Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(3): 970-973
Received: 10-03-2020
Accepted: 14-04-2020

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Enhancement of yield and economic returns of Wheat (*Triticum aestivum* L) through Frontline demonstrations in Kota district of Rajasthan

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DOI: https://doi.org/10.22271/phyto.2020.v9.i3p.11414

Abstract
Wheat is a major rabi crop in Kota district of Rajasthan covering more than 50 per cent sown acreage. To demonstrate the existing production potential of improved variety Raj-4079 and technologies, frontline demonstrations were conducted on wheat crop by Krishi Vigyan Kendra, Kota during rabi 2016-17 to 2019-20 on 150 farmer fields. Major interventions under demonstration consisted of improved variety Raj-4079, seed treatment with carbendazim50 WP @2.0 g/kg^{-1}seed & inoculation of Azotobacter & PSB culture, optimum seed rate 100-120 kg ha^{-1}, recommended doses of NP (120-40 kg ha^{-1}) with proper scheduling, soil application of zinc sulphate @ 25 kg ha^{-1} and need based weed management. Study of four years data reveled that demonstrated technologies recorded mean grain yield of 50.55q ha^{-1} which represents 12.20 per cent yield enhancement over local check (45.06 q ha^{-1}). Economic analysis confirmed the feasibility of the demonstrated techniques. Mean additional cost of improved technologies recorded to be Rs.1098 ha^{-1} which in turn, provided average addition returns of Rs. 8315 ha^{-1}. Improved techniques on pooled basis, fetched net returns of Rs.61170 ha^{-1} with B:C ratio of 3.09, higher in comparison to local practice (Rs.52856 ha^{-1}, B:C ratio 2.87). Analysis of yield gap shows average extension gap of 5.50 q ha^{-1} which clearly emphasizes the need for bridging existing extension gap through transferring the improved technologies. Values of technology gap ranged from 11.07 to 15.40 q ha^{-1}, with a four years mean of 13.20q ha^{-1}while technology index in the present study varied between 17.66 to 24.72 per cent.

Keywords: Wheat, B:C ratio, frontline demonstration, technology index, yield gap

Introduction
Wheat (*Triticum aestivum* L.) is the largest cultivated food crop in the world (USDA,2019) [1] and is the second most important cereal after rice in India. Wheat is a major contributor to the food security system and Indian economy, occupies 29.55 million hectares area and produced 101.20 million tonnes of wheat in 2018-19 (ICAR-IIWBR, 2019) [2]. Rajasthan is one of the major wheat producing states which share about 10 per cent in both area as well as production in India with fourth rank. In Rajasthan, area and production of wheat during 2016-17 was recorded as 3.19 million ha and 11.00 million tonnes, respectively with an average productivity of 3368 kg ha^{-1}. Wheat is a major *rabi* crop of the district Kota covering more than 50 per cent acreage of total *rabi* sown area. As per the average of last five years ending in 2016-17, wheat was cultivated in the area of 1.32 lakh ha with average productivity of 3716 kg ha^{-1} in the Kota district (Anonymous, 2017) [3]. More than 95 per cent of its net sown area is irrigated in the district and soils are clay loam with higher production potential, However, the productivity in the district is stagnated around 40-42 q ha^{-1}. Major factors behind yield stagnation of wheat in the district includes use of old varieties, inadequate & improper fertilizer use, lack of bio-fertilizers & Zn application, lack of seed treatment, improper irrigation scheduling, lack of proper weed management and use of high seed rate. Beside, high temperature stress at crop maturity phase is also being a climatic yield limiting factor. There are several technologies generated at agricultural universities and research stations but the productivity of wheat is still stagnated due to extension gap. Frontline demonstrations (FLD) is most effective tool for transfer of improved technologies among the farmers, because farmers in general, are driven by the perception that 'seeing is believing'. The main objective of frontline demonstration is to demonstrate newly released crop production technologies and its management practices under different farming situations. Therefore, frontline demonstrations were laid out on wheat crop during *rabi* seasons of the year 2016-17 to 2019-20 on farmer's fields in Kota district under irrigated conditions with the objectives of demonstrating the

performance of improved variety Raj 4079 and recommended improved agro-techniques and to analyse the economics returns of FLDs on wheat.

Material and Methods

Frontline demonstrations (FLDs) were conducted on wheat crop by the Krishi Vigyan Kendra Kota to assess the performance of improved variety Raj-4079 and recommended technologies during four consecutive *rabi* seasons 2016-17 to 2019-20 on 125 farmer fields of the Kota district (Rajasthan). Farmer's for the FLDs were selected based on group meeting taking in to consideration mainly the suitable site and adaptive attitude of the farmers and after final selection, FLDs were laid out in in total 50 ha area covering nine different villages of operational area of KVK, Kota namely Gandifali, Bhandahera, Haripura Manjhi, Rajpura, Bhunen. Manasgaon, Railgaon, Aanwa and Charinda. Kota District falls under Agro-climatic Zone-V "Humid South-eastern plain zone" of Rajasthan. The climate in the district is semi-arid and moderate. Soils of the study area are clay loam in texture with low nitrogen, low to medium phosphorus, high in available potassium and widely deficient in zinc. The area under each FLD's were kept 0.4 ha. The demonstrations were laid out on irrigated fields with soybean-wheat, paddy-wheat and blackgram-wheat rotations which are most prevalent in the area. Technological interventions demonstrated under FLDs mainly consisted of improved variety Raj-4079, seed treatment with carbendazim 50 WP @ 2 g kg^{-1}seed and integrated nutrient management (N 120 kg & P 40 kg ha^{-1} + *Azotobector*+ PSB @ 600g ha^{-1}, soil application of zinc sulphate @ 25 kg ha^{-1}). Farmers were also suggested for efficient use of fertilizers by drilling in furrows, split application of urea, need based weed management and irrigation at critical stages.

Table 1: Comparison between farmers practice and demonstrated FLD interventions

Technological point	Existing Farmer's practice	Improved technology under FLD
Variety	Local seed /variety Raj-4037, Lok-1	Variety Raj-4079
Seed rate	Seed rate 140-160 kg ha^{-1}	Seed rate 100-120 kg ha^{-1}
Seed treatment	No or rare proper seed treatment	Seed treatment with carbendazim 50WP @ 2.0 g kg^{-1}seed
Bio-fertilizer inoculation	No use of Azotobacter and PSB cultures	Inoculation with Azotobacter and PSB cultures
Fertilizer application	Improper method of use of NP fertilizers (N 120 kg & P 50 kg ha^{-1}) (DAP fertilizer mixed with seed, use of urea at first irrigation only)	Recommended doses of N 120 Kg & P 40 kg ha^{-1}, $ZnSo_4$ 25 kg ha^{-1} (Drilling of DAP fertilizer below seed, split application of urea)
Weed management	Inadequate weed management. Use of ready mixed herbicides at 30-45 DAS	2,4-D Easter salt @ 500 g ai/ha for broad leaved weeds, Sulfosulfuron @ 25g ai/ha for grassy weeds and other ready mixed recommended herbicides for mixed population at 30-35 DAS

Before onset of sowing time, trainings on improved technological interventions of wheat were conducted for the selected farmers. Critical inputs of demonstrations were decided based on technological gap analysis and provided to the farmers and other suggested inputs were managed by farmers. The sowing was done during first week of November to first week of December by drilling in 22.5 cm rows apart with seed rate of 100-120 kg ha^{-1} and harvesting of crop was done during first fortnight of April. All steps like site and farmer selection, layout of demonstration, farmer's participation etc. were followed as suggested by Choudhary (1999) [4]. Monitoring of FLD sites were done by periodical visits of KVK scientists and needful suggestion were given to the farmers. Field days were also organized at crop maturity to demonstrate the results of FLDs among other farmers of the neighboring area for acceptance & further adoption of improved technologies. Data related to yield performance and cost of cultivation were collected separately for FLD plots and farmers practice (local check) plots. The average prices of inputs and output commodities prevailed during each year of demonstrations were taken for calculating cost of cultivation, net return and benefit cost ratio. The technology gap, extension gap and technology index were calculated as suggested by Samui *et al.* (2000) [5].

Technology gap = Potential yield - Demonstration yield
Extension gap = Demonstration yield - Farmers yield
Technology index (%) = (Technology gap/ Potential yield) × 100

Results and Discussion

Yield performance: The data on average yield of wheat recorded over the years under FLD plots as well as farmers practice are presented in table 2. The data clearly shows that application of improved technologies resulted in substantially higher wheat grain yield in comparison to local check (farmer's practice) during all the four years (2016-17 to 2019-20). The yield of wheat during four years ranges from 48.93 to 53.52 q ha^{-1} under improved technologies as against 43.20 to 47.14 q ha^{-1} under local check. Highest yield under improved as well as farmers practice was recorded during the year 2019-20 which might be due to favourable low temperature conditions prevailed at maturity phage during the season. Pooled data of four years reveals that improved technologies gave mean yield of 50.55 q ha^{-1} which represents 12.20 per cent increase over local check (45.06 q ha^{-1}). The higher productivity of wheat under demonstration in comparison to farmers local practice could be ascribed to the use of improved variety Raj-4079 which might have perform well under higher temperature conditions at maturity phase, as it has been reported as heat tolerant variety (Kumar *et al.* 2018) [6]. Improved agronomic practices *viz*. use of optimum seed rates, proper use of recommended doses of NP fertilizers, bio-fertilizers inoculants and zinc sulphate application might have contributed in yield enhancement over farmer practice. Similar yield enhancement trends in wheat crop due to application of improved technologies were also reported in different locations by Sharma *et al.* (2013) [7]. Verma *et al.* (2014) [8] and Kanojia *et al.* (2020) [9].

Table 2: Yield performance under Front Line Demonstrations of wheat in Kota District

Season & Year	No. of FLD	Area of FLD (ha)	Yield (q/ha)		Per cent increase in yield over FP
			IT	FP	
Rabi 2016-17	25	10.0	49.60	44.08	12.50
Rabi 2017-18	40	16.0	48.93	43.20	13.26
Rabi 2018-19	40	16.0	50.15	45.80	8.68
Rabi 2019-20	20	8.0	53.52	47.14	13.53
Total/Mean	125	50.0	50.55	45.06	12.20

IT- Improved techniques FP- Farmer's local practice

Yield gap & Technology Index: Analysis on yield gap of wheat crop in Kota district (table-3) reveals that extension gap in present study ranged from 4.35 to 6.38 q ha^{-1} with an average of 5.50 q ha^{-1} during the period of demonstration which emphasizes the need for transferring the feasible improved technologies among farmers to bridge the extension yield gap. Technology gap which implies researchable issues for realization of potential yield ranged from 11.07to 15.40 q ha^{-1}. On average basis, the technology gap of all the 150 demonstrations was found to be 13.20 q ha^{-1}. Yearly variation in the technology gap might be due to dissimilarity in soil fertility status, temperature variation as well as change in location of demonstration sites. Technology index shows the feasibility of evolved technology at the farmer's field and lower the value of technology index more is the feasibility of the technology (Katare *et al*., 2011) [10]. Technology index in the present study varied between 17.66 to 24.72 per cent and averaged 22.23 per cent.

Table 3: Yield gap and technology index under Front Line Demonstrations of wheat

Season & Year	Potential Yield (q/ha)	Extension Gap (q/ha)	Technology Gap (q/ha)	Technology Index (%)
Rabi 2016-17	65.0	5.52	15.40	23.69
Rabi 2017-18	65.0	5.73	11.07	24.72
Rabi 2018-19	65.0	4.35	14.85	22.85
Rabi 2019-20	65.0	6.38	11.48	17.66
Total/Mean	65.0	5.50	13.20	22.23

IT- Improved techniques FP- Farmer's local practice

Economic Analysis: Based on average prices of inputs and output commodities prevailed during each year of demonstrations, values of economic indicators i.e. gross cost of cultivation, gross returns, net returns and B:C ratio are presented in table 4. The data clearly indicates that cost of cultivation of wheat increased over the years which might be ascribed to the increased cost of cash inputs and labour. The gross cost of cultivation for wheat under improved practice ranged from Rs. 26304 to 32667 ha^{-1} with a mean value of Rs. 29295 ha^{-1} against local check where it ranged from Rs.25210 to 31280 ha^{-1} with an average of Rs. 28197 ha^{-1}. Further, higher net returns were fetched under improved technologies in comparison to the farmers practice during all the years of demonstration. Based on four years average, improved technologies fetched net returns of Rs. 61170 ha^{-1} with B:C ratio of 3.09, higher in comparison to local practice (Rs.52856 ha^{-1}, B:C ratio 2.87). Economic analysis further reveals that average additional cost of improved technologies observed to be Rs.1387 ha^{-1} which in turn provided average additional returns of Rs. 8315 ha^{-1} with a mean IBCR value of Rs. 7.57. Higher IBCR and additional returns clearly reveals that demonstrated techniques were found cost effective & feasible for yield enhancement of wheat on farmer's fields. Farmers were also found highly convinced with the technological interventions due to higher economic returns with least additional investment and management practices. The variation in cost benefit ratio during different years might be due to variation in yield performance and input output cost in that particular year.

Table 4: Impact of Front Line Demonstration on economic indicators of wheat in Kota District

Year	Gross Cost (Rs. ha^{-1})		Gross Return (Rs. ha^{-1})		Net Returns (Rs. ha^{-1})		B:C ratio		Add. cost due to IT (Rs. ha^{-1})	Add. Return due to IT (Rs. ha^{-1})	IBCR
	IT	FP	IT	FP	IT	FP	IT	FP			
2016-17	26304	25210	81840	72732	55536	47522	3.11	2.89	1094	8014	7.32
2017-18	26557	25702	84894	76479	58337	50777	3.20	2.98	855	7560	8.84
2018-19	31652	30595	91899	84263	60247	53668	2.90	2.75	1057	6579	6.22
2019-20	32667	31280	103228	90735	70561	59455	3.16	2.90	1387	11106	8.00
Mean	29295	28197	90465	81052	61170	52856	3.09	2.87	1098	8315	7.57

IT- Improved techniques FP- Farmer's local practice

Conclusion

Front line demonstrations conducted on wheat clearly revealed that wheat productivity was enhanced to the extent of 12.2 per cent on farmer fields through improved technologies with least additional cost of only Rs. 1098 ha^{-1}. The average extension gaps of 5.50 q $ha^{-1}$and higher IBCR (7.57) in present study clearly emphasize that yield gap can be minimized by popularizing recommended improved techniques *viz*. variety Raj-4079, seed treatment, proper seed rate, use of bio-fertilizer inoculants, use of recommended fertilizers and weed management techniques. It is concluded that the FLD programme is a successful approach in enhancing the productivity and profitability of wheat crop through changing the knowledge, attitude and skill of farmers.

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