

Full Length Research Paper

Economics of finger millet (*Eleusine coracana* G.) production and marketing in peri urban area of Pokhara valley of Nepal

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A study was conducted on the economics of finger millet production and marketing in peri urban area of Pokhara valley of Nepal in 2006 AD. The sampling frame was 154 and 193 producers selected from Kalabang and Begnas study sites respectively. Sampling intensity of 30% was used to randomly select the population sample size which gave 47 for Kalabang and 58 for Begnas. Household survey was carried out to collect the primary information from the selected finger millet producers and traders by using the pre-tested interview schedules. The cost of production (NRs. 23847.60/ha) and gross revenue (NRs. 24638.23/ha) were significantly higher at Kalabang site than in Begnas. The productivity (1156.12 kg/ha) of finger millet was significantly higher in Kalabang. The price of finger millet was NRs. 16.91/kg at Kalabang and NRs. 17.35/kg at Begnas. Profit of finger millet cultivation was higher (NRs. 790.58/ha) at Kalabang than in Begnas (NRs 602.45/ha) while higher benefit cost ratio (1.05) was in Begnas. Share of female labor cost to total cost of cultivation was highest among cost factors in both sites. Share of male labor, female labor and fertilizer costs were positively significant to total revenue at Kalabang while only fertilizer and female labor costs were positively significant at Begnas. Direct marketing of finger millet from producers to the consumers was most frequent in rural areas while involvement of middlemen was common in the urban areas. Attack of rat to standing crop and damage by disease especially, blight were the major production problems.

Key words: Finger millet, production, marketing, Cobb-Douglas, elasticity coefficients.

INTRODUCTION

Finger millet (*Eleusine coracana* G.) is the fourth most important crop in Nepal after rice (*Oryza sativa*), maize (*Zea mays*) and wheat (*Triticum aestivum*) (MoAC, 2010). Finger millet cultivation is an indispensable part of farming system in the mountain terrain of Nepal where agricultural land is limited and food deficit is a problem (Subedi et al., 2009). Finger millet was grown in 268,473 ha in 2009/2010 having a productivity of only 1.11 t/ha (MoAC, 2010). Finger millet occupies almost nine percent of the total cultivated area in the country and about 75% finger millet cultivation area lies in the mid-hills (Upreti, 2002). It is generally grown as a solo crop in Terai while it is sequenced or relayed with maize in the mid hills. Relay cropping is by far the most predominant pattern, accounting for at least 60% of the total cropped area of

finger millet (FMDP, 1985). This crop is more important for marginal lands where crops are grown without the use of external inputs.

Finger millet is a more nutritious food than other cereals (Bhandari et al., 2005; NARC, 2005; Dida and Devos, 2006). This is a major food in the hilly villages, particularly, among the poor (Riley et al., 1992). It is usually converted into flour and made into *Roti* (cakes), *Dhindo* (puddings) and *Khole* (thin porridge). It is also popular for making of fermented beverages among certain communities of the country which is needed for their religious and cultural rituals. The straw of finger millet is an important animal fodder particularly, during the feed deficit months and helps to sustain animal management, improved compost application, soil fertility

and crop yield.

Underutilized crops are the lesser known species in terms of trade and research, and often adapted to marginal and stress conditions (Joshi et al., 2002). Finger millet is one of the under utilized crop species in Nepal. Although, it possesses promising nutritional and industrial importance for a variety of purposes, its commercial importance and market value is still unknown to majority of the people. It is being devalued and graded as low grade food item in Nepal due to the wrong and narrow perception of the people.

According to Riley et al. (1992), finger millet has the potential to improve resource management in the hills of Nepal and serve as a staple food, weaning food, or a cash crop which provides income generating opportunities. Research and improvement efforts are needed to explore the potential of finger millet to increase agricultural production, crop diversification and a better nutritional environment. Improvements in small scale brewing and distilling and in market development are also recommended. Although, it is the fourth major crop in Nepal, research work and necessary information for crop improvement, market promotion and commercialization are rarely found. Therefore, the objective of this study is to assess the economic prospects of finger millet production and marketing in peri urban area of Pokhara valley of Nepal.

METHODOLOGY

Kalabang of Pumdi Vumdi Village Development Committee (VDC) and Begnas of Lekhanath municipality were purposively selected for the study because of the (i) representative of the peri-urban area of Pokhara valley, (ii) potentiality of finger millet production and (iii) the researcher's time and budgetary constraints. All the finger millet producers of Kalabang and Begnas site constituted the sampling frame. The total numbers of farmers in Kalabang and Begnas sites were 154 and 193 respectively. Simple random sampling method was used to select 30% of the population. Consequently, 47 and 58 households from Kalabang and Begnas were selected respectively. Primary information was collected by using pre-tested interview schedule by applying face-to-face interview method. The collected information were first tabulated, coded and entered into the computer. The following analyses were done by using the following computer software packages: Microsoft Excel and Statistical Package for Social Science (SPSS).

General description of study site

The study areas of Kalabang and Begnas represent the mid hill area of Nepal, however, Kalabang is facing the South and located at the altitude ranging from 1000 to 1400 masl while Begnas is to the East and located at 600 to 800 masl (Sapkota et al., 2005). These sites experienced most of the monsoon rain during the wet season that is, between July and September, while frost in winter and hailstorm during March/April and October/November. Kalabang is characterized by a high rainfall while Begnas experiences an erratic and relatively less rainfall (Sapkota et al., 2005). Both are peri-urban village site near Pokhara city. Kalabang village is linked by a rural road and inhabited mostly by the Gurung ethnic group (75%) where Begnas is linked with fair season road and is

characterized by a majority of Brahmin/Chhetri communities (80%) (Bhandari et al., 2010).

Cost of production

For estimating the cost of production, only the variable cost items were considered. The variable cost was the expenditure on seed, fertilizers, human labor, bullock labor and so on. Total cost of production was calculated by adding all the expenditure on variable inputs under consideration.

Gross margin analysis

The gross margin provides simple and quick method for analyzing farm business which is the difference between the gross return and the total variable cost incurred that is:

Gross margin = Gross return - total variable cost

Where, Gross return = \sum gross returns = return from main product + return from by products

Total variable cost = \sum cost of all variable inputs used for the production.

Benefit cost ratio analysis

Benefit cost ratio is the ratio between the gross return and total cost of any enterprise. In this study, benefit cost ratio was calculated by using the formula:

$$B/C \text{ ratio} = \frac{\text{Gross return}}{\text{Total cost}}$$

Where, gross return was obtained by adding income from grain and straw, while total cost was obtained by adding all the expenditure in the production process.

Factor share to total output

Cobb Douglas production function was used to estimate the coefficients of factors of production affecting the total revenue of finger millet. All the variables were converted into value term and linear regression model was used after converting the variables into natural log. The general form of Cobb-Douglas production function used to determine the contribution of different factors of production and to estimate the coefficients of the variable factors of production was as follows:

$$Y = a S^{b_1} F^{b_2} B^{b_3} ML^{b_4} FL^{b_5} e^u$$

Where, Y, S, F, B, I, ML, and FL were the values (in Rs) of output, seed, fertilizer, bullock, male labor and female labor respectively and u is a random disturbance term. The intercept denoted by 'a' and 'b_i' is the slope coefficient of the associated variable, where i = 1...5. Due to the problem of multicollinearity, the land area variable was dropped and the production function was estimated on per hectare basis.

Problems on production and marketing

The index was found mainly by taking into account the qualitative data. To prioritize the problems of finger millet production and

marketing weighted indices were calculated by using five point scale indicating most serious, serious, moderate, little bit serious, no problem by giving value on the basis of priority that is, 5 for most serious, 4 for serious, 3 for moderate serious, 2 for little bit serious and 1 for no problem at all. The index of importance was computed by using the formula:

$$I_{imp} = \sum \left(\frac{S_i f_i}{N} \right)$$

Where, I_{imp} = index of importance

Σ = summation

S_i = i^{th} scale value ($i = 1, 2, 3, 4$ and 5)

F_i = frequency of i^{th} importance given by the respondents

N = total number of respondents

RESULTS AND DISCUSSION

Characteristics of the respondents

The mean age of the respondents of Kalabang was 46.31 years while it was 44.51 years in Begnas. Out of the total respondents, 60.95% were males and 39.05% were females. Brahman was the dominating caste in both of the research sites. In total sample, 30.09% of the respondents were Brahman, 22.85% Chhetri, 21.91% Baisa and 17.15% Sudra. Out of the total respondents, 40.95% had attained the secondary level of education, 26.67% were illiterate, 17.15% had attained primary level, 7.61% had informal, 3.83% have attained certificate level and 3.81% had attained university level education. Among the total respondents, agriculture was found to be the major occupation for the majority (79.05%) followed by service (13.34%), foreign employment (4.76%) and business (2.85%).

Cropping pattern

The main crops grown in the study areas were rice, finger millet, maize and other minor crops like mustard and legumes. In most parts of Bari land, finger millet was grown in rainy season after the maize. In Kalabang area, finger millet was transplanted within the maize field without cleaning the field but in Begnas area, finger millet was found to be transplanted after the harvesting of maize. The major cropping systems found in Bari land were:

Maize – finger millet – mustard / vegetables/ fallow

Maize – finger millet – winter season crops/ fallow

The major and predominant cropping systems in khet land were:

Rice – fallow – fallow

Rice – wheat / mustard – fallow

Cost and revenue in finger millet cultivation

The major cost attributing items were seed, fertilizer, bullock labor and human labor. Fixed costs were not included to estimate the cost of cultivation. The average total cost of production was found to be NRs. 23847.65 at Kalabang site which was higher than that of Begnas site (NRs. 21005.57). The productivity of finger millet was significantly higher in Kalabang (1.15 t/ha) than Begnas (0.98 t/ha). The gross revenue of finger millet cultivation at Kalabang was NRs. 24638.23/ha which was significantly higher than that of Begnas (NRs. 21608.03/ha) while the gross margin of finger millet cultivation was NRs. 790.58 at Kalabang and NRs. 602.45 at Begnas but the benefit cost ratio was higher at Begnas. The detail of cost and return analysis is presented in Table 1.

Factor shares to total revenue

The Cobb Douglas production function model was found to be the best fit since the F-ratio was highly significant (at 1% level of significance). For Kalabang site, the coefficient of multiple determinations (R^2) was found to be 0.657 which indicated that the 65.7% variation in the dependent variable was described by the explanatory variables included in the model. It was found that only male labor, female labor and fertilizer costs have significant contribution to the total revenue of finger millet in Kalabang site while seed and bullock costs were found not to be significant factors contributing to gross revenue. The details of the contribution of different factors of production to the total revenue in Kalabang site is presented in Table 2.

Similarly for Begnas site, the coefficient of multiple determinations (R^2) was found to be 0.640 which indicated that 64.0% variation in dependent variable was described by the independent variables included in the model. It was also found that only fertilizer cost and female labor cost have significant contributions to total revenue. Table 3 gives the detail of the factors share to total revenue at Begnas site.

Use of finger millet

The major uses of finger millet were food for human being by preparing different food items like *roti*, *dhindo*, *khole*, feed for lactating and draft animals and in wine making. Use of finger millet for different purposes was more in Kalabang site (147.99 kg/hh) than Begnas site (86.81 kg/hh). The average quantity of finger millet used for food purpose is presented in Table 4.

Problems in finger millet production and marketing

From the study, attack of rat to the standing crop was the

Table 1. Cost and revenue of finger millet cultivation by research sites.

Particular	Unit	Site		t-statistic	p-value
		Kalabang	Begnas		
Seed cost	NRs per ha	201.92	296.95	-2.460	0.016
Fertilizer cost	NRs per ha	3747.07	5176.75	-2.956	0.004
Bullock cost	NRs per ha	784.30	1874.80	-4.671	0.000
Male labor cost	NRs per ha	3967.10	2962.73	2.888	0.005
Female labor cost	NRs per ha	13606.95	9298.06	4.274	0.000
Interest	NRs per ha	1540.28	1396.26	1.229	0.222
Total cost	NRs per ha	23847.65	21005.57	1.897***	0.061
Productivity	Kg per ha	1156.12	985.87	2.169**	0.032
Price	NRS per kg	16.91	17.35	-1.420	0.159
Grain revenue	NRs per ha	19596.57	17073.23	1.847	0.068
Straw revenue	NRs per ha	5041.65	4534.80	1.124	0.264
Gross revenue	NRs per ha	24638.23	21608.03	2.041**	0.044
Gross Margin	NRs per ha	790.58	602.45	.192	0.848
Benefit cost ratio	-	1.049	1.058	-2.17	0.829

Table 2. Factors shares to total revenue in finger millet cultivation at Kalabang site.

Variable	Estimated coefficients	Standard error	Standardized coefficients	t-statistic	p-value
Constant	4.394*	1.067		4.119	0.000
Seed cost	0.043	0.090	0.063	0.475	0.637
Fertilizer cost	0.006**	0.011	0.067	0.556	0.045
Bullock cost	0.001	0.006	0.028	0.240	0.811
Male labor cost	0.005**	0.018	0.031	0.256	0.049
Female labor cost	0.568*	0.121	0.659	4.713	0.000

Multiple R = 0.769, R² = 0.657, Adjusted R² = 0.540, F-ratio = 6.894*, *significant at 1% level of significance, ** significant at 5% level of significance.

Table 3. Factors shares to total revenue in finger millet cultivation at Begnas site.

Variable	Estimated coefficients	Standard error	Standardized coefficients	t-statistic	p-value
Constant	5.347	0.791		6.762	0.000
Seed cost	0.091	0.057	0.174	1.578	0.121
Fertilizer cost	0.009**	0.013	0.073	0.661	0.031
Bullock cost	0.001	0.008	0.012	0.104	0.918
Male labor cost	0.020	0.015	0.161	1.373	0.176
Female labor cost	0.427*	0.088	0.551	4.828	0.000

Multiple R = 0.724, R² = 0.640, Adjusted R² = 0.510, F-ratio = 7.227*, *significant at 1% level of significance, ** significant at 5% level of significance.

most serious production problem followed by disease occurrence and lack of quality seeds at both research sites. In Kalabang site, low social status for finger millet food items was the fourth problem followed by labor, technical, insect pest, irrigation, and credit. At Begnas area, the problem of insect was ranked at fourth position followed by low social status of finger millet food item,

labor, irrigation, technical and credit related problems. The detail of the production problem with their index value is presented in Table 5. On the other hand, price of finger millet was the major marketing problem faced by the farmers in the study areas. At Kalabang, lack of organized market was the second major problem followed by low social status of finger millet, transportation,

Table 4. Uses of finger millet.

Uses	Quantity across site (Kg/hh)		
	Kalabang	Begnas	Total
Food	111.3 (75.2)	52.38 (60.3)	81.84 (69.7)
Animal feed	23.5 (15.9)	19.7 (22.7)	21.6 (18.4)
Wine	13.3 (9.0)	14.8 (17.0)	14.05 (12.0)
Total	147.99 (100)	86.81 (100)	1117.4 (100)

Figures in parenthesis indicate percentage.

Table 5. Production problems of finger millet by research sites.

Variable	Kalabang		Begnas	
	Index	Rank	Index	Rank
Credit	1.234	IX	1.120	IX
Disease	2.595	II	2.258	II
Insect Pests	1.595	VII	1.534	IV
Irrigation	1.340	VIII	1.362	VII
Labor	1.638	V	1.396	VI
Rat	3.063	I	2.258	I
Seed	2.255	III	1.655	III
Social	1.957	IV	1.5	V
Technical	1.617	VI	1.275	VIII

Table 6. Marketing problems of finger millet by research sites.

Problem	Kalabang		Begnas	
	Index	Rank	Index	Rank
Information	1.425	V	1.689	V
Market	2	II	2.137	III
Price	3	I	2.896	I
Social	1.914	III	1.741	IV
Storage	1.340	VI	1.275	VI
Transport	1.659	IV	2.293	II

information and storage problems. At the Begnas area, transportation was the second most important problem followed by market, social, information and storage. Table 6 gives the detail picture of the marketing problem with their index values.

Marketing of finger millet

Major portion of the marketable finger millet was found to be marketed directly from producers to the consumers. The local buyers of the finger millet were the consumers as well as local wine makers. Very little amount of finger millet was found to be marketed through the middle men. From the research sites, very small quantity of finger

millet was found to be sold in valley market centre or other places Figure 1 gives the general marketing channel of finger millet in study sites.

In Kaski district, the marketing channel of finger millet was different from other crops. Most of the finger millet produced in study sites was consumed at the same production site and to meet the demand of finger millet in the district, it was imported from market centers of the country. Hetaunda and Trisuli were found to be the major source of finger millet for Pokhara valley which was marketed up to the villages through wholesalers, millers, and retailers. Direct selling of finger millet from producers to consumers was observed as the strongest marketing channel, however, small amount was found to be handled by local traders (millers and retailers) in the study areas.

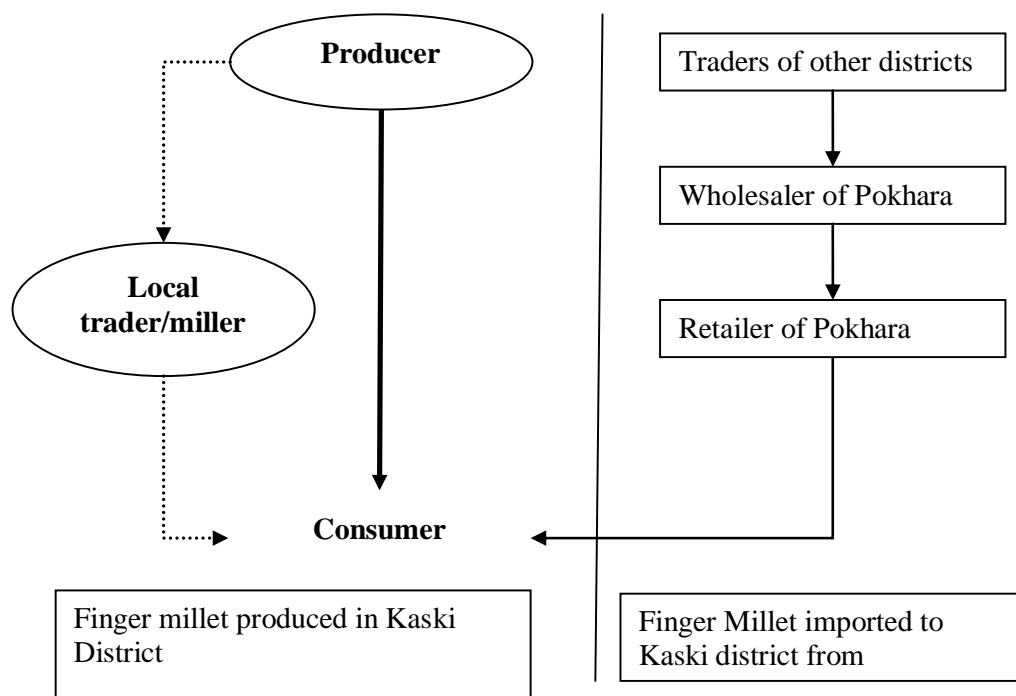


Figure 1. Marketing channel of finger millet in Kaski district.

Abtraco (2006) has also found direct marketing of finger millet in Nepal while Bhandari et al. (2010) identified new marketing channel that is, involvement of entrepreneurs in flour mills and product diversification enterprises.

DISCUSSION

Finger millet is one of the most important field crops for mid hills of Nepal which can be cultivated up to 2400 masl. Despite the significant effects of drought on the yield of finger millet, farmers are still compelled to cultivate finger millet in their marginal uplands where other crops can not be grown in the season. Cultivation of finger millet in rain-fed condition is one reason for low productivity in the study sites and it has a resemblance with that reported by Nepal's national average (NARC, 2005; MOAC, 2010). Higher grain productivity obtained in Kalabang area could be due to higher average rainfall at Kalabang than Begnas area (Sapkota et al., 2005). In addition, the use of traditional seeds of less production potential and not adoption of improved crop management practices are also equally important (Maqsood and Azamali, 2007). This crop is not only devalued by the consumer but also by government's research and development priorities; the reason why improved varieties and improved farming practices were not developed. Since 1960 to 2007, the government of Nepal has released 44 varieties of rice, 19 varieties of maize and 28 varieties of wheat but only 3 varieties of finger millet

(NARC, 2007).

Results obtained from this study highlights that fertilizer and human labor more especially, female labor, are significantly important input factors to achieving higher revenue from finger millet farming in study area. Upreti et al. (1991) found family or exchange labors that are used almost exclusively for millet production where family labor accounts for an average of 62 to 70% labor used for finger millet cultivation; however, women provided more labor than men. Higher labor requirement was mainly due to high transplanting rate (1 to 1.5 million plants/ha) (Upreti et al., 1991) and separate harvesting of heads and straw where female were more engaged (Bhandari et al., 2010). Cost of cultivation of finger millet in study sites was also consistent with the findings of Bhandari et al. (2010). Lower cost of cultivation in Begnas was due to the use of bullock labor in land preparation that substituted human labor (Upreti et al., 1991). Cost on female labor was found to be the highest among different cost factors in both sites because finger millet cultivation is labor intensive where women provides more labor than men in production operations (Upreti et al., 1991).

The gross revenue of finger millet cultivation was significantly varied from NRs. 21608.03/ha in Begnas to NRs. 24638.23/ha in Kalabang area and gross margin of NRs. 602.45/ha and NRs. 790.58/ha respectively. Upreti et al. (1991) also found similar gross margin (NRs 641 - 951/ha) in Eastern and Western hills but negative gross margin in Kaski (-1785/ha) (Bhandari et al., 2010) and far Western mid hill villages (NRs. -3101/ha) (Upreti et al.,

1991). In spite of low gross margin and negative gross margin, farmers were still cultivating finger millet in their uplands mainly because they do not have the option of growing other crops other than finger millet in these marginal lands (Bhandari et al., 2010) and wisely utilizing the surplus family labor that have zero opportunity cost.

Conclusion

From the findings of this study, finger millet is an indispensable part of farming system and a major source of livelihood for the people of peri-urban area of Pokhara valley of Nepal. Kalabang area is more suitable for the cultivation of finger millet than Begnas area due to high rainfall intensity at Kalabang area. However, the use of bullock labor could greatly replace the human labor requirement and thus, potentially reduce the cost of cultivation and increase income. The difference in potential yield and existing yield shows the scope of adoption of improved farming practices including irrigation facility and the positive significance of fertilizer's coefficient. Male labor and female labor costs in the Cobb Douglas production function shows the potentiality of increasing total revenue by increasing the use of fertilizer and human labors. Among the several problems, attack of rat and incidence of disease especially, blight, are the major marketing problem in finger millet cultivation while low price of finger millet and lack of market are the major marketing problem faced by the producers.

Suggestions for future study and policy implication

From the findings of this study, the following suggestions for future study and policy implication were made:

1. Research on less labor requiring technology is the need for reducing the cost of production and increasing the benefit from finger millet cultivation.
2. Programs for increasing nutritional awareness and value addition for market development are suggested.
3. Technical support for mini brewery industry is also needed because rural poor households can earn cash from selling the fermented beverage of finger millet.
4. Screening of disease resistant varieties, technology development and transfer for combating the diseases and pests problem are to be done.

REFERENCES

- ABTRACO (2006). Analysis of existing national policies that enable or inhibit the wider use of underutilized plant species for food and agriculture in Nepal. Agri-Business & Trade Promotion Multi-Purpose Cooperative Ltd, Nepal and Global Facilitation Unit for Underutilized Species (GFU), Italy.
- Bhandari B, Subedi A, Gyawali S, Baral KP, Chowin KR, Shrestha P, Staphit B (2010). Promoting Neglected and Underutilized species in Nepal: a case of finger millet. In *Minor Millets in South Asia: Learnings from IFAD-NUS Project in India and Nepal.* (Ed M Bhag, S Padulosi and S Bala Ravi). Bioersity International, Italy and MS Swaminathan Resarch Foundation, India. P. 147-175
- Bhandari B, Gyawali S, Baral KP, Chowin KR, Rijal DK (2005). Promoting the Utilization of Fingermillet and its Products through Public Awareness Activities in Kaski, Nepal. Proceeding of Progress Review Workshop on Fingermillet under IFAD-NUS Project:Nepal Component, NARC and LiBird.
- Dida MM, Devos KM (2006). Finger Millet. In *Genome Mapping and Molecular Breeding in Plants, Vol 1 Cereals and Millets* (C.Kole (Ed.)) Springer-Verlag Berlin Heidelberg p. 333-343
- FMDP (Finger Millet Development Programme) (1985). Annual Report for 1984. Integrated Cereal Project. Agronomy Division, HMG Nepal. P. 158
- Joshi V, Gautam PL, Mal B, Sharma GD, Kochhar (2002). Conservation and Use of Underutilized Crops: an Indian Perspective. In: *Managing Plant Genetic Diversity* (JMM. Engels, VR Rao, AHD Brown and MT Jackson (Eds.)). IPGRI. pp. 61-73.
- Maqsood M, Azam Ali SN (2007). Effects of Drought on Growth, Development, Radiation Use Efficiency and Yield of Finger Millet (*Eleusine Coracana*). *Pak.J.Bot.*,39(1): 123-134
- MOAC (2010). Statistical Information on Nepalese Agriculture 2009.2010. Agri-Business Promotion and Statistical Division, Ministry of Agriculture and Cooperatives (MOAC), Singha Durbar, Kathmandu, Nepal.
- NARC (2005). NARC Newsletter Vol.12 No.1 p.5
- NARC (2007). Released and Registered Crop Varieties in Nepal (1960-2007). Nepal Agricultural Research Council, Khumaltar, Lalitpur.
- Riley KW, Shakya PB, Upreti RP, Vaidya (1992). Finger Millet in Nepal: Importance, farming systems and utilization in a socio-economic context. *In: Recent Advances in Small Millets.* p. 209-226
- Sapkota TB, Aryal KP, Tamang BB, Regmi BR (2005). Findings of the Baseline Study in Kaski and Tanahun Districts, Nepal. Local Initiatives for Biodiversity, Research and Development (LI-BIRD), Pokhara, Nepal/The Development Fund, Oslo, Norway. P. 1-2.
- Subedi A, Maharjan SK, Silwal S, Devkota R, Upadhyaya D, Pandey S, Bhandari B (2009). Community-based Biodiversity Management in Nepal: Site Selection Report. Local Initiatives for Biodiversity, Resarch and Development (LI-BIRD), Pokhara, Nepal.
- Upreti RP (2002). Production System with Millets as Component. *In.* Enhancing the contribution of nutritious but neglected crops to food security and to incomes of rural poors: Nepal Component-Nutritious Millets. Proceeding of the Inception Workshop. 2-3 May 2007, NARC Kathmandu, Nepal.
- Upreti RP, Shakya PB, Vaidya S, Riley KW (1991). A study on finger millet in Nepal: Importance, nutrition, utilization and farming system in a socio economic and ecological context. Paper presented at the second international small millet workshop Zimbabwe. April 8-12, 1991.