Agriculture Development Journal

ISSN : 2091-0738 (Print) **ISSN :** 2091-0746 (Online)

Volume 8 July 2011

Hybrid Maize Seed Production: A New Initiative for Reliable and Sustainable Hybrid Maize Seed Supply in Nepal

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Abstract

Hybrid maize development is undoubtedly one of the most productive innovations in plant breeding. Breakthrough in agriculture was only possible in the 20th century due to exploitation of heterosis in cereal crops. Heterosis is exploited more in cross-pollinated crops and less in self pollinated crops. In recent years, the demand for maize hybrids and hybrid maize technology in Nepal is tremendously increased. Hybrids are preferred over open-pollinated varieties because of their higher yields, greater uniformity in terms of plant height, maturity and other important traits. Farmers have been growing hybrid maize extensively in many terai districts and in some mid hill districts. Hybrids are mainly cultivated in terai during winter season after rice harvest. Unavailability of Nepalese hybrids and underdeveloped seed industries have resulted 100 percent import of hybrid maize seed every year. National Seed Board had released a NMRP (National Maize Research Program) developed hybrid named “Gaurav” in 2003 and recommended for terai and inner terai production domains. Parents of Gaurav hybrid were given to a private seed company for seed production. However, the private company could not commercialize this hybrid due to nicking problem and lack of proper seed production technology. The present area under hybrid maize in Nepal is sufficient to establish our own hybrid seed enterprise for supply and marketing of hybrid seeds within the country. Giving high priority to this issue, NMRP has developed and identified some superior and high-yielding single-cross hybrids. Seed production of some hybrids was tried in the farmers’ field and found economically feasible and could easily be commercialized due to its high demand. Hybrids developed and evaluated in the local environments are more tolerant to biotic and abiotic stresses. Hybrid seed production technology has been developed and wrapped up for dissemination to the farmers and seed producer groups. Hybrid seed production is a highly remunerative seed enterprise and could transform livelihood, of farmers through increased production and productivity of hybrid maize. This paper has given a perspective on technical and economic aspects of hybrid maize seed production and its possibility of commercialization in Nepal. It is hoped that this article would serve as guidelines to seed companies, community based seed production groups and others, who are keen to carry out hybrid maize seed production in Nepal under the technical assistance of NMRP, Rampur, Chitwan.

Key words: Commercialization, economic seed production, single-cross hybrid

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1. Introduction

Hybrid maize development is undoubtedly one of the finest and most productive innovations in plant breeding. Breakthrough in the 20th century in agriculture was only possible due to exploitation of heterosis in cereal crops. Heterosis is exploited more in cross-pollinated crops and less in self pollinated crops. Hybrid revolution is not only limited in cross-pollinated crops but it is rapidly spreading in self-pollinated crops. Hybrid cotton and hybrid rice are already well known success stories.

In recent years, there is overwhelming demand of maize hybrids and hybrid maize technology in Nepal due to increasing demand for maize for feeds. Because we cannot increase yields in OPVs from certain point even more inputs are provided. Development of non-conventional hybrids for short-term and conventional hybrids for long-term is the best alternative to increase production and productivity of maize in Nepal (Gurung et al., 2007).

Hybrids are preferred over open-pollinated varieties because of their higher yields, greater uniformity in terms of plant height, maturity and other important traits. It is comparatively less susceptible to diseases and insects than OPVs. Hybrid maize has been extensively growing in many terai districts and in some mid hill districts. These are mainly cultivated in Terai during winter season after rice harvest. Unavailability of Nepalese hybrid cultivars and underdeveloped seed industries have resulted 100 percent import of hybrid maize seed every year.

Hybrid maize covers about 46,799 ha area in terai and inner terai of Nepal. The area is increasing every year because of higher demand for maize grains for poultry and animal feeds. The demand is also increasing in the areas where there are irrigation facilities and availability of chemical fertilizers and other essential inputs due to higher grain yield of hybrids compared with OPVs. Hybrid maize has also been introduced in some hill districts in recent years where there is potential of hybrid maize cultivation.

Nepal imports about 100 percent hybrid seed mainly from India. The quantity of hybrid seed import has been estimated to be more than 800 metric tons every year and it is increasing year after year (Personal communication with Kiran Dahal, a representative of Mansanto multi-national Seed Company based in Birgunj, Nepal). Lack of high-yielding hybrids is one of the major constraints for terai and inner terai regions (Paudyal et al, 2001). National Maize Research Program (NMRP), Rampur released a single-cross hybrid named “Gaurav” in 2003 (NARC, 2007) but the private sector could not commercialize this variety due to nicking problem between the parents and also lack of proper knowledge on hybrid seed production. Due to lack of proper policy and limited resources for hybrid maize research, the country could not make substantial progress in hybrid maize development and thus the NARC was not able to release even a single hybrid maize after the year 2003. Consequently, the farmer’s dependency on foreign hybrid maize seeds went on increasing which led to import of huge quantity of hybrid seeds from outside.

Cultivation of hybrid maize is one of the alternatives to minimize the gap between the demand and supply of hybrid maize seeds and to substitute the import of maize for feeds. International Corn Foundation (ICF), an NGO of South Korea and Nepal Agriculture Research Council (NARC) started a collaborative hybrid maize research program at NMRP, Rampur and at Agri-Botany Division, Khumaltar in 2006. The hybrid program took a momentum in developing inbred lines and hybrids with the funds and technical support from ICF. Within a very short period of collaboration, NMRP has been able to develop many high-yielding single-cross hybrids. Most of the parents of the newly developed hybrids are well adapted to the local environment. Because of this, the hybrids are relatively easy for F1 seed production. This paper has aimed to offer a perspective on technical and economic aspects of hybrid maize seed production and its commercialization in Nepal. It is hoped that this article will serve as guidelines to seed companies, community based seed production groups and others, who are keen to carry out hybrid maize seed production in Nepal under the technical assistance of the NARC.

2. Scope of Hybrid Maize Seed Production in Nepal

Hybrid maize development was initiated at NMRP, Rampur in 1987 mainly to develop conventional hybrids. Hybrids developed by using inbred lines from IITA did not perform well as compared to Indian commercial hybrids and Rampur composite. Results of hybrid work carried out from 1988 to 1993 are not documented well. The yield of hybrid developed at NMRP in 1994 using S3 x S3 lines had at par yield with Indian hybrids but was not stable (Koirala et. al., 2003). Systematic flow of hybrid trials was started from 1997 in the form of TAMNET hybrid trials and none of the evaluated hybrids was superior over the best check. NMRP had started developing its own inbred lines from well adapted OPVs (Rampur Composite and Arun-2) in 1988. Agriculture Botany Division (ABD) had also developed about 100 S4 lines from Manakamana-2 and Arun-4.

Inbred lines from CIMMYT, Mexico and hybrids from ARMP, Thailand were evaluated for multi-location testing. Evaluation of 127 hybrids were carried out in multi-location trials in Stations at, Parwanipur, Surkhet, Pakhribas, Lumle, Khumaltar and NMRP, Rampur). Since then, hybrid trials are being received regularly from CIMMYT through HMRP (Hill Maize Research Project) since 1997 and testing of these materials is being continued in different environments. Systematic work on hybrid maize breeding was only started from 1999, in Nepal. Extensive testing of hybrids was carried out at different locations. As a result, 'Gaurav' a single cross hybrid was released for the first time in Nepal in 2003. But the hybrid could not be commercialized due to nicking problem between parents resulting to the unavailability of seeds to the hybrid growing farmers.

1n 2006, a hybrid maize project was started with limited funds from International Corn Foundation (IFC), South Korea and number of hybrids have been tested under this project. Funding from the ICF could not be regular. Therefore, this project is kept under a NARC regular program. More than 400 inbred lines have been developed and maintained at NMRP for maize hybrid breeding program. Three heterotic groups (A, B and AB) have been developed and maintained for developing inbred lines. NMRP has started an intensive hybrid maize development program at Rampur and its collaborating research stations. A number of inbred lines have been developed, crossed and tested in different locations for yield, disease, insect resistance and per se performance and a few outstanding hybrids were identified. Two of them are namely RML-4 x NML-2 and RL-111 x RL-189 and are in the process of release with package of practices for F1 seed production. These selected hybrids are high yielding than the popularly grown imported hybrids and are tolerant to major foliar diseases.

F1 seed production of these promising hybrids in farmers' field and seeds have been successfully produced. The yield potential of the parents for these hybrids is 3-4 tones/ha which has made a hybrid seed production highly profitable. There is not much variation in flowering between the parents. Both the parents are almost synchronized in flowering (Pandey et al., 2007) (Table 1). Flowering can be adjusted with staggered planting. Problems will not arise in seed production due to variation in flowering. Hybrid maize production technology such as seed production of hybrids, their parents and complete package of practices is being developed. Private seed companies need not to worry in finding hybrid production technology. NMRP, being a public sector, is ready to hand over the technologies to the private sector for commercial hybrid seed production. Market size of hybrid maize seed is big enough to establish a medium scale seed enterprise in the countries. The F1 seed production is neither very easy nor very complex. Innovative farmers and community-based seed production groups can produce hybrid maize seeds after a short training. There is a high potentiality of hybrid maize seed production in Chitwan and thus a huge quantity of seeds can be easily produced. Many seed producer groups are being involved in seed production of rice, maize, vegetable and other crops in Chitwan.

Despite these potentialities, private sector has not come forward aggressively for hybrid maize seed production. This could be due to misconception that country' present demand is not enough for starting a hybrid seed production business. It is also perceived that hybrid seed production is not as easy as the seed production of OPVs. Private sector and Agro-vets may be more interested for making profits from selling imported seeds rather than carrying out seed production activities within the country. It is true that development of a hybrid maize variety takes several years for extraction of inbred lines, crossing and testing of hybrids over a wide range of locations. This demands a huge resources which could be a reason for lagging behind in hybrid breeding program in public sector and seed production in private sector.

3. New Hybrids for Terai Production Domains

After years of multi-location testing, NMRP has selected two single-cross hybrids for immediate release. These hybrids are RML-4 x NML-2 and RL-111 x RL-189. The former is developed using CIMMYT inbred lines and the later one is derived from the inbred lies developed from Upahar and Pool-21, respectively. The characteristics of both the hybrids and their parents have been discussed below.

3.1 RML-4 x NML-2

This is a full-season hybrid and has yield potential of 7.5 to 10.5 tones ha^{-1}. Kernel is yellow and flint type. Plant stature is similar to Gaurav hybrid (Figure. 1). Its erect leaves and medium plant height offers high density planting. Stem is robust and has no lodging problem. Seed parent (RML-4) is short (Figure 3) and has cylindrical ears with irregular row arrangement (Figure 5) and produces a good seed yield (about 3 tones/ha). Pollen parent (NML-2) has medium plant height (Figure 4) with erect leaves and glabrous leaf sheath. Pollen parent takes 69 growing degree unit GDU to shed pollen of seed parent (Table 1) when the seeds are planted at the same time. Parents are easy for crossing and varietal maintenance is not difficult.

Figure 1. RML-4 x NML-2 in field at NMRP, Rampur

Figure 2. Ears of RML-4 x NML-2

Figure 3. Seed Parent (RML-4)

Figure 4. Pollen parent (NML-2)

Figure 5. Ears of RML-4

3.2 RL-111 x RL-189

This hybrid is also a full-season variety and has a high grain yield potential (7.0-11.0 tones ha^{-1}). The hybrid has long ears with purple coloration on husk. Kernel is flint and yellow. Seed parent (RL-111) is medium in height and has cone shaped tassel (Figure 7). The well exerted tassel allows easy detasseling. Ears are medium in size (Figure 7) producing high seed yield (about 4 tones ha^{-1}). Both the parents are easy for varietal maintenance and crossing.

Figure 6. RL-111 x RL-189 at NMRP, Rampur

Figure 7. Seed parent (RL-111 in field (above) and ears (below)

4. Hybrid Seed Production Technology

A single-cross hybrid has only 2 parents involved in seed production. Its seed production has three isolations; seed production plots for two parents and a plot for F1 seed production. Here focus will be on F1 seed production aspect. For one hectare of land, 15 kg of seed parent and 5 kg seeds of pollen parent are required following 3:1 (female/male) planting ratio. Since inbred lines are usually short in plant height the spacing of 60 cm x 25 cm (66,666 plants/ha) can be easily adjusted. The parents need to be planted in such a way that pollen parents could shed pollens 2-3 days after silking of seed parent. Planting of pollen parent can be delayed because female parent can wait pollen grain for more than a week or more. Many techniques in this respect can be applied such as leaf clipping of plants at early stage, shoot tip cutting for early silk emergence and use of primed seeds to hasten uniform germination. Use of nitrogenous fertilizers delays the female parents and application of phosphorus and potash enhances flowering. Leaf clipping delays flowering by few days

(3-5) and primed seed hastens flowering by 2-3 days. Leaf clipping should be done in case of pollen parent. In case of RML-4 x NML-2, seed parent produces silk at 69 GDU earlier than the pollen shed by the pollen parent (Table 1). A few days of early silking is desirable because silk can wait for pollination and a short duration of pollen shed can pollinate the emerged silk (Russel and Hallauer, 1980). RML-4 and NML-2, thus, can be planted together or NML-2 can be planted together after seed priming for 16 hours if one wants it to shed. For proper utilization of fertilizers, full dose of phosphorus and potash and 10 percent nitrogen is to be applied at the time of planting. When plants reach 4-6 leaves stage, we need to apply 20 percent of the nitrogen fertilizer. Similarly, when plants attain 8 leaves stage, apply 30 percent of the nitrogen. At the time of flowering and grain filling stages, we should apply 30 and 10 percent nitrogen, respectively. One must be very cautious about the proper management of chemical fertilizers and other field management of the seed production plots. By doing this a very good quality hybrid seeds can be produced. Hybrid seed production could be a very remunerative seed business in Nepal. Modern inbred lines give at least 3 tones ha^{-1} of seeds. Seed parent covers about 75 percent of total area if we plant in a ratio of 3:1. If we assume only 80 percent pollination success, hybrid seed yield from one hectare would be 3000 x 0.8 x 0.75 = 1800 kg of seeds. Retail price of single-cross hybrid in market is above NRs.300 kg^{-1}. If we sell at wholesale rate of NRs. 250 kg^{-1}, one hectare will generate a total income of 1800 x 250 = NRs. 450,0000. A cost involved in seed production depends on the localities where the seed production is done. According to a rough estimation, Rs.100, 000 ha^{-1} would be sufficient to cover all the production costs including packaging. Thus, net profit would be Rs. 350,000 per ha. This clearly shows that hybrid maize seed production is a highly profitable business. Private seed companies should come forward to commercialize the hybrid seed production in Nepal. Doing this, the dependency of seed imports and flow of foreign currency outside the country will certainly be reduced. This would also help to increase maize production substantially in the hybrid maize growing areas thereby improving feed and food security in the long-run.

5. Conclusion and Recommendations

There is greater demand of hybrids and hybrid maize technology in Nepal. Huge quantity of hybrid seeds is imported from outside and millions of rupees flowing out every year. Despite the higher prices of hybrid seeds, farmers are sometimes victimized by inferior quality of seeds. Country has learnt a great lesson from the last year's unprecedented problem of grain setting in winter hybrid maize cultivation especially in Bara, Parsa, Sarlahi, Rautahat, Morang and in Nawalparasi districts. The severity of the problem was reported to be 20-80 percent loss in maize production. The problem was seen more in single-cross hybrids than double and three way crosses. There was no reporting of grain setting problem in OPVs. Farmers have lost millions rupees worth of maize production last year. Government of Nepal has allocated 200 million rupees as compensation to the affected farmers. This is not a permanent solution to overcome the current problem. Problem may occur in the future, too. For this, there must be a strong hybrid maize breeding program with sufficient resources so that the program can develop test and release hybrid maize on a regular basis. It was learnt from this exceptional event that borrowed technologies may not be sustainable and testing need to be done under local environments before taking it into the farming communities. For this, Nepal must have its own hybrid policy so that unsystematic and illegal inflow of hybrids from outside can be controlled and farmers will not suffer again as they suffered last year.

Multi-national seed companies interested to sell their seeds in Nepal, must apply formally to Seed Quality Control Centre (SQCC) for testing their materials in Nepal. The SQCC will then request NARC to carry out testing of these materials in different environments. For this NMRP should take a lead role in testing the materials and will evaluate the materials based on yield and other important traits. Then the NMRP recommends the best hybrids to SQCC based on their performances. SQCC will have to register those hybrids, which are found suitable for certain locations. Seeds of the registered hybrids should come through the strict inspection of Plant Quarantine based at respective Custom Offices along the border. For this, plant check-posts offices should be well equipped with required resources.

Seed distributors, dealer, and agro-vets can sell the seeds of those registered hybrids with labels. The seed dealer must be responsible if any seeds and seed-related problems occur. This initiative will make the seed dealers more responsible and accountable to the Nepalese farmers.

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Effect of Tillage, Mulch and Time of Nitrogen Application on Yield of Wheat (*Triticum aestivum* L.)

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Abstract

A field experiment was conducted at the research block of Institute of Agriculture and Animal Science (IAAS), Rampur, Chitwan, Nepal during winter season of 2007/08 to assess the effect of tillage, mulch and time of N application on yield of wheat. The experiment consisted of two levels of tillage (no tillage and conventional tillage), two levels of mulch (no mulch and mulch with rice straw @ 4 t ha^{-1}) and two timings of nitrogen application (half at sprouting and half at CRI and half at CRI and half at 40 days after sowing) and was laid out in factorial RCBD with three replications. Results showed that all the phenological stages of wheat were initiated significantly earlier in surface seeded plot and no mulch and half N at sprouting and half at CRI stage. Higher plant height was observed in surface seeded, mulched and half N at sprouting and half at CRI plot. Grain yield (3.62 t ha^{-1}) and harvest index (39.35%) were significantly higher in surface seeded plot than conventionally tilled plot due to the higher number of effective tillers m^{-2}, longer spike length and higher spike weight, grain weight $spike^{-1}$ and test weight. Similarly, mulched crop had also shown significantly higher grain and straw yield than non-mulched crop due to the longer spike length and higher grain weight $spike^{-1}$ and test weight. Likewise, higher gross income (69480 $Rs.ha^{-1}$), net income (42090 $Rs.ha^{-1}$) and benefit cost ratio (2.53) were significantly higher in surface seeded and mulched plot. So, surface seeding with application of mulch was considered better for higher productivity of wheat in terms of yield, gross income, net income and benefit cost ratio in the long run.

Key words: Conventional tillage, surface seeding, mulching

1. Introduction

In Nepal, wheat is the third most important cereal crop in acreage and production after rice and maize and therefore plays an important role in national food security. Though, wheat is one of the major cereal crops in Nepal the national average yield is only 2.15 t ha^{-1}, which is very low in comparison to neighbouring countries like India (2.67 t ha^{-1}) and China (4.59 t ha^{-1}) (FAOSTAT, 2007). Wheat yield under rice-wheat system is low due to delay sowing, nutrient deficiencies, excess soil moisture (Giri et al., 2005) and weed problems (Devkota, 1995).

Different tillage practices significantly influenced the input-use efficiency and economics of cultivation, for example, zero tillage or surface seeding improved the input-use efficiency, reduced

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cost of seed bed preparation gave opportunity for early sowing of wheat in rice-wheat system and reduced the incidence of problematic weeds *Phalaris minor* Retz. and *Chenopodium album* L (Mishra *et al.*, 2005).

Application of organic mulch serves as a good source of organic matter and also reported to be effective in suppressing weed growth. Organic mulches are cheap and easily available and also have beneficial effects like soil conservation, moderation of temperature and improvement of soil structure.

Uninterrupted nutrient supply during the growth period of wheat is pivotal to realize full yield potential. Among the nutrients, nitrogen plays important role in wheat production but it is very difficult to manage in surface seeding conditions. So, split application at appropriate time, can minimize the nitrogen loss, which results higher production and productivity (Giri, 1995). Angonin et al. (1996) also suggested that nitrogen dose should be adjusted at a favorable time in order to enhance the yield components not affected by the weed and reported split application of nitrogen at least 10 days after seeding and 20 days after seeding in full dose greatly influence yield and yield attributes of wheat.

Keeping in view the effect of long-term tillage, mulch and time of nitrogen application and yield of wheat in Chitwan conditions, the present investigation was conducted at the research block of Institute of Agriculture and Animal Science, Rampur, Chitwan, Nepal during the winter season of 2007/08.

2. Materials and Methods

The experiment was laid out in factorial randomized complete block design (RCBD) with three factors and eight treatments and was replicated thrice.

After harvesting of rice, field was made weed free by hand weeding and seeding was done immediately in surface seeding plot but in case of conventional tillage plot, it was dug thrice before planting. The crop was fertilized with 100:50:50 kg NPK ha^{-1} through urea, single super phosphate and muriate of potash respectively. Full doses of phosphorus and potash were applied as basal dose at sowing in all the treatments while nitrogen was applied according to the treatment assigned. In case of surface seeding, seeds were soaked in water for about 16 hours and then mixed with cow dung and dried in shade for about three hours and sowing was done in

Table 1: Details of treatment combination of the experimentation during winter season of 2007/08

S. N.	Treatment combinations	Symbol
T_1	Surface seeding + No mulch + N [½ at sprouting and ½ at CRI]	$T_1M_1N_1$
T_2	Surface seeding + No mulch + N [½ at CRI and ½ at 40DAS]	$T_1M_1N_2$
T_3	Surface seeding + Mulch @ 4 t ha^{-1} + N [½ at sprouting and ½ at CRI]	$T_1M_2N_1$
T_4	Surface seeding + Mulch @ 4 t ha^{-1} + N [½ at CRI, ½ at 40DAS]	$T_1M_2N_2$
T_5	Conventional tillage + No mulch + N [½ at sprouting and ½ at CRI]	$T_2M_1N_1$
T_6	Conventional tillage + No mulch + N [½ at CRI, ½ at 40DAS]	$T_2M_1N_2$
T_7	Conventional tillage + Mulch @ 4 t ha^{-1} + N [½ at sprouting and ½ at CRI]	$T_2M_2N_1$
T_8	Conventional tillage + Mulch @ 4 t ha^{-1} + N [½ at CRI, ½ at 40 DAS]	$T_2M_2N_2$

line on the surface keeping 25 cm distance between row to row. In case of conventional tillage, dry seeds were sown on furrow opened with spade. A seed rate of 120 kg ha^{-1} was used for sowing and the variety was BL 1473. In plots where mulch was assigned, rice straw chopped into 3-4 inches long pieces @4 t ha^{-1} was broadcasted evenly all over the plot in the following day of sowing.

Phenological observations of wheat viz. tillering, jointing and heading were recorded on plants of 1 m^2 of net area of each plot while observation of milking, dough and physiological maturity were recorded on randomly selected 20 plants from second sampling rows of each plot. Approximately 75 percent attainment of each of the stage was treated as completion of particular stage. Plant height was measured on the second and the third row from outer side of each plot taking 10 plants randomly at an interval of 15 days from 30 days after sowing to the physiological maturity stage. Effective tillers were recorded on plants of 1 m^2 of net area of each plot before harvesting the crop. The length and weight of panicles, number of grains per spike of the 20 randomly selected plants of net plot were recorded and averaged. Thousand grains were counted from the grain yield of net plot and weighed with the help of portable automatic electrical digital balance. Grain and straw yield (t ha^{-1}) was recorded from the rows of net plot and converted into hectare basis.

3. Result and Discussion

3.1 Phenology

All the phenological stages i.e. tillering, jointing, heading, dough and physiological maturity stages were significantly earlier in surface seeding, no mulch and half N at sprouting and half at CRI (Crown Root Initiation) stage plot (Table 2). Earlier occurrence of these phenological stage in surface seeded plot were due to the fact that in conventional tillage system, primary root gets favorable moisture and growth condition, which resulted late appearance of these phenological stages. Tripathi *et al.* (2007) reported that earlier occurrence of phenological stages in no mulch plot due to the low moisture and exposure of the surface to direct sunlight. Kuikel (2004) also observed the earlier appearance of vegetative and reproductive stages of wheat in surface seeded and mulched condition. In case of time of N application, the earlier appearance of phenological stages was under half N applied at sprouting and half N at CRI stage due to the earlier availability of nitrogen.

3.2 Plant Height

Significantly higher plant height was observed at reproductive stages i.e. at 60, 75, 90 and 105 days after sowing (DAS), however, it was also higher at 30 and 45 DAS but the effect was insignificant. Mishra et al., (2005) also reported higher plant height of wheat under zero tillage than minimum and deep tillage. Significantly higher plant height was observed in mulched crop in all stages of the crop due to the less weed population as an effect of mulch on weed growth. Similar results were also reported by and Rahman et al., (2005). Time of N application also affected the plant height significantly at 30, 45, 60 and 75 DAS but was insignificant at 90 and 105 DAS. The higher plant height with half N at sprouting and half N at CRI may be due to the earlier and greater uptake of nutrients during vegetative growth stages. Kuikel (2004) and Tripathi et al., (2007) also reported similar results.

Table 2 : Phenological stages of wheat as influenced by tillage, mulch and time of N application at IAAS, Rampur, Chitwan, Nepal during 2007/08

Treatment	Phenological Stages (DAS)					
	Tillering	**Jointing**	**Heading**	**Milking**	**Dough**	**Maturity**
Tillage						
Surface seeding	29.58[b]	45.17[b]	71.58[b]	91.08[b]	100.80[b]	114.60[b]
Conventional tillage	33.50[a]	50.58[a]	73.92[a]	92.92[a]	105.50[a]	116.30[a]
Mulch						
No mulch	30.50[b]	46.83[b]	71.25[b]	91.00[b]	102.60[b]	114.60[b]
Mulch	32.58[a]	48.92[a]	74.25[a]	93.00[a]	103.80[a]	116.30[a]
Nitrogen						
N_1	30.83[b]	46.75[b]	72.08[b]	91.33[a]	102.30[b]	114.80[b]
N_2	32.25[a]	49.00[a]	73.42[a]	92.67[a]	104.00[a]	116.00[a]
Grand mean	31.54	47.87	72.75	92.00	103.16	115.41
LSD	0.37	0.84	0.67	1.68	1.07	0.76
SEm ±	0.12	0.27	0.22	0.55	0.35	0.25
CV %	1.36	2.02	1.06	2.09	1.19	0.76

Means followed by the common letter(s) within a column are insignificantly different based on DMRT at P = 0.05. DAS = days after sowing; N_1 = ½ N at sprouting stage and ½ N at CRI stage; N2 = ½ N at CRI and ½ N at 40 DAS

Table 3 : Plant height of wheat at different dates as influenced by tillage, mulch and time of N application at IAAS, Rampur, Chitwan, Nepal during 2007/08

Treatment	Plant height (cm)					
	Days After Sowing (DAS)					
	30	45	60	75	90	105
Tillage						
Surface seeding	23.51[a]	48.75[a]	67.86[a]	85.03[a]	104.40[a]	104.70[a]
Conventional tillage	22.40[a]	46.87[a]	60.84[b]	76.99[b]	96.70[b]	98.16[b]
Mulch						
No mulch	20.76[b]	45.48[b]	61.34[b]	77.97[b]	95.63[b]	96.26[b]
Mulch	25.15[a]	50.14[a]	67.36[a]	84.05[a]	105.5[a]	106.6[a]
Nitrogen						
N_1	24.27[a]	50.08[a]	66.43[a]	82.13[a]	101.5[a]	102.30[a]
N_2	21.64[b]	45.54[b]	62.27[b]	79.88[b]	99.67[a]	100.50[a]
Grand mean	22.95	47.81	64.34	81.00	100.56	101.43
LSD	1.16	2.24	2.09	2.02	2.01	1.80
SE ±	0.38	0.74	0.69	0.66	0.66	0.59
CV%	5.81	5.37	3.72	2.86	2.29	2.03

Means followed by the common letter(s) within a column are insignificantly different based on DMRT at P = 0.05. N_1 = ½ N at sprouting stage and ½ N at CRI stage; N_2 = ½ N at CRI and ½ N at 40 DAS

3.3 Root Length

Significantly longer root was observed with conventional tillage at all growth stages of the crop (Table 4). The shorter root length in surface seeded plot may be due to the aeration problem and restriction in the penetration of root into the soil due to compaction. Kuikel (2004) and Khan et al., (1997) also reported longer root with conventional tillage than surface seeding wheat crop. Mulched crop had significantly longer roots than non-mulched crop at all growth stages of the crop. In mulched conditions, there was higher soil moisture, so, there is longer root length. Verma and Acharya (1996) and Kuikel (2004) also reported similar results. Variations in time of nitrogen application could not affect root length significantly at all growth stages.

3.4 Weeds Status in Wheat Field

The weed floras observed in the experimental plots with their description are presented in Table 5.

3.5 Yield and Yield Attributes

Significantly higher number of effective tillers m^{-2}, grain weight $spike^{-2}$, sterility percentage and 1000 grain weight. was found in surface-seeded plot than conventionally tilled plot (Table 6). Similarly, higher number of spike length, grain weight per spike, spikelets per spike and 1000 grain weight were observed in mulched plot. In case of time of N application, higher spikelets per spike was observed in half N at sprouting and half at CRI stage. Malik et al. (2000) also reported higher number of effective tillers in surface-seeded crop. Kuikel (2004) and Yadav et al. (2007) also reported higher number of effective tillers m^{-2} in mulched crop. Upadhyay and Tiwari (1996) reported that longer spike length and higher grain weight per spike under rice straw mulch.

Table 4 : Root length (cm) per plant of wheat at different growth stages as influenced by tillage, mulch and time of N application at IAAS, Rampur, Chitwan, Nepal during 2007/08

Treatment	Root length (cm) $Plant^{-1}$					
	Tillering	Jointing	Booting	Heading	Milking	Maturity
Tillage						
Surface seeding	9.23^{b}	10.10^{b}	9.85^{b}	9.79^{b}	10.51^{b}	10.74^{b}
Conventional tillage	10.07^{a}	11.31^{a}	11.36^{a}	11.39^{a}	12.20^{a}	13.00^{a}
Mulching						
No mulch	8.83^{b}	9.77^{b}	9.56^{b}	9.91^{b}	10.79^{b}	11.07^{b}
Mulch	10.46^{a}	11.64^{a}	11.65^{a}	11.27^{a}	11.92^{a}	12.68^{a}
Nitrogen						
N_1	9.61^{a}	10.77^{a}	10.72^{a}	10.72^{a}	11.41^{a}	11.84^{a}
N_2	9.68^{a}	10.64^{a}	10.50^{a}	10.46^{a}	11.31^{a}	11.90^{a}
Grand mean	9.65	10.70	10.60	10.59	11.35	11.87
LSD	0.57	0.58	0.46	0.56	0.58	0.40
SEm ±	0.18	0.19	0.15	0.18	0.19	0.13
CV%	6.80	6.23	5.05	6.13	5.83	3.85

Means followed by the common letter(s) within a column are not significantly different based on DMRT at P = 0.05. N_1 = ½ N at sprouting stage and ½ N at CRI stage; N_2 = ½ N at CRI and ½ N at 40 DAS

Table 5 : Description of the weeds recorded at different growth stages of wheat crop in the experimental plot at IAAS, Rampur, Chitwan, Nepal during 2007/08

Scientific Name	Families	Cotyl-edon	Habit	DAS		
				35	70	120
Ageratum houstonianum Mill.	Asteraceae	D	AH	+	-	-
Alternanthera sessilis (L.) DC.	Amaranthaceae	D	AH	+	+	-
Centella asiatica (L.) Urb.	Apiaceae	D	PH	+	+	+
Chenopodium album L.	Chenopodiaceae	D	AH	+	+	+
Cynodon dactylon (L.) Pers.	Poaceae	M	PH	+	+	+
Digitaria sanguinalis (L.) Scop.	Poaceae	M	AG	+	+	+
Erigeron sp.	Asteraceae	D	AH	+	-	-
Gnaphalium purpureum auct. non L.	Asteraceae	D	AH	+	+	-
Hemistepta lyrata Bunge	Asteraceae	D	AH	+	+	-
Hydrocotyle sibthorpioides Lam.	Apiaceae	D	AH	+	+	+
Ixeris polycephala Cass.	Asteraceae	D	AH	+	+	-
Mazus pumilus (Burm. f.) van Steenis	Scrophulariaceae	D	AH	+	-	-
Oxalis corniculata L.	Oxalidaceae	D	AH	+	+	+
Polycarpon prostratum (Forssk.) Aschers. & Schweinf. ex Aschers	Caryophyllaceae	D	AH	+	+	+
Polygonum plebeium R. Br.	Polygonaceae	D	AH	+	+	+
Rumex dentatus L.	Polygonaceae	D	PH	+	+	-
Salvia plebeia R. Br.	Lamiaceae	D	AH	+	+	-
Senecio ramosus Wall. ex DC.	Asteraceae	D	PH	+	+	-
Vicia spp.	Fabaceae	D	AH	+	+	-

+: presence of weed; -: absence of weed; A: annual; P: perennial; H: herb; G: grassy; D: dicot; M: monocot; DAS: days after sowing

3.6 Grain Yield, Straw Yield and Harvest Index

Significantly higher grain yield and harvest index was obtained from the surface-seeded crop (Table 7). The higher grain yield from surface-seeded crop was due to the earlier planting, higher number of effective tillers and higher test weight of grain. Tripathi et al., (2007) also reported higher grain yield from surface-seeded crop. Singh *et al.* (2001) also reported higher harvest index from surface seeded crop.

Similarly, mulched crop produced significantly higher grain and straw yield than the non-mulched crop. But higher harvest index was observed significantly in no mulched crop. The higher grain yield from mulched crop was due to the longer spike length and higher test weight and there was also less weed population and weed dry matter which resulted less weed-crop competition. Rahman et al., (2005) and Yadav et al., (2007) also reported higher grain yield under mulched condition. The higher straw yield in mulched crop was due to the higher plant height and LAI (Leaf Area Index) over no-mulch crop. Das et al., (2003) also reported higher straw yield due to mulching.

3.7 Organic Carbon (%) and Nitrogen Content (%) after Harvest of Wheat

Significantly higher soil organic carbon content was found in surface seeded plot. It was due to the reduced rate of mineralization. Denef et al., (2004) also reported similar results. Reduced soil organic carbon in conventionally tilled plot was due to the greater aeration, which thus stimulated more microbial activity and increased rate of disappearance of soil organic carbon. Similar result was also reported by Tisdale et al., (1985). Tillage had insignificant effect on soil nitrogen content, though higher nitrogen was found in surface seeded plot

Significantly higher soil organic carbon and nitrogen content was found in mulched plot than no mulch plot. It may be due to the decomposition of rice straw mulch. Gautam (2007) also observed higher soil nitrogen content under mulched conditions.

3.8 Economic Analysis

Significantly higher gross income, net income and B/C ratio was observed from surface- seeded and mulched crop but, time of N application had insignificant effect. Mishra et al. (2005) reported higher net income from zero tillage than deep and minimum tillage. Joshi (1996) also reported higher B/C ratio from zero tillage than the conventional tillage.

4. Conclusion

The results obtained from the investigation indicated that all the phenological stages of wheat were significantly earlier in surface-seeded and no mulch plot and half N applied at sprouting and half at CRI stage plot. Likewise, significantly longer plant height was observed in surface-seeded plot and mulched plot and half N applied half at sprouting and half at CRI stage at all the growth stages except at 90 DAS and 105 DAS. Similarly, significantly higher root length was observed in conventionally tilled and mulched plot. The yield attributes, grain yield, gross income, net income and benefit cost ratio was significantly higher from surface-seeded and mulched plot. Significantly, higher soil organic carbon content was found in surface-seeded and mulched plot but time of N application had no significant effect. Similarly, significantly higher nitrogen content was observed from mulched plot though tillage and time of N application had no significant effect. The results obtained from the investigation indicated that in long run, higher productivity of wheat under the agro-climatic conditions of Rampur, Chitwan, Nepal can be achieved from surface seeding with application of mulch which was better for higher productivity in terms of yield, gross income, net income and benefit cost ratio.

Acknowledgements

The authors wish to express their appreciation to the Directorate of Research, IAAS, Rampur, Chitwan, Nepal for providing necessary fund to conduct this research. Sincere thanks are due to Dean, Assistant Dean and Coordinator, PG Program, IAAS, Rampur for providing necessary facilities during the research.

Table 6 : Yield attributes of wheat as influenced by tillage, mulch and time of N application at IAAS, Rampur, Chitwan, Nepal during 2007/08

Treatment	Effective tillers m^{-2}	Spike length (cm)	Spike weight (g)	No. of grains $spike^{-1}$	Grain wt $spike^{-1}$ (g)	Spikelets $spike^{-1}$	Sterility %	1000-grain weight (g)
Tillage								
Surface seeding	349.0[a]	9.39[a]	2.53[a]	33.56[a]	1.74[a]	14.79[a]	12.99[a]	49.59[a]
Conventional tillage	296.9[b]	9.29[a]	2.39[a]	33.73[a]	1.53[b]	15.01[a]	10.62[b]	48.34[b]
Mulch								
No mulch	321.2[a]	9.09[b]	2.44[a]	33.42[a]	1.59[b]	14.48[b]	11.64[a]	48.33[b]
Mulch	324.8[a]	9.59[a]	2.49[a]	33.86[a]	1.68[a]	15.33[a]	11.97[a]	49.59[a]
Nitrogen								
N_1	321.1[a]	9.43[a]	2.41[a]	33.66[a]	1.67[a]	15.10[a]	12.17[a]	49.13[a]
N_2	324.8[a]	9.25[a]	2.51[a]	33.63[a]	1.61[a]	14.71[b]	11.43[a]	48.80[a]
Grand mean	322.95	9.34	2.46	33.64	1.64	14.90	11.80	48.96
LSD	18.66	0.22	0.17	0.17	0.07	0.35	1.53	0.54
SEm ±	6.15	0.07	0.05	0.05	0.02	0.11	0.50	0.18
CV %	6.60	2.79	7.90	7.90	5.34	2.72	14.88	1.28

Means followed by the common letter (s) within a column are not significantly different based on DMRT at P = 0.05. N_1 = ½ N at sprouting stage and ½ N at CRI stage ; N_2 = ½ N at CRI and ½ N at 40 DAS

Table 7 : Grain yield, straw yield and harvest index as influenced by tillage, mulch and time of N application at IAAS, Rampur, Chitwan, Nepal during 2007/08

Treatment	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
Tillage			
Surface seeding	3.62[a]	5.65[a]	39.35[a]
Conventional tillage	3.39[b]	5.67[a]	37.58[b]
Mulch			
No mulch	3.23[b]	4.87[b]	39.97[a]
Mulch	3.77[a]	6.45[a]	36.96[b]
Nitrogen			
N_1	3.50[a]	5.87[a]	37.55[b]
N_2	3.50[a]	5.44[b]	39.39[a]
Grand mean	3.50	5.66	38.46
LSD	0.15	0.31	1.12
SEm ±	0.05	0.10	0.36
CV %	4.92	6.38	3.33

Means followed by the common letter(s) within a column are non-significantly different based on DMRT at P = 0.05. N_1 = ½ N at sprouting stage and ½ N at CRI stage; N_2 = ½ N at CRI and ½ N at 40 DAS

Table 8 : Soil organic carbon (%) and nitrogen (%) as influenced by tillage, mulch and time of N application after harvest of wheat at IAAS, Rampur, Chitwan, Nepal during 2007/08

Treatment	Organic carbon (%)	Nitrogen (%)
Tillage		
Surface seeding	2.74[a]	0.73[a]
Conventional tillage	2.52[b]	0.66[a]
Mulch		
No mulch	2.47[b]	0.65[b]
Mulch	2.79[a]	0.74[a]
Nitrogen		
N_1	2.65[a]	0.68[a]
N_2	2.62[a]	0.71[a]
Grand mean	2.63	0.70
LSD	0.19	0.08
SEm ±	0.06	0.02
CV %	8.59	14.13

Means followed by the common letter(s) within a column are not-significantly different based on DMRT at P = 0.05. N_1 = ½ N at sprouting stage and ½ N at CRI stage; N_2 = ½ N at CRI and ½ N at 40 DAS

Table 9 : Economic analysis of wheat as influenced by tillage, mulch and time of N application at IAAS, Rampur, Chitwan, Nepal during 2007/08

Treatment	Gross income (× 000 Rs. ha^{-1})	Net income (× 000 Rs. ha^{-1})	B/C Ratio
Tillage			
Surface seeding	69.48[a]	42.09[a]	2.53[a]
Conventional tillage	65.31[b]	35.99[b]	2.22[b]
Mulch			
No mulch	61.93[b]	35.04[b]	2.30[b]
Mulch	72.86[a]	43.03[a]	2.44[a]
Nitrogen			
N_1	67.55[a]	39.20[a]	2.38[a]
N_2	67.23[a]	38.88[a]	2.37[a]
Grand mean	67.39	39.03	2.37
LSD	2.86	2.86	0.09
SEm ±	0.94	0.94	0.03
CV%	4.85	8.38	4.84

Means followed by the common letter(s) within a column are not-significantly different based on DMRT at P = 0.05. N_1 = ½ N at sprouting stage and ½ N at CRI stage; N_2 = ½ N at CRI and ½ N at 40 DAS

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Economic Analysis of Underutilized Crop: A Case of Ricebean Landraces from Ramechhap District of Nepal

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Abstract

Ricebean (*Vigna umbellata* T.) is an underutilized crop, which continues to be grown, managed or collected, particularly in rural areas of developing economies, and are thus contributing to the livelihoods of the poor. They are locally plentiful but nationally and therefore also globally rare, scientific information and knowledge about them is little, and their current use is limited related to their economic potential. The crop has received little scientific attention with the consequence that no improved varieties exist but possesses tremendous landraces diversity in Nepal. Ricebean is heterogeneous in phenotypic characteristics such as form, colour and size. Average area of Ricebean landraces was 0.56 ha with 0.67 mt ha^{-1} productivity. The contribution of Ricebean enterprise to the total annual household cash income was 11 percent. Sano seto, ghorle, kalo, rato and pahelo were the common Ricebean landraces which have been maintained by farmers for time immemorial due to social, cultural, geographical and economic reasons.

Key words: economics farmer, landraces, livelihood ricebean underutilized

1. Introduction

Nepal has immense potential for improving farmer's food security and livelihoods through sustainable utilization, value addition and conservation of its rich agro-bioresources (Gauchan et al., 1999). Agro-ecological variations even within a small geographical area of the nation favor specification of flora and fauna that provides ample opportunities for diversifying agriculture. Ricebean (*Vigna umbellata* T.) belongs to the group of underutilized plant species which survive because they are still useful to local people or occupying special niches in production systems because of their adaptability to low input and marginal lands (GRUÈRE et al., 2006). They are continued to be grown, managed or collected, particularly in rural areas of developing economies, and are thus contributing to the livelihoods of the poor. They are locally plentiful but nationally and therefore also globally rare, scientific information and knowledge about them is little, and their current use is limited related to their economic potential.

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A Ricebean variety with all quality characteristics demanded by consumers will increase the market value, improve their marketability and generate income for the local producers. Ricebean is a rainy season crop, extensively grown as an intercrop with maize in *bari* land, on the edges of the upland terraces with millet and on rice bunds in *khet* land, in sloppy-marginal to sub-marginal lands of Nepal (Lohani, 1980). Nepalese farmers produce about 270,000 mt of pulses per year for about 28.6 million people (Doreen et al., 2009). Until 2003, Nepal was a net-exporter of pulses, since 2004 the quantity imported has exceeded that exported (Doreen et al., 2009). The most important pulses are lentil, chickpea and pigeon pea. Ricebean along with other pulses like field pea, cow pea, broad bean, *Phaseolus*, and mungbean occupy 319557 ha area with the production of 274,375 mt and productivity 859 kg ha^{-1} in Nepal (ABPSD, 2007). Lack of farmer's networks, access to market information and poor institutional capacities are some of the key problems that exclude farmers to receive direct economic benefits from the existing biodiversity. Consequently, these valuable and diverse Ricebean landraces prevalent in different parts of the country are disappearing from farmer's field at alarming rate. The diversity of Ricebean genetic resource retained for use within modern agriculture will be very important input for future improvement and sustainability of Ricebean-based production system. In the marginal environments, diverse Ricebean landraces are highly valued because of their various production, consumption and cultural values. It is an important component of the dry land farming system in Nepal. Nepalese consumers spend about 3 percent of their food expenditure on pulses, somewhat lower than in India (Doreen et al., 2009). The market channel for pulses in general involves six stages: farmers, commission agents/brokers, wholesalers, mills, retailers, and consumers. Most Ricebean growing farmers in India and Nepal produce only small quantities, with an average of 40 kg per farmer. About 40 percent sell Ricebean, with an average marketed surplus of about 30 percent of the production (Doreen et al., 2009). Four stages with intermediaries were identified in the Ricebean marketing channel: producers, commission agents, wholesalers, retailers, and consumers. Farmers sell to collectors, wholesalers and retailers. Most farmers sell to *kiranas* because they pay the highest price. The average margin for Ricebean is 19 percent of the buying price in India and 15 percent in Nepal (Doreen et al., 2009).

1.1 Objective

The objective of this study is to analyze the economics of Ricebean landraces in Ramechhap district of Nepal.

2. Materials and Methods

2.1 Selection of Study Area

Three Village Development Committees (VDCs) namely Ramechhap, Bhaluwajor and Pakarbas were selected purposively based on area coverage and production of Ricebean from Ramechhap district.

2.2 Sample Size and Sampling Procedure

For the measurement of selected variables, the farmers who grow at least one Ricebean landrace were considered as survey population and were thus included in the sampling frame. Therefore, 34 producers' form each VDCs, meeting the criteria for sampling unit were selected by applying simple random sampling technique. Altogether 102 Ricebean growers were selected randomly for this study.

2.3 Selection of Ricebean Traders and Consumers

For this study, three types of Ricebean traders, village level collectors/commission agents, wholesalers, and retailers were identified and selected for the interview. Village level collectors and commission agents were identified during the visit of study sites and at local *hat*. Therefore, six village level collectors, six local retailers, four commission agents and five consumers were selected purposively and interviewed from Ramechhap district. Similarly, three wholesalers, five retailers and five consumers were selected purposely and interviewed from the Kathmandu valley, since more than 70 percent of the total production of Ricebean at Ramechhap district flows to Kathmandu valley (DDC, 2006).

2.4 Techniques of Data Collection and Analysis

Pre-tested interview schedule was administered to the selected Ricebean producers to collect primary data. A number of field visits were made to understand production and marketing systems of Ricebean in the study sites. The secondary data were obtained through reviewing publications of concerned intuitions. Data entry and analysis was done by using computer software packages like SPSS and MS-EXCEL. Descriptive statistics like mean, standard deviation, percentage and frequency were applied to describe socio-economic and farm characteristics.

2.5 Conceptual Framework for Data Analysis

2.5.1 Benefit-Cost Ratio Analysis of Ricebean Landraces Production

Benefit cost ratio simply gives an idea about recovery of cost incurred during the production by return from products. This analysis was done after calculating the total cost and gross return from Ricebean production. Total variable cost was considered total cost of production as almost no fixed cost was observed to be incurred during Ricebean landraces production except land revenue. The benefit-cost analysis was carried out by using following formula.

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

2.5.2 Marketing Margin and Producers Share Analysis

Marketing margin (MM) is used synonymously with the term "Price Spread" and is the difference between the price paid by the consumers and the price received by the farmers. This was calculated by subtracting farm gate price from retailer price.

Marketing margin
= Retailer price – Farm gate price

$MM = P_r - P_f$

Similarly, producers share is the price received by the farmer expressed as a percentage of the retail price, which is the price paid by the consumer. Considering P_r

is the retail price and P_f is the producer's price (farm gate price), the producers share (P_s) is calculated as:

$$P_s = \frac{P_f}{P_r} \times 100$$

2.5.3 Gross Margin Analysis

For any enterprises, gross margin is the difference between total value product of the enterprise and variable cost attributed to it. Gross margin is also termed as gross profit or "returns over variable costs" in the economic literature. For the analysis of gross margin, only the variable costs were considered. The variable cost must be specific to single enterprise and vary approximately in proportion to the size of the enterprise. Gross margin is the value of output produced by the producer, which is evaluated at the farm gate price minus the total variable cost.

Gross margin
= Gross return – Total variable cost

Where,
Gross return = Price of Ricebean * Total quantity marketed

Total variable cost = Summation of cost incurred in all the variable items

Gross margin of different Ricebean landraces may differ each other. So, the average gross margin of different Ricebean landraces at current market price was compared through univariate analysis of variance.

2.5.4 Marketing Efficiency

Marketing efficiency is essentially the degree of market performance. The movement of goods from producer to consumers at the lowest possible cost, consistent with the provision of the services desired by the consumer, may be termed as efficient marketing (Acharya and Agarwal, 1999). A change that reduces the costs of accomplishing a particular function without reducing consumer satisfaction indicates an improvement in the efficiency. But a change that reduces costs but also reduces consumer satisfaction need not indicate increase in marketing efficiency. A higher level of consumer satisfaction even at a higher marketing cost may mean increased marketing efficiency if the additional satisfaction derived by the consumer outweighs the additional cost incurred on the marketing process. An efficient marketing system is an effective agent of change and an important means for raising the income levels of satisfaction of the consumers.

An ideal measure of marketing efficiency, particularly for comparing the efficiency of alternate markets/channels, should be such which takes into account all of the following:

a. Total marketing costs (MC)
b. Net marketing margins (MM)
c. Prices received by the farmer (FP)
d. Prices paid by the consumer (RP)

The marketing efficiency was measured empirically with the help of Acharya's Modified Approach for Marketing Efficiency (Acharya and Agarwal, 1999).

$$\text{MME} = \frac{FP}{MC + MM}$$

Where,

MME = the modified measure of marketing efficiency
FP = Price received by the farmer
MC = Marketing cost
MM = Marketing margin

3. Results and Discussion

3.1 Food Sufficiency

Numerous field exercises on wealth ranking with terai and mountain communities in Nepal have indicated that food sufficiency months of households based on production from own (shared-in and rent-in) land was the true reflection of well being in marginal and agrarian society (Rana et al., 1999). In fact, in very marginal and agrarian society this could be the single most important indicator explaining the majority of the variation in social community. Because of its importance in discriminating households information on food sufficiency level it was collected in household survey of this study as well (Table 1). The food sufficiency criteria used here is adopted from Sah and Khan (2002).

Only 10.8 percent of the sampled households were food self sufficient (i.e. 12 month and above) and economically well-off. Around 21 percent of households were capable poor and better-off and they had food for 6 to 12 months only. Majority of households (i.e. 68.6 %) were very poor and poor and they had food just for 3 to 6 months. On comparison across the study sites the economically well-off households were the highest in Ramechhap where 17.6 percent household had surplus food for more than 12 months. Likewise 50.0 percent households in Pakarbas and 35.3 percent households in Bhaluwajor were having poor and very poor economic status. The information indicated that majority of households from poor and medium categories have to resort to alternative sources of income to tide over the food deficit months, which became evident when analyzing sources of income at household level across wealth categories.

Table 1: Economic status-wise food sufficiency of the sampled households by VDC

Food sufficient For (months)	Economic status	VDC							
		Ramechhap		Bhaluwajor		Pakarbas		Total	
		F	%	F	%	F	%	F	%
0	Destitute	0	0.0	0	0.0	0	0.0	0	0.0
>0-3	Very poor	7	20.6	12	35.3	7	20.6	26	25.5
>3-6	Poor	12	35.3	15	44.1	17	50.0	44	43.1
>6-9	Capable poor	4	11.8	3	8.8	1	2.9	8	7.8
>9-12	Better-off	5	14.7	1	2.9	7	20.6	13	12.7
>12	Well-off	6	17.6	3	8.8	2	5.9	11	10.8
Total		34	100.0	34	100.0	34	100.0	102	100.0

F = Frequency

3.2 Farmers' Local Knowledge on Ecosystem and Varieites

Farmers employ multiple criteria to characterize Ricebean ecosystem. Moisture and inherent fertility status of soil as well as productivity potential influenced by human managed factors were the major determinants in characterizations of Ricebean ecosystems. Findings also suggest that only a limited number of landraces exit for extreme conditions, whereas plenty of options exist for favorable conditions for farmers to choose from local diversity bank. *Sano seto, ghorle, kalo, rato* and *pahelo* were the common Ricebean landraces grown by farmers in Ramechhap district (Table 2). For instance, there was not a single modern variety of Ricebean introduced. Therefore, farmers operating in marginal ecosystems have limited choice of genetic materials.

3.3 Contribution of Ricebean Landraces to Household Food Security

Food security of household member is the prime concern for any households. The issue of food security can be seen at various levels depending on whose perspective one takes. For instance, the subject could be dealt at national, regional, community, household and intra-household levels. However, for the purpose the food security issue at household level only would be discussed. Furthermore, food security issue at micro-level is dealt with either increasing the purchasing capacity of household or by directly producing the required commodities in the farm itself (Rana et al., 1999). The former approach works well when households are fully integrated with market. But later option would be preferred when the market access and distribution mechanism is less than dependable. The role of landraces in food security at household (resource poor) level could be one of the strongest justifications for their consideration in conservation programmes (Rana et al., 1999). Food security is understood with two interrelated concepts, food utilization and food access. Food utilization means the ability of household to properly absorb food in order to benefit from its nutrient and energy content whereas food access means the ability of households to be able to produce or purchase a sufficient amount of diversity of food items.

Table 2 : Distribution of Ricebean landraces diversity by agro-ecological domains

Landraces	Altitude (masl)	Adaptation by habitat type		
		Land type	Farmer's Soil type	Cropping system
Sano seto (Determinate)	600-1050	Upland b*ari* Rice bunds	*Kalo gagreto mato* (Black stony soil)	Sole and mixed cropping with maize
Sano seto (Indeterminate)	600-1500	Upland *bari*	*Rato gagreto mato,* (Red stony soil)	Mixed cropping with maize
Ghorle	1200-2200	Upland *bari*	*Rato chimte mato* (Red sticky soil)	Mixed cropping with maize
Kalo	850-1500	Upland *bari*	*Khairo mato* (Brown soil)	Mixed cropping with maize
Rato	850-1500	Upland *bari*	*Rato gagreto mato* (Red stony soil)	Mixed cropping with maize
Pahelo	800-1500	Upland *bari*	*Kalo domat mato* (Black loamy soil)	Mixed cropping with maize

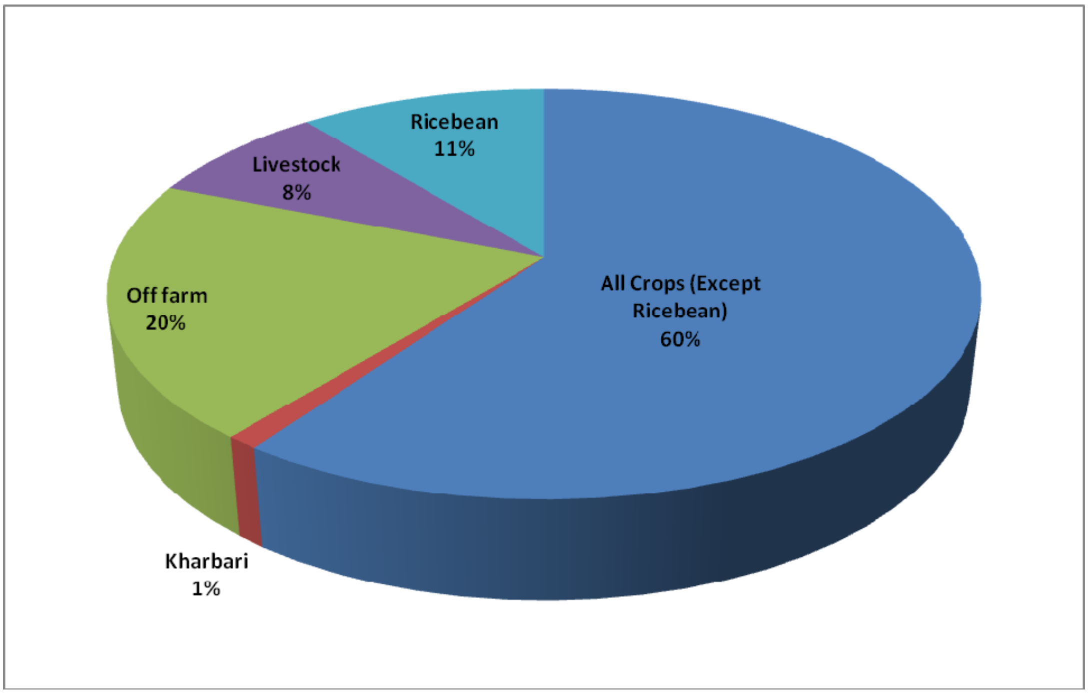

Figure 1. Source of household's annual cash income

Household's members in the study sites were observed to support their household needs by engaging in different kinds of farm and off-farm activities. As stated earlier, only about 10.8 percent of households across the study sites were of self food sufficient and remaining others were of self food insufficient category (Table 1). The study indicated that the share of total farm cash income to the annual household cash income was large (i.e. 80 %) as compared to total annual off-farm cash income (i.e. 20 %) (Figure 1). Among all farm enterprises income from all crops except Ricebean is a vital component in farming system, which contributes 60 percent to the total household economy throughout the study sites. Out of total household cash income Ricebean alone had contributed about 11percent to the total household economy, which underscore the importance of Ricebean enterprises in the rural farming economy. In this study, the contribution of Ricebean landraces to the household food security was taken into analysis. Households in the study sites especially which are self food insufficient were observed to sell Ricebean to the market as cash crop mainly because of their compulsion to purchase other food grains especially rice. If they did not sell, the amount of food grain (ready to consume) produced on their own land would be sufficient for few months only. If they sell Ricebean in the market, they can get premium price almost more than double the price of other food grain. Then they purchase other food grains (especially milled rice) from the cash returned from selling of Ricebean as the household accessibility (in terms of purchasing capacity) increased. Then the balance of total food grain increased as compared to the condition of before marketing of Ricebean, and household would be food sufficient for months. The result on the Fig. 1 showed that the cash income obtained from selling Ricebean had great contribution to increase household food availability.

3.4 Cost of Production and Return from Ricebean

Cultivation of Ricebean landraces incurs various types of cost, since it uses various kinds of input in terms of labor, fertilizer, seed, irrigation, chemicals etc. The study showed that average cost of production of *kalo* was the highest (i.e. 19.09 ± 0.49 thousand rupees ha^{-1}) followed by *rato, ghorle, pahelo and seto* across the study site (Table 3). Comparing the average cost of production of *sano seto*, households of Bhaluwajor incurred the lowest (i.e. 17.41 ± 0.28 thousand rupees ha^{-1}) cost of cultivation. The average return from *sano seto* was the lowest (i.e. 20.78 ± 0.73 thousand rupees ha^{-1}) in Pakarbas and it may be due to lower productivity of *sano seto* at Pakarbas as compared to Ramechhap and Bhaluwajor. The benefit cost (B/C) ratio of *sano seto* was observed the highest (i.e. 1.78 ± 0.05) in Ramechhap followed by Bhaluwajor (i.e. 1.52 ± 0.07) and Pakarbas (i.e. 1.14 ± 0.04). In case of *ghorle,* the average cost of production was observed the lowest in Bhaluwajor (i.e. 17.71 ± 0.29 thousand rupees ha^{-1}) but the total return was observed the highest in Ramechhap (i.e. 28.43 ± 0.82 thousand rupees ha^{-1}). Therefore, the B/C ratio for *ghorle* was the highest in Ramechhap (i.e. 1.45 ± 0.05). Likewise, in case of *kalo,* the average cost of production was observed the lowest in Bhaluwajor (i.e. 18.53 ± 0.34 thousand rupees ha^{-1}) but the total return was observed the highest in Ramechhap (i.e. 32.20 ± 1.37 thousand rupees ha^{-1}). Therefore, the B/C ratio for *kalo* was highest in Bhaluwajor (i.e. 1.50 ± 0.15). In case of *rato,* the average cost of production was observed lowest in Pakarbas (i.e. 18.54 ± 0.01 thousand rupees ha^{-1}) but the total return was observed the highest in Bhaluwajor (i.e. 27.09 ± 1.05 thousand rupees ha^{-1}). Therefore, the B/C ratio for *rato* was the highest in Ramechhap (i.e. 1.48 ± 0.07). Similarly, in case of *pahelo,* the average cost of production was observed the lowest in Pakarbas (i.e. 18.53 ± 0.06 thousand rupees ha^{-1}) but the total return was observed the highest in Bhaluwajor (i.e. 32.84 ± 1.29 thousand rupees ha^{-1}). Therefore, the B/C ratio for *pahelo* was the highest in Bhaluwajor (i.e. 1.74 ± 0.05).

3.5 Ricebean Marketing

Agricultural marketing system can be loosely defined as the activities and processes involved in moving a commodity from farmers to consumers (Doreen et al., 2009). The pulse marketing systems in India and in Nepal are known to be fragmented, complex, and even chaotic (World Bank, 2008). This suggests that no single theoretical perspective would be sufficient for describing and analyzing the Nepalese marketing systems adequately. Therefore, five perspectives were selected in the hope of accommodating the complexity. These were marketing system, marketing channels, marketing margin, producer's shares and marketing efficiency.

3.5.1 Ricebean Marketing System

Marketing cost, marketing margin and price spread were different for different marketing channels. Therefore, value chain approach has been used here to study the marketing system, marketing channels, marketing margin, producer's shares and marketing efficiency of Ricebean (*sano seto)* landrace (Figure 2).

Figure 2. Value chain map for Ricebean (*sano seto*) in the study site

Where,

SP = Selling price

Com. Agents = Commission Agents

SP_1 = Selling price for commission agents at local Hat/Bazzar

SP_2 = Selling price for local collectors, retailers and consumers

SP_3 = Selling price for commission agents

SP_4 = Selling price for local retailers

Table 3: Average cost and return of Ricebean landraces (in thousand rupees ha^{-1})

Landraces	Items	Ramechhap	Bhaluwajor	Pakarbas	Total
		Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
Sano seto	Average return	34.31 ± 0.90	26.47 ± 1.28	20.78 ± 0.73	27.12 ± 0.79
	Average cost	19.42 ± 0.40	17.41 ± 0.28	18.27 ± 0.15	18.36 ± 0.18
	B/C ratio	1.78 ± 0.05	1.52 ± 0.07	1.14 ± 0.04	1.48 ± 0.04
Ghorle	Average return	28.43 ± 0.82	22.41 ± 1.26	17.44 ± 0.65	23.67 ± 0.79
	Average cost	19.70 ± 0.42	17.71 ± 0.29	18.41 ± 0.08	18.67 ± 0.22
	B/C ratio	1.45 ± 0.05	1.26 ± 0.07	0.94 ± 0.03	1.27 ± 0.04
Kalo	Average return	32.20 ± 1.37	28.04 ± 3.30	19.19 ± 2.55	29.42 ± 1.52
	Average cost	19.31 ± 0.76	18.53 ± 0.34	18.85 ± 0.32	19.09 ± 0.49
	B/C ratio	1.46 ± 0.16	1.50 ± 0.15	1.02 ± 0.15	1.40 ± 0.12
Rato	Average return	23.91 ± 3.16	27.09 ± 1.05	14.04 ± 2.91	21.65 ± 2.24
	Average cost	19.28 ± 0.89	18.86 ± 0.16	18.54 ± 0.01	19.02 ± 0.51
	B/C ratio	1.48 ± 0.07	1.43 ± 0.04	0.91 ± 0.06	1.35 ± 0.07
Panhelo	Average return	32.59 ± 1.60	32.84 ± 1.29	21.67 ± 1.29	30.31 ± 1.57
	Average cost	18.58 ± 0.91	18.86 ± 0.16	18.53 ± 0.06	18.63 ± 0.50
	B/C ratio	1.64 ± 0.24	1.74 ± 0.05	1.16 ± 0.07	1.56 ± 0.15

SE = Standard Error

Ricebean producers, market intermediaries and consumers were the stakeholders of Ricebean value chain map. Ricebean from producer was found to flow from different market intermediaries to final consumers. Most of Ricebean was traded through the involvement of middle men (commission agents). Few village level collectors, local retailers and commission agents had been involving in collection of Ricebean directly from producers at household level across the study sites. But most of the producers (about 87%) used to bring their produce at local hat/bazzar for sell. The local hat/bazzar had been occurring once upon a week. Producer used to bring Ricebean grain at local hat/bazzar for sell and after selling Ricebean, they used to purchase other food grains (e.g. milled rice) vegetables, meat, clothes, stationary items and other daily necessary goods from the cash receipt from Ricebean. At local hat/bazzar, commission agents used to purchase Ricebean grain from producers and local level collectors. The commission agents used to sell the Ricebean to the wholesalers. Those wholesalers may be local (wholesale market at Manthali) or distant (i.e. Kalimati wholesale market, Kathmandu). From wholesaler Ricebean was distributed to retailers and from retailers to consumers. The flow of product form producer at Ramechhap to consumers at Kathmandu valley, marketing margin and price spreads across the different stakeholders has been presented in the value chain map (Figure 2). Increase in selling price of Ricebean from the first stage of marketing (i.e. producers) to final stage of marketing (i.e. retailers – consumers) was due to value addition and marketing cost involved on post harvest handling and marketing. The value addition activities that were observed in Ricebean were, cleaning, drying, coloring, milling (i.e. making pulse) etc. of grains. Such types of value addition activities had been performing by producers, wholesalers and sometime by retailers of Ricebean. Milling in Ricebean was very rare, only two producers at Ramechhap used to sell Ricebean pulse (*masyang ko dal*) after milling.

3.5.2 Gross Margin Analysis

The univariate analysis of variance of gross margin from Ricebean landraces was done to test whether the gross margin received by producer from different Ricebean landraces were different significantly or not. Similar analysis was done by Bastakoti (2001) on mandarin orange. The study revealed that the gross margin (Rs kg^{-1}) of different Ricebean landraces were significantly different ($p<0.01$) and the gross margin (Rs kg^{-1}) of Ricebean landraces were also differed significantly ($p<0.05$) across the different VDCs (Table 4).

Among the Ricebean landraces, the gross margin (Rs kg^{-1}) was observed maximum for *sano seto* in Ramechhap (Table 4), that was observed maximum for *pahelo* in Bhaluwajor. But in case of Pakarbas, the gross margin (Rs kg^{-1}) was observed maximum for *sano seto.* The reason behind the different gross margin values of Ricebean landraces within the same agroecological domain and under same management condition was due to difference in productivity and market price for each landraces. The productivity is a multidimensional and complex factor, which is governed by management, soil characteristics, microclimatic conditions, and genetic makeup of plant species (Jarvis et al., 2000). The difference in productivity for each Ricebean landraces within the same agroecological domain and under the common management condition is associated with their respective genetic makeup. Therefore, this finding further strongly proves that the Ricebean landraces were not only morphologically diverse but also differ genetically among each other.

The market price for Ricebean was determined by market forces like demand and supply of commodity in the market. Therefore, the different market price for each Ricebean landraces were associated with determinants of demand and supply like consumers tests and preferences, consumers' purchasing capacity, cultural and spiritual value in the community, supply of commodity in the market, availability of other complementary and substitutionary commodities in the market etc. Different Ricebean landraces had different socioeconomic values in the society. Therefore, this finding further proves that those Ricebean landraces had not only morphological diversity, but also they had socioeconomic diversity. Conclusively, it can be said that the Ricebean landraces differed genetically and socio-economically among each other throughout the study sites.

Table 4: Average gross margin from Ricebean landraces across the study sites

Location	Landraces	Gross margin (Rs kg^{-1})
		Mean ± SE
Ramechhap	*Sano seto*	15.78 ± 0.82
	Ghorle	7.96 ± 0.87
	Kalo	12.94 ± 1.17
	Rato	8.22 ± 1.35
	Panhelo	14.74 ± 1.86
Bhaluwajor	*Sano seto*	9.56 ± 1.62
	Ghorle	2.30 ±1.98
	Kalo	9.52 ± 3.61
	Rato	8.09 ± 0.76
	Panhelo	15.09 ± 0.76
Pakarbas	*Sano seto*	11.70 ± 0.82
	Ghorle	5.19 ± 1.00
	Kalo	8.40 ± 1.77
	Rato	4.24 ± 0.82
	Panhelo	11.69 ± 1.26
Location	F ratio	5.955**
	P value	0.026
Landraces	F ratio	12.362*
	P value	0.002

SE = Standard Error.
Note: * and ** refers to the significant at 0.01 and 0.05 level of significance, respectively

3.5.3 Marketing Channels and Marketing Efficiency

Marketing efficiency is essentially the degree of market performance. The movement of goods from producers to consumers at the lowest possible cost, consistent with the provision of the services desired by the consumer, may be termed as efficient marketing (Acharya and Agarwal, 1999). A change that reduces the costs of accomplishing a particular function without reducing consumer satisfaction indicates an improvement in the efficiency. An efficient marketing system is an effective agent of change and an important means for raising the income levels of satisfaction of the consumers. Marketing margin and producer share give an indication of efficiency of existing marketing system. Lower marketing margin and higher producer share on retail price ensures efficiency of marketing system (Acharya and Agarwal, 1999).

Altogether, five marketing channels were identified that had been operating for Ricebean marketing throughout the study sites. Those marketing channels have been presented hereunder.

1. Producers → Consumers
2. Producers → Local Retailers → Consumers
3. Producers → Local Collectors → Local Retailers → Consumers
4. Producers → Commission Agents → Wholesalers → Retailers → Consumers
5. Producers → Local collectors → Commission Agents
   Wholesalers → Retailers → Consumers

Ricebean value chain analysis has revealed that marketing efficiency and producer's share on consumer rupees was decreasing with increasing in the number of intermediaries in the marketing channels. Among these marketing channels, channel-1 was most efficient because of the highest (128) index of marketing efficiency (Table 5). The producer had 100 percent share on consumer rupees in that channel because of almost no involvement of any marketing intermediaries. But that channel was followed by very few stakeholders (<5 percent) because producer could not sell all their produce through this channel and there was the compulsion to go in local hat/bazzer to purchase other necessary goods. Therefore, this channel was the most efficient but not dominant at Ramechhap district. In an ideal market condition, the producers would have maximum shares on consumers' rupee if all the stakeholders operate through this channel. But at ground reality, channel-5 was dominant because more than 80 percent of Ricebeen produced at Ramechhap district used to pass through this channel. The index of marketing efficiency and producers share associated with this channel were 1.45 and 67.22 percent, respectively. Similarly, channel-6 was least efficient (1.25) and producer's share on consumer rupees was also the lowest (53.78 percent) for this channel. Therefore, conclusively it can be said that the prevailing marketing system of Ricebean landraces was not efficient and most of the produces were receiving low share on consumer's rupees in Ramechhap.

Critical analysis over the price spread of Ricebean across the market participants shows that the share of middlemen on consumer rupee was more as compared to producer in all marketing channel (Figure 2) (Table 5). It is not unusual to encounter the view that the farmer's share of the retail price of agricultural commodities is too small and that retail-farmgate margin are excessive and include elements of excess profit (Bastakoti, 2001). In many instances this charge has been judged to be unsupported since a careful analysis of the profits of middlemen and processing firms shows them to be commensurate with the business risk involved. Generally, a higher farm-retail margin is associated with the demand of marketing services and the cost uncured for these. In developing countries like Nepal, marketing services are costly due to very poor transportation infrastructure and marketing margins tend to be high (Bastakoti, 2001). This is highly affected by the accessibility conditions of production sites. Generally, high marketing margin was linked with exploitation of middlemen. However, the higher marketing margin may not necessarily be due to innate efficiency and excess profits of the middlemen.

Table 5: Estimates of marketing costs, margins, and marketing efficiency for Ricebean

Particulars	Marketing Channels*				
	1	2	3	4	5
Net price received by producer (FP)	32.00	32.00	32.00	40.00	32.00
Total marketing costs (MC)	0.25	0.50	1.00	11.75	11.75
Total marketing margins (MM)	-	2.50	2.50	15.75	13.75
Retailer's sale price (RP)	32.00	35.00	35.00	59.50	59.50
Value added (VA)	-	3.00	3.00	19.50	27.5
Producer’s share (PS) %	100.00	91.42	91.42	67.22	53.78
Index of marketing efficiency (MME)	128.00	10.66	9.14	1.45	1.25

* Numbers 1 to 5 are explained in Section 3.5.3.

4. Conclusion

Farmers have been maintaining Ricebean landraces for time immemorial due to social, cultural and economic reasons. Ricebean is an important summer legume crop grown as sole crop, intercrop with maize in marginal *bari* land and on rice bund under different farming systems by all categories of rural people in Ramechhap. The district is highly characterized with subsistence farming with marginal risk prone environment. In such highly variable risk-prone environments and subsistence systems, landraces are economically competitive. In addition, in such marginal and risk-prone environments there were no alternatives at present to these landraces. All the landraces have potentiality to grab competitive and comparative advantage in the local and national markets. Lack of farmer’s networks, access to market information and poor institutional capacities were some of the key problems that exclude farmers to receive direct economic benefits from the existing technologies and biodiversity. On the other hand, the study has illustrated that there is high market demand of Ricebean products in urban areas of Nepal like Kathmandu, Bhaktapur and Lalitpur. Ricebean products are not readily available in these urban markets and urban people don’t have access to the countryside to buy these products. This situation reveals that both producers in rural areas of Ramechhap district and consumers in urban cities of Kathmandu valley would be mutually benefited if an effective marketing system of these local products could be established. In addition, this mechanism will help to realize local communities that local products prepared form the locally available biodiversity could be marketed for urban consumers and cash income could be ploughed back into the rural community. Thus, it is also possible to increase farm incomes of many rural farmers through targeted commercialization and diversification of Ricebean landraces, and it is important to link these local products to the market. Therefore, commercialization and diversification of Ricebean products and linking these products to the national market not only gives an economic return to farming communities but also contribute to conserve biodiversity for future.

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Effect of Different Organic Manures Management on Cabbage (*Brassica Oleraceae L. Var. Capitata*) at Farmer's fIeld of Phulbari, Chitwan, Nepal

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Abstract

The experiment was conducted at farmer's field of Phulbari V.D.C, Chitwan to evaluate the efficacy of the different organic manures on the performance of cabbage varieties. The treatments included Copenhagen Market and Green Coronet varieties and the poultry manure, improved FYM, biogas slurry compost, goat manure, vermi-compost and Nasabike manure, and chemical fertilizer as control. Data on various parameters like growing attributes and the yield and quality parameter of cabbage were recorded. The highest number of outer leaves per plant (16.30) at 45 DAT was in poultry manure treatment, the highest plant height (45.97 cm) and the highest stem diameter (3.01 cm) were in poultry manure treatment at 60 DAT. The greater plant spread (60.68 cm) was in *Nasabike* manure treatment. The shorter period for days to harvest (82.33 days) was in biogas slurry compost and the longer period for days to harvest (91.83 days) was in chemical fertilizer treatment. The highest marketable yield (74.84 Mg ha^{-1}) was in poultry manure treatment followed by chemical fertilizer. The higher specific weight (0.835) was in poultry manure treatment. The longer storage period was in heads produced using *Nasabike* manure (25.67 days) whereas the shortest storage period (20.17 days) was in chemical fertilizer treatment. Copenhagen Market had the higher vitamin C content (68.86 mg) than Green Coronet (64.86 mg). Vermi-compost produced the highest vitamin C content (80 mg) while chemical fertilizer produced the lowest vitamin C content (56 mg). The highest B-C ratio was in chemical fertilizer treatment (3.69) followed by poultry manure (3.42), improved FYM (2.34).

Key words: mineralization, microbial activities, nutrient availability

1. Introduction

Common cabbage, *Brassica oleracea* L. var. *capitata* (2n=18), is grown as fresh commercial vegetable throughout Nepal. It is one of the important exportable vegetablecrops produced in hills as well as in terai by market gardeners, especially vegetable growers and general farmers in the vicinity of large and small markets of Nepal (Budathoki, *et al.*, 2001). Cabbage is the rich source of protein, vitamins A, B_1, B_2, and C, minerals and contains all the essential amino acids, particularly the sulphur containing amino acids. It is low in

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calories, fat and carbohydrates (Work, 1997) and has high medicinal values. It can be cultivated in all types of fertile soils with good water regime (Chatterjee, 1999 and Chadha, 2001). In the fiscal year 2008/09, 3430.3 Mg cabbage worth of Rs. 1, 70, 22,582 was exported to India, China and Bangladesh (MOAC, 2009).

The increased use of agro-chemicals causes disturbance on natural resources (soil, water, and forest) and environmental degradation. The consequences are the low agricultural productivity, soil degradation, loss of agro-biodiversity, pest outbreak, human health hazard etc. The poor soil respiration rate and complete vanishing of natural decomposer communities from agroecosystems has questioned the land sustainability and future food security (Suthar, 2008). Also, the escalation in the cost of chemical fertilizers has focused attention on the use of application of nutrients through organic sources in crop production (Place et al., 2000). The nutrient supply through organic manure is an eco-friendly, economically viable, ecologically sound and socially acceptable as it improves soil biology, chemistry and physics without affecting the gross plant production.

Farmers in Nepal now have realized the bad impact of agro-chemicals and increased awareness of the organic produce. They are trying to re-introduce their previously used farming practices i.e., the use of organic manures. Therefore this research was conducted to identify the efficacy of different manures/fertilizers management practices for commercially grown cabbage varieties.

2. Materials and Methods

The experiment was conducted at farmer's field of Deepak Neupane in Phulbari VDC - 5, Chitwan, Nepal at an elevation of 256 masl. The soil was loamy sand in texture with pH 5.13. The soil was low in organic matter content (2.06%), medium in available nitrogen (0.12%), high in available phosphorus (254.3 kg/ha) and high in available potassium (428 kg/ha). The maximum temperature and relative humidity were ranged from 25.6 to 31.9^{0}C and 92 to 96.5 percent respectively during the crop season. The total rainfall recorded was 2.2 mm during the experiment. The experiment was conducted in two factorial RCBD with three replications. There were 14 treatment combinations with 6 different organic manures viz; poultry manure, improved FYM (FYM that is prepared with proper decomposition of material and nutrient conservation), biogas slurry compost, goat manure, vemi-compost, *Nasabike* manure and chemical fertilizer as the first factor and two cabbage varieties, hybrid Green Coronet and open-pollinated Copenhaghen Market as the second factor. The analysis of organic manures was done at Regional Soil Laboratory, Pokhara. The nitrogen percent of vermi-compost, poultry manure, improved FYM, *Nasabike* manure, biogas slurry compost, goat manure was 1.76, 2.0, 1.42, 1.95, 1.33 and 1.47 respectively. The recommended dose of the organic manure was calculated on the basis of nitrogen content present in the organic manures and the nutrient requirement of the cabbage crop for the average national production based on the previous research activities. The recommended dose of organic manures were 10.40 Mg ha^{-1}poultry manure, 14.65 Mg ha^{-1} improved FYM, 15.64 Mg ha^{-1}biogas slurry compost, 14.15 Mg ha^{-1} goat manure, 11.81 Mg ha^{-1} vermi-compost, 10.67 Mg ha^{-1} *Nasabike* manure. Growth parameters such as number of non-wrapper leaves, length and width of leaf, plant height, plant spread, stem diameter and yield parameters like total biological yield, root weight, marketable head yield, head diameter and production quality, specific weight, vitamin C content, storage duration and weight loss, dry matter content of cabbage head were recorded. All the collected data were subjected to analysis of variance and Duncan's Multiple Range Test (DMRT) for mean separation using MSTAT-C version 2.10.

3. Results and Discussion

3.1 Number of Outer Leaves per Plant

Green Coronet and Copenhagen Market exhibited significant variation (P<0.05) in number of outer leaves per plant at 45 days after transplanting. The higher number of outer leaves per plant (15.72) was observed in Green Coronet than Copenhagen Market (15.26) at 45 DAT. The effect of different organic manures on number of outer leaves per plant was highly significant (P<0.001) at 45 DAT, later on there was decrease in the number of outer leaves (Table 1). Poultry manure produced the highest number of leaves per plant (16.3) whereas the biogas slurry compost and improved FYM produced the lowest number of leaves per plant (14.87). The greater number of outer leaves in poultry manure treatment might be due to high mineralization of organic nutrient because of low C: N ratio.

3.2 Plant Height

The highly significant variation (P<0.001) was observed between the varieties Green Coronet and Copenhagen Market in plant height. The effect of different organic manures on plant height was highly significant (P<0.01) (Table 1). Poultry manure showed the highest plant height at 60 DAT (45.97 cm) which was at par with *Nasabike* manure (45.25 cm). Goat manure showed the lowest plant height at 60 DAT (36.85 cm). The overall plant height varied from 16.05 cm at 15 DAT to 41.67 cm at harvest. The increment in plant height was prominent between 15 to 30 DAT which represents the rapid growth stage of plant. The highest plant height with poultry manure might be due to more readily available nutrients in the manure for enhanced vegetative growth.

3.3 Stem Diameter

The highly significant variation (P<0.01) was observed among the organic manures at 60 DAT. At 60 DAT the poultry manure showed the highest stem diameter (3.01 cm) whereas biogas slurry compost showed the lowest stem diameter (2.39 cm) which was statistically at par with improved FYM (2.42 cm) (Table 1).

3.4 Plant Spread

The effect of different organic manures in plant spread was highly significant (P<0.01) (Table 1). At 60 DAT, *Nasabike* manure showed the highest plant spread (60.68 cm) whereas the goat manure showed the lowest plant spread (53.87 cm). The highest plant spread with the poultry manure might be due to more availability of nutrients after mineralization enhancing the vegetative growth of the plants.

Table 1 : Effect of different organic manures on number of outer leaves per plant at different time interval after transplanting of cabbage varieties at Phulbari, Chitwan, 2010.

Treatments	Number of outer leaves at 45 DAT	Number of non-wrapper leaves at harvest	Plant height at 60 DAT	Stem diameter at 60 DAT	Plant spread at 60 DAT
Varieties					
Green Coronet	15.72 [a]	11.09[a]	44.28[a]	2.71	57.90[a]
Copenhagen Market	15.26[b]	11.10[a]	39.07[b]	2.62	55.45[b]
SEM±	0.1385	0.2493	0.6215	0.0330	0.9556a
$LSD_{0.05}$	0.4027	ns	1.807	ns	ns
Organic manures					
Poultry manure	16.30 [a]	10.70[b]	45.97[a]	3.01[a]	59.48[ab]
Improved FYM	14.87 [c]	12.40[a]	39.22[cd]	2.42[d]	55.53[ab]
Biogas slurry compost	14.87[c]	11.00[ab]	38.77[cd]	2.39[d]	55.28[ab]
Goat manure	15.17 [bc]	11.40[ab]	36.85[d]	2.57[cd]	53.87[b]
Vermi-compost	15.70[ab]	10.43[b]	41.38[bc]	2.63[c]	55.78[ab]
Nasabike manure	15.63[abc]	10.20[b]	45.25[a]	2.75[bc]	60.68[a]
Chemical fertilizer	15.90[ab]	11.53[ab]	44.27[ab]	2.89[ab]	56.10[ab]
Mean	15.49	11.10	41.67	2.665	56.68
SEM±	0.2592	0.4664	1.163	0.0619	1.788
$LSD_{0.05}$	0.7534	1.356	3.380	0.1800	5.197
CV%	4.10	10.30	6.83	5.68	7.73

Means with same letter within columns do not differ significantly at p=0.05 by DMRT. DAT = Days after transplanting, SEM = Standard error of mean, LSD = Least significant difference and CV = Coefficient of variance, ns= non-significant

3.5 Fifty Percent Heading and Days to Harvest

The highly significant differences (P<0.01) was observed between the varieties and organic manure for days to 50 percent heading and days to harvest (*P*<0.01). Shorter period to 50 percent heading (45.57 DAT) and days to harvest (76.29 DAT) was observed in Copenhagen Market than in Green Coronet that took longer duration for 50 percent heading (49.57 DAT) and days to harvest (94.43 DAT). The shortest period to harvest (82.33 DAT) was observed with biogas slurry compost treatment whereas the longest period to harvest (91.83 DAT) was observed with chemical fertilizer.

3.6 Marketable Head Weight

The highly significant difference (*P*<0.001) was observed in marketable head weight of cabbage between the varieties. Green Coronet exhibited the higher average marketable head weight (1.59 kg) than Copenhagen Market (1.43 kg). Similar type of finding was reported by Kafle (2009) on the marketable head weight of Green Coronet (2.07 kg) and Copenhagen Market (1.52 kg). The effect of different organic manures on marketable head weight was highly significant (*P*<0.01) (Table 2). The highest marketable head weight (1.79 kg) was recorded with the poultry manure. The lowest marketable head weight was recorded with goat manure (1.26 kg) which was at par with biogas slurry compost (1.34 kg) The highest head weight with the poultry manure and *Nasabike* manure might be due to the greater availability of nutrients to the plants during growth period as the microbial activities is enhanced in the soil for better nutrient uptake. The findings was similar to the findings of Shrestha (2008) on cabbage in Illam, Nepal.

3.7 Total Biological Yield and Marketable Yield

Both the varieties Green Coronet and Copenhagen Market were significantly different (*P*<0.01) in total biological yield and marketable yield. Green Coronet produced the higher total biological yield (90.42 Mg ha^{-1}), marketable yield (66.12 Mg ha^{-1}), and harvest index (75.44 %) than Copenhagen Market that produced total biological yield (83.19 Mg ha^{-1}) and marketable yield (59.41 Mg ha^{-1}) (Table 2). These findings are in agreement with the findings of Jaiswal and Subedi (1996) and Kafle (2009) who reported the marketable yield of Green Coronet (62.15 Mg ha^{-1}) and Copenhagen Market (52.46 Mg ha^{-1}). The effect of different organic manures on both the biological and marketable yield was highly significant (*P*<0.01). Poultry manure produced the highest total biological yield (100.6 Mg ha^{-1}) and marketable yield (74.84 Mg ha^{-1}) whereas the lowest total biological yield (76.34 Mg ha^{-1}) and marketable yield (52.69 Mg ha^{-1}) was recorded with goat manure treatment. Shrestha (2008) also reported similar types of findings in variety T-621 with *Nasabike* manure in Illam.

The highest marketable yield with the poultry manure might be due to higher availability of nutrients in the soil from the manure that is readily absorbed by plants for proper growth for the accumulation of food material for higher yield. The higher content of phosphorous, potassium, sulphur, calcium and magnesium in poultry manure contributed the higher yield in cabbage (Farid et al., 1998).

3.8 Root Weight

The effect of different organic manures on root weight of cabbage after harvest was highly significant (*P*<0.01).The highest root weight (92.27 gm) was recorded in *Nasabike* manure whereas the lowest root weight (78.88gm) was observed in chemical fertilizer (Table 2). The highest root weight in *Nasabike* manure might be due more microbial activities around the root zone.

3.9 Polar and Equatorial Diameter of Cabbage Head

There was highly significant difference (*P*<0.01) between the varieties in polar and equatorial diameter of head. The polar diameter was bigger in Copenhagen Market (16.45 cm) whereas the equatorial diameter was bigger in Green Coronet (19.01 cm) (Table 3). The effect of different organic manures was significant (*P*<0.05) on polar diameter of cabbage head. Poultry manure showed the highest polar diameter (16.97 cm) whereas the biogas slurry showed the lowest polar head diameter (14.22 cm) which was at par with improved FYM (14.63 cm), goat manure (14.69 cm), vermi-compost (15.29 cm) and *Nasabike* manure (15.41 cm).The effect was highly significant (*P*<0.01) on equatorial diameter of cabbage head. Poultry manure showed the highest equatorial diameter (18.98 cm) which was at par with chemical fertilizer

Table 2 : Effect of different organic manures on days to 50 percent heading, days to harvest, marketable head weight, total biological yield, marketable yield and root weight of cabbage varieties at Phulbari, Chitwan, 2010.

Treatments	Days to 50% heading	Days to harvest	Marketable head weight	Total biological yield	Marketable yield	Root weight
Varieties						
Green Coronet	49.57[a]	94.43[a]	1.59[a]	90.42[a]	66.12[a]	87.67
Copenhagen Market	45.57[b]	76.29[b]	1.43[b]	83.19[b]	59.41[b]	86.59
SEM±	0.3459	0.4911	0.0267	1.283	1.111	0.776
$LSD_{0.05}$	1.006	1.427	0.0777	3.731	3.230	ns
Organic manures						
Poultry manure	47.67[b]	85.17[bc]	1.79[a]	100.6[a]	74.84[a]	90.75[ab]
Improved FYM	45.00[c]	83.67[bc]	1.39[de]	80.65[cd]	58.13[de]	86.55[bc]
Biogas slurry compost	45.00[c]	82.33[c]	1.34[e]	77.84[d]	55.82[e]	85.53[c]
Goat manure	47.33[b]	84.00[bc]	1.26[e]	76.34[d]	52.69[e]	88.42[abc]
Vermi-compost	47.33[b]	84.67[bc]	1.51[cd]	88.29[b]	63.02[cd]	87.50[bc]
Nasabike manure	49.17[b]	85.83[b]	1.55[bc]	86.97[bc]	64.71[bc]	92.27[a]
Chemical fertilizer	51.50[a]	91.83[a]		96.94[a]	70.15[ab]	78.88[d]
Mean	47.57	85.36		86.81	62.76	87.13
SEM±	0.6472	0.9187		2.401	2.079	1.451
$LSD_{0.05}$	1.881	2.671		6.980	6.043	4.219
CV%	3.33	2.64		6.77	8.11	4.08

Means with same letter within columns do not differ significantly at p=0.05 by DMRT. DAH = Days after harvesting, SEM = Standard error of mean, LSD = Least significant difference and CV = Coefficient of variance

(18.98 cm). The highest polar diameter and equatorial diameter with the poultry manure might be due to the higher availability of nutrients from the manure for better head growth during the heading stage.

3.10 Specific Weight (Head Compactness)

Highly significant difference ($P<0.01$) was observed in specific weight (head compactness) between two varieties Green Coronet and Copenhagen Market. Green Coronet had higher specific weight (0.866) than Copenhagen Market (0.785) (Table 3).

The effect of different organic manures in specific weight of cabbage head was highly significant ($P<0.01$). The highest specific weight (0.835) was in poultry manure and the lowest (0.810) was in goat manure (Table 3).

3.11 Dry Matter Content of Cabbage Head

There was highly significant variation ($P<0.01$) among different organic manures in dry matter percentage of cabbage head. Goat manure showed the highest dry matter percentage of cabbage head (12.26) which was at par with *Nasabike* manure (12.21).

Chemical fertilizer showed the lowest dry matter percentage of cabbage head (9.83) (Table 3).

3.12 Post Harvest Life

Both the varieties Green Coronet and Copenhagen Market showed highly significant variation ($P<0.01$) in post harvest life and post harvest weight loss during the time of storage. Green Coronet had the longer postharvest life (24.38 days) than Copenhagen Market (22.86 days). Copenhagen Market had the higher weight loss (0.96 gm/day/100gm) than Green Coronet (0.54 gm/day/100gm) (Table 3).

The effect of different organic manures in post harvest life and weight loss was highly significant ($P<0.01$). Heads produced using *Nasabike* manure had the longest postharvest life (25.67 days) which was at par with the poultry manure (25.50 days).The shortest postharvest life (20.17 days) was observed in chemical fertilizer treatment (Table 3). The longest post harvest life with the *Nasabike* manure and poultry manure might be due to the compact head and less water content. The highest amount of post harvest weight loss (1.29 gm/day/100gm) was observed in heads produced in chemical fertilizer treatment whereas the lowest postharvest weight loss (0.52 gm/day/100gm) was observed in the heads produced in poultry manure treatments.

Table 3. Effect of different organic manures on polar and equatorial head diameter of cabbage varieties at Phulbari, Chitwan, 2010.

Treatments	Polar head diameter (cm)	Equatorial head diameter (cm)	Specific weight of head	Dry matter percentage of cabbage head	Post harvest life for marketable quality (days)	Weight loss (gm/day/100 gm fresh head)
Varieties						
Green Coronet	14.14^{b}	19.01^{a}	0.866^{a}	11.80^{a}	24.38^{a}	0.54^{b}
Copenhagen Market	16.45^{a}	16.68^{b}	0.785^{b}	11.09^{b}	22.86^{b}	0.96^{a}
SEM±	0.2722	0.2454	0.00218	0.1630	0.287	0.055
$LSD_{0.05}$	0.7913	0.7135	0.00634	0.4739	0.835	0.160
Organic manures						
Poultry manure	16.97^{a}	18.98^{a}	0.835^{a}	11.12^{bc}	25.50^{a}	0.52^{b}
Improved FYM	14.63^{b}	16.49^{c}	0.826^{ab}	11.98^{ab}	23.00^{b}	0.57^{b}
Biogas slurry compost	14.22^{b}	16.90^{bc}	0.825^{ab}	11.80^{abc}	23.00^{b}	0.81^{b}
Goat manure	14.69^{b}	17.28^{bc}	0.810^{c}	12.26^{a}	24.33^{ab}	0.63^{b}
Vermi-compost	15.29^{b}	18.02^{ab}	0.829^{ab}	10.92^{c}	23.67^{b}	0.74^{b}
Nasabike manure	15.41^{b}	18.25^{ab}	0.833^{ab}	12.21^{a}	25.67^{a}	0.68^{b}
Chemical fertilizer	15.84^{ab}	18.98^{a}	0.820^{bc}	9.83^{d}	20.17^{c}	1.29^{a}
Mean	15.30	17.84	0.825	11.45	23.62	0.75
SEM±	0.5092	0.4592	0.00408	0.3050	0.537	0.103
$LSD_{0.05}$	1.480	1.335	0.0118	0.8865	1.561	0.300
CV%	8.16	6.30	1.17	6.52	5.57	33.51

Means with same letter within columns do not differ significantly at p=0.05 by DMRT. SEM = Standard error of mean, LSD = Least significant difference and CV = Coefficient of variance

3.13 Vitamin C Content of Cabbage

Copenhagen Market had the higher vitamin C content (68.86 mg) compared to Green Coronet (64.86 mg). Vermi-compost produced the highest vitamin C content (80 mg) in Copenhagen Market while the chemical fertilizer produced the lowest vitamin C content (56 mg) in Green Coronet (Figure 1). The highest vitamin C content in Copenhagen Market with vermi-compost could be due to the essential elements present in the vermi-compost for enhanced vitamin C synthesis.

3.14 Economic Analysis

Gross Income

The results showed highly significant difference (P<0.01) on gross income of cabbage production between the varieties. Green Coronet had higher gross income of Rs.5, 28, 956 ha^{-1} than Copenhagen Market of Rs. 4, 75, 272 ha^{-1} (Table 4).

The effect of organic manures in gross income of cabbage production was highly significant (P<0.01). The higher gross income was obtained with poultry manure (Rs. 5,98, 707 ha^{-1}) followed by chemical fertilizer (Rs. 5,61,187 ha^{-1}) and the lowest gross income was obtained with goat manure (Rs. 4, 21, 520 ha^{-1}).

Net Benefit

The results showed highly significant difference (P<0.01) in net income of cabbage production between the varieties. Green Coronet had higher net benefit (Rs.3, 75, 427 ha^{-1}) than Copenhagen Market (Rs. 3, 30, 011 ha^{-1}).

The effect of organic manures on net benefit of cabbage production was highly significant (P<0.01) (Table 4). The highest net benefit was obtained with poultry manure (Rs. 4, 63,484 ha^{-1}) which was similar with chemical fertilizer (Rs. 4, 41, 838 ha^{-1}) and the lowest net benefit was obtained with goat manure (Rs. 2, 86,370 ha^{-1}). The highest net income (Rs. 4, 97,016 ha^{-1}) was obtained in Green Coronet with poultry manure and the lowest net income (Rs. 2, 66,158 ha^{-1}) was obtained in Copenhagen Market with goat manure.

Benefit -Cost Ratio (B/C)

The results showed significant difference (P<0.05) in B-C ratio of cabbage production between the varieties. Green Coronet had higher B-C ratio (2.55) than Copenhagen Market (2.37).

The effect of organic manures on B-C ratio of cabbage production was highly significant (P<0.01). The highest B-C ratio (3.69) was obtained in chemical fertilizer which was statistically similar with poultry manure (3.42) and the lowest B-C (1.66) ratio was obtained in vermi-compost which was statistically similar with *Nasabike* manure (1.69). The higher B-C ratio in chemical fertilizer treatment was due to less cost production with chemical fertilizer compared to other organic manures. The higher B-C ratio in poultry manure treatment was due to lower dose of manure, higher net benefit and low cost of production compared to other organic manures. The lower B-C ratio in *Nasabike* manure and vermi-compost might be due to the higher production cost of these manure during the initial year of production. But in the subsequent year the cost of production would be decreased due to lesser amount of manure to be applied as the residual nutrients could be used for some years.

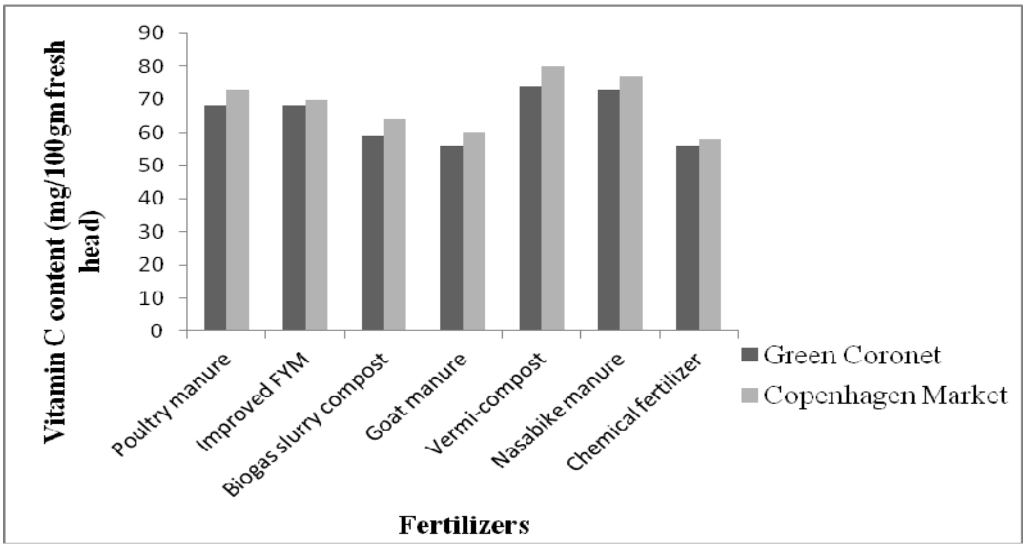

Figure 1. 'Vitamin C 'content of fresh cabbage head analyzed at Food and Quality Control Laboratory Babarmahal, Kathmandu, March, 2010

Table 4 : Effect of different organic manures and cabbage varieties on gross income, net benefit and B-C ratio of cabbage production at Phulbari, Chitwan, 2010

Treatments	Gross income (Rs. ,000)/ha	Net benefit (Rs. ,000)/ha	B-C ratio
Varieties			
Green Coronet	528.956[a]	375.427[a]	2.55[a]
Copenhagen Market	475.272[b]	330.011[b]	2.37[b]
SEM±	8.889	8.889	0.0581
$LSD_{0.05}$	25.84	25.84	0.169
Organic manures			
Poultry manure	598.707[a]	463.484[a]	3.42[a]
Improved FYM	465.027[de]	325.646[b]	2.34[b]
Biogas slurry compost	446.520[e]	311.213[b]	2.30[b]
Goat manure	421.520[e]	286.370[b]	2.12[b]
Vermi-compost	504.160[cd]	314.893[b]	1.66[c]
Nasabike manure	517.680[bc]	325.589[b]	1.69[c]
Chemical fertilizer	561.187[ab]	441.838[a]	3.69[a]
Chemical fertilizer	561.187[ab]	441.838[a]	3.69[a]
Mean	502.114	352.719	2.46
SEM±	16.63	16.63	0.1088
$LSD_{0.05}$	48.34	48.34	0.3162
CV%	8.11	11.55	10.84

Means with same letter within columns do not differ significantly at p=0.05 by DMRT. SEM = Standard error of mean, LSD = Least significant difference and CV = Coefficient of variance

4. Summary and Conclusion

Green Coronet (hybrid variety) had the better performance than Copenhagen Market (open pollinated) on almost all of the parameters except some quality attributes. The growth attributing characters were comparatively better in poultry manure followed by chemical fertilizer, *Nasabike* manure, vermicompost, improved FYM, biogas slurry compost and goat manure treatments. The application of locally available organic manures produced higher yield of cabbage crop with higher benefit-cost ratio. FYM and biogas slurry compost can improve soil physical, chemical and biological properties because of its humus contents and high organic constituents. The B: C ratio of chemical fertilizer treatment is higher in the initial year, but organic manures applied crop increases its B: C ratio in the subsequent cropping season due to its effect on soil fertility improvement. Under the circumstances of rise in price of chemical fertilizer and its negative consequences, putting emphasis on locally available organic manures for cabbage production may become the possible option for increasing the soil fertility and productivity in the long run.

Acknowlwdgments

We would like to extend our sincere gratitude to Sustainable Soil Management Programme, Lalitpur for providing financial support for this research and other research material for farm house family at Phulbari, Chitwan, Nepal.

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Response of Lime and Farm Yard Manure on Abundance and Severity of Club Root Disease of Cabbage in Sandy Loam Soils

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Abstract

An experiment was conducted to assess the alteration of chemical properties of soil with the use of lime and farm yard manure (FYM) for the control of club root disease of cabbage (*Plasmodiophora brassicae*) in sandy loam soils at Shikharkot-5, Daman, Makwanpur, Nepal from July 2007 to November 2007. The experiment was laid out in a two factorial randomized romplete block design with three replications. Six levels of lime (0, 1.5, 3.0, 4.5, 6.0, 7.5 Mg ha^{-1} $CaCO_3$) as one factor and two levels of FYM (0, 20 Mg ha^{-1}) as an another factor, in combinations formed twelve treatments. Significant differences between the individual effects of lime and FYM were observed whereas interaction effects of lime and FYM were not significant for any of the measured parameters. Soil characteristics such as soil pH, soil calcium carbonate ($CaCO_3$), soil organic matter (SOM); vegetative characteristics such as number of leaves, length and breadth of the largest leaf; yield attributing characters such as biomass, marketable yield, circumference and height and circumference of outer stump of cabbage were significantly higher as higher doses of lime, but length of stump was in consistent between treatments. The soil pH increased from 4.9 to 6.9 with the application of 7.5 Mg ha^{-1} of lime, whereas it was increased to 6.45 with 7.5 Mg ha^{-1} of lime and 20 Mg ha^{-1} FYM at the time of crop harvesting. Initially, the combined effects of lime and FYM increased the soil pH but at harvest, it was decreased as compared to the treatment with lime only. The soil $CaCO_3$ content was the highest (3.4%) from $L_{7.5}$ at crop harvest. Application of FYM did not affect on soil $CaC0_3$ content, but it influenced SOM content. The treatments with and without FYM had OM 2.7 percent and 1.4 percent, respectively at crop harvest. Comparable good plant growth was reflected from the treatments with higher dose of lime and FYM. The highest biomass (25.35 Mgha^{-1}) and marketable yield (18.51 Mgha^{-1}) was obtained from $L_{7.5}F_{20}$. The highest circumference (44.19 cm) and the highest height (10.30 cm) were found from $L_{7.5}F_{20}$. The interaction effects on the root weight was not significant, however, the highest root weight per plant (64.44 gm/plant) was found from $L_{7.5}F_{20}$. The application of FYM showed proper growth of lateral roots as compared to the control. Root weight per plant had inverse relationship with the clubroot disease severity. The clubroot pressure was severe in this experiment, with 100 percent of plants showing clubroot symptoms. However, severity of the disease or plant disease index (PDI) was significantly less (39.51%) in $L_{7.5}F_{20}$.

Key words: cabbage, clubroot, farm yard manure, lime, soil pH

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1. Introduction

Brassicae vegetables are the most important vegetables in Nepalese diet and play an important role in the economy of the farmers (Timila et al., 2007). Cabbage and cauliflower contributed 28 percent in total vegetables production. Cabbage, *Brassica oleracea* cv. *capitata* (2n=18) for the fresh commercial vegetable is grown throughout Nepal (Rana, 1997). Since cabbage cultivation is contributing considerably in uplifting the livelihood of the farmers especially to them who have very small land holding. Kathmandu, Palung and Daman are the potential places for the cabbage cultivation (Timila et al., 2007). It is one of the important exportable vegetable crops produced in hills as well as in terai (Budathoki *et al.,* 2001). It can be cultivated in all types of fertile soils with good water regime (Chatterjee, 1999). It does not grow well on a highly acidic soil but it is best grown above 6.5 pH (Singh et al., 2004).

The productivity of the cabbage in Makwanpur district is recorded to have decreasing pattern from 30.4 mt ha^{-1} (2000/01) to 20.12 mt ha^{-1} (2006/07). In recent years, club root disease caused by *Plasmodiophora brassicae* Woronin has become a serious threat for its cultivation. This disease is one of the most serious problems in Brassica crop cultivation worldwide. So far in Nepal, the disease has been appeared in cabbage, cauliflower, broad leaf mustard, knolkhol, brocauli, radish (rare), gardencress, mustard and turnip (Timila et al., 2007). The disease resting spores remains viable in the soil for more than 18 years in the absence of Brassicae host (Toit, 1990). Especially in crucifer vegetables, 70 percent yield reduction had been found from a study at Palung (Alen, 2004). Reports showed that mono-cropping of cauliflower and cabbage increased the disease incidence from 9 percent in the first year to 50 percent in the following year causing 62 percent yield reduction (Shrestha et al., 1995). Farmers are presently unable to properly manage this disease with the presently available management strategies, which mainly consist of the use of pesticides and other available chemicals.

Disease occurs when the soil-borne club root pathogen invades the plant's root system. The infected roots become swollen, forming galls or "clubs" that interfere with the plant's water and nutrient transport (Gideon et al., 2003). Yellowish, senescent leaves and wilting and stunted growth are the main symptoms that can be seen on the above-ground parts of infected plants (Dobson et al., 1983). The resulting decay may lead to the plant's death. Soils with high organic matter give the best yields. Crop rotation combined with soil liming and strategic planting should be used as a measure to reduce the incidence of this disease (Bairnsdale, 1997).

One of the most documented treatments for clubroot is to raise the soil pH to 7.2 by liming. Liming has been used as a control measure for clubroot since the early 19th century (Dixon, 1996). If soils are acidic, the strategy should be to raise soil pH by liming (Chadha, 2001). This creates an unfavorable soil environment for the pathogen, most likely by disrupting the release of zoospores. Organic manure is traditional source of plant nutrients, which is the most readily available to the farmers (Gaur et al., 1995). Soil borne pathogens and root diseases are also generally lower in organic than in conventional systems (Van Bruggen, 1995).

Cabbage is dominant commercial crop grown in Daman. Market potential and added value of the crop is very high at both local and national level. Thus, it provides farmers comparatively higher returns. The productivity of cabbage is sharply declining due to severe infestation of *P. brassicae* in the study area for the last few years. Soil chemical and physical characteristics influence both the pathogen and the development of the disease, so applying FYM as organic manure may contribute towards the control of *P. brassicae*. The objective of the study was to generate a suitable soil management technique for the control of clubroot disease of cabbage and promote its productivity.

2. Materials and Methods

The experiment was conducted at farmer's field at Shikharkot-5, Daman, Makwanpur district of Narayani zone, Nepal from July 2007 to November 2007. The geographical location of the experimental site was at 27° 37' 28.1'' north latitude and 85° 04' 41.8'' east longitude with the elevation of 1834 m above from the mean sea level. The experimental field was under cabbage cultivation (F_1 Hybrid-Green Coronet) for the last two years. Composite soil samples of tillage layer upto 30 cm depth of experimental plots were analyzed to determine pH, organic matter, calcium carbonate and available N, P, K before transplanting of cabbage seedlings. The test crop, cabbage Green coronate, a F_1 hybrid of cabbage was used for the study. Seedlings were raised on Temperate Horticulture Center, Daman, Makwanpur, Nepal. The experiment was laid out in two factorial randomized completely block design with three replications. There were 12 treatment combinations consisting of six levels of calcium carbonate (0, 1.5, 3, 4.5, 6, 7.5 Mg ha^{-1} $CaCO_3$) with or without recommended dose of FYM (20 and 0 Mg ha^{-1} FYM). Individual net plot area comprised 3 m × 2 m area with 25 plants. Plots were raised to 15 cm height. FYM prepared at the Horticulture Farm were incorporated in the field a month prior to the transplanting. Uniform sized 35-day old seedlings having 5-6 leaves were transplanted in the experimental plots on August 17, 2007 with the spacing of 60 cm × 40 cm. Each plot consisted of 25 plants. Plots were separated by a space of 35 cm while each block was separated by 75 cm. The recommended dose of mineral fertilizers (RMF-150:60:50 kg NPK per ha) for the cabbage is applied in all treatments. Standard intercultural operations were carried out. Crops were harvested on November 25-28, 2008. Soil characteristics (soil pH, $CaCO_3$ and OM) and vegetative characters of cabbage were observed at the interval of 25 days; and yield and yield components and disease scoring were done at the time of harvest. Tabulating the data in M-excel, statistical tool-MSATC was used for data analysis.

3. Results and Discussion

3.1 Effects on Unwrapped Leaf Number, Length and Breadth

At 25 and 50 DAT, pair-wise comparison revealed $L_{7.5}F_{20}$ produced the highest unwrapped leaf number (12.52 and 17.85, respectively). At 75 DAT, L_3F_{20} showed the maximum unwrapped leaf number (16.74). At 100 DAT, the highest unwrapped leaf number (14.81) from L_1F_0 and it was the lowest from $L_{7.5}F_{20}$ (12.52). Leaf number was higher in treatment with higher dose of lime and FYM before head formation of cabbage.

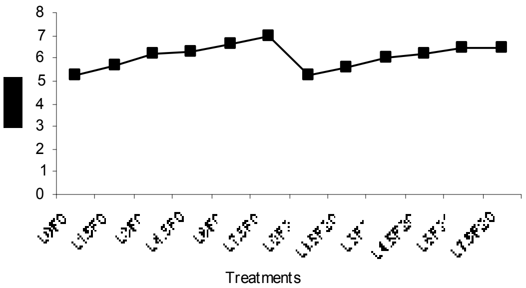

Figure 1: Soil pH at 100 DAT influenced with the application of different level of lime and FYM

Cassel (1980) agreed on this fact and claimed that liming acid soils improves the conditions for plant growth by increasing soil pH. This may have effect on the heading of the cabbage, so that lower number of unwrapped leaves was involved in head formation.

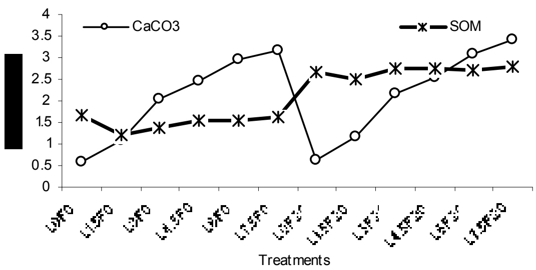

Figure 2: Influence of different level of lime and FYM on the $CaCO_3$ and SOM at 100 DAT

The effects of lime and FYM on length and breadth of unwrapped leaf were found to be insignificant at entire growth stages of crop, however, the largest leaf length and breadth was obtained from $L_{7.5}F_0$ at all growing periods. Dixon (1981) also observed similar results, and claimed that clubroot diseased plants tend to form fewer and smaller leaves which expand more slowly than those of uninfected plants. The ability of leaves to export accumulated substrate has enormous significance for plant growth and development (Leopold and Kriedemann, 1978). FYM releases nutrients slowly upon mineralization but in combination with inorganic fertilizers it releases nutrient quickly and they increases the number and area of leaves (Ali, et al., 2006).

3.2 Soil pH, Soil $CaCO_3$ and Organic matter

The soil pH was raised from 4.9 to 6.97 with $L_{7.5}F_{20}$ at the time of crop harvest. Soil $CaCO_3$ increased from 0.50 percent to 3.42 percent and similarly SOM also increased from 1.5 percent to 2.79 percent with the same treatment of the highest dose of lime and FYM.

The finding agrees with Pandey (2008) who reported that application of lime and mustard oilcake in the seedbed for raising seedling of cauliflower increased soil pH, and produced healthy crop. Similar results were found from the experiment conducted at Bhaktapur during 2005 (Timila et. al., 2007). The soil pH of manure-amended soils was significantly higher than unamended soil (Whalen et al., 2000). Tripathi et al. (2001) reported that application of agricultural lime and manure are the possible solution for improving or avoiding further increase in soil acidity. Application of lime @10-20 m ton ha^{-1} increased soil pH from 6.7 –7.9 (Datnoff et al., 1984).

3.3 Yield and Yield Components

Biological yield

The highest biological yield (25.35 Mg ha^{-1}) was recorded from $L_{7.5}F_{20}$. The biological yield obtained from L_6F_{20} was similar to $L_{7.5}F_{20}$. However, $L_{7.5}F_{20}$ was significantly higher than other treatments, including control.

Similar result was reported from Bhaktapur and Makwanpur district that lime treatment had shown significantly higher biological yield than control (Personal communication, R. R. Pandey, 20 May, 2008). Improved nutrition in response to organic manure application helped to gain in soil physical health and associated enhanced in nutrient utilization (Lal and Kang, 1982). Schreier et al. (1995) also reported that the combined lime and manure application had significantly higher biomass production than either singly the same lime or manure treatment. Tripathi (1989) showed that application of lime alone was as effective as the combined application of lime and FYM in producing higher biomass.

Table 1 : Effects of lime and FYM on biological yield of cabbage at harvest at Daman, Makwanpur, Nepal, 2007

Treatment	Biological yield (Mg ha^{-1})		
	Farm yard manure		
	F_0	F_{20}	Mean
Lime			
L_0	14.45 e	17.49 de	15.97 c
$L_{1.5}$	16.90 de	17.02 de	16.96 c
L_3	17.44 de	20.81 bc	19.12 b
$L_{4.5}$	18.54 cd	20.63 c	19.59 b
L_6	21.67 bc	23.97 ab	22.82 a
$L_{7.5}$	21.22 bc	25.35 a	23.29 a
Mean	18.37 b	20.88 a	19.625
SEM±	L×F 1.009	L 0.713	F 0.411
$LSD_{0.05}$	2.95	2.09	1.20
CV	8.90 %		

Note: $\mathbf{L_0}$ 0 Mg ha^{-1} $CaCO_3$, $\mathbf{L_{1.5}}$ 1.5 Mg ha^{-1} $CaCO_3$, $\mathbf{L_3}$ 3 Mg ha^{-1} $CaCO_3$, $\mathbf{L_{4.5}}$ 4.5 Mg ha^{-1} $CaCO_3$, $\mathbf{L_6}$ 6 Mg ha^{-1} $CaCO_3$, $\mathbf{L_{7.5}}$ 7.5 Mg ha^{-1} $CaCO_3$; $\mathbf{F_0}$ 0 Mg ha^{-1} FYM, $\mathbf{F_{20}}$ 20 Mg ha^{-1} FYM.

[a]Means followed by the same letter(s) in column and row are not significantly different at 5 percent level as determined by DMRT.

Marketable Yield

The highest marketable yield (18.51 Mg ha^{-1}) was recorded from $L_{7.5}F_{20}$ which was higher than other treatments. The marketable yield from $L_{7.5}F_{20}$ was followed by L_4F_R (17.04 Mg ha^{-1}). The marketable yield obtained from L_3F_{20}, $L_{4.5}F_{20,}$ L_6F_0 and $L_{7.5}F_0$ were in consistent or similar. However, these treatments (L_3F_{20}, $L_{4.5}F_{20,}$ L_6F_0 and $L_{7.5}F_0$) were significantly higher than control (L_0F_{20}).

The maximum harvest index (72.87%) was obtained from $L_{7.5}F_{20}$ which was similar to other treatments except L_0F_0, L_0F_{20} and $L_{1.5}F_0$.

The clubroot disease can reduce cauliflower biomass yield by 27-81percent and curd yield by 18-87 percent; however, 100 percent crop losses have been also observed (Timila et al., 2007). Liming acid soils to increase crop production has long been a common agricultural practice (Barber, 1967). farm yard manure releases nutrients slowly upon mineralization but in combination with inorganic fertilizers it releases nutrient quickly and they increases the number and area of leaves. Food accumulation in the sink depends on the ability of leaf for photosynthesis (Jain, 2003). A decline in SOM reduced the nitrogen supply and resulted in a deterioration of soil physical condition, leading to crop yield reduction (Greer et al., 1996).

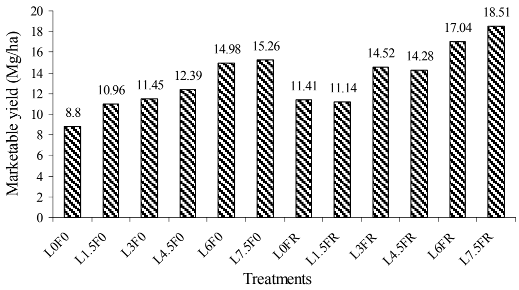

Figure 3: Interaction effects of lime and FYM on the marketable yield of cabbage at Daman, Makwanpur, Nepal, 2007

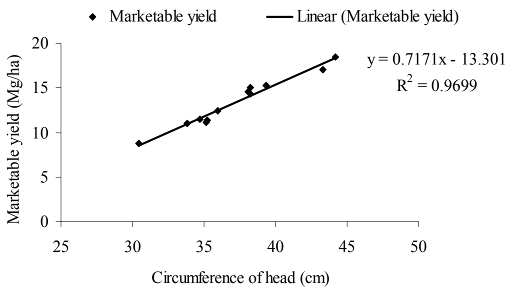

Figure 4: Relationship between marketable yield and circumference of cabbage head as influenced by lime and FYM application at Daman, Makwanpur, Nepal, 2007

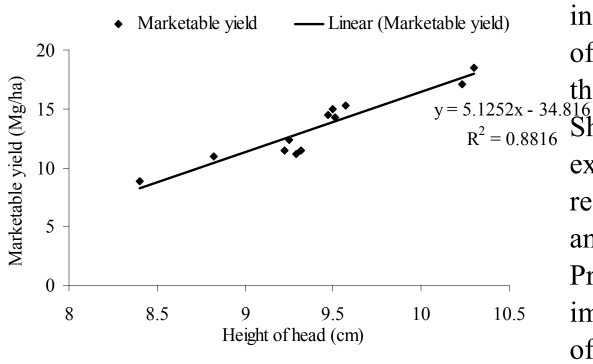

Figure 5: Relationship between marketable yield and height of cabbage head as influenced by lime and FYM application at Daman, Makwanpur, Nepal, 2007

The relationship between marketable yield and circumference of the cabbage head was found positive. These parameters were highly correlated (R^2 = 0.96). Similarly, the marketable yield of the cabbage was also positively correlated with the height of cabbage head (R^2 = 0.88).

3.4 Disease Abundance and Severity

The abundance of clubroot disease was calculated as 100 percent. All the plants were found to be infected at the time of harvesting.

The effects of lime and FYM on PDI were insignificant, however, the lowest severity of the clubroot disease was observed from $L_{7.5}F_{20}$ (39.51%) and it was the highest from the control L_0F_0 (76.30%). The severity of the disease was decreased with the application of FYM (49.82%) as compared to the control F_0 (61.08%). The interactive effects of lime and FYM on PDI were insignificant, however, the lowest severity of the clubroot disease was observed from $L_{7.5}F_{20}$ (39.51%) and it was the highest from the control L_0F_0 (76.30%).

The reduction of clubroot disease incidence and severity by lime application of the experiment was in accordance with the findings of other workers (Timila and Shrestha, 2000). In one of the recent experiments conducted at Bhaktapur, lime reduced clubroot incidence by 33 percent and severity by 34 percent (Timila, 2006). Previous crops in the field play an important role in severity and the incidence of disease, especially soil-borne diseases. Most of the fields had the cruciferous crops previously which helped in increasing the disease incidence. An epidemic was also favored by inoculum density in the soil, which might not give expected effects by the treatments (Timila et al., 2007).

Table 2 : Effects of lime and FYM on percent disease index or severity of the clubroot disease of cabbage at harvesting stage at Daman, Makwanpur, Nepal, 2007

Treatment	Percent Disease Index (PDI) percent		
	Farm yard manure		
	F_0	F_{20}	Mean
Lime			
L_0	76.30 a	62.22 abc	69.25 a
$L_{1.5}$	69.07 ab	56.85 bcd	62.96 ab
L_3	60.37 bcd	49.63 cde	55.00 bc
$L_{4.5}$	58.27 bcd	46.30 cde	52.28 bc
L_6	51.23 cde	44.44 de	47.84 c
$L_{7.5}$	51.23 cde	39.51 e	45.37 c
Mean	61.08 a	49.82 b	55.45
SEM±	L×F 4.926	L 3.4834	F 2.0111
$LSD_{0.05}$	14.45	10.22	5.898
CV	15.39%		

Note: $\mathbf{L_0}$ 0 Mg ha^{-1} $CaCO_3$, $\mathbf{L_{1.5}}$ 1.5 Mg ha^{-1} $CaCO_3$, $\mathbf{L_3}$ 3 Mg ha^{-1} $CaCO_3$, $\mathbf{L_{4.5}}$ 4.5 Mg ha^{-1} $CaCO_3$, $\mathbf{L_6}$ 6 Mg ha^{-1} $CaCO_3$, $\mathbf{L_{7.5}}$ 7.5 Mg ha^{-1} $CaCO_3$; $\mathbf{F_0}$ 0 Mg ha^{-1} FYM, $\mathbf{F_{20}}$ 20 Mg ha^{-1} FYM.

[a]Means followed by the same letter(s) in column and row are not significantly different at 5% level as determined by DMRT.

Negative correlation was observed between marketable yield and severity of clubroot disease. The coefficient of determination (R^2) value was 0.87.

Similarly, as severity of clubroot disease in cabbage increased, the root weight decreased. Increased in disease severity leads to the decaying of the roots. So the root weight was subsequently lower in the plot with higher disease severity. The coefficient of determination (R^2) was 0.88.

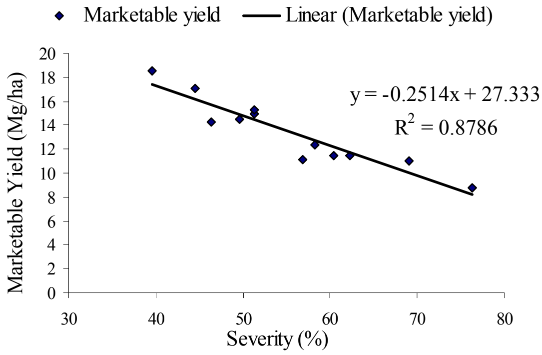

Figure 6. Relationship between marketable yield and severity of clubroot disease of cabbage as influenced by lime and FYM application at Daman, Makwanpur, Nepal, 2007

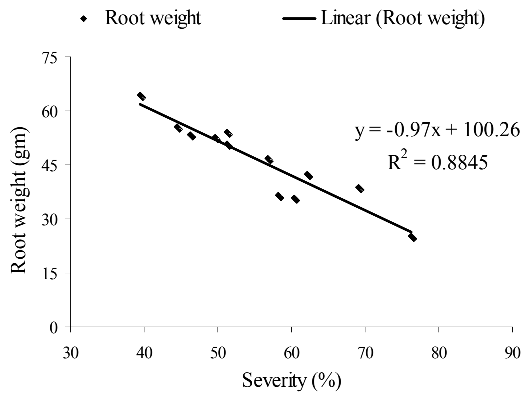

Figure 7: Relationship between root weight and severity of disease of cabbage as influenced by lime and FYM application at Daman, Makwanpur, Nepal, 2007.

Acknowledgements

The authors are grateful to Global Future Institute for providing financial support. Special thanks are for all the colleagues and farmers for their kind cooperation during this study.

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Resource Use Efficiency at Farmers' Level Apple Production in Mustang District of Nepal

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Abstract

Apple is an important fruit grown in Nepal. But apple yield per hectare in Nepal is very low compared to other countries resulting perhaps from inefficient use of inputs at farmers' level. To investigate into the fact, the study was conducted at farmers' level in Mustang district of Nepal with a sample of 80 apple growers applying Cobb-Douglas production function model. The functional analysis revealed that some input, such as human labour, manure, pesticides, training – pruning and irrigation were underutilized. Result of the study also inferred that the apple farmers although economically more rational in some cases, were not using resources at an optimum level. Uneconomic utilization of inputs on apple field resulted in decreasing return to scale.

Key words : cobb-douglas, inputs, resource use efficiency, rational, return to scale.

1. Introduction

Apple is a prominent and one of the important prioritized high value cash crops (APP, 1995). It is a main temperate fruit of Nepal, which is cultivated on 4,003 hectares productive area with production of 36,396 mt (productivity 9.092 $mt.ha^{-1}$) in hilly topography lying from east to west. Among different fruits, it contributes about 5.8 percent of the total fruit production and occupies 8.8 percent of the total fruit area in Nepal (MOAC, 2007/08). The total apple trade in the country is estimated at 7,000 metric ton valued at Rs. 3.5 corers. Most of the apples sold in Kathmandu and other major cities are imported (about 90%). Most of the apple growing districts are not linked with roadways. They are not easily accessible to the national and export marketing channels, although air transport service has contributed to a great extent to transport these apples to the urban market centers of Nepal. The construction of agricultural roads to these commercial production pockets, envisaged by Agriculture Perspective Plan (APP), will link these districts to roadways and develop opportunities for exporting Nepalese delicious apples to our neighboring countries (MDD, 2000).

Identification of optimal level of factor productivity and farmers' efficiency in resource use are very important at national level for restoring its increasing trend. One way of approaching this problem is to investigate into farmers' efficiency in resource use with available technology as land and other capital items are very limited.

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So, in the case of inefficiency in resource use, the apple production can be increased or at least can be restored its increasing trend by making adjustment in the use of factors of production in optimal direction. With scarced resources, there is a high national demand for careful exploration of production possibilities and ways for increasing the efficiency of resource use on apple farms. So, the study has been designed to evaluate the apple resource use efficiency of the farmers in apple production in Mustang district of Nepal.

2. Methodology

2.1 Sources of data

Mustang district was purposively selected for the study as the district has relatively higher area coverage by apple. Data were collected through survey from a sample of 80 farmers from two areas; Kobang and Tukuche Village Development Committees (VDCs) of Mustang district. Eighty farmers were randomly selected 40 from each study VDC. Secondary data were collected from the various publications of related organizations like Fruit Development Directorate (FDD), Market Development Directorate (MDD), Ministry of Agriculture and Co-operatives (MOAC), Agro-Enterprise Center (AEC), Central Bureau of Statistics (CBS), and District Agriculture Development Office (DADO), Mustang.

2.2 Analytical model

Cob-Douglas production function was chosen to estimate the apple production function of apple producers. The choice of the functional form was based on its theoretical fitness to agriculture and its computational manageability. Further, most production studies in agricultural sector have used this function (Sahota, 1968; Dhawn and Bansal 1977; Barman 1993; Barman and Chaudhary, 2000). The model specified and used was represented by $Y = \alpha\ X_1^{b1}X_2^{b2}\ldots\ldots\ldots X_n^{bn}$, where Y was dependent variable and X_1 through X_n were the explanatory variables. 'A' was the constant and X_1 through X_n were factors of production, respectively. The production function was converted to logarithmic form so that it could be solved by least squares method i.e. $\text{Log } Y = \text{Log } \alpha + b_1\text{Log } X_1 + \ldots\ldots\ldots\ldots\ldots + b_n\text{Log } X_n$

Mathematically, the Cobb-Douglas production function can be expressed as:

$$Y = \alpha\ X_1^{b1}X_2^{b2}\ X_3^{b3}\ X_4^{b4}\ X_5^{b5}$$

In log linear form the above model can be expressed as follows

$\text{Log } Y = \text{Log } \alpha + b_1\text{Log } X_1 + b_2 \text{Log } X_2 + b_3 \text{Log } X_3 + b_4\text{Log } X_4 + b_5 \text{Log } X_5$

Where,

Y = Gross return (Rs/*ropani*)

X_1 = Human labour cost (Rs/ *ropani*)

X_2 = Manure cost (Rs/*ropani*)

X_3 = Pesticide cost (Rs/*ropani*)

X_4= Training and pruning cost (Rs/*ropani*)

X_5= Irrigation cost (Rs/*ropani*)

α = coefficient

2.3 Measurement of variables

Gross return (Y): It was the product of per *ropani* estimated yield of apple and per unit apple price at the farm level.

Human labour cost (X_1): It was the product of ongoing wage rate and total human labour hours spent on different operations in apple production, such as land preparation, manuring, and pesticide application. Labour was measured in terms of adult 8 hours equal to one working manday. In costing the family labours, their opportunity cost was considered at ongoing wage rate and for hired labour direct expenditures were taken into account. Thus, total human labour cost per *ropani* for apple production was estimated and used in analysis.

Manure cost (X_2): The cost of manure was calculated from direct cash expenditure and imputed value of home supplied quantity of manure and converted into per *ropani* basis for analysis.

Pesticide cost (X_3): The direct expenditures on pesticides used in apple production for preventing insects and checking diseases was considered in costing and converted into per *ropani* basis for analysis.

Training and pruning cost (X_4): It was the product of ongoing wage rate and total labour hired for training and pruning of apple. Then total cost of training and pruning of apple per *ropani* was estimated and used in analysis.

Irrigation cost (X_5): The irrigation cost was calculated from the product of ongoing wage rate and total human labour hired for the irrigation canal management – maintenance operation because apple growers of these VDCs do not directly pay irrigation charge.

Area

1 Hectare = 30 *Kattha* = 19.66 *Ropani*

2.4 Problem of multicollinearity

Production analysis with cross sectional data sometimes may lead to the problem of multicollinearity which is the linear relationship between variables. However, in this study, a thumb rule was applied to visualize the magnitude of multicollinearity, i.e. "The correlation coefficient between a pair of explanatory variables was treated serious if it was greater than 0.8" (Heady and Dillon, 1961). To ascertain the problem of multicollinearity, a zero order correlation matrix for all explanatory variables was obtained for this production function.

2.5 Marginal value productivity (MVP)

Technically the marginal value productivity of a particular resource is defined as the addition to the gross return caused by an addition of one unit of that resource while other inputs are held constant. The most reliable and useful estimation of MVP is obtained by taking the inputs (Xi) as well as gross return (Y) at their geometric means (Dhawan and Bansal, 1977). The MVP was computed by multiplying the regression coefficient of the given resource with the ratio of geometric mean of gross return to the geometric mean of the given resource i.e.

$$MVP1 = b1 \frac{\overline{Y}(GM)}{\overline{Xi}(GM)}$$

Where, i = 1,2…..n and GM represents the geometric mean. The marginal value productivity for all variable inputs were measured in terms of rupees.

2.6 Economic efficiency of resources

The economic efficiency of the apple farmers as the users of resources can be measured by comparing marginal value products of inputs to their marginal cost in acquisition. Since the variables used in analysis were expressed in terms of a value, a 11 percent rate or interest was charged for the cost of all used variable inputs and considered for the period of seven months only and were expressed in rupees. So the cost of rupees was Rs. 1.064 represented as the cost of acquisition of inputs. The ratio of MVP of different inputs to their respective acquisition cost was calculated. A ratio equal to unity indicates the optimum use of that factor. A ratio more than unity indicates that the return could be increased by using more of that resource and a value less than unity indicates the unprofitable level of resource use which should be decreased to minimize the losses.

3. Results and Discussion

Regression analysis was done for the whole sample with the specified functional model i.e. Cob - Douglas production function. The coefficients and estimated values of different parameters in the model were given in table 1. The coefficient of variable X_3 pesticide application was 0.598 and found to be highly significant at 1 percent level which implied that expenditure on pesticide application of controlling disease and insect pest in apple production would increase the yield and give higher return. The regression coefficient of manure and training/pruning were 0.245 and -0.137 which were significant at 5 percent level indicating that if manure were increased in apple production by 1 percent, there would be an increase in gross return of apple by 0.23 and increased in training/pruning by 1 percent lead to decrease in gross return of apple by 0.137 percent. Similarly, regression coefficient of irrigation was found 0.006 but it was insignificant. However, the production coefficient for human labour was insignificant. This suggested excessive use of human labour in the apple production on the study site.

Table 1: Parameter estimates of regression models for gross return of apple production with different explanatory variables.

Independent variables	Unstandardized coefficients		Standardized coefficients	t-value	Significance.
	B	SE	Beta		
Constant	1.907	0.272		7.011	0.000**
Log human labour cost (X_1)	0.096	0.074	0.142	1.298	0.198
Log manure cost(X_2)	0.245	0.113	0.281	2.168	0.033*
Log pesticide cost (X_3)	0.598	0.127	0.660	4.699	0.000**
Log training and pruning cost (X_4)	-0.137	0.064	-0.213	-2.141	0.036*
Log irrigation cost (X_5)	0.006	0.012	0.039	0.451	0.653

Dependent variable: Gross return SE = Standard error.

$R = 0.888$, $R^2 = 0.788$, Adjusted $R^2 = 0.773$ and Stand error of estimate = 0.08713,

Durbin-Watson test = 2.411 and F statistics = 54.921**

Note: ** and * refers to the significant at 0.01 and 0.05 level of significance, respectively.

The sum of production coefficient was 0.808. This was less than unity, which indicated that there was a decreasing return to scale in apple production. Coefficient of multiple determination (R^2) being 0.788 and indicated that the explanatory variables used in the model specification were important and 78.8 percent variation in the apple production was explained by them. The F statistic was observed to be 54.921 and highly significant at 1 percent level implying a good fit of the model. Obviously, the larger the R^2 value is the more important the regression equation is in characterizing the dependent variable (Gomez and Gomez, 1984). It was also found that the inter correlation between independent variables was also low i.e. no correlation coefficient between explanatory variables was greater than 0.80. Thus, satisfying the criterion for non-seriousness of multicollinearity (Table 3).

Table 2: Regression coefficients and test statistics of the apple producers in study area

Parameters	Regression coefficients	MVP of factors of production	Geometric mean (Rs.)	Ratio of MVPs to their costs
Constant	1.907	-	63922.14	-
Human labour	0.096 (0.198)	0.91	6736.55	0.856
Manure	0.245* (0.033)	5.05	3100.00	4.748
Pesticide	0.598** (0.000)	7.93	4816.88	7.458
Training and pruning	-0.137* (0.036)	1.52	5795.87	1.427
Irrigation cost	0.006 (0.653)	1.66	230.907	1.561

Table 3: Zero order correlation matrix of variables for studied apple farmers

Variables	Gross return	Human labour cost	Manure cost	Pesticide cost	Training and pruning cost	Irrigation cost
Gross return	1.00	0.464	0.739	0.772	0.299	0.666
Human labour cost	-	1.00	0.557	0.551	0.741	0.511
Manure cost	-	-	1.00	0.708	0.438	0.718
Pesticide cost	-	-	-	1.00	0.431	0.772
Training and pruning cost	-	-	-	-	1.00	0.373
Irrigation cost	-	-	-	-	-	1.00

4. Conclusion

Overall functional analysis brought out that the apple farmers were rational in making expenditures on manure, pesticides and training/pruning as the ratios of MPVs of these resources to their costs were significantly greater than unity, indicating optimum level of resources use. Less than unity ratio of MPV to factor cost as found in human labour indicated that the expenditure on this input was greater than their contribution and used not at an optimal level. But greater than unity ratio could be explained in terms of risk aversion behavior of the farmers in farming. Studies have shown that the producers may not intend to maximize profit but could like to maximize the margin in order to overcome the cost of any risk and uncertainty.

These observations of the study were based on statistical estimations made through a production model specified with six explanatory variables. Land fertility and its productivity is important factor which was not included in this model due to lack of appropriate information on it. Similarly due to perennial nature of apple tree only variable costs were included for this study and all the plants taken for the study are in the productive phase and examine single year of production.

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Influence of Time and Intensity of Pruning on Flowering of Cut Rose (*Rosa hybrida*) cv. Super Tata

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Abstract

A field investigation was carried out during July 2008 to April 2009 in the farmer's field of Gunjanagar-5, Chitwan, Nepal to evaluate the influence of time and intensity of pruning on flowering of cut rose (Rosa hybrida) cv. Super Tata. The experiment was laid out in a completely randomized block design with nine treatment combinations and replicated thrice. The treatments comprised of three dates of pruning i.e. 30th July, 15th August and 30th August and three pruning intensities i.e. heavy (6 buds per plant), medium (12 buds per plant) and light (18 buds per plant). Both time and intensity of pruning significantly affected yield attributing parameters. The plants pruned heavily on 30th July produced earliest floral initiation. Flowers stem diameter was found the highest in July 30th pruned rose plants while, flower stem length was found longer (47.67 cm) in August 15th ones. Flowers stem length (50.33 cm) and diameter (0.60 cm), length (2.91 cm) and diameter (2.29 cm) of floral bud were found the highest from heavily pruned plants. Number of flower per plant was recorded the highest (22) from earlier (30th July) and lightly pruned rose plants. On the other hand, the longest duration of flowering (212.8 days) was observed from earlier and heavily pruned (198.1 days) plants. Sequential pruning can produce rose flowers at desired time and quality cut flowers can be produced by heavy pruning.

Key words : Flower production, intensity of pruning, time of pruning

1. Introduction

Roses are symbol of beauty, fragrance and are used to convey the message of love (Arora, 2007). Rose is one of the nature's beautiful creations and is universally acclaimed as the Queen of Flower (Yadav et al., 1989). The demand for rose cut flower is 2,500-4,000 sticks per day in Kathmandu and about 180 ropanies land is covered under rose cultivation (Joshi, 2009). Pruning is a major horticultural practice in rose cultivation (Edmond et al., 1994). Pruning is an invigorating process calculated to produce a definite effect in the formation of shoot, flowers and root, too (Gopalaswamiengar, 1970).

The kind and severity of pruning of the rose depend on the kind of rose grown and the size of the flower desired. The different dates of pruning seem to have influenced flower yield and quality subsequently (Mukhophadhyay, 1990). Pruning rose plants in different dates was helpful in staggering the harvest of cut

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flowers. The severity of pruning has considerable influence both on vegetative growth and flower production. Depending upon the extent and the level of shortening of stem, there are three types of pruning - Light, moderate and heavy (Dhua, 1999). Several researchers have reported increased flower production with light pruning and quality blooms with severe pruning. There is no standard time and intensity of pruning for the market oriented quality rose production in Nepal. Therefore, this research was conducted to determine the optimum time and intensity of rose pruning for efficient flowering and yield of cut flower in the farmer's field in Gunjanagar-5, Chitwan, Nepal from July 2008 to April 2009.

2. Materials and Methods

The commonly grown rose cultivar in Chitwan "Super Tata" having yellow color flower, one year old rose plants were taken as a test crop for the experiment. The treatment combinations of time and intensity of rose pruning were selected as treatments. There were nine plants in each experimental plot and observation was taken from three middle plants. The individual plant was pruned three times at 15 days interval viz. pruning on July 30, Aug. 15 and August 30 of 2008 to different intensities i.e. 6, 12 and 18 buds in each plant. The field experiment was laid out in a completely randomized block design having two factors with nine treatment combinations replicated thrice.

The rose plants were pruned to allow the intensity as desired. After pruning, cut ends were painted with fungicide paste (Bordeaux paint). All the intercultural operations like hoeing, weeding, top dressing, irrigation, earthing up; mulching and plant protection measures were done regularly. Flowers were harvested from November 2008 to April 2009 manually during evening retaining 10-12 cm stem from the branch attachment. Observations were recorded for several parameters i.e. days to floral initiation, flower stem characteristics, flower bud characteristics, number of flowers production and duration of flowering.

3. Results and Discussion

3.1 Floral Initiation Characteristics

The earlier flower bud appearance (39.42 days), days to flower initiation (43.83 days) and days to 50 percent flower initiation (58.33 days) was recorded in rose plants pruned on July 30 and maximum duration for the floral initiation was recorded in rose plants pruned on August 30 (Figure 1). The earlier flower bud initiation (40.75 days), days to flower initiation (46.96 days) and days to 50 percent flower initiation (60.78 days) (Figure 2) was recorded in rose plants pruned retaining six buds per plant and maximum days for the floral initiation was recorded in rose plants pruned retaining 18 buds per plant. The more severe was the pruning the faster was the flower initiation. This might be due to the earlier growth of stem bud and availability of nutrients. Similar results were found by Sharma et al. (1985).

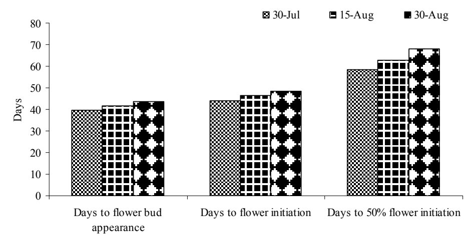

Figure 1. Effect of time of pruning on days to flower bud appearance, days to flower initiation and days to 50% flower initiation of cut rose cv. Super Tata (*Rosa hybrida*) in Chitwan (2008/09)

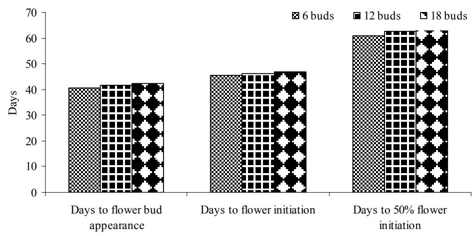

Figure 2. Effect of intensity of pruning on days to flower bud appearance, days to flower initiation and days to 50% flower initiation of cut rose cv. Super Tata (*Rosa hybrida*) in Chitwan (2008/09)

3.2 Flower Stem Characteristics

The rose plants pruned on August 15 produced flowers having the longest stem (47.67 cm) which was at par with rose plants pruned on July 30 (47.11 cm) and shortest stem (42.00 cm) was produced from rose plants pruned on August 30 (Fig. 3) after harvest. Deepauw (1985) reported that the stem length of rose was only slightly affected by time of pruning.

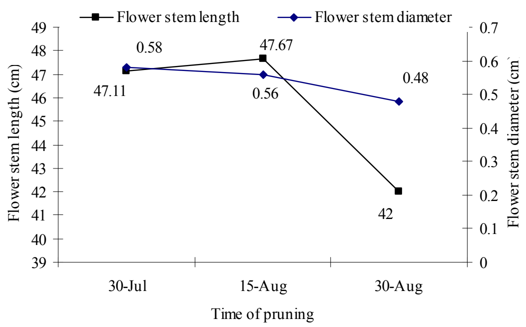

Figure 3. Effect of time of pruning on flower stem length and flower stem diameter of cut rose cv. Super Tata (*Rosa hybrida*) in Chitwan (2008/09)

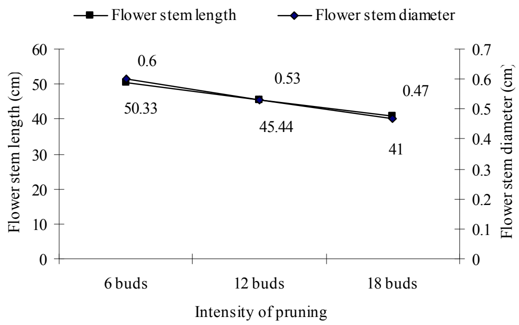

Figure 4. Effect of intensity of pruning on flower stem length and flower stem diameter of cut rose cv. Super Tata (*Rosa hybrida*) in Chitwan (2008/09)

The rose plants pruned retaining six buds produced flowers having the longest stem (50.33 cm) whereas the shortest stem (41.00 cm) was produced from rose plants pruned retaining 18 buds (Fig. 4). The rose plants pruned on July 30 produced flowers having the highest stem diameter (0.58 cm) and smallest stem diameter (0.48 cm) was produced from rose plants pruned on August 30 (Figure. 3). Figure 4 showed that the rose plants pruned retaining six buds produced flowers having highest stem diameter (0.60 cm) and smallest stem diameter (0.47 cm) was produced from rose plants pruned retaining 18 buds.

This might be due to the availability of more nutrients to each stem on rose plant under heavy pruning than light pruning. Similar result was found by Bajawa et al. (1998). The increase in flower stem length and diameter may be due to lesser number of stem produced and therefore, more nutrients coming to the share of each stem on heavily pruned rose plant. Similar results have been reported by Bajawa and Sarowa (1977) and Gupta & Singh (1987).

3.3 Flower Bud Characteristics

The rose plants pruned retaining 6 buds produced flowers having the highest flower bud length (2.91 cm) and diameter (2.29 cm) whereas the smallest flower bud length and diameter (2.23 cm and 1.90 cm) was produced from rose plants pruned retaining 18 buds (Table 1). Higher amount of carbohydrates available for the individual flower stem in heavily pruned rose plant might have contributed to better vigor of plant having longer and bigger flower bud. This result is in agreement with the result of Mukhopadhyay et al., (1987).

Table 1 : Effect of intensity of pruning on flower bud characteristics of cut rose (*Rosa hybrida*) flower cv. Super Tata in Chitwan (2008/09)

Treatments	Flower bud characteristics	
	Length of flower bud (cm)	Diameter of flower bud (cm)
Intensity of pruning		
6 buds	2.911[a]	2.298[a]
12 buds	2.578[b]	2.043[b]
18 buds	2.233[c]	1.900[c]
CV%	10.92	6.72

[a]Means in the column followed by same letter in each treatments do not differ significantly at (p=0.05) by DMRT. SEM=Standard error of mean, LSD=Least significant difference and CV=Coffficient of variance.

3.4 Number of Flowers and Duration of Flowering

Early pruned rose plant (July 30) produced the highest numbers of cut rose flowers (15.11) and the longest duration of flowering (212.8 days) followed by rose plant pruned on August 15 (13.56) and (196.4 days) and rose plant pruned on August 30 (12.67 flowers) and (178.7 days), respectively (Figure 5). The earlier pruned rose plants started to initiate flower stem buds earlier and flowering than later pruned rose plants but, the cessation of flowering was at similar time. Thus, the duration of flowering was found longer in early pruned rose plant on July 30. This result also agreed by Mukhopadhayay (1990). Deepauw in 1985 observed that later was pruning date lower the flower yield.

Heavily pruned rose plant produced the lowest numbers of cut rose flowers (8.66) followed by medium pruned plant (13.00) whereas the highest numbers of cut rose flowers (19.67) were produced by lightly pruned rose plant. Several workers have been reported increased flower production with light pruning and quality blooms with severe pruning (El. Gamassy et al., 1980; Irulappam et. al., 1993). Heavily pruned rose plant produced cut rose flowers for the longest duration (198.1 days) followed by medium pruned plant (196.0 days) and the shortest duration of flowering (193.8 days) were reported from lightly pruned rose plant (Figure 6).

4. Conclusion

Time of pruning affects all the flowering parameters of rose. The early pruned (July

30) rose plants performed significantly better than other dated pruning in all aspects. Similarly, the performance of rose flowers was also found significantly different with various intensities of pruning. Among the three intensities, heavily pruned rose plants performed better in all yield attributing characteristics but numbers of flowers per plant was found the highest in lightly pruned rose plants. This suggests that pruning of rose is an important aspect in cut flower production. Sequential pruning can produce rose flowers at successive desired time. Grower should prune heavily to produce quality cut flowers whereas higher quantity of rose flowers can be achieved by light pruning. In Chitwan conditions, cut rose growers can prune their rose plants after rainy season to produce cut rose targeting festivals and marriage months leaving 10-12 buds in each plant for quantity and quality of cut flower.

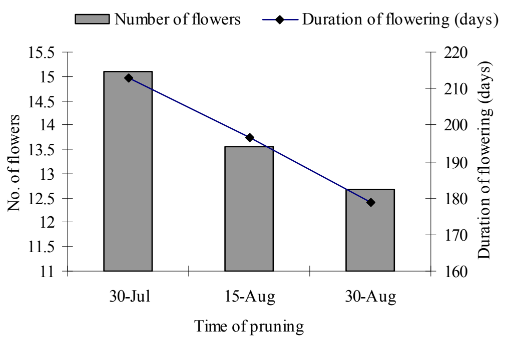

Figure 5. Effect of time of pruning on number of flowers and duration of flowering of cut rose (*Rosa hybrida*) cv. Super Tata in Chitwan (2008/09)

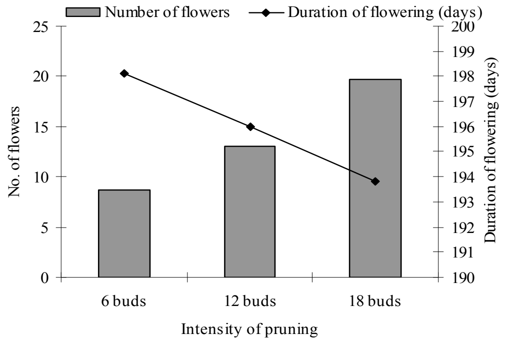

Figure 6. Effect of intensity of pruning on number of flowers and duration of flowering of cut rose (*Rosa hybrida*) cv. Super Tata in Chitwan (2008/09)

Acknowledgement

National Agriculture Research and Development Fund (NARDF), Kathmandu is highly acknowledged for financial support to attempt this study.

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Mass Production of Entomopathogenic Fungus for White Grubs Control in Nepal

Yubak Dhoj GC*

Abstract

The successful use of entomopathogenic fungi as microbial control agents of insects will ultimately depend on the use of the right propagule, formulated in an optimum fashion and applied in the field at the right time. In order to address these issues, mass production of *Metarhizium anisopliae* targeting white grubs control was studied in 2009. Comparative studies of the fungus production showed significant differences between the poly bags imported from Switzerland and the poly bags available in Nepal with a better quality of the fungus in the former type of bags. Similarly, barley kernels were better substrates than rice and wheat for fungus production. The cultures grown in Nepali bags were heavily contaminated irrespective of the solid substrates used in the experiments. Barley grains inoculated with blastospores were significantly better colonized than those inoculated with conidia.

Keywords: *Beauveria bassiana,* Biological control, insect pathogenic fungi, *Metarhizium anisopliae,* white grub

1. Introduction

White grubs are among the difficult pest insects in Nepalese agriculture. The insect pathogenic fungus, *Metarhizium anisopliae* is a potential microbial alternative to chemical pesticides. It has many good characteristics like growth on in cheap substrates, high virulence, transcuticular penetration, broad host range among insects, and safety to humans, animals, plants and the environment (McCoy et al, 1988). This fungus plays a significant role in the regulation of insect populations in nature and may potentially be exploited for commercial biological control purposes (Bidochka et al., 1995). It is used as mycoinsecticides for soil insect control in several countries, especially in USA, New Zealand, Australia, Switzerland, Austria and to some extent in Italy under different trade names (Butt et al., 2001).

Mass production of this fungus for biological control of insect pest is an area of growing interest (Bateman, 1997, Jenkins and Goettel, 1997). The infective material of the fungus can be produced in two forms, either as blastospores in liquid media (submersed culture) or as conidia on solid media (surface culture) (Aregger, 1992). Solid state fermentation is advantageous because it is easy to carry out, raw material is cheap, and most importantly, spores produced as living propagules tend to be more tolerant to desiccation and are more

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stable as a dry preparation compared with spores produced in submerged fermentation (Deshpande, 1999). Keller (2000) reported that a product based on sterilized barley kernels colonized with *Beauveria brongniartii* proved to be a suitable and economically reasonable biocontrol agent to control *Melolontha melolontha.* The production and formulation process should be followed by a quality control including purity of the product (foreign microorganisms and undesired metabolites) and virulence (Jenkins and Goettel, 1997).

The application must be done carefully and directed against the target taking full account of the biology. The success of the control of soil-borne pests with entomopathogenic fungi is mainly dependent on the efficacy and persistence of the pathogen in the soil environment coupled with soil temperature and moisture (Studdert et al., 1990), soil types (Storey et al., 1989) as well as with antagonistic organisms (Lingg and Donaldson, 1981). Another important factor is the presence of the host, which affects the persistence of mycopathogens in the soil (Kessler, 2004). Dispersal of spores is achieved by soil water, the movement of soil organisms and of infected and uninfected hosts (Hall and Dunn, 1957). Considering all these aspects, a product based on sterilized barley kernels colonized with *M. anisopliae* was produced into two different types of polybags using four different types of solid substrates. The present study investigates the selection of appropriate poly bags and medium for fungus production that could be used as a means of white grub control in Nepal.

2. Material and Methods

2.1 Fungus Culture

Seventy different indigenous isolates of *M. anisopliae* were assembled from Chitwan, which were initially cultured and maintained the Insect Pathology Laboratory at the Institute of Agriculture and Animal Science (IAAS), Rampur. In fact, this was the foundation of Helvetas-Switzerland and IAAS biocontrol project during 2003-2007. These cultures were collected from the farmer's fields of Chitwan and Nawalparasi distircts, either from soils using the Galleria Bait Method (GBM) and Selective Medium (SM) or from infected white grubs (GC, 2006). After getting pure culture, single colonies were transferred to selective medium and maintained at 22-23^{o}C at the Regional Plant Protection Laboratories (RPPL), Harihar Bhawan. They were prepared as fungal suspension either as a blastospores, an infective propagules of fungus produced in the liquid medium or conidospores, an infective conidia of the fungus produced in the selective medium. After preparing the suspension a first set of experiment for testing their virulence against third instars larvae of *Maladera affinis* were conducted.

2.2 Mass Production

Two different types of fungus inocula, conidia and blastospores were used for mass production. Peeled grains of barley, rice and wheat obtained from local markets were tested as solid substrates. Similarly, poly bags of Swiss and of Nepal origin were used for fungus production. Swiss bags were polycarbonate bags with a size of 30 x 50 cm, whereas Nepali bags were of the same size but primarily prepared for grocery uses. Assessment were carried out in terms of type of fungus inoculum (conidia and blastospores), type of poly bags (Swiss and Nepali origin) and type of solid substrates (rice, wheat and peeled barley grains).

Before inoculation of the fungus, one kg solid substrate was filled in a poly bag. About 300 ml normal tap water was added and left for four hours for uniform soaking of the kernels. The substrates were autoclaved twice with an interval of 24 hours at a pressure of 1.5 bars which is equivalent to 120^{o}C for 40 minutes. The fungus inocula consisting of conidia or blastospores were adjusted to 10^7spores/ml in a Thoma haemocytometer. After proper cooling of the grains, inoculation was conducted in a laminar flow hood.

Each flask containing blastospore suspensions was diluted 1:1 with sterilised tap water. Conidia were obtained by scrapping off from the selective medium into distilled water. The fungus inocula were well shaken to get a homogenous suspension. The bags with the sterilised medium were carefully opened at one corner and 200 ml diluted spore suspension per 1 kg solid substrate was added. In order to assure a homogenous distribution of the inocula in the solid substrates the poly bag were shaken very gently before incubation.

The bags were incubated at 22-23 ^{o}C. The bags were shaken daily at 10 am during the initial days of incubation to favour the homogenous growth of the fungus on the kernels, to improve aeration and to prevent the kernels from sticking together. The bags were put individually in an upside fashion of the openings to optimise aeration. After three to four weeks, the bags with the colonised kernels were removed from the incubator and air dried for storage on boards at a temperature of 22 ^{o}C before use. None of the bags was stored longer than three months. In all steps, bags were handled with care to avoid damages that may lead to contamination.

2.3 Quality Control of Fungus

The quality of the fungus-colonized grains was assessed for purity and growth of *M. anisopliae* with four replicates. The experimental unit in all studies was a Petri plate with moistened filter paper with fifty randomly selected fungus-colonised kernels. Eventually, quality of the fungus materials was expressed in terms of percentage colonised kernels and attributed to three groups: pure *Metarhizium* growth, *Metarhizium* present on a part of the grain with or without unwanted fungi (contaminants) and grains only with contaminants.

3. Results

3.1 Influence of Pre-culture

The comparison between inocula based on conidia and blastospores on the quality of the fungus material is presented in tables 1 and 2. Table 1 shows that isolate M1 produced comparatively less uncolonised grains and a higher percentage of pure *Metarhizium* grains as compared to the other isolates when inoculated with blastospores, however, the differences are not significant. However, when pooled data are used, the inoculation with blastospores resulted in significantly less contaminated grains (Table 2)

Table 1: Effect of different isolates of *M. anisopliae (M. a.)* and inocula types on the quality of fungus colonized barley grains in 2009

Strains	Conidiospore treated grains (%)			Blastospore treated grains (%)		
	With pure growth of *M. a.*	With presence of *M. a.*	With uncolonized *M. a.*	With pure growth of *M. a.*	With presence of *M. a.*	With uncolonised *M. a.*
M1	82.5	69.5	30.5	95.0	99.5	4.5
M6	84.5	64.0	36.0	87.0	95.0	13.0
M18	77.0	64.0	36.0	89.5	97.5	10.5
M48	79.0	67.0	33.0	93.0	96.5	7.0
M50	82.0	67.0	28.0	90.5	97.5	9.5
LSD (5%)	ns	ns	ns	ns	ns	ns
SEM	3.3	3.1	3.1	3.1	3.3	3.1
CV %	7.6	8	30.4	8.0	7.6	30.4

ns= not significant

Table 2 : Effect of *Metarhizium anisopliae* inocula (isolate MI) on the quality of fungus colonized barley grains inoculated at 22-23 ^oC

Spores	% grains with pure *M.a* growth	% grains with *M.a* present	% grains uncolonized with *M.a*
Conidiosproes	66.30	81.00	32.70
Blastospores	91.00	97.20	8.90
LSD (5%)	4.038	4.35	4.08
SEM	1.398	1.50	1.41
CV %	8.0	7.6	30.4

M.a. = *Metarhizium anisopliae*

3.2 Influence of Bags

The production of isolate M1 in two different types of poly bags revealed that, M1 strain produced comparatively pure *Metarhizium* fungus ($p<0.001$) among the tested strains (Table 3).

The colonizing attributes with respect to purity of the fungus is presented in table 4. This shows that more and more purity was obtained in case of the fungus produced in Swiss bags as compared to Nepali bags, suggestion their suitability.

The quality of the fungus in terms of uncontaminated grains was significantly higher in case of barley kernels produced in Swiss bags as compared to Nepali bags (Tables 5 and 6).

The fungus quality with references to different solid substrates (cereal grains) is presented in Table 6.

Table 3 : Quality of the fungus material in two poly bag types inoculated with (blastospores) of five strains of *Metarhizium anisopliae (M.a.)*

Strain	Fungus quality in Swiss bag			Fungus quality in Nepali bag		
	% grains with pure *M.a.* growth	% grains with *M.a.* present	% contaminated grains	% grains with pure *M.a.* growth	% grains with *M.a.* present	% contaminated grains
M1	98.00	100.00	2.00	53.00	72.50	18.00
M6	91.00	99.00	8.00	67.00	92.50	25.50
M18	90.50	97.50	6.50	27.00	47.00	20.00
M48	83.00	97.50	14.50	62.50	89.50	27.00
M50	90.00	99.00	9.00	15.00	24.00	9.00*
LSD (5%)	27.04	40.10	15.67	27.04	40.10	15.67
SEM	9.36	13.88	5.43	9.36	13.88	5.43
CV %	27.70	33.90	77.80	27.70	33.90	77.80

* In this case 52% of the grains were found uncolonised by the fungus

Table 4 : Effect of poly bag on the quality of fungus-colonised barley grains incubated at 22-23^{o}C

Type of poly bags	% grains with pure *M.a* growth	% grains with *M.a.* present	% grains uncolonized with *M.a*
Swiss Bag	90.5	98.6	8.0
Nepali Bag	44.9	65.1	19.9
LSD (5%)	12.09	17.93	7.01
SEM	4.19	6.21	2.43
CV %	27.7	33.9	77.8

M.a. = *Metarhizium anisopliae*

Table 5 : Effect of poly bag types with respect to solid substrates on the quality of M1 isolate of *Metarhizium anisopliae* (*M. a.)* inoculated with blastospores at 22-23 ^{o}C

Test substrates	Fungus quality in Swiss bags (%)			Fungus quality in Nepali bags (%)		
	Grains with pure *M. a.* growth	Grains with *M. a.* present	Contaminated grains	Grains with pure *M. a.* growth	Grains with *M. a.* present	Contaminated grains
Barley	94.5a	99.5a	5.0a	53.5b	74.0b	20.5a
Wheat	25.0b	63.0b	38.0b	10.0a	40.5a	30.5ab
Rice	38.0b	61.0b	23.0b	32.5ab	69.5b	33.5ab
LSD (5%)	11.58	30.99	23.52	11.58	30.99	23.52
SEM	3.9	10.43	7.92	3.90	10.43	7.92
CV %	18.4	30.7	63.1	18.4	30.7	63.1

Figures in the columns followed by the same letters are not significantly different at $p<0.001$ by DMRT

Table 6: Effect of solid substrates on the quality of fungus-colonized grains inoculated with *Metarhizium anisopliae (M. a.)* isolate M1 at 22-23 ^{o}C

Solid substrates	Observation parameters %		
	Grains with pure *M. a.* growth	Grains with *M. a.* present	Contaminated grains
Barley	74.0 a	86.8 a	12.7 c
Wheat	17.5 c	51.8 b	34.2 a
Rice	35.2 b	65.2 b	28.2 a
LSD (5%)	8.19	21.91	16.63
SEM	2.76	7.38	5.6
CV %	18.40	30.70	63.1

Figures in the columns followed by same letters are not significantly different at p<0.001 by DMRT

Table 6 shows the influence of solid substrates on the contamination rate which eventually is related to the quality of the fungus. The lowest contamination rate (12.7%) was obtained when the fungus was produced on barley grains (p<0.001), followed by rice. The highest contamination rate (34.2%) was found on wheat grains.

Discussion

The experiments for mass production with *M. anisopliae* in autoclavable plastic bags demonstrated the feasibility but also the importance of the bag quality. Good fungus quality was only achieved with bags of Swiss origin. Additional efforts must be undertaken to develop a production system which is based only on materials available on the national market. The present study has indicated ample opportunity of fungus production using barley kernels in suitable poly bags allowing exchange of air. During the experiments it was observed that the bags influenced the contamination. In Nepali bags most contaminants were yeasts-like with a typical smell, while the contaminants in the Swiss bags were *Penicillium*-like fungi. These marked differences between the two bag types are attributed to material characteristics. It is assumed that the Nepali bags are air-tight while the Swiss bags allow some gas exchange and evaporation of water.

The interaction of solid substrates with respect to poly bags was not significantly different. However, the intensity of contamination was comparatively low in case of Swiss poly bags. The possible reason for this may be the low stickiness of the barley grains after autoclav as compared to other solid substrates. It was also found that the wheat grains were the poorest substrate for producing quality fungus where the highest contamination (38%) was found even in the Swiss bags. It is obvious from above study that the inoculum produced from blastospores are far more effective than that of conidiospores for mass production. The possible reason for this may be the effective growth of germinating spores in the former cases, whereas considerable extent of losses of conidia in the later cases.

Based on this study, it is evident that mass production of fungus can be promoted for further production scheme along with Swiss types of poly bags. The fungus-colonized barley grains in Nepali bags were heavily contaminated with other unwanted saprophytic fungus when compared with the fungus produced in Swiss bags ($p<0.001$). This study showed ample scope of producing fungus in barley kernels in suitable poly bags. This study could be one of the cornerstones for fungus-based biopesticide production which will be useful against white grubs and similar pest insects. The important aspect is to incoroporation of such works in the regular system of the government and non-governmental organizations.

Acknowledgements

The foundation work was financed by Helvetas-Switzerland through IAAS, Rampur. I am very much thankful to IAAS, Rampur for providing me the fungus cultures. The staffs of Regional Plant Protection Laboratory, Harihar Bhawan are highly thankful for assistance in completing this study.

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Effect of Climate Change on Agriculture: A Review

B.P. Ghimire* and L.N. Acharya**

Abstract

Climate change is widely considered one of the greatest challenges to modern human civilization having uncertain consequences. The erratic behavior of precipitation, drought, floods, disease outbreaks and temperature rise up are the major symptoms of climate change that adversely affect on agrobiodiversity, crop yields, geophysical and socioeconomic factors. It is essential to develop a portfolio of strategies that includes adaptation, mitigation, appropriate technological development and research to combat the effects of climate change. Integration of mitigation and adaptation frameworks into sustainable development planning is an urgent need, especially in the developing countries at household level, so that agriculture dependent poor and vulnerable people can be appropriately targeted in research and development activities. There is urgent need to overcome the additional threats posed by a changing climate on attaining food security, enhancing livelihoods and improving environmental management. Nepal being one of the most vulnerable countries to climate changes so that unusual rainfall, drought, and insect pest epidemics affect on agriculture.

Key words : agrobiodiversity, climate change, food security, global warming, green house gases

1. Introduction

The climate change is complex and global problem. Symptoms of climatic changes such as shrinking glaciers, variations in rainfall frequency and intensity, and shifts in growing seasons and disease outbreaks have largely negative effects on food production, water supply and disease proliferation in many parts of the world (FAO/NRCB, 2008). Agriculture is important for food security in two ways viz it produces the food people eat, and it provides the primary source of livelihood for 36 percent of the world's total workforce (http://www/agr.gc/ca; ILO, 2007). There are some facts about global warming and climate changes like average global temperatures increased by about 1^0 farenheight over the 20th century, if present trends continue, by 2100 the earth's average temperature will be 1.5 to 6^0 celsius warmer than it is today, due in large part to a global increase in green house gases emissions, 15 percent of carbon emissions come from deforestation and land use change (http://www.nature.org). Climate change directly impacts on crop productivity and food production. Uncertainties in regional precipitation patterns, crops sensitivity to climate and response to rising atmospheric CO_2 affect our agriculture at both regional and global scales (World Bank, 2009).

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Nepal is also seriously affected in South Asia for erratic behavior of rain causing excessive flood and drought affecting on cropping season (Karki, 2008). Survey report by Maplecroft-a British global risk advisory firm showed that among 170 nations Nepal ranks fourth in the climate change vulnerability index (Koirala, 2010).

There is need for understanding about impact of climate change on different aspects of agriculture like agrobiodiversity, irrigation, food security, human health, production trend and many more. The purpose of this review paper is to assist our current understanding about climate change and its direct and indirect effect on global agriculture. It may remove for the dossier collections about adversarial impacts of climate change on agriculture at a glance.

2. Materials and Methods

Papers on climate change, global warming and green house gases with reference to agriculture were collected both from published and unpublished sources and studied thoroughly.

3. Results and Discussion

Global warming (effect of green house gases) is an average increase in the temperature of the atmosphere near the earth's surface and in the troposphere, which can contribute to changes in global climate patterns. Global warming can occur from a variety of causes, both natural and human-induced (ADB, 2009). Climate change (effect of global warming), which is largely a result of burning fossil fuels, is already affecting the earth's temperature, precipitation, and hydrological cycles. Continued changes in the frequency and intensity of precipitation, heat waves, and other extreme events are likely, all which will impact agricultural production. Furthermore, compounded climate factors can decrease plant productivity, resulting in price increases for many important agricultural crops (Huraera et al. 2010). The net effect of climate change on world agriculture is likely to be negative. Although some regions and crops will benefit, most will not. While increases in atmospheric CO_2 are projected to stimulate growth and improve water use efficiency in some crop species, climate impacts, particularly heat waves, droughts and flooding, will likely dampen yield potential. Indirect climate impacts include increased competition from weeds, expansion of pathogens and insect pest ranges and seasons, and other alterations in crop agroecosystems (Schmidhuber and Tubiello, 2007).

WRI, 2008 documented that agriculture is a major contributor to climate change. Stern (2006) showed the major contribution of greenhouse gases from energy emission sources (power, industry, transport, building and others) and non energy emissions (land use, agriculture, waste) were 65 and 35 percent respectively as shown in Figure 1.

There is great concern about the impacts of climate change and its variability on agricultural production worldwide. First, issues of food security figure prominently in the list of human activities and ecosystem services under threat of dangerous anthropogenic interference on earth's climate (Watson et al., 2000; IPCC 2001a,b; Ecosystem Millennium Assessment, 2005), each country is naturally concerned with potential damages and benefits that may arise over the coming decades from climate change impacts on its territory and globally as well. Current research confirms that crops would respond positively to elevated CO_2 in the absence of climate change (Kimball et al., 2002; Jablonski et al, 2002; Ainsworth and Long, 2005), the associated impacts of high temperatures, altered patterns of precipitation and possibly increased frequency of extreme events such as drought and floods, will probably combine to depress yields and increase production risks in many world regions, widening the gap between rich and poor countries (IPCC, 2001a,b).

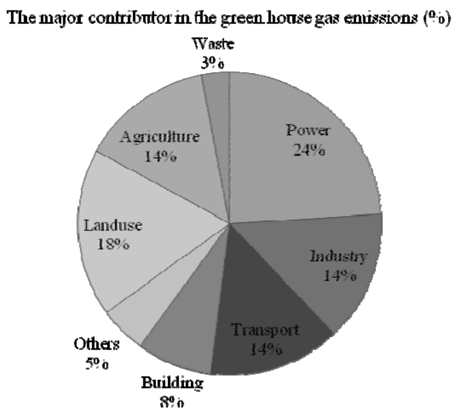

Figure 1: The major contribution in the green house gas emissions.

The impacts of climate change on agriculture and human well-being include: the biological effects on crop yields, the resulting impacts on outcomes including prices, production, and consumption; and the impacts on per capita calorie consumption and child malnutrition (www.agr.gc.ca).

The amalgamated impact of climate change are broadly categorized in three parts;

1. On agrobiodiversity, crop yield and associated factors
2. On geophysical factors
3. On socioeconomic factors

3.1 Effect of Climate Change on Agrobiodiversity, Crop Yield and Associated Factors

3.1.1 Agrobiodiversity: Climate changes may lead to the extinction of plants and animals from their habitat. The rapid nature of climate change is likely to exceed the ability of many species to migrate or adjust. Experts predict that one-fourth of earth's species will be headed for extinction by 2050 if the warming trend continues at its current rate. Intense droughts in some regions will also increase the risk of forest fires and reduce forest biodiversity (ADB, 2009, Devraj, 2010). Many literatures recapitulated that shifting of climatic regions in Nepal have led to extinction of the natural vegetation in many places (for example, unusual snowfall affecting the presence of Yarsa Gumba, a medicinal herb, and production feasibility of tomato, chilly, maize in Mustang) (Koirala, 2010).

3.1.2 Crop Yields: Rising temperatures and changes in rainfall patterns have direct effect on crop yields, as well as indirect effects through changes in irrigation water availability. In developing countries, yield declines predominate for most crops without carbon dioxide (CO_2) fertilization. Irrigated wheat and irrigated rice are especially hard hit. If current patterns of warming continue, irrigated rice production in the region is expected to decline in the range of 14–20percent; irrigated wheat, 2–44 percent; irrigated maize, 2–5 percent; and irrigated soybean, 9–18 percent in the next 40 years (ADB, 2009). Over the next 30-50 years, CO_2 concentrations will increase to about 450 parts per million by volume (ppmv) in the contrast of 390 ppmv now. The CO_2 response is expected to be higher on C3 species (wheat, rice, and soybeans), which account for more than 95 percent of world's species than on C4 species (corn and sorghum). C3 weeds have responded well to elevated CO_2 levels, symbolizing the potential for increase weed pressure and reduced crop yields (Anonymous, 2005). For almost all crops, it is the region with the greatest yield decline. With CO_2 fertilization, the yield declines are lower; in many locations, some yield increases occur relative to 2000 (Anonymous, 2005; Ramana, 2008). Thus, the direct impact of climate change on agriculture and food supply includes shortage in grain production resulting in less availability of food items, especially to the economically poor people, chemical changes in agricultural inputs such as fertilizers and pesticides, shift in planting dates of agricultural crops, preference of crop genotypes due to adaptation to changing climate, soil erosion, soil drainage and lower fertility level. Additionally, the incidence of pests, weeds and diseases in food crops will be more pronounced (The Nature Conservancy, 2010). Alan and Regmi (2005) concluded that the pattern of yield and productivity of cereal crops was decreasing in Nepal. Roy (2001) showed relationship between temperature increment and production of crops and livestock (Table 1).

3.2 Effect of Climate Change on Geophysical Factors

3.2.1 Hydrologic: More frequent and intense droughts and floods can damage and at times even destroy them. Rainfall plays a critical role in year to year variability of crops yield. Broadly speaking, precipitation is expected to increase in high latitudes and decrease at mid to low latitudes although there is high regional and seasonal variation in the level of certainty in these projections. Changes in the frequency and intensity of extreme weather events will have significant consequences for agriculture. Increases in extreme temperature events can have high impacts on crop yields and heat stress in cattle. Extreme rainfall and flooding may also have severe consequences for agriculture at the local scale and can affect grain quality as well as quantity. Because of climate change, Nepal is facing drier phases during dry seasons with wetter monsoon with chances of flooding and landslides during rainy seasons with subsequent consequence s on agriculture and livelihoods (Alan and Regmi, 2005). Koirala (2010) explained that in Nepal, changes in rainfall pattern (July to September) shortened the winter season and due to such changes in terai there is reduced crop production as a result of drought, floods and landslides.

Table 1: Relationship between increase in mean global temperature and changes in crop and livestock production.

Mean global temperature increase (^{0}C)	Crop production Change (%)	Livestock production Change (%)
1.0	0.82	-0.12
1.1	0.00	0.67
1.3	0.82	0.28
1.8	-1.58	-1.39
2.8	-2.62	-1.17
4.0	-2.68	-1.83
4.2	-2.78	-2.04
5.2	-4.78	-3.15

3.2.2 Heat: Over the next 30-50 years, average temperature is likely to increase by at least 1 °C. Anticipated regionally dependent changes include increased number of heat waves and warm nights, a decreasing number of frost days, and a longer growing season in temperate zones. In mid to high latitudes, moderate warming may benefit cereal crops and pasture yields, but in seasonally dry and tropical regions even slight warming decreases yields. Available data reflect that average temperature rise in Nepal was approximately 0.06^{0}C between 1997 to 2000. Recent projections suggest further temperature increase of 0.5^{0}C-2^{0}C by 2030 which is a much faster rate than expected globally (Koirala, 2010; Practical Action Nepal, 2003).

3.2.3 Carbondioxide: Rise in temperature and carbondioxide is helpful to some extent as it increases agricultural production by enhancing photosynthesis process. But on the other hand, this has greater adverse effects. Decrease in grain filling period due to increase in respiration process, fertilizer use efficiencies, shift in agricultural zone, introduction of new exotic animals, and increase in soil erosion have negative role in the crop production as in terai of Nepal. Elevated CO_2 is thought to decrease grain quality (Tubiello and Fischer, 2007). Intergovernmental Panel on Climate Change (IPCC) indicated that present carbon level to be 390 ppmv globally. This level is similar in Nepal as well (Koirala, 2010). A relationship between increased amounts of atmospheric CO_2 concentration and additional under-nourished people due to climate change is presented in figure 3.

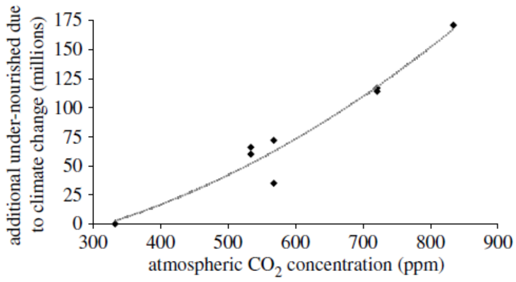

Figure 3: Additional number of people at risk of hunger in 2080 plotted against different levels of atmospheric CO_2 concentrations and associated climate change (Fischer et al., 2005).

3.3. Socioeconomic Impact of Climate Change

Climate change may reverse many of the important economic gains made by developing countries. National gross domestic product growth may be jeopardized. Revenues may be cut and spending needs increased, thus worsening public finances. As a result of these and other impacts, the effect on people's lives could be devastating, and whole communities could be threatened (ADB, 2009). Price will rise for the most important agricultural crops rice, wheat, maize, and soybeans. This, in turn, leads to higher feed prices and therefore meat prices. As a result, climate change will reduce the growth in meat consumption slightly and cause a more substantial fall in cereals consumption, leading to greater food insecurity (Anonymous, 2005). Stern (2007) projected that a 2°C increase in average temperatures would reduce world GDP by roughly 1 percent. The 2010 World Development Report of the World Bank (2009) focuses on developing countries and estimates that without offsetting innovations, climate change will ultimately cause a decrease in annual GDP of 4 percent in Africa and 5 percent in India.

4. Findings

Agricultural impacts of climate change are likely to be more adverse in tropical areas as compared to that in temperate areas. The dry weather will result in a shorter growing season and smaller crop yields across much of the developing world, challenging the livelihoods of billions of people. Production will drop to 50 percent by 2050, a decrease that could put as many as 200 million people at greater risk of hunger. From this review it is pellucid that everybody should have concern about the impact of climate change and their mitigation and adaptation strategies. Many studies recapitulated that some mitigation technologies in agriculture can be used globally. Some of them are: improved crop and grazing land management to increase soil carbon storage and restoration of cultivated peaty soils and degraded lands; improved rice cultivation techniques and livestock and manure management to reduce CH_4 emissions; improved nitrogen fertilizer application techniques to reduce N_2O emissions and dedicated energy crops to replace fossil fuel use.

These are adaptation measures that the agricultural sector can undertake to cope with future climate change. These include: changing planting dates; planting different varieties or crop species; development and promotion of alternative crops; new drought and heat-resistant varieties, more use of intercropping; using sustainable fertilizer and tillage practices; improved crop residue and weed management; more use of water harvesting techniques; better pest and disease control for crops; implementing new or improving existing irrigation systems (Reducing water leakage, soil moisture conservation - mulching); improved livestock management; more use of agroforestry practices; improved forest fire management (altered stand layout, landscape planning, dead timber salvaging, clearing undergrowth, insect control through prescribed burning); and development of early-warning systems and protection measures for natural disasters (droughts, floods, tropical cyclones, etc).

5. Conclusion

Climate change may result in detrimental effects on food security, especially in developing countries. So, government should develop well defined agricultural policy focusing judicious use of inputs (fertilizers, seeds, water, pesticides, energy and management) including pricing and marketing structures. Political commitment to investment enough in agricultural research and development is needed. The main issue confronting agriculture is how to respond, adapt and be more resilient.

The research on climate change should focus on local coping strategies that can be observed in the built environment such as, how people adapt their houses, living spaces, streets, open spaces and infrastructure to cope with existing environmental hazards. Development of drought resistant crops that have been tested for strong yields when subjected to periods of extended water shortage; plant nitrogen and water use efficiency and development of cost-efficient nitrogen uptake delivery systems; low-cost, high efficiency irrigation techniques; development of global testing sites and data collection and dissemination efforts, using standard data protocols, to assess the performance of existing and new genetic materials and management systems in today's range of agroclimatic conditions, continuous field testing to track climate change; breeding for resistance to new diseases and pests and to address changes in pollinator distribution have been identified as avenues to confront adaptation of crops in the face of climate change. Development of assessment tools that incorporate the biophysical constraints affecting agricultural productivity and include climate and socioeconomic scenarios, including improved characterization of policy and program environments and options. It is concluded that the changing temperature and rainfall patterns and increasing carbondioxide level will undoubtedly have important effects on global agriculture and thus on food security.

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Indigenous Vegetables for Food Security and Adaptation Measures for Climate Change

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Abstract

The worldwide production of vegetables has doubled over the past quarter century and the value of its global trade now exceeds that of cereals. As diverse agro-ecological and socio-economic conditions, high crop genetic diversity can be observed. Out of 1500 useful plants, 651 species are economically useful including 440 species of wild food plants in Nepal. About 200 plant species are consumed as vegetables. The paper aims to point out existing indigenous vegetables and how these are utilized for food security and adaptation measures in the context of climate change. A significant change in climate on a global scale will impact agriculture and consequently affect the world's food supply. Environmental stress is the cause of crop losses worldwide, reducing average yields for most major crops, including vegetables by more than 50 percent. Indigenous vegetables are considered valuable because of their ability to fit into year round production and high nutritional value. During food scarce period, people heavily depend on gathering indigenous vegetables from their natural habitats. Increased uses of indigenous vegetables contribute to enhance people's health and standard of living as well as economic and social status. Only few indigenous vegetables such as *Fagopyrum esculentum*, *F. tartaricum*, *Amaranthus caudatus*, and *A. lividus* are cultivated at field scale. However, many landraces of vegetables are being replaced by modern varieties and treated them as weeds. The indigenous knowledge associated with the cultivation, utilization, and conservation of indigenous vegetables is also endangered. Species such as *Dryopteris cochleata*, *Polygonum molle*, *Asparagus racemosus*, and *Rheum australe* are considered endangered. Genotypes having superior combination of alleles at multiple loci are to be identified and utilized. Inclusion of local vegetable dishes in tourist meals and processing like pickles, *petha* (sweets) are to be promoted for value addition. Identifying marketing mechanisms at local, regional and national level certainly boost up in expanding and strengthening the indigenous vegetable products.

Key words: Conservation, indigenous knowledge, landraces, vegetable diversity

1. Introduction

Nepal is situated on the southern slopes of the central Himalayas. Nepal's great biodiversity is associated with the country's exceptional diversity in topographic, climatic, and agro-ecological conditions. According to these conditions, Nepal is divided into four main physiographic zones (MFSC/GEF/UNDP, 2002), high Himal (above 5,000 m asl.); high mountains

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(3,000-5,000 m asl.) with alpine or sub-alpine climate; mid-hills (1,000-3,000 m asl.) with warm temperate or subtropical climate, and lowlands (below 1,000 m asl.) with tropical climate. As a result of diverse agro-ecological and socio-economic conditions high crop genetic diversity at farm level can be observed (Rana et al., 1998). Indigenous refers to crop species or variety genuinely native to a region, or to a crop introduced into a region where over a period of time it has evolved, although the species may not be native.

In Nepal, between 5,800 (Hara and Williams, 1979; Hara et al., 1978, 1982) and 6,500 species of flowering plants (WCMC, 1994) have been estimated, about 1,500 of which are considered useful (Manandhar, 2002). Out of these, 651 species are economically useful including 440 species of wild food plants. About 200 plant species are consumed as vegetables (Manandhar, 2002), most of them, however, are regarded underutilized or neglected. Vegetables are the best resource for overcoming micronutrient deficiencies and provide smallholder farmers with much higher income and more jobs per hectare than staple crops (AVRDC, 2006).

In Nepal, efforts to collect and utilize the largely eroding genetic resources of traditional vegetable species have only incipiently started, resulting in a lack of in-depth knowledge. So, the paper aims to point out existing indigenous vegetables and how these are utilized for food security and adaptation measures in the context of climate change.

2. Materials and Methods

The paper was prepared on the basis of review from different printed materials, books, research papers, reports of different organizations like Department of Agriculture, LI-Bird, Forest and Soil Conservation Department and related different websites. During the reviewed period, discussion was made with the professors, IAAS; technicians involved in vegetable development programs and farmers involved in cultivation and exploration of these commodities.

3. Results and Discussions

Cultivating and gathering indigenous vegetables for both self-consumption and sale are still very common in Nepal, particularly in remote areas. During food scarcity periods, people from urban and rural communities heavily depend on gathering these vegetables from their natural habitats (Manandhar, 1982). Increased use of traditional vegetables can contribute to enhance people's health and standard of living as well as the economic and social status of the food producers themselves. Genetic resources of many traditional vegetables are threatened by genetic erosion. This is mainly due to the (i) expansion of mechanized, intensive agriculture in Nepal; (ii) introduction of exotic vegetable species and improved varieties; (iii) loss and degradation of agricultural and forest land (e.g., caused by infrastructure development, soil erosion, and logging of forests to fulfill the demands of the growing population); (iv) over-exploiting of wild plants (e.g., for food, fuel, or poor marketing opportunities for traditional vegetables (Manandhar, 1989).

3.1 Role in Food Security and Adaptation Measures

Indigenous vegetables are considered valuable because of their ability to fit into year round production systems, their nutritional value, and the danger of their extinction. However, crops should be selected for domestication only if there is real nutritional or economic need (Engle and Altoveros, 2000).

Rural women are often the major players in utilizing wild traditional food plants including vegetables. They hold and maintain the knowledge about gathering locations and seasons, preservation, processing, and culinary uses of such plants. Women are also involved in cultivating and trading traditional vegetables, strengthening most likely their economic status within the families. Some traditional vegetables have a high cultural value in Nepal. Their use is part of the cultural heritage, playing an important role in maintaining customs and traditions. For example, certain *Dioscorea* sp. (Tarul) are very important for celebrating the religious Hindu festival of 'Maghe Sankranti', starting on the first day of the Nepali month of 'Magh'. On this day, tubers of *Dioscorea* species are boiled, fried, and eaten, causing a high market demand (Kehlenbeck et al., 2007).

Mostly rural people collect these tubers from natural vegetation and sale them in urban and peri-urban markets. The main season for collecting traditional vegetables is said to be from May to July. For self-consumption as well as sale in the dry season (February to April), some traditional vegetables like *Dendrocalamus* spp (Tama bans) shoots and certain leafy vegetables is preserved. Both wild and cultivated traditional vegetables are said to play an important role as emergency food during periods of scarcity.

Indigenous vegetables play a highly significant role in food security of the underprivileged in both urban and rural settings (Schippers, 1997). They can serve as primary foods or secondary condiments to dishes prepared from domesticated varieties. They are also valuable sources of energy and micronutrients in the diets of isolated communities (Grivetti and Ogle, 2000). Further, they may serve as income sources and may be marketed or traded locally, regionally, even internationally, and the primary importance of edible wild species during periods of drought and or social unrest or war is well documented (Humphry et al., 1993, Smith et al., 1995, Smith et al., 1996). However, the important role of indigenous vegetables in health sector, diets and as an income source is threatened through extinction of the genetic resources of these species. Indigenous land races that were more adapted to the conditions in the area are being lost as farmers prefer high yielding hybrid varieties (Mutekwa, 2009). So, many landraces of vegetables are in the process of being replaced by modern varieties (FAO, 1998).

Importance of indigenous vegetables in resource poor communities; thus, preserving biodiversity and indigenous knowledge on production and consumption while improving varieties and cultivation practices of indigenous vegetables will contribute to the well-being of thousands of poor farmers by enabling them to participate in markets (Weinberger and Msuya, 2004).

Indigenous vegetables could make a contribution to world food production because they are well adapted to adverse environmental conditions and generally resistant to pests and pathogens. Indigenous legumes may be alternative cheap source of protein and can alleviate protein malnutrition among the pre-school children in rural areas. Furthermore, they have been traditional part of cropping systems, especially home gardens (Midmore et al., 1991). Their cultivation, utilization, acceptability should not be problem. Indigenous fruit vegetables have longer shelf-life compared to leafy vegetables. Indigenous vegetables as a whole can therefore make an impact on nutritional status of population. The indigenous knowledge associated with the cultivation, utilization, and conservation of indigenous vegetables is also endangered. Recognition of the potential of indigenous vegetables is to contribute to poverty and malnutrition alleviation and the diversification of the agricultural environment (Engle and Faustino, 2006). So, there are strong needs to collect, conserve, and popularize the use of indigenous vegetables for food security in the nation in the context of climate change.

3.2 Role in the Context of Climate Change

There is a general consensus among scientists, economists, and policy makers that the entire globe is facing a real and serious long-term threat from climate change (Buckland, 1997; Kinuthia, 1997; Hansen et al., 2007; Matarira et al., 1995). Projections suggest that, by the end of the 21st century, climate change will have had substantial impact on agricultural production and, hence, on the scope for reducing poverty (Slater et al., 2007). A significant change in climate on a global scale will impact agriculture and consequently affect the world's food supply (Pena and Hughes, 2007).

Environmental stress is the primary cause of crop losses worldwide, reducing average yields for most major crops by more than 50 percent (Boyer, 1982; Bray et al., 2000). Vegetables are generally sensitive to environmental extremes, and thus high temperatures and limited soil moisture are the major causes of low yields in the tropics and will be further magnified by climate change (Pena and Hughes, 2007). Tomato, cabbage, onion, hot pepper and eggplant are particularly important in Asia and Sub-Saharan Africa. Most vegetables prefer cooler temperatures, thus productivity is the lowest in the hot and humid lowlands of Southeast Asia (Ali, 2000).

The tropical vegetable production environment is a mixture of conditions that varies with season and region. Climatic changes will influence the severity of environmental stress imposed on vegetable crops. Moreover, increasing temperatures, reduced irrigation water availability, flooding, and salinity will be major limiting factors in sustaining and increasing vegetable productivity. Extreme climatic conditions will also negatively impact soil fertility and increase soil erosion.

Potential impacts of climate change on agricultural production will depend not only on climate per se, but also on the internal dynamics of agricultural systems, including their ability to adapt to the changes (FAO, 2001). Success in mitigating climate change depends on how well agricultural crops and systems adapt to the changes and concomitant environmental stresses of those changes on the current systems. Farmers in developing countries of the tropics need tools to adapt and mitigate the adverse effects of climate change on agricultural productivity, and particularly on vegetable production, quality and yield.

Current and new technologies being developed through plant stress physiology research can potentially contribute to mitigate threats from climate change on vegetable production. However, farmers in developing countries are usually small-holders, have fewer options and must rely heavily on resources available in their farms or within their communities. Thus, technologies that are simple, affordable, and accessible must be used to increase the resilience of farms in less developed countries. AVRDC (Asian Vegetable Research and Development Center- the World Vegetable Center) has been working to address the effect of environmental stress on vegetable production (Pena and Hughes, 2007). Germplasm of the major vegetable crops which are tolerant of high temperatures, flooding and drought has been identified and advanced breeding lines are being developed. It has also been developing technologies to alleviate production challenges such as limited irrigation water and flooding, to mitigate the effects of salinity, and also to ensure appropriate availability of nutrients to the plants. Strategies include modifying fertilizer application to enhance nutrient availability to plants, direct delivery of water to roots (drip irrigation), grafting to increase flood and disease tolerance, and use of soil amendments to improve soil fertility and enhance nutrient uptake by plants (Pena and Hughes, 2007). Efforts are also underway to identify nitrogen-use efficient germplasm. In addition, development of production systems geared towards improved water-use efficiency and expected to mitigate the effects of hot and dry conditions in vegetable production systems are top research and development priorities.

3.3 Climate Resilient Vegetables Development

Improved, adapted vegetable germplasm is the most cost-effective option for farmers to meet the challenges of a changing climate. Breeding new varieties, particularly for intensive, high input production systems in developed countries, under optimal growth conditions may have counter-selected for traits which would contribute to adaptation or tolerance to low input and less favorable environments. Superior varieties adapted to a wider range of climatic conditions could result from the discovery of novel genetic variation for tolerance to different biotic and abiotic stresses. Genotypes with improved attributes conditioned by superior combinations of alleles at multiple loci could be identified and advanced. Improved selection techniques are needed to identify these superior genotypes and associated traits, especially from wild, related species that grow in environments which do not support the growth of their domesticated relatives that are cultivated varieties. Plants native to climates with marked seasonality are able to acclimatize more easily to variable environmental conditions (Pereira and Chavez, 1995) and provide opportunities to identify genes or gene combinations which confer such resilience (Pena and Hughes, 2007).

3.4 Options to Address Impact of Climate Change

The holistic strategy will need global integration of efforts; the resulting synergies will produce impact more quickly than the individual institutions working in isolation could accomplish. For this to succeed, adequate and long-term funding is necessary, scientific results have to be delivered, best approaches utilized and effective methods sustained to deliver global public goods for impact (Pena and Hughes, 2007).

AVRDC focused on vegetable research and development, has expanded its research to further address the potential challenges posed by climate change. The Center's success in its major objectives of reducing malnutrition and alleviating poverty in developing countries through improved production and consumption of safe vegetables will involve adaptation of current vegetable systems to the potential impact of climate change. Vegetable germplasm with tolerance to drought, high temperatures and other environmental stresses, and ability to maintain yield in marginal soils must be identified to serve as sources of these traits for both public and private vegetable breeding programs. This germplasm will include both cultivated and wild accessions possessing genetic variation unavailable in current, widely-grown cultivars. Genetic populations are being developed to introgress and identify genes conferring tolerance to stresses and at the same time generate tools for gene isolation, characterization, and genetic engineering. Furthermore, agronomic practices that conserve water and protect vegetable crops from sub-optimal environmental conditions must be continuously enhanced and made easily accessible to farmers in the developing world. Capacity building and education are key components of a sustainable adaptation strategy in the context of climate change (Pena and Hughes, 2007).

3.5 Loss of Indigenous Vegetable Diversity

Despite their importance for subsistence, income generation, and culture, the use of traditional vegetables is declining at an alarming rate in all areas of Nepal, combined with genetic and cultural erosion. This occurs particularly in easily accessible regions, where commercialization of the production is possible. Only few traditional vegetables such as *Fagopyrum esculentum* (Mithe phapar), *F. tartaricum* (Tite phapar), *Amaranthus caudatus* (Latte), and *A. lividus* (Lude) are still cultivated at field scale due to their high market value. Cultivation of exotic vegetables for subsistence and sale increases more and more at the expense of traditional ones, partly promoted by development programs (Shrestha et al., 2004).

The availability of wild traditional vegetables has also declined drastically due to land use and habitat change, excessive collection from natural habitats, climate change causing more frequent droughts and fires, and deforestation. In the research area, species such as *Dryopteris cochleata* (Danthe), *Polygonum molle* (Thotne), *Asparagus racemosus* (Kurilo), and *Rheum australe* (Padamchal) are considered to be endangered because they have a high demand at markets, but are mostly (and often excessively) gathered from their natural habitats. For many wild species, rural farmers depend on volunteer plants for gathering during the rainy season instead of making deliberate efforts to cultivate them permanently as vegetables in their fields or home gardens. The disappearance of traditional vegetables in some areas may also be a consequence of the introduction of improved agricultural techniques, in which many traditional vegetables are treated as weeds (kehlenbeck et al., 2007).

3.6 Conservation Need

Commercialization, in general, results in the erosion of varietal diversity. Documenting and understanding of farmers' view and belief on indigenous plant protection measures demand immediate attention from scientific community (Rana et al., 1998). This aspect becomes even more important in pocket areas where commercialized agriculture is practiced with abusive use of pesticides. Another important aspect for consideration is improvement on agronomic practices for better returns from landraces. Agronomic research is seldom conducted on landraces to improve their overall return. Therefore, it represents an important but unexplored avenue with the potential to deliver much in the conservation of landraces through utilization.

Genetic diversity has enormous value for present and future generations, and more strenuous efforts must be made for its conservation and sustainable utilization (Brush, 1995). If vegetables are not prepared and consumed, this is the first step to their extinction (Keller, 2004). In the present context, conservation of genetic resources is done through ex-situ or in-situ methods. Both the methods are complementary in nature with their strengths and weaknesses, and lately later method has been advocated mainly for the reason that dynamics of evolutionary processes are not disrupted, and resembles to the reality in farmers' fields. The essence of in- situ conservation strategy of agricultural diversity is to understand farmers' circumstances and encourage them to maintain the special habitat that generated such diversity in the first place. Community level seed banking, in which farming communities take active part in the maintenance, use and exchange of indigenous genetic resources is one of the ways of in-situ conservation.

3.7 Market Promotion for Vegetable Landraces

It can be argued that in the absence of other feasible options to conserve landraces, market promotion for local varieties with reasonable yield and other preferred traits could provide incentives to the growers for maintaining them on-farm. Exploration of ways and means to sensitize consumers to develop preference for local vegetables could be the first step forward. One of the effective ways of promoting vegetable landraces would be to work jointly with local hotels and restaurants by blending indigenous culinary knowledge while developing seasonal menus. Simultaneously identifying markets, marketing channels, marketing mechanisms for these products at local, regional and national level will ultimately facilitate in expanding and strengthening opportunities for such produce. Exploring possibilities for the value addition to local vegetables viz. inclusion of local vegetable dishes in tourist meals, such as *karkalo* (green stems of taro), *pharsi ko munta* (tender shoots of pumpkin) etc. processing of some local vegetables for the preparation of both pickles and *petha* (sweets) from ash gourd. Value addition of vegetable landraces can be taken up as cottage industry thereby generating employment opportunity and cash generation at village level. Involving women in this activity would be advantageous since the nature of the work requires less physical strength and can be performed at any time within the house. Moreover, women already have expertise in food processing, and this will add to their knowledge and skills, at the same time will give access and control over cash (Rana et al., 1998).

3.8 Awareness Creation

Creating awareness on genetic resources wealth and need for conservation at different levels: community, governmen and non government organizations, entrepreneurs and consumers. It is essential to demonstrate the linkage between conservation and the benefits accruing thereafter. Experiences have shown that farmers actively participate in activities where they see clear benefits from their involvement. However, community members are yet to see the benefits associated with conservation of biodiversity and their utilization aspect. In this context, activities should be focused to generate awareness at all the levels that are directly or indirectly involved in the use and conservation of biodiversity. This could be effectively done through mass media, talk programs in schools, colleges and other institutions for variety of audiences. Agriculture fares and demonstrations organized in the area also provide a forum where information on vegetable landraces and their end products could be effectively disseminated to the public (Rana et al., 1998).

4. Conclusion

Vegetables are significant component of the Nepalese diet, and traditional ones are still important, although they have mostly been neglected in research and development. Indigenous vegetables could make a contribution to world food production because they are well adapted to adverse environmental conditions and generally resistant to pests and pathogens. They can also give good production in stress condition. To avoid or minimize the impending genetic and cultural erosion of indigenous vegetables, their germplasm should intensively be collected and conserved on-farm as well as in gene banks. The related indigenous knowledge urgently needs to be documented for serving future generations. Utilization of indigenous vegetables is to be made good option for food security and adaptation measures in the context of climate change in Nepal.

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Appendix 1. List of indigenous vegetables found in Nepal

SN	**Scientific name**	**Family**	**Local name**	**SN**	**Scientific name**	**Family**	**Local name**
1	*Abelmoschus manihot*	Malvaceae	Ban nalu	104	*Lygodium japonicum*	Schizaeaceae	Janai lahara
2	*Abelmoschus moschatus*	Malvaceae	Lata kasturi	105	*Macropanax dispermus*	Araliaceae	Chiniya
3	*Acmelia caliva*	Asteraceae	Lato ghans	106	*Malva verticillata*	Malvaceae	Laphe sag
4	*Ageratum conyzoides*	Asteraceae	Gane	107	*Manihot esculenta*	Euphorbiaceae	Simal tarul
5	*Allium stracheyi*	alliaceae	Jangali	108	*Medicago falcata*	Fabaceae	Bhirin sag
6	*Allium wallichii*	alliaceae	Dundu	109	*Moringa oleifera*	Moringaceae	Sajiwan
7	*Alternanthera Sessilis*	Amaranthaceae	Saranchi sag	110	*Mucuna pruriens*	Fabaceae	Kauso
8	*Amaranthus caudatus*	Amaranthaceae	Latte sag	111	*Natsiatum herpeticum*	Icacinaceae	Kali lahara
9	*Amaranthus lividus*	Amaranthaceae	Lude sag	112	*Oenanthe javanica*	Apiaceae	
10	*Amaranthus spinosus*	Amaranthaceae	Ban lunde	113	*Oenanthe linearis*	Apiaceae	Khaki baku
11	*Amaranthus viridis*	Amaranthaceae	Lude sag	114	*Ophioglossum nudicaule*	Ophioglossaceae	Jibre sag
12	*Anagallis arvensis*	Primulaceae	Armale	115	*Ophioglossum reticulatum*	Ophioglossaceae	Jibre sag
13	*Arisaema consanguineum*	Araceae	Raksya banko	116	*Oreocnide frutescens*	Urticaceae	
14	*Arisaema flavum*	Araceae	timchu	117	*Oroxylum indicum*	Bignoniaceae	Tatelo
15	*Arisaema jacquemontii*	Araceae	Sarpa komaka	118	*Osmunda claytoniana*	Osmundaceae	
16	*Arisaema tortuosum*	Araceae	banko	119	*Peperomia pellucida*	Piperaceae	Lata pate
17	*Arisaema utile*	Araceae	dhokaya	120	*Persicaria microcephala*	Polygonaceae	Ban pire
18	*Artocarpus heterophyllus*	Moraceae	katahar	121	*Persicaria nepalensis*	Polygonaceae	Priya ghans
19	*Asparagus filicinus*	Asparagaceae	Ban kurilo	122	*Persicaria perfoliata*	Polygonaceae	Ghumauro kanda
20	*Asparagus racemosus*	Asparagaceae	kurilo	123	*Persicaria runcinata*	Polygonaceae	

SN	Scientific name	Family	Local name	SN	Scientific name	Family	Local name
21	*Basella alba*	Basellaceae	Poi sag	124	*Phlogacanthus thyrsiformis*	Acanthaceae	
22	*Bassia latifolia*	Sapotaceae	mahuwa	125	*Phoenix acaulis*	Arecaceae	Thakal
23	*Bauihinia malabarica*	Fabaceae		126	*Phytolacca acinosa*	Phytolaccaceae	Jaringo sag
24	*Bauihinia purpurea*	Fabaceae	Tanki	127	*Pilea symmeria*	Urticaceae	
25	*Bauihinia vahii*	Fabaceae	Bhoria	128	*Pilea umbrosa*	Urticaceae	Nil danthe
26	*Bauhinia variegate*	Fabaceae	Koiralo	129	*Piptanthus nepalensis*	Fabaceae	Suga phool
27	*Blumea lacera*	Asteraceae	Khicha bhwatha	130	*Pithecellobium dulce*	Fabaceae	Jalebi
28	*Boerhavia diffusa*	Nyctaginceae	Punarva	131	*Plantago erosa*	Plantaginaceae	Isapgo
29	*Bombax ceiba*	Bombaceae	Simal	132	*Plantago lanceolata*	Plantaginaceae	
30	*Botrychium lanuginosum*	Ophioglossaceae	Jaluko	133	*Pleurospermum angelicoides*	Apiaceae	
31	*Caitha palustris*	ranunculaceae		134	*Pleurospermum apiolens*	Apiaceae	
32	*Capparis spinosa*	Capparaceae	Bagh mukhwa	135	*Polygonatum cirrhifolium*	Liliaceae	
33	*Capsella bursa-pastoris*	Brassicaceae	Tori ghans	136	*Polygonatum verticillatum*	Liliaceae	Khinraula
34	*Caragana brevispina*	Fabaceae		137	*Polygonum molle*	Polygonaceae	Thotne
35	*Cardamine scutata*	Brassicaceae	Chamsure ghans	138	*Polygonum plebeium*	Polygonaceae	Baluni sag
36	*Cassia tora*	fabaceae	Chakramandi	139	*Polystichum squarrosum*	Dryopteridaceae	Phusre neuro
37	*Cautleya spicata*	Zingiberaceae	Sano saro	140	*Portulaca oleracea*	*Portulaca oleracea*	Nundhiki
38	*Centella asiatica*	Apiaceae	Ghodtapre	141	*Pouzolzia sanguinea*	Urticaceae	
39	*Chenopodium album*	chenopodiaceae	Bethe	142	*Pteridium aquilinum*	Dennstaedtiaceae	
40	*Chenopodium ambrosioides*	Chenopodiaceae	Rato latte	143	*Ranunculus diffusus*	Ranunculaceae	Nakore
41	*Chenopodium murale*	chenopodiaceae	Kalo bethe	144	*Ranunculus sceleratus*	Ranunculaceae	

SN	**Scientific name**	**Family**	**Local name**	**SN**	**Scientific name**	**Family**	**Local name**
42	*Chloropohytum nepalense*	Liliaceae	Ban pyaj	145	*Remusatia pumila*	Araceae	
43	*Cirsium wallichii*	Asteraceae	Thakal	146	*Rheum australe*	Polygonaceae	Padamchal
44	*Clematis acuminata*	Ranunculaceae	Junge lahara	147	*Rhododendron arboreum*	Ericaceae	Laligurans
45	*Clematis buchananiana*	Ranunculaceae	Junge lahara	148	*Rorripa indica*	Brassicaceae	Pahelo jhar
46	*Cleome viscosa*	Capparaceae	Swibhama	149	*Rorripa nasturtium*	Brassicaceae	Sim sag
47	*Clintonia udensis*	liliaceae		150	*Rumex acetosa*	Polygonaceae	Amile ghans
48	*Colocasia esculenta*	Araceae	Pindalu	151	*Rumex dentatus*	Polygonaceae	
49	*Commmelina bengalensis*	Commelinaceae	Ban kane	152	*Rumex hastatus*	Polygonaceae	Charemala
50	*Commmelina paludosa*	Commelinaceae	Kane sag	153	*Rumex nepalensis*	Polygonaceae	Halhale
51	*Chorchorus acutangulus*	Tiliaceae	Nalu	154	*Rumex vesicarius*	Polygonaceae	Bhote palunge
52	*Cortia depressa*	apiaceae	Bhutkesh	155	*Sagittaria sagittifolia*	Alismataceae	
53	*Costus apeciosus*	Zingiberaceae	Betlauri	156	*Sambucus adnata*	Caprifoliaceae	
54	*Crateva religiosa*	Capparaceae	sipligan	157	*Smilax aspera*	Smilacaceae	Kukurdiano
55	*Crotalaria pallida*	Fabaceae	Chhinchhine swan	158	*Smilax ferox*	Smilacaceae	Kukurdiano
56	*Crotolaria spectabillis*	Fabaceae	Ban sanai	159	*Smilax lanceifolia*	Smilacaceae	Chhatiwan
57	*Crotolaria tetragona*	Fabaceae		160	*Smilax ovalifolia*	Smilacaceae	Kukurdiano
58	*Deeringia amaranthaoides*	Amaranthaceae		161	*Smilax perfoliata*	Smilacaceae	Kukurdiano
59	*Dendrocalamus hamiltonii*	Poaceae	Tama bans	162	*Smilax rigida*	Smilacaceae	
60	*Dendrocalamus strictus*	Poaceae	Tama bans	163	*Solanum nigrum*	Solanaceae	Kalo bihi
61	*Deparia boryana*	Dryopteridaceae	Kalo neuro	164	*Solanum torvum*	Solanaceae	Thulo bihi
62	*Dillenia indica*	Dilleniaceae	Panchphal	165	*Solena heterophylla*	Cucurbitaceae	Golkankri

SN	**Scientific name**	**Family**	**Local name**	**SN**	**Scientific name**	**Family**	**Local name**
63	*Dioscorea alata*	Dioscoreaceae	Ghar tarul	166	*Sonchus oleraceus*	Asteraceae	Dudhi kanda
64	*Dioscorea bulbifera*	Dioscoreaceae	Ban Tarul	167	*Sonchus wightianus*	Asteraceae	Tite sag
65	*Dioscorea deltoidea*	Dioscoreaceae	Tarul	168	*Spermadictyon suaveolens*	Rubiaceae	Ban champa
66	*Dioscorea esculenta*	Dioscoreaceae	Tarul	169	*Stellaria monosperma*	Caryophyllaceae	Jethimadhu
67	*Dioscorea pentaphylla*	Dioscoreaceae	Mithe tarul	170	*Tamilnadia uliginosa*	Rubiaceae	Pidar/Maidal
68	*Diplazium esculentum*	Drypteridaceae	Masino neuro	171	*Tectaria macrodonta*	Dryopteridaceae	Kalo neuro
69	*Diplazium*	Drypteridaceae	Neuro	172	*Thamonocalamus aristatus*	Poaceae	Ban nigalo
70	*Diplazium*	Drypteridaceae	Neuro	173	*Thelypteris multilineata*	Thelypteridaceae	Koche
71	*Diplazium*	Drypteridaceae	Neuro	174	*Trianthema portulacastrum*	Aizoaceae	Gadapuraina
72	*Disporum cantoniense*	liliaceae	Sano kukur daino	175	*Urtica dioica*	Urticaceae	Sisnu
73	*Drepanostachyum falcatum*	Poaceae	Nigalo	176	*Vicia angustifolia*	Fabaceae	Kutilkosa
74	*Drymaria cordata*	Caryophyllaceae	Abhijalo	177	*Vicia hirsuta*	Fabaceae	Kutilkosa
75	*Dryopteris cochleata*	Dryoperidaceae	Danthe	178	*Woodwardia biserrata*	Blechnaceae	
76	*Edgaria darjeelingensis*	Cucurbitaceae	Chathil	179	*Unidentified a)*	Araceae	Dudhe pidalu
77	*Elatostema platyphyllum*	Urticaceae	Sano gangleto	180	*Arrorphophallus campanulatus*	Araceae	Hathi paile pidalu
78	*Elatostema sessile*	Urticaceae		181	*Unidentified b)*	Araceae	Khari pidalu
79	*Emilia sonchiholia*	Asteraceae	Tori phool	182	*Unidentified c)*	Araceae	Panchmukhi pidalu
80	*Eryngium foetidum*	Apiaceae	Brameli dhaniya	183	*Unidentified d)*	Zingiberaceae	badeer
81	*Erysimum hieracifolium*	Brassicaceae		184	*Trichosanthes cucumerina*	Cucurbitaceae	Ban chichinda
82	*Euphoria hirta*	Euphorbiaceae	Dudhe ghans	185	*Solanum aculeatissum*	solanaceae	Chharheta
83	*Fagopyrum dibotrys*	Polygonaceae	Ban phaper	186	*Unidentified f)*		Chhitarik sag

SN	Scientific name	Family	Local name	SN	Scientific name	Family	Local name
84	*Fagopyrum esculentus*	Polygonaceae	Mithe phaper	187	*Unidentified g)*		Chuchche palungo
85	*Fagopyrum tataricum*	Polygonaceae	Tite phaper	188	*Hibiscus sabdariffa*	Malvaceae	Chhuka
86	*Ficus auriculata*	moraceae	Timila	189	*Unidentified h)*		Dankarioth
87	*Ficus hispada*	moraceae	Khasreto	190	*Unidentified i)*		Dhungre sag
88	*Ficus lacor*	moraceae	kavro	191	*Monochoria hastana*	Pontederaceae	Thokara
89	*Girardiana diversifolia*	Urticaceae	Lekali sisnu	192	*Arisaema orubescens*	Araceae	Gurbo
90	*Holarrhena pubescens*	Apocynaceae	Indrajau	193	*Guizotia abyssinica*	Asteraceae	Jhuse til
91	*Impatiens bicornuta*	Balsaminaceae		194	*Comellina benghalensis*	Comellinaceae	Kane bon
92	*Indigofera hebepetala*	Fabaceae	Masino sakhino	195	*Gmelina arborea*	Verbenaceae	Khamari
93	*Indigofera pulchella*	Fabaceae	sakhino	196	*Thelypteris auriculata*	Pteridaceae	Kochaya
94	*Ipomoea alba*	Convolvulaceae	Chandra kali	197	*Malva parviflora*	Malvaceae	Kongatahari
95	*Ipomoea aquatica*	Convolvulaceae	Kalmi sag	198	*Coccinea grandis*	Cucibitaceae	Kudurani
96	*Justicia adhatoda*	Acanthaceae	Asuro	199	*Xeromphis spinosus*	Rubiaceae	Main kanda
97	*Lathyrus aphaca*	Fabaceae	Bahabulaba	200	*Phragmites maxima*	Gramineae	Narkat
98	*Launaea asplenifolia*	Asteraceae	Dudhe jhar	201	*Lygodium flexuosum*	Schizaeaceae	Parandi sag
99	*Lecanthus peduncularis*	Urticaceae	Khole jhar	202	*Typha latifolia*	Typhaceae	Pat
100	*Leucas cephalotes*	Lamiaceae	Guma	203	*Typha anguistifolia*	Typhaceae	Pat (caftail)
101	*Lilium nepalense*	Liliaceae	Ban Lasun	204	*Gardenia companiluta*	Rubiaceae	Pedar
102	*Physalis minima*	Solanaceae	Photongi	205	*Piper sp.*	Piperacae	Pipla
103	*Murdania nudiflora*	Commelinaceae	Ryau ryau	206	*Sagittaria sagittifolia*	Alismataceae	Sigangodai

(Source: Shakya et al., 1995 and Kehlenbeck et al., 2007)

Natural Resources Utilization : A Case of Non-Timber Forest Products in Chepang Community of Chitwan District, Nepal

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Abstract

Non-timber forest products (NTFPs) are widely known as one of the potential sub-sectors for rural livelihoods improvement and poverty reduction. NTFPs play key role in conserving biodiversity as well as providing food, medicine and cash income to the rural people. A survey research was conducted in 2007/08 to explore the indigenous utilization as well as assess the contribution of NTFPs in the livelihoods of highly marginalized Chepang Community in Chitwan district. Based on food sufficiency for more than 8 months, 6 to 8 months and upto 6 months, Chepang households of Shaktikhor, Siddhi and Korak VDCs were stratified into rich, medium and poor economic categories, respectively and one hundred and five households were selected as sample for the study. Primary information was collected from the households through pre-tested semi-structured interview schedule, focus group discussions and key informant interviews. The study revealed various uses (food, medicine and income generation) of NTFPs in the community. Githa (*Dioscorea bulbifer*), Bhyakur (*D. deltoidea*), Sisnu (*Urtica dioca*), Tanki (*Bauhinia purpurea*), Tarul (*Dioscorea sagittata*) and Gurbo (*Alcea rosea*) were the major wild edibles on which the community relied substantially for fulfilling food requirements during food deficit seasons. Various NTFPs were utilized as medicine by the community. However, such indigenous knowledge was found disappearing into the young generations of the community. The collection, preparation and sale of NTFPs were one of the major activities of the community to generate cash income for sustaining livelihoods. Overall, NTFPs stood in the third position of the major income sources after agriculture and livestock with 18.14 percent (Rs. 7,200) contribution in the total household income. However, the contribution of NTFPs in the total household income for poor households was 26.48 percent (Rs. 6,774), higher than for medium and rich households and stood in the second most income generating source after agriculture. Among the various NTFPs traded, major share of income was derived from the bamboo handicrafts (Rs. 2038.57) followed by *Persea odoratissima* (Rs. 1785.42), Honey (Rs. 702.85), *Bassia butyracea* (Rs. 486.19), *Tinospora cordifolia* (Rs. 435.96) and *Thysanolaena maxima* (Rs. 328.47) and *Asparagus racemosus* (Rs. 322.38).

Key words : Chepang community, indigenous utilization, livelihoods, non-timber forest products (NTFPs)

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1. Introduction

Forest resources are an integral part of the livelihoods support system in Nepal, and non timber forest products (NTFPs) play a crucial role in the livelihood strategy of the people particularly in hill and mountain areas where very few economic opportunities exist (Subedi, 2003). Nepal hosts a wide range of NTFPs which forms the important part of biodiversity and national economy (Subedi, 1997; Luitel, 2002). NTFPs in Nepal are used as foods, spices, herbal medicine, tannins, natural dye, gums, resins, incenses, oils, fibers and construction materials for sustaining livelihoods (Edwards, 1996). NTFPs are an integral part of the rural economy of Nepal as many of people in rural areas are traditionally engaged in the collection, cultivation, processing and marketing of the forest resources both for subsistence and income generation. Importance of NTFPs has been increasingly recognized because of their commercial, socio-economic and ecological values together with use values, providing livelihoods support to many poor rural families of Nepal (Kanel, 2002). In Nepal, 5 percent of total GDP's comes from the trade of NTFPs (Subedi, 1997).

The altitudinal variation of Nepal from 60 meters to more than 8,000 meters within a small area of 14.7 million hectares provides diversified habitat for the natural growth of various plants (Kanel, 2002). Nepal is endowed with about 7,000 species of higher plants, and out of which 784 plant species have been identified having medicinal value (Bhattarai, 1997), and 238 species are used in day-to-day livelihood and only 100 species of medicinal and aromatic plants are currently exploited for commercial purposes (Bhattarai,1997; Subedi, 2006; Rawal, 1995). Nepal is also a leading supplier of important medicinal and aromatic herbs to the Indian and other international markets. The collection, transportation and trade of commercially valuable medicinal and aromatic plants have long been a steady basis of the rural household economy (Bhattarai et al., 2003). NTFPs do not only support the local economy by generating cash income and employment but also provide the opportunity to fulfil health care and nutritional needs of the majority of rural population in Nepal. People in the remote and mountainous regions of Nepal collect wild edible plants for daily consumption as food (Walters and Hamilton, 1993) because of low agricultural production and also make use of NTFPs for traditional medicines because of limited health service available in such regions. The knowledge of such medicinal plants has been developed, tested and adapted across generations. Generally, this knowledge is transmitted orally and confined to a limited number of people (Subedi, 2000).

Chepang community is one of the highly marginalized communities living on the hilly and steeper slopes of Chitwan, Dhading, Gorkha, Makawanpur, Lamjung and Tanahu districts of Nepal (SNV/NCA, 2008). This community is still living semi-nomadic way of life and their primary lifestyle includes hunting, foraging for wild roots, fishing and traditional farming near forests. Current agricultural activities of this community include slash-and-burn practices and most of the people have produce from their land adequate for 6 to 8 months of a year. For the rest of the year, i.e. between February and June, they have to resort either to the forest for gathering wild edibles or to the village money lenders for borrowing to meet the family needs. The community possesses immense knowledge about forest products and their collection and preparation (Gurung, 1995). Traditionally, Chepangs have a great reliance on forest for wild edible foods, medicine and cash from NTFPs, apart from firewood, fodder and timber needs. Collection of NTFPs from the forest is one of the resources of household income of Chepang community (Chhetri et. al., 1997).

NTFPs are crucial for the livelihoods particularly to such forest dependant marginalized communities in Nepal as they make use of NTFPs as wild edible foods during food deficit periods, as medicines to cure the health problems and as an important source of income for improving livelihoods (Bhattarai et al., 2003). Despite the various roles that NTFPs play to the rural communities, the quantitative analysis of NTFP`s contribution on the household economy of Chepang community has not been amply analyzed. Although this community is making use of NTFPs as foods and medicine since long, there is limited documentation of indigenous knowledge of the community on NTFPs utilization (Khan, 1997; Manandhar 1989). Hence, this study was conducted with an objective of assessing the contribution of NTFPs in the household economy of Chepang Community as well as documenting the indigenous utilization of NTFPs by this community in Chitwan district, Nepal.

2. Materials and Methods

Three Village Development Committees (VDCs), namely, Shaktikhor, Siddhi and Korak of Chitwan district were purposively selected for this study. The study sites are located between 305 m to 1946 m altitude and densely populated by Chepang community. As Praja Co-operative Limited (PCL) established in 1998 AD in Shaktikhor VDC was in operation to improve the marketing of agro-products and NTFPs at fair prices particularly for Chepang community and had shareholdings from Chepang as well as non-Chepang households, PCL was selected as the focal institution for this research purpose. The total Chepang shareholder members of PCL from these VDCs were 220 households with 105, 69 and 46 in Shaktikhor, Siddhi and Korak VDCs, respectively. A list of 90 non-shareholder Chepang households involved in NTFPs marketing at different time periods was obtained from PCL and other key informants. All the Chepang shareholder members of PCL from these VDCs and 90 non-shareholder Chepang households were considered as the study population. Based on food sufficiency in months for more than 8 months, 6 to 8 months and upto 6 months, a composite of 310 (220 PCL shareholder + 90 non-shareholder) households were categorized into rich, medium and poor economic categories. Out of the total 310 households, a total of 105 households (75 PCL shareholder member + 30 non-member) covering 34 percent from each category were selected in equal proportion from each stratum as the final sample by using stratified simple random sampling technique.

Primary data were collected through pre-tested interview schedule and a number of focus group discussions, key informants interview and observation visits were made to explore the extraction, utilization, marketing and distribution of NTFPs in the study area by the community. The secondary data were obtained through reviewing relevant publications. The collected data were analyzed through Statistical Package for Social Science (SPSS) and interpreted. This study confined NTFPs only as all the forest products other than timber, fodder and fuelwood obtained from forest or any land under similar use (marginal lands or Khoriya of the community) and the value obtained from timber, fodder and fuelwood were not included in income accounts.

3. Results and Discussion

3.1 NTFPs: Last Resort for Food Supplement

A large proportion of Chepang households in the study area were either seasonally or chronically short of basic foods. Majority of the households had the food sufficiency only for six months and they had to rely considerably on the forest products during food deficit seasons especially from February to July. Ensuring an adequate supply of staple foods throughout the year was the most difficult task for the poor people and the supplementary foods were obtained from wild collection of NTFPs. The collection and consumption of wild edibles from the forest was very common and undeniable to the poorest Chepang households during food scarcity periods. NTFPs performed as safety net to the community by providing supplementary food during food deficit seasons. The most common NTFPs utilized by the community in fulfilling household food need, their seasons of collection and consumption, availability and method of use are presented in the table 1.

3.2 NTFPs: Indigenous Utilization as Medicines

Chepang community has a deep attachment with and heavily dependent on the forests for food, fiber, medicine, fuel, fodder and housing materials. The community holds immense knowledge and skill in collection and utilization of the forest resources for the various purposes (Chhetri et al. 1997; Pandit, 2001; Gurung, 1995). The various plant parts of NTFPs trees, shrubs, herbs and creepers were utilized by the community for medicinal purpose in the study area. The most common NTFPs with the parts used, status, market value and ethno-botanical uses made by the community are presented in the table 2.

Although variety of NTFPs were utilized by the community as medicines for different health problems, the transfer of such indigenous knowledge on use of forest products as medicine was disappearing to the younger generations. Only the faith healers and few elder members of very few households were familiar with the medicinal uses of NTFPs in the study area. Most of the people of younger generation had inadequate knowledge regarding the medicinal use value of NTFPs, however, they were known of the market value of NTFPs that they could generate income by selling those products and were more oriented towards obtaining cash value from the sale of NTFPs rather than using them for medicinal purpose.

Table 1: List of NTFPs utilized as food items by Chepang Community (2007/08)

Local name	Botanical name	Use parts	Season of collection/ consumption	Status	Method of uses
Githa	*Dioscorea bulbifer*	Bulb	Mangsir-Jestha (Nov-May)	C	Uprooted bulbs are cut into thin pieces peeling off the bark and boiled with ash and eaten as food and vegetable.
Bhyakur	*Dioscorea deltoidea*	Tuber	Paush- Jestha (Dec-May)	C	Uprooted tuber is cut into thin pieces and boiled with ash and eaten as food and vegetable.
Tarul	*Dioscorea sagittata*	Root	Mangsir- Jestha (Nov-May)	D	Boiled root is eaten as food and vegetable.
Sisnu	*Urtica dioca*	Fresh leaves and root	Around the year	A	Young leaves and shoots are boiled and eaten as green vegetables.
Tanki	*Bauhinia purpurea*	Young leaves and flowers	Baisakh-Ashad (April-July)	C	Young leaves and flowers are eaten as green vegetable.
Chiuri	*Bassia butyracea*	Fruits	Ashad-Bhadra (June-August)	C	Juice is consumed from riped fruits; seeds are used for making cooking oil and ghee.
Bharlang	*NA*	Root	Mangsir-Jestha (Nov-May)	C	Barks are peeled off, cut into pieces and boiled in ash water and fully merged in flowing water for 24 hrs and eaten as food and vegetable.
Gurbo	*Alcea rosea*	Young leaves	Chaitra-Jeth (March-June)	C	Leaves eaten as vegetable.
Kurilo	*Asparagus racemosus*	tender shoot	Chaitra-Jeth (March-June)	C	Tender shoot is Consumed as vegetable.

Note: Status: A = abundant, C = common, D = common but declining, NA = Not available

Among different products consumed as food items, Tarul or wild yam (*Dioscorea sagittata*) was common but in declining condition of availability and also the most preferred over other wild edibles consumed by the community.

Table 2: List of NTFPs used as medicines by Chepang community (2007/08)

S.N.	Local name	Botanical name	Use parts	Status	Market value	Ethno-botanical uses
1.	Ajammari	*Cuscuta reflexa*	Whole part	D	NM	Used in jaundice, ring, stone and as anthelminthic.
2.	Ankhe Timur	*Zanthoxylum armatum*	Fruit Root	C	MR	Fruit and root mixture is used as blood purifier, appetizer, anthelminthic, and for fever, toothache, and abdominal pain.
3.	Amala	*Phyllanthus emblica*	Fruit Root	C	MR	Edible fruits are mixed with *Harro* and *Barro* to prepare *Trifala*. Fresh fruits are used as blood purifier, stomachic, cooling, diuretic
4.	Areli	*Hypericum cordifolium*	Root Bark	D	NM	Dried root and bark powder is used for curing abdominal pain and bone dislocation.
5.	Bajuri	*NA*	Root	D	MR	Used for fever, dysentery and anti-poisoning.
6.	Barro	*Terminalia belerica*	Bark, Fruit	C	MR	Edible fruits are used to prepare *Trifala*. Bark is used for Anaemia; fruits are used in cough, bronchitis and diarrhoea.
7.	Batul Pate	*Cissampelos periera*	All parts	C	NM	All parts are used for curing fever and diabetes.
8.	Bhakamlo	*Rhus succedenia*	Root	C	MR	Used as digestive, and for dysentery.
9.	Jasmine (Chameli)	*Jasminum officinale*	Flower	D	MR	Used in tea and for curing heart disease.
10.	DahiKamlo	*NA*	Root	D	MR	Powdered root is mixed with Rudilo and used in fever, typhoid and pneumonia.
11.	Gaikhure	*NA*	Root	D	MR	Used in kidney stones.
12.	Ghodtapre	*Centella asiatica*	Leaf Root	A	NM	Juice of leaf and root is used for typhoid fever, pneumonia, and appetite and gastric.
13.	Gundarganu	*Cissmpelos periera*	Stem Rhizome	D	MR	Stem and rhizome is used as anthelminthic, in abdominal pain, gastric.

S.N.	Local name	Botanical name	Use parts	Status	Market value	Ethno-botanical uses
14.	Gurjo	*Tinispora cordifolia*	Stem	C	MR	Used for diabetes, jaundice, and gastric.
15.	Hadchur	*Viscum articulatum*	Stem Vines	D	MR	Dried vines are mixed with *Sikari Lahara* and obtained paste is used to cure minor fractures.
16.	Harro	*Terminalia chebula*	Fruit Bark	C	MR	Edible fruits are used to prepare *Trifala*. Fruit and bark is used for cough, gastric and constipation.
17.	KukurDaino	*Smilax macrophylla*	Stem Root	C	NM	Used for wounds.
18.	Pakhanbed	*Berginia ciliate*	Rhizome	D	MR	Boiled root powder is used as analgesic, *Tridosha*, tonic and for fever, heart diseases, diarrhoea and dysentery.
19.	Pipla	*Piper longum*	Fruit	D	MR	Fruits are used in diarrhoea, dysentery, cough, and tonsils.
20.	Rudilo	*Pogostemon Benghalensis*	Leaves Root	C	NM	Used for cough, fever, pneumonia, TB, malaria.
21.	Sarpgandha	*Raulvolfia serpentine*	Root Flower	D	NM	Used for blood pressure and as neutralizer.
22.	Sikari Lahara	*NA*	Vine	D	MR	Mixed with *Hadchur* and powder is used to cure fractured bones.
23.	Siltimur	*Litsae citrate*	Seed	C	MR	Fruits are used in indigestion, and nausea.
24.	Timur	*Zanthoxylum armatum*	Fruit Root	C	MR	Used as anti-vomiting and for diarrhoea.
25.	Titepati	*Artemisia vulgaris*	Leaf Root	A	NM	Used for purifying blood, common cold and as antispasmodic.

Note: Status: A = abundant, C = common, D = common but declining, R = rare
Market Value: MR = Marketable, NM =Non-Marketable; NA= Not available

3.3 NTFPs: Important Source of Income to the Poor Chepang Households

NTFPs play a significant role in the livelihoods of rural people by providing a great deal of household requirements like food, medicine, cash income and employment opportunities. Chepang community living in the vicinity of forests have greater reliance on forest products for survival. The variety of NTFPs were collected and utilized for food, medicine and income generation by the community. The most common NTFPs collected and sold by the community and their contribution in the household economy is given below.

3.4 Collection/Extraction and Sale of NTFPs and Household Income

Irrespective of the economic category, all Chepang households collected and sold varieties of NTFPs in small or large amount that were available in the study area. Among the various NTFPs, *Bassia butyracea*, *Terminalia chebula*, *Terminalia belerica*, *Tinospora cordifolia*, *Persea odoratissima*, *Asparagus racemosus*, *Phyllanthus emblica, Jasminum officinale*, *Cinnamomum tamala*, honey, *Sapindus mukorossi*, and *Thysanolaena maxima* were the major NTFPs that were collected and sold by the community.

Among the various NTFPs collected and marketed, the average amount of extraction of *Persea odoratissima* was found higher (140.45 kg) followed by *Tinospora cordifolia* (42.64 kg), *Bassia butyracea* (33.88 kg), *Terminalia chebula* (21.23 kg), *Terminalia belerica* (12.71), honey (7.07 kg), and *Phyllanthus emblica* (6.02kg) with very small quantity of *Asparagus racemosus*, *Cinnamomum tamala* and *Jasminum officinale*. The average extraction of *Terminalia chebula, Terminalia belerica, Tinospora cordifolia*, *Persea odoratissima*, *Asparagus racemosus*, and *Phyllanthus emblica* was found higher in the poor households gradually declining to medium and the rich. Whereas, households from rich economic category extracted higher amount of *Bassia butyracea* and honey than medium and poor as they had greater number of *Bassia butyracea* trees and bee hives than medium and poor households (Figure 1).

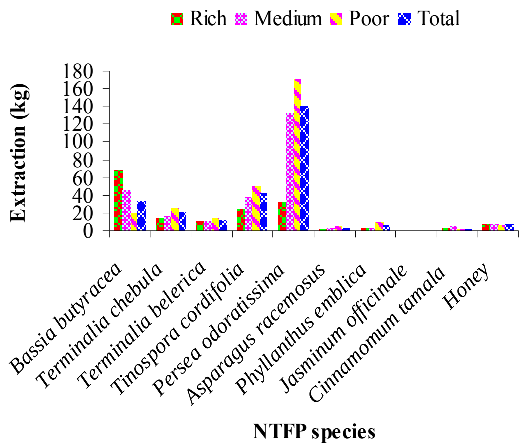

Figure 1. Average amount of NTFPs extraction by economic category (2007/08)

The extraction rate of *Persea odoratissima* bark in state forest was higher than that of other NTFP species. This species was extracted in huge quantity (maximum upto 30 tons dry weight by a collector) with concerning little on its sustainability in the state forests. There was free access in the state forests to the collectors and also the local demand for this species was higher which pushed up the extraction rate of this species. The bark of this tree was extracted unscientifically i.e. chopping down the tree, even uprooting the trees in the state forests whereas collectors in the community forest extracted the bark of young trees scientifically i.e. extracting bark from one side of the trunk leaving another side undisturbed in

Table 3 : Average annual income from NTFPs by economic category (Rs.) (2007/08)

NTFPs	Economic Category			Total
	Rich	Medium	Poor	
Bassia butyracea	850.00	507.18	388.47	486.19
Terminalia chebula	147.14	208.43	279.66	240.28
Terminalia belerica	125.71	124.37	144.91	136.09
Tinospora cordifolia	237.57	403.12	500.84	435.96
Persea odoratissima	385.71	1700.62	2163.55	1785.42
Asparagus racemosus	142.85	396.87	324.57	322.38
Phyllanthus emblica	35.71	43.75	174.74	116.28
Jasminum officinale	0.00	43.75	31.35	30.95
Cinnamomum tamala	160.71	238.28	107.96	154.71
Thysanolaena maxima	364.28	453.12	252.37	328.47
Bamboo handicrafts preparation	825.00	2162.5	2259.32	2038.57
Honey	814.28	725.00	664.40	702.85

order to have regeneration and take next harvest after 2-3 years from the same side when the wound is healed up again.

The collection and sale of NTFPs was done by all economic category households. The local merchants and PCL were the major buyers of NTFPs in the study area and for some products like bamboo handicrafts, *Phyllanthus emblica* and *Thysanolaena maxima* the collectors went upto the nearby villages and either sold them in cash or bartered for food grains. The income from various NTFPs collected and sold by the community is given in table 3.

Among different products traded by the community, the major share of income was derived from the bamboo handicrafts (Rs. 2,038.57) followed by *Persea odoratissima* bark (Rs. 1,785.42), honey (Rs. 702.85), *Bassia butyracea* (Rs. 486.19), *Tinospora cordifolia* (Rs. 435.96), *Thysanolaena maxima* (Rs. 328.47) and *Asparagus racemosus* (Rs. 322.38). A nominal part of the income was also obtained from selling of *Terminalia chebula*, *Terminalia belerica*, *Phyllanthus emblica*, *Cinnamomum tamala*, *Jasminum officinale* and *Girardinia diversifolia* bark, *Zanthoxylum armatum*, *Sapindus mukorossi* and Bajuri. About 60 percent of the respondents prepared handicraft items like basket, *doko, dalo, nanglo, bhakari,* pen stands, wall frames from *Dendrocalamus species* and *Drepanostachym intermedium* and sold the items for cash or bartered with food grains in nearby village markets. Comparatively poor households derived higher income from all the NTFPs except *Bassia butyracea* and honey, for which rich people earned higher.

3.5 Income Sources and NTFP`s Contribution on Household Economy

Although most of the Chepangs owned inadequate fertile lands and made use of primitive technologies and traditional practices of slash and burning (*Khoriya)* farming in their largely available marginal lands to grow crops, yet agriculture was the mainstay of the community. Along with agriculture, the collection and trade of NTFPs, livestock raising and off-farm activities (services, business and wage labouring) were the major sources of income supporting the livelihoods of Chepang community (Table 4).

Table 4 : Average annual income from different income sources by economic category (2007/08) (Rs. '000)

Income sources	Economic category			Average income
	Rich	Medium	Poor	
	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
Agriculture	25.766 ± 3.28 (38.92)	19.117 ± 1.55 (44.02)	10.344 ± 0.67 (38.05)	15.072 ± 0.92 (40.36)
Livestock	31.828 ± 6.10 (48.06)	14.882 ± 2.25 (34.27)	6.526 ± 0.62 (24.00)	12.445 ± 1.37 (33.33)
NTFP	5.102 ± 0.71 (7.70)	6.720 ± 1.10 (15.47)	7.200 ± 0.97 (26.48)	6.774 ± 0.64 (18.14)
Off-farm	3.521 ± 2.84 (5.31)	2.702 ± 1.00 (6.22)	3.110 ± 1.34 (11.44)	3.048 ± 0.89 (8.14)
Average Total income (in Rs.)	66.217 (100)	43.421 (100)	27.181 (100)	37.335 (100)

SE = Standard error; Figures in parentheses indicate percentage.

Among the various income sources, agriculture contributed the highest (Rs.15,072) contributing 40.36 percent of the total household income followed by livestock (Rs.12,445) with 33.33 percent and NTFPs (Rs. 6,774) with 18.14 percent contribution in the total household income. While off-farm activities contributed the least with the Rs. 3,048 contributing 8.14 percent in the household total income (Table 4).

While analyzing the contribution of different sources of income in different economic category households, the highest income (Rs.31,828) was obtained from livestock contributing 48.06 percent in the total household income of rich households. Chepang households falling under rich economic category had the highest livestock unit and ability to bear the cost of raising improved breeds, managing shed, pens and concentrate feeds, and the veterinary services which was beyond the capacity of poor households. While the share of NTFPs in the total household income of poor category households was found higher (Rs. 7,200) contributing 26.48 percent followed by medium (Rs. 6,720) with 15.47 percent and the rich (Rs. 5,102) with 7.70 percent contribution in the total household income. NTFPs stood in the second most important source of income after agriculture for the poor households whereas for rich and medium households, it stood in third position. Off-farm income sources had though the least contribution in total household income of every economic category, it contributed the highest (Rs.3,110) with 11.44 percent to the total income of poor households followed by medium (Rs. 2,702) 6.22 percent and the rich households (Rs. 3,521) 5.31 percent contribution in the total household income. The seasonal migration and wage labouring was common to the poor Chepangs and the major factors in having higher off-farm income to the poor economic category households than others.

4. Conclusion

Chepang community is socio-economically marginalized section of the society and depends on forest products for fulfilling various household needs. Most of the Chepang households have inadequate produce from their marginal lands and are often constrained with food deficit for about six months of a year. They have low capacity to manage the household needs because of the poverty and are left with too little alternatives for sustaining the livelihoods. In such context, the forest products act as not the first choice but the last resort to the community. The collection and utilization of NTFPs has remained as one of the major livelihoods options for this community as they rely on such products for meeting their food, nutritional, healthcare and cash needs. The increasing market demand for NTFPs has offered a good opportunity of taking economic benefits to support the livelihoods of the community. However, the market oriented collection and sale of NTFPs for fulfilling the immediate cash needs of the community has resulted in eroding of the indigenous utilization of NTFP species. The transmission of indigenous knowledge on medicinal use value of NTFPs to the younger generation of this community was scanty as they were less familiar of the medicinal use value of NTFPs. In addition, the growing market demand has encouraged the unhealthy practices like unscientific harvesting and over exploitation of the forest products among the collectors and such practices has led to the rapid declining of certain NTFP species like *Persea odoratissima* in the state forests. The disappearance of the indigenous knowledge not only affects on the unique culture, tradition and identity of the community but also affects on the conservation and management practices of NTFPs that are critical to their livelihoods. Hence, it is very essential to encourage, implement and promote indigenous knowledge and sustainable natural resource management programs along with the value addition technologies of NTFPs in active participation of Chepang community to ensure sustainable tangible and intangible benefits to the community and to promote NTFP sub-sector.

Acknowledgements

The authors are highly thankful to Social Inclusion Research Fund (SIRF), SNV/Nepal, for providing financial support through an *'Apprenticeship Research Grant 2007'* that enabled to undertake this research activity. The authors also would like to thank all the Chepang respondents, Praja Cooperative Limited and Forum for Rural Welfare and Agricultural Reform for Development for their cooperation and support during this study.

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Study of prospects of Agritourism development : A case study of kirtipur municipality

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Abstract

A survey was carried out to analyze the potentiality of agritourism in Kirtipur Municipality in 2008. Ninetyfive farmers, 5 from each ward and 8 politicians of Kirtipur were selected randomly along with 20 visitors, 20 hotels and restaurants, 20 travel agency and tour operators, and 20 tourism or agriculture institutions/organizations from Kathmandu valley. Six sets of interview schedules were used for different respondents. Approximately 75 percent of the farmers belonged to ethnic group among which 68 percent were Newars. Interestingly, although agritourism is at initial stage 43 percent of respondents conceptualized the term as attracting tourists by demonstrating agricultural activities (30%) and visit for gaining knowledge/training on farming perspective/new technology (29%). Findings suggest agritourism development committee should be established in collaboration with different government bodies, farmers, institutions and others.

Key words: Agritourism, agrobiodiversity, tourism

1. Introduction

Agritourism is defined as a combination of natural settings and products of agricultural operations combined within a tourism experience (Williams et al., 2001): It is developing into a large part of the tourism industry. It is one of the important types of tourism in Germany (Oppermann, 1995), Austria (Sharpley and Vass, 2006), Greece, Poland, China (Upadhyaya, 2006), Jamaica (IICA/OAS, 2007), Norway (Haugen and Vik, 2008), and other parts of Europe and America (Williams et al., 2001).The symbiotic relationship between tourism and agriculture that is found in agritourism is a key element of an environmentally and socially responsible tourism (Kuo and Chiu, 2006).

In Nepal, tourism was estimated to contribute about 3 percent of the GDP and about 7 percent of the foreign exchange earnings and has multiplier effects on the economy. The total revenue from tourism has increased from US$ 230,617 in the year 2007 to US$ 351,968 in the year 2008 (MoTCA, 2008). The government has come up with new tourism policy 2065 to make tourism industry as one of the major sources of national economy and by tourism vision 2020 by niche production - agritourism, community-based tourism, village tourism, eco-tourism etc. (MoTCA, 2009).

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In the context of agritourism, farmers are searching for an additional source of income to their traditional agricultural practices. While many modern tourists lack an understanding of farming system and farm life. Their desire to be addressed and an appreciation for agritourism as an exciting and unique experience have given farmers an opportunity to support their livelihood and continue to be a part of tourism industry (Curtis and Monson, 2005). Agritourism enterprise is the only sector which can distribute tourists in different geographical locations. The comparative advantages of horticulture, floriculture, and tourism in Nepal are being developed rapidly (Banskota et al., 2000). Nepal is a potential destination for launching agritourism (Dangol, 2007) as various tourism activities are associated in agritourism and the country can avail a lot if its potentials are explored and brought into practice (Singh, 2004). Most of the areas and activities based in agriculture like *Ropai jatra* would be a wonderful opportunity to expose Nepal to the outside visitors. However, farmers' recognition has hardly received any procreative consequences about tourism, and agritourism is visualized by them as separate component, agriculture and tourism.

2. Methodology

Kirtipur Municipality situated in the southwest of the Kathmandu Valley was selected for revealing the agritourism potentiality. A total of 95 farmers from 19 wards (representing 5 from each ward) were selected on the random basis to explore their wiliness to participate in agritourism. Besides, for examining knowledge and perception of agritourism and its marketing prospect 20 visitors, 20 hotels and restaurants, 20 travel agencies and tour operators, 20 tourism or agriculture institutions/organizations and 8 politicians were considered tolling the sample size to be 183. The primary sources were the farmers of Kirtipur and other respondents selected. The secondary sources were collected from different institutions (ICIMOD, NTB, IUCN, IAAS, KATH, and NTTR), various government and non-government organizations. For the collection of required information different techniques like face-to-face interview, participatory rural appraisal, focus group discussion, informal meeting, observation methods and analytical tools like preference ranking, pile sorting were applied.

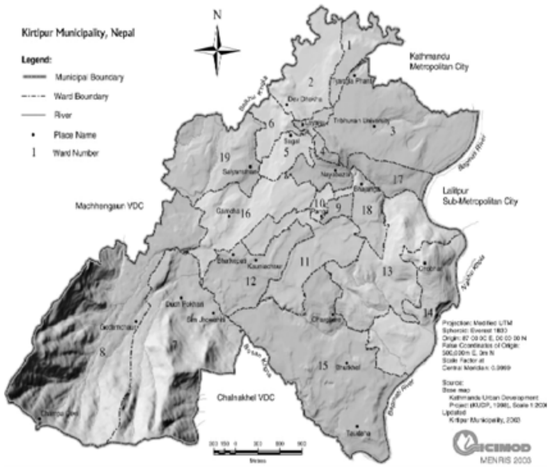

Figure 1: Political map of Kirtipur Municipality

3. Results and Discussion

3.1 Farming system

Understanding the farming system and its relationship with tourism is necessary because farming, fishing and animal husbandry are the principal tourism activities for agritourism. Stimulating agricultural production for tourism represents an opportunity to build on the existing skills of the farmers without requiring a major shift in economic livelihood strategy, lifestyle and tradition (Williams et al., 2001). Though significant changes have been seen in the land use patterns and occupational structure of Kirtipur municipality, agriculture is predominant land use type. Steep cultivated land (17%), medium slope cultivated land (30%), and flat cultivated land (25%) is three main types of agricultural land (ICIMOD, 2003). From the point of view from crops land is divided as i. *Khet* and ii. *Bari*.

Rice-wheat cropping system (71.6%) was major cropping system of lowland (*khet land*) and maize intercrop with seasonal vegetables (44.8%) was the dominant cropping system on upland (*bari* land) across the study sites. Most of households used to grow blackgram on rice bund in *khet* land. However land nearby streams, spring have irrigation facilities where rice, potato, oilseeds and vegetables are cultivated. Oilseeds (Mustard-Rayo, Tori-Rapeseed, Sarsyoo) are cultivated as these have high demand for the milling purpose. Some of the farmers were also found to cultivate vegetables (Tomato, cole crops, cucurbits) only as for market purpose. Most of the land being rain-fed type the cropping pattern follows the seasonal conditions for production of different crops which is shown in table 1.

Table 1 : Cropping pattern of the study sites

Lowland (*Khet*)	Upland (*Bari*)
Rice – Wheat (71.6%)	Maize + Vegetables (44.8%)
Rice – Wheat + Mustard	Maize – Legumes (Broad bean, Pea)
Rice – Wheat + Pulse crop (Pea)	Maize – Soyabean + Vegetables
Rice – Wheat + Seasonal vegetables	Maize – Oilseeds
Rice – Wheat + Oat (Jai)	Seasonal vegetables
Rice – Wheat – Potato	Vegetables* – Potato
Rice – Potato	Vegetables* + Mushroom
Rice – Tori	Mustard + Vegetables
Rice – Vegetables	Soyabean – Mustard
Rice – Fallow	Soyabean + Vegetables*
Potato – Oilseeds	
Rice – Wheat – Fallow	
Rice – Oat	

* Cauliflower, Cabbage, Broccoli, Bean, Cucurbits, Tomato, Brinjal, Chilly, Capsicum, Radish

3.2 Agrobiodiversity

The components of agriculture that is crop plants and livestock along with their gene providing wild relatives and landraces, bio-control agents and those offering vital ecosystem services such as pollinators, decomposers and which recycle nutrients, is known as agrobiodiversity (Thapa, 2006). The vegetation of Kirtipur area is of subtropical type and most of the area is under cultivation (Joshi and Ghimire, 1999). Horticulture center, Kirtipur has been maintaining the germplasm of different fruit species and varieties which are essential for agro-biodiversity conservation. A study on agrobiodiversity was carried out in farmers' fields to document the diversity of domesticated plants and animals.

3.3 Plant diversity

Nepalese home garden are largely vegetable-based (vegetable species accounting for 37-48% of total species planted), followed by fruits, fodders, medicinal and ornamental plants, in that order of numbers planted (Gautam et al., 2005). Similar results are found in the study area and 95 farmers about 66.1 percent maintained the homegarden (*Gharbagaincha*) / kitchengarden (*Karesabari*). Majority of them use garden for vegetables (89%), spices (73%), ornamental plants (60%) and fruit production (32%). Subedi (2002) in his study found green leaf vegetables, pumpkins, cauliflower, cabbage etc. easily available in Kirtipur area. Similarly, table 2 presents list of top 5 vegetables, spices, ornamental/other plants and fruits showing up various edible plant species and aesthetic plants are part of the garden system of the study sites.

3.4 Animal diversity

The main agricultural animals found in study area comprised of domesticated mammals, birds, fishes and insects.

1. Mammals – Cattle, Buffalo, Goat, Swine, Dog, Cat
2. Birds – Hen, Ducks, Pigeon
3. Fishes – Rohu, Common carp, Grass carp, Silver carp, Bighead carp, Cat fish (Mahur), Naini, Bhakur.
4. Insects and others – Honeybees, Earthworm, Frogs

3.5 Special recognition of Kirtipur

Figure 2 shows the responses of farmers for special recognition of the study area. The recognition as farming area and traditional system is responded most (57.9%) followed by views of hills and hillocks/natural landscape (33.7%), historical place (27.4%), proximity to Kathmandu valley (17.9%) and combination of all (16.8%).

3.5 Attitude towards tourists

The attitudes of farmers towards the tourists are likely to have a substantial influence in terms of agritourism implementation. Out of 87 farmers most of them (56.3%) showed positive attitude towards both domestic and international tourists and 27.6 percent preferred domestic tourists and 16.1 percent preferred international tourists (Figure 3). Davies and Gilbert, (1992) in their study show that Wales had observed an increase in demand for farm based tourism to a larger extent with the result of changing attitudes of the visitors.

Table 2 : The top 5 most common garden plants grown in Kirtipur, 2009

Garden plants	F (%)	Rank
Vegetables	(89)	
Broad Leaved Mustard *(Brassica juncea),* Soyabean *(Glycine max)*	56 (89)	I
Tori *(Brassica Campestris* var. *tori)*, Cowpea *(Vigna radiata)*	55 (87)	II
Radish *(Raphanus sativus)*, Cauliflower *(B. oleraceae* var.*botrytis),* Tomato *(Lycopersicum esculentum)*	54 (86)	III
Spinach *(Spinacea oleraceae)*, Broad bean *(Vicia faba)*	52 (83)	IV
Cress *(Lepidium sativum)*, Turnip *(Brassica rapa)*	51 (81)	V
Spices	(73)	
Coriander (*Coriandtum sativum)*	46 (73)	I
Garlic (*Alium sativum*)	39 (62)	II
Chilly (*Capsicum fructescen*)	37 (59)	III
Fenugreek *(Trigonella foenum-graecum)*	36 (57)	IV
Onion (*Alium cepa*)	34 (34)	V
Ornamental and others	(60)	
Marigold *(Tagetus patula)*	38 (60)	I
Rose (*Rosa sinensis)*	32 (51)	II
Titepati *(Artmesia vulgaris)*	30 (48)	III
Peepal *(Ficus reliogiosa)*	23 (37)	IV
Chrysanthemum *(Chrysanthemum spp.)*	20 (32)	V
Fruits	(32)	
Orange (*Citrus reticulata),* Guava *(Psidium guajava)*	20 (32)	I
Persimom *(Diosprus kaki)*	17 (27)	II
Pumilo *(Citrus maxima)*	16 (25)	III
Pomegranate *(Punica granatum)*	14 (22)	IV
Pear *(Pyrus communis)*	13 (21)	V

* *Figures in parenthesis indicate percentage*

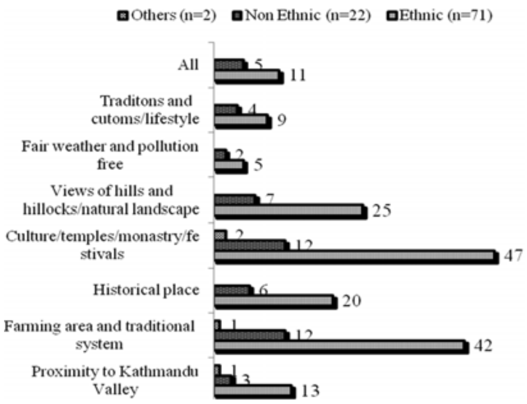

Figure 2 : Farmers' responses for special recognition of Kirtipur area

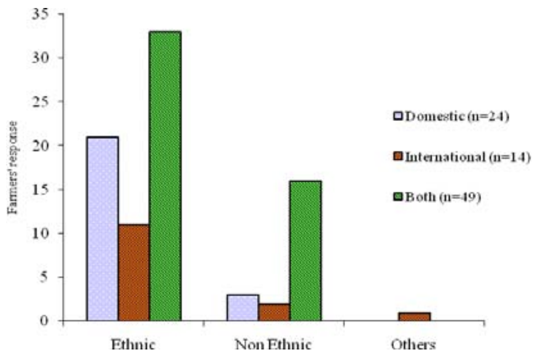

Figure 3: Farmers' responses for different types of tourists

3.5 Agritourism knowledge

All categories of respondents perceived the term agritourism of including all in their own way. Among forty three percent of respondents, 40 percent of farmers (39% of ethnic farmers, 41% of non ethnic farmers, 50% others), 90 percent of tourism or agriculture institutions (TAI/O), 50 percent of Politicians, 45 percent of tourists, 25 percent of hotels and restaurants (H&R) and 25 percent of travel agency and tour operators (TATO) interpret agritourism (Figure 4).

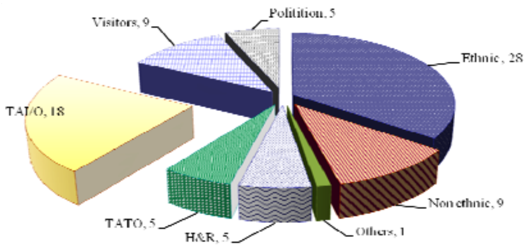

Figure 4 : Categorical division of respondents knowing about agritourism

3.6 Meaning of agritourism

Defination of agritourism according to respondents was categorized in 6 concepts which are DAA-Attracting tourists by demonstrating agricultural activities; VGK-Visit for gaining knowledge/training on farming perspective/new technology; OFV-Organizing farmers' visit to different farms; SAL- Showing agricultural land and its management; PAT-Promoting agriculture for tourism, and ALL-combination of all. Most of the respondents viewed that agritourism is experiencing agriculture activities and farming system. The concept that agritourism can really provide additional income generating option was lacking among them (Figure 5).

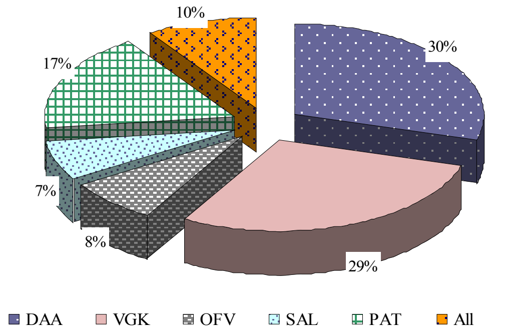

Figure 5 : View about agritourism with respect to different respondents

3.7 Prerequisites of agritourism development

The challenge in agritourism is to develop the human resources and skills, bring together all actors and stakeholders to provide all inputs and resources necessary to initiate and kick-start the development process. This type of tourism allows many families to fully use their domestic resources and generates social benefits for the surrounding community (Schulze et al., 2007). Likewise table 3 depicts that the most important requirements of agritourism is human resource development and awareness program (55%). Further establishing agricultural museum (48%), emphasized on increasing agricultural activities and knowledge on agro-products (45%) are other prerequisites. This corroborates a common impression that agritourism is particularly not well empowered with a skilled and experienced individuals. Agrobiodiversity management and conservation (36%) and arrangement for tourist stay (36%) were also important in respondents' view.

Table 3 : Prerequisites of agritourism development

Requirements of agritourism	Farmers	H&R	TATO	TAI/O	Visitors	Politicians	Total
Increase agricultural activities and knowledge of agro-products	14(37)	3(60)	4(80)	13(72)	2(22)	-	36(45)
Traditional knowledge sharing	14(37)	-	-	10(56)	3(33)	1(20)	28(35)
Human resource development and awareness program	27(71)	2(40)	1(20)	7(39)	4(44)	3(60)	44(55)
Establish agriculture museum	27(71)	2(40)	-	5(28)	3(33)	1(20)	38(48)
More study and research	13(34)	-	2(40)	7(39)	3(33)	2(40)	27(34)
Agrobiodiversity management and conservation	20(53)	-	-	7(39)	1(11)	1(20)	29(36)
Arrangement for tourist stay	21(55)	1(20)	2(40)	2(11)	1(11)	2(40)	29(36)

** Figures in parenthesis indicate percentage*

4. Conclusion

Kirtipur has collective advantage of agricultural and tourism milieu depicting it as one of the potential agritourism destinations. As fair percent of farmers knew about tourism (54.7%), agritourism (40%) has positive attitude towards tourism (73.36%) and farmers can conduct agritourism in Kirtipur with improved access to credit, markets, and training and private-sector joint ventures. Conservation of agrobiodiversity, community forestry and wetlands has already been carried out which added benefit for implementation of agritourism program. The farms maintained can host farmer workshop, students' seminar and other activities to show people what can be achieved with a small piece of land and lot of initiative. However, before going out for the developing and promoting agritourism the obstacles must be worked out first by close collaboration among Government, Municipality, farmers, tour operators, hotel and restaurants, Nepal tourism board, Bhrikutimandap , Central horticulture center, Kirtipur, media and academic institutions.

In short more empirical research is required to understand the impacts of agritourism and to find out the potential areas for the development of agritourism in the nation.

Acknowledgement

The authors extend their sincere thanks to all the informants of Kirtipur Municipality and other respondents for their cooperation during field study and Directorate of Research and Publication and Nepal Tourism Board for their assistance and encouragement.

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Gender Mainstreaming in Planning for Food Security in Developing World

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Abstract

Globally more than one billion people are suffering from hunger severely prevalent in the developing world. Millions of children are dying and being malnourished due to acute hunger. Though the agricultural production has increased considerably in the last two decades, people to be fed and freed from food insecurity is mounting alarmingly. Women are the key actors for food security and said to be feeding the world. A farm woman extends the food chain from the farm to the household. Women's access to income and management of household resources is directly linked with the household level food security. Women's incomes are more strongly associated with improvements in children's health and nutritional status than are men's incomes. Women are solely responsible for breast-feeding, and mainly for preparation of nutritious food, and health and hygiene practices. Empowering women is central to food security and living conditions of people. Despite these facts, women are excluded from decision and policy-making which is adding to persistent poverty and food insecurity. This article aims to suggest incorporating gender in the planning for food security on the basis of equal access to assets, knowledge, skills and services, and human dignity through equal participation in the development process. The findings show decentralized, bottom-up planning with participatory approach at micro-level, restructuring the organizations by establishing a gender sub-unit within planning unit at all levels in public sector, deputing gender-trained staff within the planning unit, incorporating the guidelines and nature of program for gender in the National Development Strategy and establishing a gender-disaggregated data-base can enhance gender incorporation in the planning process. Besides these, NGOs can be mobilized to increase participation of women at community level and lobbying at central and district levels to incorporate gender in planning.

Keywords: Developing world, food security, gender, planning

1. Introduction

1.1 Food Security Scenario in Developing World

The world has come to a major cross-road for the food situation. Globally more than one billion people – one sixth of the world population are suffering from chronic hunger and malnutrition. Bulk of the starving population belong to the developing world as evidenced by Asia and the Pacific region estimated to have about 642 million hungry people in 2009, Sub-

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Saharan Africa 265 million, Latin America and the Caribbean 53 million while the Near East and North Africa 42 million. On the other hand, the world's rich countries have 15 million people who are suffering from chronic hunger (FAO & WFP, 2009).

Millennium Summit 2000 and World Food Summit have set a goal to reduce the number of human being who are food insecure by at least half by no later than 2015. Over the last two decades and before the global financial crisis, the world had made remarkable progress in increasing food production and reducing food insecurity. According to FAO (Braun 2003), the number of food-insecure people in developing countries fell from 920 million in 1980 to 799 million in 1999, and the number of food insecure people dropped from 28 percent to 17 percent. The number and ratio of malnourished children is decreasing globally, though it is increasing in Sub-Sahara Africa (Smith and Haddad, 2000). World agriculture produces 17 percent more calories per person today than it did thirty years ago, despite a 70 percent population increase (Mousseau and Mittal, 2006). Global food production at present is sufficient to provide everyone the minimum calorie needs, if distributed according to need (Braun, 2003, Mousseau and Mittal 2006). If China is excluded, the number of food-insecure people in the rest of the developing world increased by more than 50 million during the past decade. According to Mousseau and Mittal (2006), 'Chronic hunger victimize 6.5 million children who die from hunger- related causes each year more than thirty children die in each minute around the world; and malnourished increase by 4.5 million each year'. By 2025 the world population will be 8.5 billion (Karunarathna, 2002) hence 2.5 billion more people need to be fed. According to Braun (2003), to achieve the millennium development goal by 2015, 400 million more people need to be freed from hunger. An estimated increased global demand for only cereal crops by 2020 is 690 million tones, out of which 38 percent needed for China and India only (Pinstrup et.al., 1999). These all figures are based on nationally available food data and calorie intake, if we go beyond these dimensions, this situation may be even worse.

1.2 Gender and Food Security

i) Gender

Human being born in mainly two sexes and society assign differentiated roles for each sex based on the particular culture. The differential social roles assigned to them in that very specific cultural context, which define them as male and female, is termed as gender. It's a psychological difference. It is not natural, and changes over time and place. Stephens (2002) states gender roles have an impact on development goals and often change in response to new priorities, demands, systems and technologies. This has resulted in one or other sex being nutritionally disadvantaged or differentially affected *vis a vis* the other. Gender analysis is therefore an integral part of the formulation and administration of food policy, which recognizes differences in roles, contributions, remuneration, needs and distribution on the sex.

Historically, evolution of society determined the different gender roles. Public domain, social work belonged to men and perceived as a breadwinner for family. Domestic sphere - rearing children, looking after sick and elderly people at home, food storage, process, cooking, distribution, cleaning and nearby gardening etc. presumed as women's role. Besides these, women do nearly half of farm production activities, mainly almost all repetitious and time-consuming tasks but farmers are still generally perceived as 'male' by policy-makers, development planners and agricultural service deliverers. These all roles of women reflect their greater contribution for food security.

ii) Food Security

Year round food security is an important component of human development and regarded as a basic human right. Food security has now become an important global issue and its concept has assumed the growing attention of the global community and international organizations. The notion of food security is a complex one which cannot be reduced solely to the problem of food production. Amartya Sen in 1981 (quoted in Korf, 2001), highlighted the entitlement thesis of famines, which argues that people might be starving even though sufficient food might be locally available. Malnutrition and starvation is often more a problem of purchasing power or other entitlements. However, World Bank (1986) has suggested a most widely accepted definition, "access by all people at all times to the food needed for an active and healthy life". This definition has four dimensions: physical and economic access, sufficiency (availability), security (sustainability), and time (SLE, 1999). The term 'food needed' highly generalize the definition. The FAO/WHO in 1992 (quoted in Reinhard and Wijeratne, 2000), came up with more specific description of food security, "Food should be in terms of energy, but also in protein, fat and micronutrients. It should be adequate with regard to quantity, quality, safety, and it should be culturally accepted". This definition covers the nutritional, cultural and safety aspects of food security. This is the basic consideration for the term 'Food and nutritional security (FNS)' recently being used, and the nutrition security is defined as "an environment that encourages and motivates society to make food choices consistent with short and long-term good health." (ADA, 2002), but in this article the term 'food security' is used for convenience. The concept food security/FNS distinguishes three dimensions (Korf, 2001; SLE, 1999); availability of food at all times, access to food at all times, use and utilization of food according to good dietary termed as 'food safety'.

Food insecure conditions can be categorized into two - transitory and chronic food insecurity. Transitory food insecurity is caused by unfavorable climatic conditions (season, rainfall), lack of inputs and credits; conflicts, and natural disasters etc. whereas chronic food insecurity is deputed with poverty. However, in long-run, unmanaged transitory food insecurity can lead to chronic ones.

Conceptually, food security can be achieved at different levels, global, national, regional, local, household, and intra household level.

As Amartya Sen has argued (quoted in Korf, 2001) that food availability at local level does not ensure freeing people from starvation, and the actual problem lies at household and intra household level, intervention at those levels ensures the achievement of food security goal. Addressing at intra household level requires changes in social structure, values, norms entire family structure etc., and family still perceived as an internal affair, needs a long period and multi-sectoral interventions at both macro and micro-levels. This article focuses mainly at household level.

iii) Household Level Food Security

The food security situation of households (and individuals as well) is affected by the policy and institutional environment under which they live, over which they have little control. The vulnerability context of households is influenced by time trends in variables like population growth, resources, technology, shocks resulting from factors like bad health, natural calamities, economic events and conflicts and seasonality of prices, production, employment, etc., all of which eventually affect household (and individual) livelihood systems (FAO, 2001). Proper understanding of household behavior in responding to such external effects is crucial in analyzing food security in both static and dynamic contexts. The three major factors in making food security possible at the household level are (Dulayapach, 2002):

- capability to produce sufficient food;
- economic capacity to always acquire and provide adequate food; and
- ability to utilize to fullest extent the food based on the individual nutrition needs.

Taking into account the above three factors, the people who are in the best position to ensure food security of family are women - rural women in particular.

iv) Food Security Policy

Food security, being a human right, is a state's obligation to fulfill it, but as the people are the victims, it's their duties as well to achieve food security. Effective achievement of food security needs to have a policy at different levels. A policy approach in food security at various levels is presented in the table 1.

Table 1 : Food security policies on different levels

Level	Policy	Interventions
Micro-level (household level)	Overcoming structural food insecurity of rural and urban poor	Integrated food security programmes
Macro-level (national level)	Prevention of temporary and acute food supply crisis	Food security programmes aimed at preventing and overcoming acute food crisis
Micro, meso, and macro-level (household, regional and national level)	Compensation for acute/temporary as well as chronic food shortages	Emergency food aid programme aid
Macro-level (national economy)	Food security strategies to overcome acute/temporary and structural food security problems	Food security policy advice

Source: SLE, 1999.

v) Food Security Planning

The word "planning" can be defined as "making of an overly sequence of action that will lead to achievement of a stated goal or goals" (Rogel, 2002). In fact, it is a continuous process, which involves decision, or choices, about alternative ways of using available resources, with the aim of achieving particular goals at some time in future. Food security planning can be defined, according to Jayaweera (1989) as, 'interventions in allocating and distributing resources to attain desired goals.' Planning is guideline for the actions to be followed. These all definitions convey the important elements of the concept planning as - making decisions as central point, to adopt the best action, to allocate resources, and as a means of achieving goals.

The three dimensions of food security-sufficient production, purchasing capacity, and preparation of nutritious food, health, sanitation and hygiene; availability receives the high importance, because if there is food available, then only it can be distributed or purchased. Three quarters of the world's poor live in rural areas and make their living from agriculture. Hunger and child malnutrition are greater in these areas than in urban areas. Moreover, the higher is the proportion of the rural population that obtains its income solely from subsistence farming, the higher is the incidence of malnutrition. So, to achieve food security, agricultural sector planning gets more priority but other sectors are equally important and can't be ignored. Policy, institutional environment, vulnerability context, employment and household behavior etc. have implications on food security. Leading of transitory food insecure condition to chronic food insecurity is due to economic reasons, all needs to be carefully considered. These all-diverse and complex situations show the need for proper planning to address in a convergent way through multi sectoral policy formulations, planning and interventions at various levels.

Planning is categorized differently based on various aspects. These are, centralized and decentralized planning, top-down and bottom-up approach of planning, categorized based on the influences of people of different hierarchical position in the decision-making. Centralized and top-down planning represents the idea of higher authority, whereas decentralized and bottom-up planning represents the ideas/demands coming from the grass root level. Participatory and non-participatory approach of planning is categorized based on the mode of participation. Participatory approach ensures optimum participation of all stakeholders including people in decision-making in planning process and represents the real needs of the people. Decentralized, bottom-up participatory planning at micro-level assures the achievements of desired results and the objectives.

Sound development plans require good projects but effective project preparation and analysis must be set in the framework of a broader development plan (Gittinger, 1995). The project itself is an analytical tool, and provides an important means by which investment and other development expenditures foreseen in plans can be clarified and realized. Plans and projects are interdependent (Gittinger, 1995), and project approach to planning gives better insight for target and goal setting and achievement, which can be effective to achieve to food security goal as well.

Sound planning rests on the availability of a wide range of information about existing and potential situations and their likely effects. Information on sex-disaggregated data can only facilitate gender sensitive planning for food security.

1.3 Rationale for Mainstreaming Gender in Food Security Planning

Women's important role and contribution to food security remained nearly invisible to policy and decision makers across the world. In many parts of the world, women continue to play an important role as rural information sources and providers of food to urban areas. A farm woman extends the food chain from the farm sector to the household, and takes responsibility for various food-related activities to ensure food security of her family. In the process of production, handling and preparation of food, women play a multiple role throughout the sequence. They are said to be "feeding the world". Farm women work more than men, farm women's working hour amounts 3,894 hours per year in farm and in home, whereas men work for 2,250 hours per year (APO, 2002).

The sustainable production of food is the first pillar of food security. On a global scale, women produce more than half of all the food that is grown. Women account for 70 to 80 percent of household food production in Sub-Saharan Africa, 65 percent in Asia and 45 percent in Latin America and the Caribbean (Quisumbing et al., 1995 and FAO, 1995). After the harvest, they are almost entirely responsible for operations such as storage, handling, stocking, marketing and processing. Despite this situation, women own hardly any land, have difficulty in obtaining credit and are overlooked by agricultural service providers.

The second pillar of food security is economic access to available food. In recent years, studies have found that, women's incomes are more strongly associated with improvements in children's health and nutritional status than are men's incomes (Quisumbing et al., 1995). Furthermore, there is a direct link between women's access to income and management of household resources and the improvement of household level food security and nutritional well-being of family members (FAO, 1995).

The different modes of expenses are due to societal and cultural norms have assigned women the role of ensuring that household members, especially children, receive an adequate share of available food. Also, since women's income tends to come more frequently and in smaller amounts than men's income, it may be more readily spent on daily subsistence needs. The combination of poverty and gender inequality poses an even greater threat because of the nutritional benefits associated with increasing women's incomes. Prakash (2003) argue, the growing percentage of female-headed households around the world is a cause for concern, for past studies suggest an association between female headship and poverty and consequently food insecure condition.

The third pillar of food security is the achievement of nutrition security. Ensuring the nutrition security of the household, through the combination of both food and other resources, is almost the exclusive domain of women. Nearly all non-food inputs into nutrition require time investments, and in general these investments are made by women. According to Pinstrup et al., (1997), 'one out of four children will be malnourished in 2020'. Children need care which ensures nutrition security in two broad ways: breast-feeding and preparation of nutritious food, and health and hygiene practices. These cares are provided solely by women. One of the most important reasons to incorporate women in planning for food security is that, during 1970 –1995 reductions in child malnutrition, estimated contribution of women's role, status and education is 55 percent whereas that of food availability is 26 percent and health facility contributed 19 percent (Smith and Haddad, 2000). Women's nutritional status itself counts for care, as Maxwell et. al., (2000) found 'better care giving practices were associated with a better nutritional status of women.'

Another reason is that, women are the main victims of food insecurity. Most of the hunger and malnutrition-affected people are: children under five years of age, especially girls; women of childbearing age, especially those who are pregnant or breast-feeding; and low-income households, a large percentage of which are female-headed. Yet, rural female household members often get less food than males both absolutely and in terms of nutritional requirements (FAO, 1995). Studies have shown that the female-headed households have less access to food as compared to male-headed household. Most disadvantaged population in the world today comprises rural women in developing countries who have been the last to benefit - or negatively affected - by prevailing economic growth and development processes. Prakash (2003) states that, since the 1970s, the number of women living below the poverty line has increased by 50 percent in comparison with 30 percent for their male counterparts. Though family is perceived as cohesive and harmonious unit, the expected trickle down effects of benefits is not working, as Jayaweera (1989) found that 'gender inequalities within the family structure often responses to policies and prevent equitable resource allocation within the household' which emphasize the incorporation of women into the planning.

Women produce equal or even better results than men for the same resources used by them and for the access to resources. Quisumbing and Meizen-Dick (2001) found that 'assets that women control has a positive impact on the next generation particularly on education and health'. To reflect equal results, Prakash (2003) states, 'where both men and women have equal access to modern methods and inputs there is no evidence that either sex is more efficient than the other.

Besides these contributions and being vulnerable, women's role in the process of planning and decision-making facilitates both men and women to exchange views, ideas and experiences and thereby harness the development potentials of women. This process will act as an effort to change inherited gender imbalances, which are connected with traditions, outdated procedures and customs. Within these contexts, women's incorporation in planning for food security will be central to achieving raising levels of nutrition, improving production of food and agricultural products, and enhancing living conditions of their households.

The objective of this article is to provide suggestions to mainstream gender into the planning for food security in developing world.

2. Methodology

The secondary source of information was used mainly in this study. The information was gathered through literature and websites. Various conference reports, journal articles, case studies and research reports were studied intensively. The information was also collected through the personal conversation with the policy makers and executives.

3. Discussion and Analysis on Mainstreaming Gender in Food Security Planning

Incorporation of women in planning process is a part of goals of equality. In consonance with the goals of equality, the World Plan of Action formulated in Mexico in 1975, and the programme of action prepared, at the Mid-Decade (of UN) Conference in Copenhagen in 1980 prioritized the need for incorporation of women in development (Jayaweera, 1989). The incorporation envisaged for women is on the basis of:

- equal access to assets, knowledge, skills and services; and
- human dignity through equal participation in the development process and in resource allocation in the family and society and ability to control one's own resources.

These processes of incorporation through the equal participation in resource allocation and development process reveals equal share of women in decision-making. Other dimensions are access to facilities and control over resources. Same in the case of incorporation of gender in planning for food security means, equal share of women as men in the decision-making process of planning, subsequently which ensure equal access to assets, skills, and services. Prevailing situation of men getting high priority and women are being overlooked, demands higher emphasis on incorporation of women in planning process. The incorporation of women in planning in general, and equal share in decision-making process of planning in particular, needs various interventions collectively. These are presented below.

3.1 Decentralized Planning Process

Incorporation of women in planning for food security needs decentralized planning process at micro-level. Since food security needs interventions of different sectors, this planning process should be applied to all concerned sectors i.e. multi-sectoral decentralized planning process. The planning process in many developing countries has been traditionally centralized. The centrally originated plans are highly influenced by the perceptions of political and economic decision makers, planners and administrators. These plans are formulated by quite a few planners, administrators or bureaucrats without consultations. As it is evident that women are affected by conditions in their society, and in their socio-economic classes or groups, as well as by their position as women per se. They are affected by social values, norms and significantly by the patriarchal values. These values make women, as an invisible issue and development objects, and they are not being incorporated in the centralized planning process. The centrally development plans either do not include their aspirations, real needs and problems or represent merely as a recipient or beneficiary of social welfare programs. Moreover, centralized planning system do not effectively distribute the effects of development and cannot mobilize local resources as Alwis (1998) found 'disenchantment with the efficacy of the trickle down effect for the distribution of the economic benefits across the population', and again mention 'past failures of centrally planned system to mobilize human and physical resources', for development. Studies show, centralized planning process prohibits women's incorporation in the process as Oakley et al., (1991) mention, 'centralized administrative structures retain control over decision making, resource allocation and the information and knowledge', which people require to play an effective part in development activities. Having these drawbacks centralized planning process does not facilitate incorporation of women in the planning process.

After 1970s many countries followed decentralized planning process to seek better representation of different sectors of people to integrate their needs but practically the process reflects a remodeling of centralized planning. The decentralization did not extend beyond district or regional level, excluding the village or community level - which ensures increased active participation of people. Decentralized planning at district/regional level also influenced as the centralized planning by the perception and concepts of higher authorities through guided instructions, directives and guidelines of bureaucrats and planners at central levels, as Jayaweera (1989) found 'process of decentralization has been 'largely a political exercise with little departure from the conceptual framework of macro-level and district sectoral planning'. Moreover, these plans threaten to dichotomize development programs on gender-differentiated lines and to direct economic policies to men and social policies to women who are conceptualized to housewives. District level planners have to be engaged in matching with the policy and guidelines of higher authorities rather responding to people's need, as it is revealed by the finding 'district level planners and staff still have to deal with the top-down administration of the Ministry and the difficulties of trying to match the policy directives that come down from the top and their limited financial resources with the needs that emerge from the bottom' (Sontheimer et al., 1997). Decentralization upto district level does not facilitate incorporation of women in planning process.

Studies show, it should go beyond district level units to micro-level i.e. to local and/or community level units, for the incorporation of women in the planning process. Capacity of these units should be enhanced for planning and management in a participatory method. Alwis (1998) in his study found that 'need to facilitate the strengthening of the planning and management capability of local organizations by providing them the authority to design and implement local projects in a learning process.' Plans formulated at bottom level facilitate effective integration of local people's needs through fair discussion of stakeholders including women, so planning should be bottom-up.

3.2 Participatory Approach of Planning

Incorporation of women in planning for food security can be achieved through participatory approach. Women's participation is needed to be increased throughout the planning process at all levels from grass-root to central level and at all stages of a planning cycle. More emphasis should be paid for women's active participation at project identification, project preparation and project implementation. The participation should be active, not passive. Through active participation, women will be involved directly in the decision making of their concern, and reflect/put forth their needs effectively. A policy for participatory approach should be formulated and it should be implemented and monitored through effective mechanisms. In developing countries where centralized government system prevails, it has to face problems from administrators' attitudes (Oakely et al., 1991).

Participatory planning enables people to decide and to take the actions, on which they believe are essential for their development. Participation is an exercise of empowering deprived people. Women's equal position is fundamental to participatory approach. It nurture the enthusiasm and capabilities of participants i.e. women in this case. Participatory approaches remove the mentality of dependency among women and foster desired social change.

Participatory approach to planning ensures equal participation of women in the planning process. At grass root levels, community action plans are developed through participatory methods, such as participatory rural appraisal, which are to be institutionalized. Women's participation can be increased by conducting such participatory methods, when the women are relatively free, by providing 'free space' for women to be unhindered by men, and pretraining of facilitators to listen to women's voices, handle male dominance (Sontheimer et al., 1997). A longer period of working in each community is needed to sensitise men to women's situation, and at the same time, to empower women so that they can demand their fair share in decision-making and benefits.

Equal participation of men and women in the planning process is needed to develop a gender sensitive plan for food security. A model of gender sensitive planning model suggested in the figure 1.

3.3 Restructuring of Organization and Reallocation of Guidelines

The planning units at lower level follow the guidelines of central planning unit of sectoral ministry / department, and national development strategy developed by the government through national planning commission. Plans are being formulated for various sectors as agriculture, education, public health, forestry, drinking water, electricity, irrigation, roads and so on. These all components vary basically and by nature are technical components.

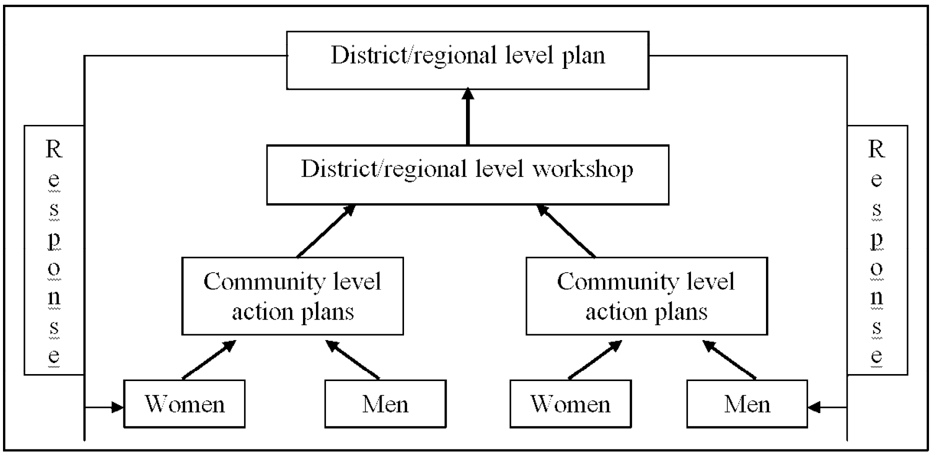

Figure 1: Gender Sensitive Planning Model (Source: Sontheimer et al., 1997 'modified')

In most of the countries there are ministry, departments, bureau, and/or commission to look after women's affairs. Even in sectoral ministries/departments there are women development divisions, which are quite efficient for the gender issues. These ministries and divisions send guidelines and directives to incorporate certain gender specific programs into the plan. But as mentioned earlier, the planning units at lower level mainly plan for their related field, and 'follow the guidelines of sectoral ministry/department and national development strategy' (FAO 1998), and the organizations established solely for women's affairs are marginalized. So, many programs are not being incorporated, and even if incorporate just as allocation of certain numbers to women, which ultimately turn out to be a program having women beneficiary. The women's affairs are being out of mainstream and isolated, and failed to integrate women's program in such structure, as Jayaweera (1989) found 'it has failed to integrate women in development planning because the bureau itself has operated outside the mainstream of planning at national and district levels. As consequence, bureau became a state implementation agency of relatively isolated 'women's sector programmes'.

Incorporation of women in planning for food security in such situation can be assured through restructuring the organizations by establishing a sub-unit of 'gender' within planning unit at all levels in public sector. Deputing gender-trained staff within the planning unit will assure it more. Another recommendation is to incorporate the guidelines and nature of program for 'gender' in the 'National Development Strategy (NDS). Since all planning units follow the guidelines of NDS, it should be channelized to the bottom level planning unit through sectoral ministries for gender incorporation.

3.4 Information/Data-Base for Planning

Gender-disaggregated data-base is a pre-requisite for the incorporation of women in planning process. Existing data-base, particularly analysis of quantitative data, influence the planning perspectives. Gender issues can only be adequately addressed in policies and plans when the data and information available is reliable and complete. In women's case, their work is often not recorded in statistics or not mentioned in reports. As a result, their contribution is seriously underestimated for development and for society, and planners and development workers have the vaguest idea of gender as a social value. A 'gender-disaggregated data-base on division of labour' (Stephens, 2002), access to and control over income and resources, employment, decision-making and management will reflect their contribution and position, and lead to their increased incorporation in planning process.

3.5 Capacity Building

The senior level planners, administrators and other concerned staff have to be trained in gender analysis, gender-needs assessment, gender role assessment and gender monitoring and evaluations, decentralized and participatory planning, and methods of participatory approaches etc. District and community level staff needs to be further trained in facilitation during planning workshop, human resource mobilization for participation etc. Training of senior managers and other staff influences the decision-making to result a gender sensitive, gender specific policy, which will enhance women's incorporation in planning. Besides this, capacity of women's units in the organizations needs to be strengthened (Sontheimer et al., 1997) and networking among them and with other organizations has to be promoted.

3.6 Mobilization of NGOs

Women's incorporation in planning needs their own involvement i.e. participation by themselves, which is less and by social system and less awareness among them. NGOs can be mobilized to increase participation of women at community level and for lobbying at central and district level to incorporate women in the planning process.

4. Conclusion

Women are key actors to meet challenge of food security. They ensure the food and nutrition security of the household, through the combination of both food and other resources. Women produce half of the world food and are said to be "feeding the world". Women's incomes, role, status are strongly associated with the reduction in malnutrition of children, household level food security and well-being of family. But they are the main victims of hunger of the root causes of persistent poverty and food insecurity is women's exclusion from decision- and policy-making. These contexts demand for the incorporation of women in planning for food security, which can be achieved through:

- Decentralized, bottom-up-planning adopting a participatory approach at micro level;
- Restructuring the organizations by establishing a sub-unit of 'gender' within planning unit at all level, in public sector and deputing gender-trained staff within the planning unit;

- Incorporating the guidelines and nature of program for gender in the National Development Strategy;
- Establishing a gender-disaggregated data-base on division of labour, access to and control over income and resources, employment, and decision-making;
- Providing training on gender analysis, gender-needs assessment, decentralized and participatory planning, and methods of participatory approaches etc. to the planners, administrators, and other concerned staff and
- NGO mobilization to increase participation of women at community level and for lobbying at central and district level to incorporate women in the planning.

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