield gap in the demonstration and farmers plot in different ACZs of Bihar. This was mainly due to climatic conditions, sowing window and adoption of agronomic practices (Dubey *et al.*, 2018).

Table 2: Performance of biofortified wheat varieties

Variety	District	ACZ	Av. demo yield (q/ha)	Av. FP yield (q/ha)	PY (q/ha)	DY (q/ha)	SY (q/ha)	% increase
HPBW 01	Kishanganj	ACZ-II	21.18	19.50	51.70	22.37	29.50	8.6
	Katihar		37.05	33.80	51.70	29.26	29.50	9.6
	Aurangabad	ACZ-IIIA	31.50	30.80	51.70	23.60	29.50	2.2
	Rohtas		42.35	31.00	51.70	34.19	29.50	36.6
WB 02	Katihar	ACZ-II	40.70	31.50	51.60	29.26	29.50	29.2
	E. Champaran	ACZ-I	44.40	38.40	51.60	24.64	29.50	15.6
	Darbhanga		42.00	39.20	51.60	22.59	29.50	7.1
DBW 187	E. Champaran		44.12	39.60	48.80	24.64	29.50	11.4
	Darbhanga		43.50	38.40	48.80	22.59	29.50	13.2
	Muzaffarpur		44.90	43.20	48.80	22.03	29.50	3.9
DBW 332	Muzaffarpur		55.50	42.60	78.30	22.03	29.50	30.2
SD			8.68	6.88	8.39	3.98	0.00	11.5
SEM			2.62	2.08	2.53	1.20	0.00	3.4

PY: Potential yield; FP: Farmers practices; DY: District yield; SY: State yield (Year 2022-23)

Yield gap

Yield gap analysis is a powerful tool to assess opportunities to increase agricultural productivity in the district. The absolute yield gap of biofortified wheat varieties with respect to potential yield at the district, state and farmers' level; demonstration yield and yield gap percentage were analyzed and presented in Table 3. The data revealed that variety HPBW 01 depicted larger variation (17.51-29.33 q/ha) in absolute yield gap w.r.t potential yield whereas, varieties WB 02 and DBW 187 had lower difference (22.34-29.01 q/ha) and (24.16-27.77 q/ha), respectively. Whereas, var DBW 332 had the largest absolute yield gap (56.27 q/ha). Absolute yield gap at state level had relatively lower values except in variety DBW 332 in almost all districts. Data at the farmers plot also revealed more differences in case of HPBW 01 in comparison to other varieties WB 02 and DBW 187. The percent yield advantage with respect to demonstration yield was highest in Kishanganj district in variety HPBW 01 under Bihar ACZ II at all levels DYGP, SYGP and

FYGP and minimum yield advantage in Bihar ACZ I districts. However, variety DBW 332 had the highest value in both the parameters at all level may be due to lesser performance of variety in comparison to other varieties as this variety was released for North-West plain zone.

Table 3: Yield gap of biofortified wheat varieties in selected districts of of Bihar

Variety	District	ACZ	Absolute yield gap w.r.t to potential yield (q/ha)			Percent yield advantage w.r.t. demo. yield		
			DYG	SYG	FYG	DYGP	SYGP	FYGP
HPBW 01	Kishanganj	Bihar ACZ-II	29.33	22.20	32.20	138.4	104.8	152.0
	Katihar		22.44	22.20	17.90	60.5	59.9	48.3
	Aurangabad	Bihar ACZ-IIIA	28.10	22.20	20.90	89.2	70.4	66.3
	Rohtas		17.51	22.20	20.70	41.3	52.4	48.8
WB 02	Katihar	Bihar ACZ-II	22.34	22.10	20.10	54.8	54.3	49.3
	East Champaran	Bihar ACZ-I	26.96	22.10	13.20	60.7	49.7	29.7
	Darbhanga		29.01	22.10	12.40	69.0	52.6	29.5
DBW 187	East Champaran		24.16	19.30	9.20	54.7	43.7	20.8
	Darbhanga		26.21	19.30	10.40	60.2	44.3	23.9
	Muzaffarpur		26.77	19.30	5.60	59.6	42.9	12.4
DBW 332	Muzaffarpur		56.27	48.80	35.70	101.3	87.9	64.3
SD			8.68	6.88	9.98	8.3	9.3	27.6
SEM			2.62	2.08	3.01	2.5	2.8	8.3

DYG: District yield gap; SYG: State yield gap; FYG: Farmer's yield advantage; DYGP: District yield gap percentage; SYGP: State yield gap percentage; FYGP: Farmer's yield gap percentage

Yield advantage of biofortified varieties

Yield advantage provides a comparative analysis of demonstration yield over district, state and farmers field level. Date on variety-wise quantitative yield advantage and percent yield advantage are presented in Table 4. Biofortified varieties WB 02, DBW 187, DBW 332 and HPBW 01 showed quantitative yield advantage over demo varieties in all the districts except Kishanganj district where negative values were recorded at district and state level. Maximum district and state yield advantage of 33.47 and 26.00 q/ha, respectively was recorded in Muzaffarpur district for variety DBW 332. Similarly, higher percentage yield advantage was also recorded in Muzaffarpur over district and state average yield. The best variety was DBW 332 with the highest yield performance in Muzaffarpur, though it exhibits variability in terms of declines in percentage yield. The most consistent variety was DBW 187 which showed a consistent positive gain in all regions, both in quantitative and percentage terms, making it the most reliable performer overall. Mixed performance was exhibited by var HPBW 01 with wide variability in performance, with significant declines in some districts but moderate gains in others. Variety WB 02 showed steady results and performed well across all districts, with moderate but consistent gains. The overall trend suggests that DBW 187 and DBW 332 were the most promising varieties in terms of both quantitative and percentage yield advantages, while HPBW-01 showed variability in performance depending on the district.

Technology gap and impact over farmers' practices of biofortified wheat varieties

The technology gap refers to difference between potential yield and demonstration plot yield. For biofortified wheat varieties (HPBW 01, WB 02, DBW 187 and DBW 332), maximum technology gap was recorded in Kishanganj (30.52) in var. HPBW 01 and lowest in Darbhanga (3.90) in var. DBW 187 followed by Muzaffarpur (22.80) in var. DBW 332 and East Champaran (4.68) in var. DBW 187 (Fig. 2). These findings are in line with findings of Singh *et al.* (2023).

Extension gap

Extension gap refers to yield difference between demonstration yield and farmers' yield. This gap can be minimized by different extension activities such as front-line demonstration, farmer's awareness training programme etc. (Kumar *et al.*, 2023). Muzaffarpur district recorded highest extension gap (12.90) for the var. DBW 332 and lowest (0.70) in Aurangabad district for var. HPBW 01 followed by Rohtas (11.35) for var. HPBW 01 and Muzaffarpur (1.70) for var. DBW 187 (Fig. 2). These findings are in line with findings of Kumar *et al.* (2023), Choudhary (2013) and Dwivedi *et al.* (2014).

Table 4: Yield advantage of biofortified wheat varieties in selected district of Bihar

Variety	District	Quantitative yield advantage (q/ha) w.r.t. demo. yield			Percent yield advantage w.r.t. demo. Yield		
		DYA	SYA	FYA	DYA	SYA	FYA
HPBW 01	Kishanganj	-1.19	-8.32	1.68	-39.28	-39.28	7.93
	Katihar	7.79	7.55	3.25	20.38	20.38	8.77
	Aurangabad	7.90	2.00	0.70	6.35	6.35	2.22
	Rohtas	8.16	12.85	11.35	30.34	30.34	26.80
WB 02	Katihar	11.44	11.20	9.20	27.52	27.52	22.60
	East Champaran	19.76	14.90	6.00	33.56	33.56	13.51
	Darbhanga	19.41	12.50	2.80	29.76	29.76	6.67
DBW 187	East Champaran	19.48	14.62	4.52	33.14	33.14	10.24
	Darbhanga	20.91	14.00	5.10	32.18	32.18	11.72
	Muzaffarpur	22.87	15.40	1.70	34.30	34.30	3.79
DBW 332	Muzaffarpur	33.47	26.00	12.90	46.85	46.85	23.24
SD		9.60	8.68	4.10	18.98	22.97	8.24
SEM		2.89	2.62	1.24	5.72	6.93	2.48

DYA: District Yield Advantage; SYA: State Yield Advantage; FYA: Farmer's Yield Advantage

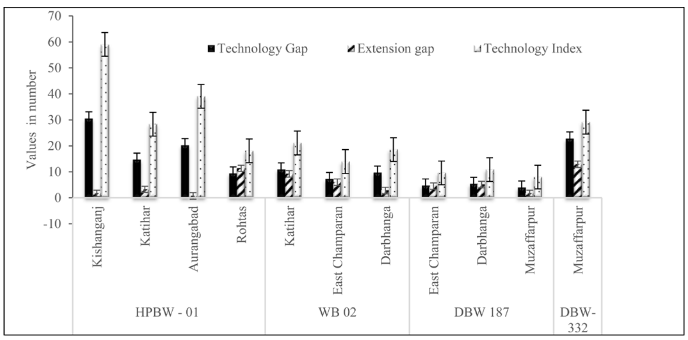

Fig 2: Extension gap, technology gap and technology index in different districts

Technology Index

Technology index is another important tool for judging the adoption and impact of different technologies. It is derived as the ratio between technology gap and potential yield in terms of percentage. Lower value of technology index means better performance of technological intervention. In the present study, technology index varied from 7.99 to 59.03 with highest (59.03) in Kishanganj district for Var. HPBW 01 and lowest (7.99) was recorded in Muzaffarpur district with var. DBW 187 followed by Aurangabad (39.07) with var. HPBW 01 and lowest in East Champaran (9.59) with var. DBW 187. Similar results were also obtained by Choudhary (2013). Large variation in technology index might be due to variation in existing weather condition, soil fertility status and insect-pest infestation.

Economics

Economic analysis of data indicated that cost of cultivation under farmers practice was lower compared to demonstration plot (Table 5). The higher cost of cultivation under demonstration was mainly due to adoption of seed treatment package, balanced nutrient management and water management. Net returns of demonstration were higher than that of farmer's practice in all districts. Higher net returns of Rs 75940/ha were recorded in Muzaffarpur with var. DBW 332 and lower in Kishanganj (Rs 17610/ha) in var HPBW 01. Maximum B:C ratio (2.81) was recorded in Muzaffarpur and minimum B:C ratio (1.64) in Kishanganj. In case of farmers yield, B:C ratio of 2.71 was recorded with demonstration and 1.55 with farmer's practice. B:C ratio of demonstration yield was comparatively higher than of farmer's practices which showed that technology under demonstration was supportive to farmers and economically viable (Khedkar *et al*., 2017; Singh 2016, Kumar *et al.,* 2023). Potential yield of biofortified wheat varieties can be achieved by imparting scientific knowledge to the farmers, providing the quality seeds, need based advisories and proper application techniques of the inputs. Horizontal spread of improved technologies might be achieved by the successful implementation of frontline demonstrations and various extensions activities.

Table 5: Economics of demonstration (biofortified wheat) and farmer's practice under different agroclimatic conditions of Bihar

Bihar ACZ	Variety	District	Demonstration yield			Farmers yield		
			COC	NR	BCR	COC	NR	BCR
ACZ-II	HPBW 01	Kishanganj	27400	17610	1.64	26700	14740	1.55
		Katihar	33700	45040	2.34	31900	39930	2.25
ACZ-IIIA		Aurangabad	31300	35640	2.14	30900	34550	2.12
		Rohtas	36400	53600	2.47	34000	31880	1.94
ACZ-II	WB 02	Katihar	37000	49490	2.34	31200	35740	2.15
ACZ-I		E. Champaran	37900	56450	2.49	33900	47700	2.41
		Darbhanga	34800	54450	2.56	33900	49400	2.46
	DBW 187	E. Champaran	36400	57360	2.58	35700	48450	2.36
		Darbhanga	36000	56440	2.57	32300	49300	2.53
		Muzaffarpur	36800	58620	2.59	35800	56000	2.56
	DBW 332	Muzaffarpur	42000	75940	2.81	33400	57130	2.71

COC: Cost of cultivation; NR: Net return; BCR: Benefit:cost ratio

Conclusion

It was observed that the FLD program effectively communicated technical messages and shifted the attitudes of other farmers toward adopting new and improved farming and management practices. Higher demonstration yields not only reduced technology gap but also created interest among farmers in adopting demonstrated technology which ultimately bridges the extension gap. Lower technology index value showed better performance of technological intervention. Adoption of biofortified wheat varieties result in higher yield and economic returns.

Acknowledgements

The financial and monitoring facility given by ICAR-ATARI, Patna, Zone-IV, KVK East Champaran, Muzaffarpur, Kishanganj, Darbhanga, Aurangabad, Katihar and Rohtas is duly acknowledged.

References

Choudhary AK. 2013. Technological and extension yield gaps in oilseeds in Mandi district of Himachal Pradesh. *Indian Journal of Soil Conservation,* 41(1): 88-97.

Choudhary BN. 1999. Krishi Vigyan Kendra-A guide for KVK manager. *Division of Agriculture Extension, ICAR,* 73-78.

Dubey SK, Gautam US, Singh AK, Singh A, Chahal VP, Singh AK, Singh C and Srivastava A. 2018. Quantifying the yield gap minimization in lentil (*Lens culinaris*) under cluster frontline demonstrations (CFLD) conducted in Uttar Pradesh. *Indian Journal of Agricultural Sciences,* 88(6): 851-859.

Dwivedi AP, Mishra A, Singh SK and Singh M. 2014. Yield gap analysis through front line demonstration in different agro-climatic zones of M.P and Chhattisgarh. *Journal of Food Legumes,* 27(1): 60-63.

Kadian KS, Sharma R and Sharma AK. 1997. Evaluation of frontline demonstration trials on oilseeds in Kangra valley of Himachal Pradesh. *Annals of Agricultural Sciences,* 18(1): 40-43.

Khedkar R, Shinde V and Chaudhari P. 2017. Role of cluster frontline demonstrations in enhancement of chickpea production. *Journal of Krishi Vigyan,* 6(1): 940-942.

Kumar A, Kumar A, Kumari P and Kumar S. 2023. Impact assessment of CFLD pulses on pigeon pea productivity and profitability in farmer's field. *Indian Journal of Extension Education*, 59 (2): 36-40.

Kumar A, Singh R, Singh G, Sharma RK, Saharan MS, Chhokar RS, Tyagi BS, Sendhi R and Sharma I. 2014. Wheat cultivation in India. Directorate of Wheat Research, Karnal, Ext. Bullet., 52, 34.

Rana VS, Malik AC, Midha LK. 2002. Evaluating gaps in transfer of dryland technology in mustard front line demonstration in Haryana. *Haryana Journal of Agronomy,* 18(1&2): 1148-1149.

Sagar RL, Chandra G, Sagar RL and Chandra G. 2004. Evaluation of front-line demonstration on mustard in India. *Indian Journal of Extension Education,* 40(3 & 4): 96-7

Samui SK, Maitra S, Roy DK, Mandal AK and Saha D. 2000. Evaluation on front line demonstration on groundnut. *Journal of Indian Society of Coastal Agricultural Research,* 18(2): 180-183.

Singh KK, Singh PK, Kumar P and Singh O. 2023. Evaluation of biofortified wheat varieties in district Bijnor (Uttar Pradesh) with the special reference to the yield performance, yield gap and their adoption in district. *International Journal of Environment and climate change,* 13(9): 299-304.

Singh R. 2016. Productivity enhancement of chickpea (*Cicer arietinum*) through improved production technologies on farmer's field. *Indian Journal of Agricultural Sciences,* 86(10): 1357–1360.

Velu G, Singh RP, Huerta-Espino J, Peña RJ, Arun B, Singh MA and Pfeiffer WH. 2012. Performance of biofortified spring wheat genotypes in target environments for grain zinc and iron concentrations. *Field Crop Research,* 137: 261-267.

Received: April 2024 Accepted: June 2024