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An Investigation in Yield Gap and Technology Transfer of Small Millets in the Hilly Tracts of Uttarakhand

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ABSTRACT

The study has examined the status of technology transfer and yield gap of major small millets in the Tehri Garhwal district of Uttarakhand. Stratified random sampling has been used for selection of 60 small millets growers, 20 each from high hills, mid hills and valleys. Two major small millets, viz. Barnyard Millet (*Sawan*) and Finger Millet (*Ragi/Mandua*) have been selected for the study. The study has revealed that the farmers deviated from the recommended package of practices. The farm level yield gap in both millets have been found statistically significant when tested using '*t*' test. The yield gap between the best and average farms in Barnyard millet and finger millet was of the order of about 40 per cent. The study has suggested the strengthening of input delivery system in the area to ensure timely availability of inputs in required quantity and quality to the growers of millets at reasonable price.

JEL Classification: Q 16, Q12, Q18

Keywords: Technology transfer, Yield gap, Uttarakhand, Barnyard Millet and Finger Millet

Small millets are important dry land crops. India is producer of several kinds of these millets viz. Sorghum (*Jowar*), Pearl millet (*Bajra*), Finger millet (*Ragi*), and few other types of millets like Kodo millet, Foxtail millet, Little millet, Proso millet, and Barnyard millet. Their cultivation extends from sea level in coastal Andhra Pradesh to 8,000 feet above sea level in Uttaranchal and other North-East states.

Small millets enjoy a special status in hills of Uttarakhand. They occupy almost half of the rainfed cultivable area in *Kharif*. Small millets are more hardy and low risk crop. They give an assured harvest even when soil moisture and fertility are limiting. Being a low input crop, millets are first choice to hill farmer whose economic recourses are meager. The hill farmer consumes these food grains in balanced diet, as small millets are highly nutritious and superior to rice and wheat in certain constituents. Recognizing the nutrients composition of these grains, they are now considered as nutria-cereals (nutritious grains). Finger millet is richest source of calcium (300-350 mg/100 gm grain) and other small millets are good source of phosphorus and iron too (AICSMIP, Annual report 2003-2004). The protein content ranges from 7 to 12 percent and fat content from 1.12 to 5.5 percent. The millet protein has well balanced amino acid profile and good source of metheonine, cystine and lycine. These essential amino acids are of specific benefit to those who depend on plant food for their protein nourishment. The grains have long storage life and hence serve as reserve food for any possible future shortage (Mushonge *et al*. 1994).

Infact, the state is manifested with ideal agro-climatic conditions and has vast potential to grow a wide range of these small millets. There is a need to tap this potential for the benefit of farmers. Their importance is also growing in terms of increasing export potential and their slowly rising demand as a ingredient of baby food, beverages etc. It is their hardy nature which has supported them to survive in unfavorable conditions. However, local varieties, rainfed production, improper input mix and traditional practices characterize the present status of agricultural technology in these areas. Although the new technology has made some impact but it has not been completely realized in practice in these hilly regions.

In this backdrop, the present study was conducted to investigate status of technology transfer and yield gap of major small millets in the Tehri Garhwal district of Uttarakhand.

METHODOLOGY

District Tehri-Garhwal was selected purposely for the present study as the district has well equipped research centre of All India Coordinated Small Millets Improved Project which provides the extension work for the better technological adoption of small millets in the area. This research centre is working since 1987–88. Chamba block was then selected on the basis of highest probability proportion to the cultivated area of small millets in each block. Selection of the block was the first stage in three stage stratified sampling design, adopted in the study.

For the study the villages were stratified into three groups depending upon altitude i.e. (*i*) high hills (above 1500 MSL) (*ii*) Mid hills (1,000 – 1,500 M MSL) and (*iii*) Valleys (below 1,000 M MSL).

The cultivated area of all the 203 populated villages of Chamba block were noted from District statistical office, New Tehri and six villages were selected (2 from each group) based on the probability proportion of cultivated area in each village. A list of all the farmers in the six selected villages was prepared. It was found that there were in all 213 cultivators, comprising 60 in high hills, 68 in mid hills and 85 in valleys. From the above three categorization i.e. high-hills, mid-hills and valleys, 20 farmers in each group were selected randomly. The major small millets in the study area, viz. Barnyard Millet (Sawan) and Finger Millet (*Ragi/ Mandua*) were selected for the present study.

ANALYTICAL FRAMEWORK

The level of technology adoption

The term technology in agriculture production refers to the pattern and magnitude of use of input factors. In the present study, to examine the level of technology adoption at the three altitudes in major small millets, a comparison was made between the recommended practices and practices adopted by sample farmers. Simple statistical tools such as averages and percentages deviations were employed to examine the level of technology adoption in small millets in the area.

Yield gap

Three type of yield gaps may be conceptualized in crop production. First, the yield gap may be between the genetic potential yield and actual research level yield. This theoretical gap may be termed as ‘Research level yield gap’. This gap can be minimized through intensive inter-disciplinary research efforts by the agro-biological scientists. Second, the yield gap may exist between the potential yield created by research and the best yield obtained at field level by the best farmers, termed as ‘field level yield gap’ and it can be minimized through a better assimilation of technological components at field level. The third and most important concept of yield gap relates to the field level potential yield obtained by best farmers and the actual yield of average farmers in an area. This gap is usually termed as ‘farm level yield gap’. The present study aimed to estimate only farm level yield gap which existed account of partial adoption or non-adoption of the technological development. This farm level yield gap represents the difference between the yield obtained and technology adopted by the farmers at the farm level.

To estimate farm level yield gaps of the major millets in the study area, sample farmers were classified into two categories, *viz*., best and average farmers according to their yield levels of the millet. The top five farmers on the basis of the yield obtained by them were considered as best farmers and the remaining farmers were categorized as average farmers. The mean yield was worked out separately for each category of sample farmers. The difference between the mean yield of the best farmers and the average farmers was tested for its statistical significance using Fisher's 't' test by employing following formula:

$$t_{cal} = \frac{\bar{X} - \bar{Y}}{\sqrt{S^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

$$S^2 = \frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2}$$

$$S_1^2 = \frac{1}{n_1 - 1}\left[\Sigma X_1^2 - \frac{(\Sigma X_1)^2}{n_1}\right]$$

$$S_2^2 = \frac{1}{n_2 - 1}\left[\Sigma Y_1^2 - \frac{(\Sigma Y_1)^2}{n_1}\right]$$

Where,

$X–Y$ = difference between two means

X_i = yield of i^{th} farmer in first subsample on per ha basis

Y_i = yield of i^{th} farmer in the second subsample on per ha basis

S_i^2 = sample mean square of i^{th} subsample where i = 1, 2

S^2 = combined sample mean square

n_1 and n_2 = number of observations in the first and second subsamples

RESULTS AND DISCUSSION

Level of technology adoption

To assess the level of technology adoption in major small millets crops in the study area *viz.*, finger millet and Barnyard millet, the recommended package of practices has been compared with the existing practices adopted by the farmers in the study area. Various parameters *viz.*, time of sowing, seed rate, use of chemical fertilizers, FYM, plant protection measures, irrigation etc. have been taken into consideration to assess the level of technology adoption in the these crops.

Barnyard Millet (*Sawan*)

The level of technology adoption in barnyard millet in the study area is presented in Table 1. The Barnyard millet is a *kharif* season crop, sown in month of March and April. However, in the absence of assured irrigation facilities in the area and dependence of farmer on rainfall, these farmers have different sowing time and deviates from the recommended sowing dates (depending upon the different altitudes). Tripathi and Pandey (1989) and Hasan *et al.* (2010) has also reported the lack of irrigation facilities in hills of Uttarakhand. It was found that the farmers in the valleys used to grow the crop in the month of May and June whereas in mid-hills and high hills the sowing time was April and May. Normally 8-10 kilograms of seed are sufficient for one hectare of land, but the sample farmers used high seed rate than the recommended level. This seems justified due to seed quality and low soil moisture in the study area. The farmer of the study area use local varieties of seed. These varieties have high mortality and low germination percentage which force the farmer for use of high seed rate. Moreover, the soil moisture of the area was not adequate to break seed dormancy which further increases the seed rate. Even the sowing method used by the farmers also influences the seed rate. The farmers of the area were using broadcasting method instead of line sowing.

This method involves wastage of huge amount of the seed and thereby increases the seed rate. These were the main factors due to which seed rate was found to be so much high. Among the different altitudes the seed rate was found to be highest in high hills (490 per cent), followed by mid hills (450 per cent) and valleys (320 per cent). For better yield, seed must be treated with certain chemicals. In the study area, no case of seed treatment was reported. So far as application of fertilizer is concerned, about 40 kg of nitrogen. 20 kg of each phosphorus and potash were scientifically recommended for a hectare of land. In the area, due to lack of proper irrigation facilities (or rainfed agriculture) and low economic status of farmers the use of fertilizers was found to be negligible. Even the FYM application was found to be low which is due to the fact that these farmers used to allocate a large quantity of FYM in other cereals crops which are highly nutrients intensive. The use of FYM in the study

Table 1: Level of technology adoption in Barnyard millet

Sl. No.	Particulars	Recommended practices	Practices adopted by farmers		
			Valley	Mid-Hills	High-Hills
1	Field preparation	2-3 ploughing	1 ploughing	1 ploughing	1 ploughing
2	Seed treatment	Carbandiazine @ 2 kg/kg seed or Agrosen G.N. 15 gm/400gm seed	—	—	—
3	Variety	VL-29 (89-90 days), VL-21 (100 days), CL 172	Local verities (home grown)		
4	Seed rate	8-10 kg/ha	42 kg/ha (+320)	55 kg/ha (+450)	59 kg/ha (+490)
5	Sowing time	March-April	May/June	April/May	April/May
6	Spacing	Line to line 25 cm, Seed to seed 7.52 to 10 cm, shallow depth	Broad casting		
7	FYM (qt/ha)	40-60	17 (-66)	16 (-66)	14 (-72)
8	Chemical fertilizers (kg/ha				
	(i) Nitrogen	40	—	—	—
	(ii) Phosphorus	20	—	—	—
	(iii) Potash	20	—	—	—
9	No. of irrigation	2-3	Dependent on Rain		
10	Plant protection measures	Dithane M-45 @ 2kg/1000 lt of H_2O per hectare	—	—	—
11	Harvesting	July-August	Oct.	Sept.	Aug.
12	Yield	20-25 qt/ha	10 q/ha (-55.56)	7 qt/ha (-68.89)	7 qt/ha (-68.89)

Note: *Figures within the parentheses shows percentage of deviation from the recommendation.*

area was found to be to 60 to 70 per cent lower than the recommended level. Regarding the use of plant protection chemicals, a very small proportion of farmers were found to use these chemicals. The comparison of yield levels obtained by farmers with potential yield show that on an average the yield in the study area was low and found to be 8 quintals per hectare. The yield of the crop was found to be highest in valleys (10 quintals per hectare) which was 56 per cent less than the experimental stations, followed by mid hills and high hills (7 quintals per hectare) which was les (69 per cent) than the experimental yield .

The result presented and discussed, in the section thus, indicate that the production of Barnyard millet can be increased in the area by adopting recommended package of practices by the farmers.

Finger Milelt (*Mandua*)

Table 2 reveled the level of technology adoption in finger millet in the study area. Finger millet is a major kharif crop of the study area, whose recommended time of sowing is May-June. But due to rainfed farming in the area and dependence of farmers on the monsoon they have different sowing time which varies from altitude to altitude i.e. from valley to high hills. It was found that the farmers of the valley seed the millet in the month of June and July as compared to mid hills and high hills which were found to sow in the month of May and June. Normally the recommended quantity of seed is 8-10 kg per ha but the farmers of the study area use high seed rate. This seems justified due to poor germination percentage of the millet and harshy nature of weather in the area. The seed rate was found to be highest in high hills (400 per cent), followed by mid-hills (370 per cent) and valleys (220 per cent). In the study area no case of seed treatment was reported due to lack of knowledge and poor economic status of the farmers. Further, it was found that the use of fertilizers was minimal. This is due to rainfed agriculture and meager economic resources of farmers. The FYM application was also found to be low (60 to 70 percent). Regarding the use of plant protection chemicals, a very small proportion of farmers reported using these chemicals. Similar results were obtained by Tripathi (1992) and Singh *et al.* (2006). The comparison of yield obtained by farmers with the demonstrated level was found

Table : Level of technology adoption in finger millet

Sl. No.	Particulars	Recommended practices	Practices adopted by farmers		
			Valley	Mid-Hills	High-Hills
1	Field preparation	2-3 ploughing	1 ploughing	1 ploughing	1 ploughing
2	Seed treatment	Agrosen G.N. Thiran @ 2.5 g/ kg seed	—	—	—
3	Variety	VL-Mandua-124, VL-149	Local variety (home grown)		
4	Seed rate (kg/ha)	8-10 kg/ha	32.15 (221.5)	47 (370)	50 (400)
5	Sowing time	May/June	June/July	May/June	May/June
6	FYM (qt/ha)	40-60	14 (-72)	16 (-68)	16 (-68)
7	Spacing	Line to line 25 seed to seed 7.5 -10 cm shallow depth	Broadcasting		
8	Chemical fertilizer (kg/ha)				
	(i) Nitrogen	40	—	—	—
	(ii) Phosphorus	20	—	—	—
	(ii) Potash	—	—	—	—
9	No. of irrigation	2-3	Dependent on Rain		
10	Plant protection measure	Carbendazine 50 E.C. @ 0.1%/ 700-800 lt./ha or Dithane M-45 (0.02%)	—	—	—
11	Harvesting	Aug-Sept.	Sept-Oct	Aug-Sept	Aug.-Sept
12	Yield (q/ ha)	18-25	7.24 (-66.33)	7.73 (-64.05)	10.43 (-51.49)

Note: *Figures within the parentheses shows percentage of deviation from the recommendation.*

to be as low as 50 to 60 per cent. The yield of the millet was found to be highest in high hills (10.43 quintals per hectare), followed by mid hills and high hills (7-8 quintals per hectare). The yield was so low due to negligance of framers towards the millet. The farmers of the study area used to practice these millet because of their wide adaptability to the harshy climate of the area. The result presented and discussed in the section, indicates that the production of the millets can be increased in the area if due attention is given to the millets and by adopting recommended package of practices by the farmers.

Yield gap

Yield gap is difference between the potential productivity and realized productivity at farm levels. As described in methodology, there are three types of yield gaps *viz.,* Research level yield gap, field level yield gap and farm level yield gap. The present analysis has been attempted to estimate only farm level yield gap for small millets in the study area. For this the sample growers were classified into two categories *viz.,* best and average farmer accordingly to the level of their millet productivity. The yield of millet obtained by the best five sample farmers were considered as the potential yield of the millet in the area. This was treated as a farm level potential yield which can be realized through proper input use and management. This farm level potential yield was then compared with the average yield obtained by remaining farmers (average farmers). Therefore, the yield gap in the present study was calculated between the best and the average sample farmer. The result pertaining to yield levels and yield gap in small millet are presented in Table 3.

Table 3: Yield levels and yield gap in small millets

Sl. No.	Particular	Yield (Qt/ha)	
		Barnyard nillet	Finger millet
1	On farm average yield level		
	(a) Best farmers	12.10	11.35
	(b) Average farmers	7.20	6.89
2	(a) Yield gap in absolute term	4.90	4.46
	(b) Yield gap in percentage term	40.49	39.29

It can be observed from the Table 3 that the average yield of best farmers for both Barnyard millet and finger millet were considerably high (12.10 quintals per hectare and 11.35 quintals per hectare, respectively) than the average yield levels (7.20 quintals per hectare and 6.89 quintals per hectare, respectively) of the average farmers. Tripathi (1992) and Yadav and Yadav (2009) have also reported the low productivity of small millets in Uttarakhand. The results reveled that there was significant difference between the yield of the best farmer and average farmers, which was about 4.9 quintals per hectare for Barnyard millet and 4.46 quintals per hectare for finger millet in absolute terms. The farm level yield gap in both millets was also found statistically significant when tested using '*t*' test. It was seen that the total magnitude of yield gap between the best and average farms in Barnyard millet and finger millet was of the order of about 40 per cent. The results indicate that there is scope for average farmer to increase millets yield up to level of best farmers even under the existing technology available. The yield of millets in the region can be increased to a significant extent by minimizing the gap through improving the productivity of these millets on the average farms.

CONCLUSION

Small millets (Finger millet and Barnyard millet)were found to be subsistence crop on all the altitudes. These crops were grown due to their wide adaptability to harshy climate of the study area. There was significant difference in levels of inputs per hectare and yield per hectare between the valleys, mid hills and high hills.

In the light of significant yield gap and low level of technology adoption at small millets farms over all the altitudes, there is a need to strengthen input delivery system in the area to ensure timely availability of inputs in required quantity and quality to the growers of millets at reasonable price. This will help to increase productivity and decreasing cost of cultivation. Further there is need to follow strong extension programme in the area regarding the adoption of improved varieties of crops and correct method of use of particular input. Such knowledge would serve as a guide to policy makers, producers and all those who are interested in these millets in increasing and mobilizing its potential and improving various functions of production process which would ultimately benefit the producer.

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