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Research Article

Economic impact of high yielding rust resistant wheat varieties suitable for hill region of Uttarakhand

Renu Jethi[1*], Lakshmi Kant[1], Raghu B.R[2] and NavinChander Gahtyari[1]

[1]*ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora-263601, Uttarakhand, India.*
[2]*ICAR-Indian Institute of Horticultural Research, Bengaluru, Karnataka, India.*

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****Corresponding author***
Email: renujethi2009@gmail.com

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Abstract

Wheat is a major rabi crop grown in hills of Uttarakhand although still under subsistence farming at a majority of the places. Consequently, there is a great scope of increasing the production and productivity in the region with scientific interventions. Frontline demonstrations (FLDs) of improved high yielding varieties *viz.,* VL Gehun 907 and VL Gehun 953 were conducted by ICAR-VPKAS, Almora during rabi 2014-15, 2016-17, 2017-18 and 2018-19 covering a total of 252 farmers. The yield and economic returns of FLD plots were compared with the corresponding farmers' practices. Results revealed that technology index was much lower for VL Gehun 953 (range 8.2 to 23.6) than VL Gehun 907 (range 27.9 to 44.4) at farmers' field which shows that VL Gehun 953 has more potential to achieve higher yield levels under hill conditions. Both the varieties recorded higher gross returns, net returns and B:C ratio in demonstrated plot. The profitability analysis exhibited that VL Gehun 907 with B:C ratio 2.06 (2014-15), 3.02(2016-17), VL Gehun 953 with B:C ratio 2.93(2016-17), 2.80(2017-18) and 2.91(2018-19) were more profitable than local wheat varieties.

Keywords: Wheat, frontline demonstration, economic analysis, Uttarakhand,

1. Introduction

Uttarakhand consists of hilly as well as plain (tarai) areas where wheat *(Triticum aestivum)* is the most important winter food crop. The total area under wheat crop in Uttarakhand was 0.33 million hectares which was 1.12 % of total area under wheat in India. Productivity of wheat in 2018-19 was 2880 kg /ha whereas the national average was 3507 kg/ha (Anonymous, 2019). A wide gap (2482 kg/ha) between the productivity of wheat crop in hilly areas (1028 kg/ha) and tarai areas(3510 kg/ha) of Uttarakhand is a matter of concern (Anonymous, 2017). This low level of productivity in hills is mainly due to non-availability of seed of improved varieties, lack of irrigation facilities, small and fragmented land holdings, shallow soil depth, severe soil erosion, difficult terrain and frequent occurrence of diseases. Application of Farm Yard Manure (FYM) range from 3000 to 8000 kg/ha whereas chemical fertilizers are rarely adopted by the farmers in hill region (Gupta and Kant, 2012). Seed Replacement Rate (SRR) in Uttarakhand is 31.6 % (Anonymous, 2012). Low seed replacement rate, problems in distribution of seed, weak extension mechanism and lack of awareness amongst the farmers were the major factors behind the lack of promotion of certified seeds in the state (State Agriculture Plan, Uttarakhand, 2012-17). As a result of the above described factors, majority of the hill farmers are still cultivating indigenous wheat varieties which can be characterized by having tall and weak stem, more biological yield, small ear head, low harvest index, late in maturity, less responsive to higher doses of inputs and susceptible to rusts and various other diseases. Invariably these local land races are highly susceptible to the prevalent races of rusts (Tandon and Rao, 1986).

The yellow and brown rusts are the important ones for Northern hills. During the recent years, stripe rust caused by *Puccinia striiformis* f. sp. *tritici* has emerged as major threat to the wheat cultivation in hilly areas, consequently to the wheat crop of Plains. In 2010-11; in Uttarakhand hills, stripe rust severity reached up to 80S with high prevalence on the local wheat and around 40S on the non-recommended improved varieties (Kant and Jain, 2011). Cloudy weather with high humidity and low temperature is conducive for rust attack. Many researches emphasized the urgent need of developing stripe rust resistant varieties for nutritional and food security of the country (Sharma and Saharan, 2011).

Keeping these constraints under consideration, ICAR-VPKAS has developed improved rust resistant high yielding wheat varieties like VL Gehun 907 and VL Gehun 953. These varieties are highly resistant to yellow and brown rust, the most prevalent disease in hills.VL Gehun 907 is notified for timely sown rainfed (before 30th October) and irrigated (1-15th November) condition of hills of Uttarakhand, Himanchal Pradesh, Jammu & Kashmir, Manipur and West Bengal. Its potential yield in hill region goes up to 2870 kg/ha under rainfed condition and 4760 kg/ha under irrigated conditions.VL Gehun 953 is notified for irrigated area in hills (under organic) and plains (under inorganic) with a sowing window of 1-15th November. Its potential yield in hill of Uttarakhand goes up to 3700kgha-1under organic irrigated conditions. These improved wheat varieties were demonstrated in farmers' fields, in close supervision of scientists of ICAR-VPKAS, in hill region of Uttarakhand. Frontline demonstration (FLD) is one of the most powerful tools of extension as it has got inherent principle of 'Seeing is believing'. Realizing the importance of frontline demonstrations in transfer of technologies, ICAR-VPKAS, Almora, Uttarakhand is regularly engaged in conducting FLDs on wheat at farmers' field in different hill districts of Uttarakhand with the objective of convincing farmers and extension functionaries together about the production potentialities of the wheat technologies for further wide scale diffusion.

2. Materials and methods

Frontline demonstration on wheat was conducted by ICAR-VPKAS, Almora during the year 2014-15, 2015-16, 2016-17, 2017-18 and 2018-19 involving 39, 62, 90, 130 and 63 farmer beneficiaries, respectively, in different villages of hill districts *viz;* Almora, Bageshwar and PauriGarhwal in Uttarakhand. These were wheat growing areas ranging from low hills (750 meter AMSL) to mid hills (1,450 meter AMSL). Demonstration sites selected were easily accessible to farmers of neighboring villages and extension workers coming from different parts of the district. In order to create better and visible impact of improved variety, these demonstrations were conducted in cluster approach. During year 2015-16 wheat production was affected by severe drought, therefore, data for the year has been excluded for the study as it may grossly vitiate the inferences. Frontline demonstrations were planned at the farmers' field to show worth of improved wheat varieties *viz.,* VL Gehun 907 and VL Gehun 953 along with farmers' practice. In general soil of the area under study was sandy loam having low to medium fertility status. Each demonstration consisted of both scientific and local farmers' variety as control. Sowing of improved wheat varieties were done during 1-15th November. The farmers were provided with critical inputs to be applied as per the scientific package of practices recommended by ICAR-VPKAS, Almora (Table 1). The data on production cost and monetary returns were collected for four consecutive years (2014-15, 2016-17, 2017-18 and 2018-19) from front line demonstrations plots in order to work out the economic feasibility of improved wheat variety cultivation. Besides, the data from traditional farms were also collected where farmers used their own local varieties for cultivation of wheat. Potential yield is the yield of a cultivar when grown in environments to which it is adapted; with nutrients and water non limiting; and with pest, diseases, weeds, lodging and other stresses effectively controlled. In the present study potential yield is the wheat yield obtained on research stations.

The yield data were collected from both the demonstration and farmers' practice by random crop cutting method and analyzed by using simple statistical tools.

Yield increase over farmer' practice (%)=

$$\frac{\text{Demonstration yield} - \text{Local check yield}}{\text{Local check yield}} \times 100$$

Technology gap, extension gap and the technology index were worked out using methods developed by Samui *et al.,* (2000) as stated below:

Technology Gap = Potential Yield – Demonstration Plot Yield

Extension Gap = Demonstration Plot Yield – Farmers' Plot Yield

Technology Index=(Technology gap)/(Potential Yield) x 100

Profitability analysis was done by calculating cost of cultivation of wheat, gross returns and benefit-cost ratio. For estimating cost of cultivation, only operational costs were included i.e., cost incurred on inputs like seed, fertilizers/manure, pesticides, irrigation, labour charges for land preparation, sowing, weeding, harvesting and post-harvest operations. Benefit-cost ratio was worked out as a ratio of gross returns to total cost of cultivation. Z test was used to determine statistical significance on the differences between demonstration yield and farmer's actual yield of wheat.

The problems and constraints faced by the farmers in wheat production were worked out. The farmers were asked to rank the constraints perceived as limiting wheat production in the order of preferences. Based on responses obtained from 40 selected respondent farmers, the Rank Based Quotient (RBQ) for each constraint was calculated.

Rank Based Quotient= (fi (n+1-i))/(N x n) x 100

Where, fi = frequency of farmers for ith rank of the constraints

N = Number of farmers

n = Number of constraints identified

i = concerned ranks

3. Results & discussion

In a majority of the demonstrated villages, the farmers were using local varieties which was invariably mixture of seed of different varieties retained by them over the years. A good amount (approximately on an average 25-30 tunne ha-1) of farm yard manure was available on the farm, therefore, farmers were rarely using chemical fertilizers. Only 11 percent farmers applied chemical fertilizers like urea through broadcasting. In demonstration plots, farmers were provided the quality seed of improved varieties *viz.*,VL Gehun 907 and VL Gehun 953 developed by ICAR-VPKAS, Almora. These varieties are suitable for timely sown rainfed (before 30th October) and irrigated (1-15th November) conditions of hills. These varieties are highly resistant to yellow rust [VL Gehun 907 5S(1.4)], VL Gehun 953 [5S (2.9)] and brown rust [VL Gehun 907 10MS(2.3)], VL Gehun 953 [5MS (2.0)] diseases. The seed was sown in line by some of the farmers whereas others has followed broadcasting as a usual practice. Optimum seed rate of 100 kg/ha was used. Total (Metsulfuron + Sulfosulfuron) @ 16 g ac^{-1} was sprayed 30-35 days after sowing in some of the demonstration plots in irrigated areas, whereas no herbicide was applied in rainfed areas.

The gap between the existing and recommended practices of wheat cultivation in selected villages of hill regions of Uttarakhand is presented in Table 1. Full gap was observed in case of use of improved high yielding wheat varieties suitable for hills, seed rate, seed treatment, fertilizer application, weed management and plant protection which are some of the factors responsible for achieving potential yield. Farmers were not aware about recommended package of practices. Farmers followed broadcast method of sowing against the recommended practice of line sowing, therefore, applied higher seed rate than the recommended.

3.1 Yield analysis of VL Gehun 907

In case of VL Gehun 907, demonstrations were laid in farmers' field during 2014-15 and 2016-17 in 6 and 4 hectares with 39 and 28 farmers, respectively. Results revealed that VL Gehun 907 produced an average yield of 2670 and 3460 kg/ha, which was 49.1 and 37.8 percent higher than local varieties. There was a significant difference between demonstration yield of VL Gehun 907 and farmers actual yield at 0.05 probability level (Table 2).

Technology gap imply researchable issues for realization of potential yield whereas extension gap implies what can be achieved by the transfer of the existing technologies.The trend of technology gap ranging between 2130 to 1340 kg/ha during 2014-15 and 2016-17could be attributed mainly to weather conditions, difference in soil fertility status and hilly terrain of farmers' fields selected for demonstration. The technology index showed the feasibility of the evolved technology at farmers' field. The lower the technology index, more is the feasibility of the technology. The reduction in technology index from 44.4 percent during 2014-15 to 27.9 percent during 2016-17 exhibited the feasibility of the demonstrated technology in this region (Table 3). Similar results have been reported by Deshmukh *et al.,* (2013), Kumar *et al.,* (2010) and Joshi *et al.,* (2014).

3.2 Yield analysis of VL Gehun 953

Demonstrations of VL Gehun 953 were laid in farmers' field during 2016-17, 2017-18 and 2018-19 in 2, 8 and 7.2 hectares with 55, 130 and 63 farmers, respectively in mid hills of Uttarakhand. Results of demonstrations exhibited 40.9 and 20.5 percent higher, respectively, then, the local varieties grown by the farmers. There was a significant difference in demonstration yield of VL Gehun 953 VL

Gehun 953 and farmers' actual yield at 0.05 percent probability level (Table 4). The findings are in line with Meena and Singh, (2020), who found that the variety KRL 19 and KRL 213 with improved technologies of wheat in frontline demonstration were superior to local check. Similar results have been reported earlier by Singh (2017); Deshmukh *et al.,* (2013); and Kumar *et al.,* (2010).

The technology gap was maximum in the year 2017-18 (970 kg/ha) and lowest in the year 2018-19 (340 kg/ha). The extension gap ranging from 640 kg/ha to 910 kg/ha during the period of the study emphasized the need to make farmers aware about the improved production technologies through various means for their adoption. Lower values of technology index exhibited the feasibility of the demonstrated technology in the mid hills of Uttarakhand. Technology index was lowest during 2018-19 (8.2 %) which shows that improved production technology of VL Gehun 953 performed better in farmers' field (Table 5). Incidentally, 2018-19 was a good rainfall year too suggesting that this variety is responsive to the inputs and may capitalize if inputs are available. Jain *et al.,* (2019) reported decreasing trend of technology index from 39 to 21 percent from 2011 to 2014, which shows the feasibility of cluster bean variety RGC 936. Similar results were reported by Singh *et al.,* 2017, Soni *et al.,* 2017 and Tiwari *et al.,* 2015.

3.3 Economic analysis

The year wise economics of wheat production under frontline demonstration were estimated for both the improved varieties of wheat and the results are presented in Table 6. The inputs and outputs prices of commodities prevailing during the respective years of demonstrations were considered for calculating cost of cultivation, net return and benefit cost ratio. Cost of cultivation of demonstration fields were more than farmers' field due to higher prices of improved wheat varieties seeds. The economic analysis of the data shows that cultivation of improved variety of VL Gehun 907 along with recommended practices gave higher net return of Rs. 26,671 on farmers' fields indicated that improved wheat production technologies under FLD of VL Gehun 953 produced an average yield of 3360, 3130 and 3760 kg/ha during 2016-17, 2017-18 and 2018-19 respectively, which were 34.9 and 54,950 compared to 12,388 and 39,972 per hectare under farmers practice during 2014-15 and 2016-17, respectively. The profitability analysis exhibited that cultivation of VL Gehun 907 was more profitable with benefit cost ratio of 2.06 (2014-15) and 3.02 (2016-17). Further, economics analysis of the data shows that cultivation of improved variety of wheat VL Gehun 953 along with recommended practices gave higher net return of Rs. 52,575, 50,013 and 63,939 ha^{-1} compared to Rs. 39,457, 35,352 and 54,963 ha^{-1} under farmers' practice during year 2016-17, 2017-18 and 2018-19, respectively. The profitability analysis exhibited that cultivation of VL Gehun 953 was highly profitable with benefit cost ratio of 2.93 (2016-17), 2.80 (2017-18) and 2.91 (2018-19). Singh *et al.,* (2017) also reported that improved practices in barley frontline demonstrations exhibited high value returns. Results of the present study are in consonance with the findings of Hiremath and Nagaraju, (2009), Meena and Singh (2017) and Dhaka *et al.,* (2016) and Hussain *et al.,* (2019).

3.4 Constraint analysis

It is evident from table 7 that non availability of quality seeds (RBQ, 94.3) was the most important constraints under socio-economic constraints faced by farmers. Similar results were found by Sethy *et al.,* (2010). High cost of input was ranked second (RBQ, 78.2) by the farmers. Higher prices of inputs increase the cost of production as a result farmer get less profit. Smaller and fragmented landholdings are also one of the major constraints (RBQ 69.6) which was ranked third by the farmers. In small and fragmented landholdings farming activities becomes difficult and uneconomical. Non availability of labour (RBQ 52.8), lack of marketing facilities (RBQ 42.5). low prices of produce (40.7) and non-availability of credit facilities (RBQ 21.8) were ranked fourth, fifth, sixth and seventh, respectively. Similar results were also reported by Meena *et al.,* (2015) and Saravanan (2012).

Results clearly indicated that crop damage by wildlife was major constraints and ranked first under technological constraints faced by farmers. Pandey *et al.,* (2019) also reported in a study that wild pig emerged as a major menace followed by porcupine and mouse that raids the cereal and vegetable crops. Weed problems was also a major constraint and was ranked second (RBQ 75.3) followed by lack of irrigation facilities (RBQ 58.2), water stress (RBQ 46.8) diseases (RBQ 46.4) which were ranked third, fourth and fifth, respectively. Similar results were also reported by Bhutia *et al.,* (2017) and Bhartiya *et al.,* (2017).

The performance of modern improved cultivars *viz.,* VL Gehun 907 and VL Gehun 953 in term of yield under organic conditions differ significantly from that of the

Table 1: Differences between technological intervention and farmers practices under FLD on wheat.

Particular	Technological Intervention	Existing practices
Variety	VL Gehun 907 and VL Gehun 953	Local variety or mixture of seeds
Seed rate	100 Kg/ha	125 Kg/ha
Seed treatment	2.5 g Carboxin/Kg of seed	No seed treatment
Fertilizer dose	120:60:40 kg $N:P_2O_5:K_2O$ /ha	No use of fertilizer
Weed management	Two manual weeding /Total (Metsulhuron+Sulphosulfuron)	No weeding
Irrigation schedule (Critical stages for irrigation and method of irrigation)	1. CRI Stage 2. Late tillering stage 3. Jointing stage 4. Panicle initiation stage 5. Grain filling stage	No planned irrigation
Plant protection	Not required as both were rust resistant varieties.	No plant protection applied by the farmers even though the local varieties were highly susceptible of rust

Table 2: Yield analysis of wheat variety VL Gehun 907 grown under FLD

Year	Area (ha)	Potential yield (kg/ha)	Demonstration yield (kg/ha)	Farmers actual yield (kg/ha)	% increase over farmers actual yield	Z test
Irrigated						
2014-15	06	4800	2670	1790	49.1	8.9*
2016-17	04	4800	3460	2510	37.8	16.7*

*Significant at 0.05 percent probability level

Table 3: Gap analysis and technology index of VL Gehun 907 grown under FLD

Year	Technology gap (kg/ha)	Extension gap (kg/ha)	Technology index (%)
2014-15	2130	880	44.4
2016-17	1340	948	27.9

Table 4: Yield analysis of wheat VL Gehun953 grown under FLD

Year	Area (ha)	Potential yield (kg/ha)	Demonstration yield(kg/ha)	Farmers actual yield(kg/ha)	% increase over farmers actual yield	Z test
Irrigated Condition						
2016-17	02	4100	3360	2490	34.9	6.9*
2017-18	08	4100	3130	2220	40.9	22.9*
2018-19	7.2	4100	3760	3120	20.5	10.1*

*Significant at 0.05 percent probability level

Table 5: Gap analysis and technology index of wheat VL Gehun 953 grown under FLD

Year	Technology gap (kg/ha)	Extension gap (kg/ha)	Technology index (%)
2016-17	740	870	18.0
2017-18	970	910	23.6
2018-19	340	640	8.2

Table 6: Economic impact of frontline demonstration of wheat

Year	Cost of Cultivation (ha-1)		Gross Return (ha-1)		Net Return (ha-1)		Benefit Cost Ratio	
	Demonstration plot	Farmers' Plot	Demonstration plot	Farmers' Plot	Demonstration plot	Farmers ' Plot	Demonstration plot	Farmers' Plot
VL Gehun 907								
2014-15	25,060	24,620	51,731	37,008	26,671	12,388	2.06	1.50
2016-17	27,225	24,660	82,175	64,632	54,950	39,972	3.02	2.62
VLGehun 953								
2016-17	27,225	24,660	79,800	64,117	52,575	39,457	2.93	2.60
2017-18	27,767	24,255	77,780	59,607	50,013	35,352	2.80	2.46
2018-19	33,445	32,085	97,384	87,048	63,939	54,963	2.91	2.71

Table 7: Socio-economic and Technological constraints faced by farmers

Socio-economic Constraints	R.B.Q	Overall Rank
High prices of HYV seeds	78.2	II
Non availability of labour	52.8	IV
Non availability of institutional credit	21.8	VII
Non availability of quality seeds	94.3	I
Small land holdings	69.6	III
Low prices of produce	40.7	VI
Lack of marketing facilities	42.5	V
Technological constraints		
Diseases (Rust)	46.4	V
Weed Problems	75.3	II
Lack of irrigation facilities	58.2	III
Lack of knowledge	40.0	VI
Crop damage by wildlife	93.9	I
Lack of mechanization	37.8	VII
Water stress	46.8	IV

conventional system and both the varieties performed better than the local varieties. However, VL Gehun 953 showed better results under farmers' field condition than VL Gehun 907. The reason for this could be that VL Gehun 953 is high yielding, rust resistant wheat variety notified for hills under organic irrigated conditions. Interestingly, it has also been recommended for inorganic, timely sown conditions of plains, indicating that it can respond to inorganic input too. In Uttarakhand hills, wheat cultivation is by default done under organic conditions. Therefore, cultivation of VL Gehun 953 can be profitable and sustainable under organic farming in the hilly region of the state. During the period of demonstration, both the varieties have shown higher degree of resistance against yellow and brown rust. These varieties have proved their wider adaptability, profitability and acceptability among farmers of Uttarakhand. There a need to promote them through different extension programmes of State Department of Agriculture to make wheat cultivation more profitable to the farmers.

4. Conclusion

In terms of area among various crops, wheat occupies the maximum area in Uttarakhand where agriculture is the main source of livelihood. Most of the area is under hilly terrain where possibility of expansion of arable land is just negligible. Wheat is a staple food crop in the area but its average productivity is low. In order to increase the wheat production and productivity of wheat in the region, scientific interventions such as FLDs on wheat can be a better option. Mass level demonstrations and mini kit programme on VL Gehun 953 and VL Gehun 907 could be remarkable intervention to replace older varieties. On one hand it will increase the yield on the other hand it will improve the B:C ratio and will ultimately make wheat cultivation profitable to the adopting farmers. The higher benefit cost ratio of demonstration plots has insured the profitability and economic viability of these varieties in the hilly areas. Further, there is huge shortage of quality seeds in hills. To boost the productivity, farmers need to have access to quality seeds of the recommended improved varieties at right time, right place and at a reasonable price. If these demonstrations could result in seed production of improved varieties through farmers participatory seed production, this will play an important role in enhancing seed replacement rate in hills.

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