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Agriculture

Agricultural transformations in a remote community of Kengkhar, Mongar, Bhutan

Tayan Raj Gurung[1]

Abstract

The transformation of agriculture from a traditional subsistence based to a semi-commercial form is a global phenomenon. The rate of transformation may vary from one place to the other, however, such transformation is related to evolving ecological and economic conditions of the farmers. Although Bhutanese agriculture is predominantly traditional subsistence oriented mixed farming, the changes are visible and often triggered by ecological, social, economic, and political factors. A study of agricultural transformation in Kengkhar, a remote community in Mongar Dzongkhag was done with the help of agrarian systems analysis framework. The study very evidently brings out the chronological changes and its associated foundation to provide a specific basis to relate the change. The transformation in Khengkhar although gradual, seemed to be influenced by the accessibility to services, road, livelihood sources and external inputs/services. The methodology of agrarian systems analysis is versatile to encompass all issues arising from the renewable resource in question and inclusive of all stakeholders.

Keywords: Agricultural transformation, Agrarian systems analysis

INTRODUCTION

Bhutanese agriculture is still largely based on the traditional subsistence oriented mixed farming systems that integrate cropping, livestock rearing, and use of forest products. It has evolved over a long period of time characterised by diversity of ecological conditions and a high degree of self reliance. The unique mountain agriculture system characterised by diversity, variability over time and heterogeneity over space has led to the development of diverse farming systems specific to different localities. Agriculture in Bhutan is labour intensive with relatively low intensity of use of external farm inputs. An annual average of 27 kg/ha of chemical fertilizer is used on farm land by 38% farmers and 7 kg/ha of commercial pesticides by 20% of farmers predominantly involved in growing rice, potato, apple, and citrus (MoAF, 2009). Although the overall share of agriculture contribution to GDP has been declining from 26% in 2001 to 19% in 2008 (NSB, 2009), agriculture remains to be one of the most important sectors of the Bhutanese economy.

1 CoRRB, MoAF, Thimphu; traj_gurung@moaf.gov.bt

The Bhutanese farmer subsists by growing crops ranging from rice, maize, wheat, buckwheat, potatoes and barley depending on the climatic conditions. Livestock rearing is an integral part of the farming life, as it supports food, draught power and nutrient recycling. The major crops cultivated in Bhutan include paddy, maize, wheat, barley, buckwheat, millet, potato and mustard. In acreage terms maize and paddy accounted for the largest share, covering around 27,227 hectares and 19,356 hectares respectively in 2008 (MoAF 2009). Owing to the improved infrastructure and government support, there is an increasing tendency to cultivate cash crops like apples in the temperate north; oranges, areca nut and cardamom in the subtropical south (MoAF, 2009). Other cash crops that are exported include ginger, chillies and various kinds of vegetables. There is a gradual but definite progression of subsistence agriculture into a commercial form of agriculture and livestock industry.

The progression of agriculture from a traditional subsistence based to a semi-commercial form is indeed a result of evolving ecological and economic conditions of the farmers (Trébuil and Dufumier, 1993). To establish a well founded understanding of an agrarian system and its transformation, a holistic analysis that provides scope to investigate within a time-scale the social, economic, and ecological factors and their interactions is crucial.

MATERIALS AND METHODS

Site description

The study was conducted in Kengkhar village in eastern Bhutan. It is a small highland settlement located on the confluence of Kurichu and Gangrichu in Mongar district.

Agrarian systems analysis

The way farmers exploit the environment within the limits and ability to reproduce by using the relations and interactions that occur between all of its social and physical components, can be considered as an agrarian system (Sacklokham and Baudran, 2005). Although agrarian system analysis can be conducted in different ways, broadly it can be implemented in four distinct steps: (i) agro-ecological zoning, (ii) analysis of recent transformations, (iii) in-depth farm household survey and construction of a farmer typology, and (iv) economic analysis of each main type of production system (Trébuil and Dufumier, 1993; FAO, 1999).

As geo-databases are not well developed for Kengkhar, participatory mapping was used in the form of resource mapping and delineation of areas for specific purposes. Zoning was done based on local knowledge and field observations. It was done to segregate areas into units of similar characteristics to identify and localize agro-ecological and socio-economic constraints and potentials. Apart from agro-

ecological zone and resource maps were also prepared based on information from key informants and observations from the transects.

RESULTS AND DISCUSSIONS

Agricultural transformations

Ever since the country was unified in 1907, there has been a chain of socio-economic and political events either planned or incidental that led to transformation of agro-ecological conditions. From a sparsely inhabited and self-contained farm families migrating with herds of livestock and practicing shifting cultivation, in two decades it evolved into the present landscape where farming is driven by income generation objectives and people competing for (both local and external) renewable resources. Based on the historical timeline, the agrarian transformations can be broadly classified into three main phases as (i) 1950-1970: Subsistence farming by predominantly shifting cultivators, (ii) 1970-1990: self-subsistence to part-commercial, and (iii) 1990-2009: Semi-commercial farming.

Table 1. Evolution of socio-economic conditions and related agro-ecological transformations in Kengkhar.

	Agro-ecological transformation	Year	Socio-economic changes
Subsistence agriculture	- Abundance of primary forest and renewable resources (including water)	Before 1950	- Feudalistic, few households, shifting cultivation, few crops with low yields
	- Few farmers own large land holdings	1952	- Land ceiling up to 10-12 ha per household
	- Large tracks of forest being cleared and burnt for cultivation		- People from Trashigang start to settle in Kengkhar
	- Clearing forest for cultivation, opening large tracks for cattle grazing	1960	- Start of craft making at household level
	- Pressure on water source		
	- Wood carving leads to felling of trees	1963	- School was built in Kengkhar
	Agro-ecological transformation	Year	Socio-economic changes

Subsistence agriculture	-Cultivation of crops like maize, millet, nigerseed, chilli, legumes in parcels less than 0.1 Ha. -Cultivation in fallow dryland with maize	1969	-Start of taxation in the form of cash -Nationalization of forest and natural resources
Semi-Subsistence agriculture	-Started production of crops like kidney beans and field beans for the market to generate income -Indiscriminate felling of trees for woodcraft and house building -Land slide near Ebee village damaging spring pond and agriculture land	1979	-Implementation of Land Act which standardized the land ownership and tenancy -Rural water supply scheme implemented under development programs
	-Multiple land use systems to maximize crop production -Neglect of catchment area for natural ponds	1980-1984	-UNICEF grant for the supply of drinking water -Citrus marketing in Pemagatshel started
	-Landslides expands in Ebee damaging more forest area -Expansion of citrus plantation	1990	
Semi-Commercial agriculture	-Cultivation of citrus in dryland and along the farm boundaries, enhance better vegetative cover -Landslide in Mogola – piped drinking water defunct as landslide damage the spring pond and pipes	1998	-Construction of Basic Health Unit in Kengkhar
	Agro-ecological transformation	Year	Socio-economic changes

Semi-Commercial Agriculture	- Appreciation of local healing practices, complementing with modern treatments. - Water share with health facility	2000	- Water source protected, introduction of high yielding maize and vegetable variety, more human resource in the geog
	- Protection and rehabilitation of all natural spring ponds in the catchment	2002	- Extension office constructed - Initiated water harvesting using large ponds and plastic drums
	- Access to extension advice and guidance in cropping and renewable resource management		- Small shop started in Kengkhar
	- Few check dams/ponds were dug-lined with plastic sheet to collect roof water during rainy season	2005	
	- People contribute labour to construct 17Km long Larjap Water supply: it is unreliable and non-functional		
	- Neglect of natural spring ponds within the village and catchment area degraded as people fell trees	2007	- Community collectively request to District administration for support to address water supply problem
	- Construction of 6 concrete tanks and connecting them with HDPE pipe as network to transfer water		- Peer pressure to Block development committee to mobilize people to develop and manage the new tank network
	- Catchment protection for all operational spring ponds.	2008-2009	- 6 member tank network management group led by a monk is established - Community has access to clean water supply scheme

1950-1970: Land reform and subsistence farming

Prior to the 1950s, slavery and serfdom prevailed in Bhutan and it was only in 1952

when a land ownership ceiling was set at 10-12 hectares per individual, serfdom abolished and King granted land to landless people (Hasrat, 1980) leading to the emergence of an independent household based mode of farming free of the bondage.

As Kengkhar has been a traditional North-South trade route for people of Lhuentse, Pemagatshel and Samdrupjongkhar[2], the early settlers as per the historical profile were the descendents of Dungkhar Cheoje from Dungkhar in Lhuentse who gradually opened up forest areas for cultivating maize and millets. People in Kengkhar are proud to report the visit of the First King of Bhutan sometime in 1919 and the subsequent construction of the Dungkar Goenpa located on the top of the village. In 1950, Kengkhar was made a Drungkhag of Mongar. In 1952 when land ceiling and taxation in cash were introduced in the country, the household with land holdings of less than 0.1 Ha. were exempted from land taxation. It was during this time that people from Trashigang, Trashiyangtse and Lhuentse came and settled in Kengkhar, which the respondents related to people escaping the tax and free labour contribution to the development activities in their original domicile. It was during this time that forest was cleared in several areas and scattered settlements were built. People harvested bamboos to build houses from bamboo mats, and opened up forest areas for cattle grazing. In 1960, two monks[3] started making wooden cask (*palang*) from a locally available tree (locally named *Dongtshushing*: *Boehmeria regulosa*) and wooden mask[4] (*bap*).

The wooden mask and cask is the trademark of Kengkhar now and forms a major livelihood source for households. Around same time a local monk, Lopen Phujay started painting of wooden mask and altar (*Choesum*). With the start of woodcraft, people indiscriminately fell trees. In 1963 with the construction of a school in Kengkhar, many children were forced to the school as parents did not readily enrol them for fear of losing farm labour. Most predominant agro-ecological change was the opening of new farm land and the introduction of upland crops like finger millet (*Eleusine coracana*), nigerseed[5] (*Guizotia abyssinica*), Perilla or Chinese Basil (*Perilla frutescens*), upland rice, mustard by the resettled populations.

2 There are elders in Menbi, Lhuentse district who narrate stories of how they along with people from Pemagatshel, Samdrupjongkhar and Mongar went to Tibet to bring salt in exchange for chilli and products from India. Traders used the Mongar-Deprong-Kengkhar-Denchi-Yangbari-Nanglam route.

3 Tiku Rinzin from Murung and Tiku Mindu from Shaytongbi started making palang and Lopen Phujay initiated painting in Kengkhar.

4 While the best mask is made from *Bombax ceiba*, it is commonly made from chirpine (*Pinus roxburghii*) and in that matter any softwood is used for making mask.

5 *Guizotia abyssinica* is an annual herb grown for its seed to extract edible oil and pickling.

1970-1990: Government initiatives to agriculture development and semi-subsistence farming

In the agricultural development of Bhutan this period was the most crucial as enactment of Land Act and nationalization of forest occurred during the 1970s. Further development of irrigation occurred, and rural credit and technical support for agricultural production were also launched during the 1980s to the 90s.

As woodcraft became popular, timber in the locality became the most sought after resource. Some respondents related the excessive felling of trees from catchment areas and on the upper reach, both for construction of houses and woodcraft, as a possible cause for the drying up of natural springs in Kengkhar. The Land Act 1979 was a major incentive for the farmers in remote place like this as it provided the legitimate rights to the plots they were cultivating, and it was during this time people started fencing, protecting and regularly cultivating their fields. Even today it is a common feature to see live fences with Jatropa (Physic nut: *Jatropha curcas*) or other commonly found shrubs. However, as people only had dryland fields, they grew local varieties of maize, chilli and beans. Household maintained 2-3 cattle heads, cows for milk and ox for draught power. In Kengkhar farmers use Mithun bulls to plough field with 3-4 males helping the ploughman.

As the number of households permanently residing increased people started to feel the insufficiency of drinking water. In 1980, the government, through the rural water supply scheme, provided materials (pipes and cement) to tap water from Mogola. Under this program, a network of tap-post was constructed. However, 2-3 years later the source was washed away by land slides and the scheme became non-functional. People abandoned the scheme including the tap-post (their remains can be seen in several locations now). The network of pipe water supply scheme in the area made people complacent, and they tend to ignore the natural springs and their catchment conditions. Some respondents reported of complete degradation of catchment above Rotapari spring pond when a land slide washed away the pond in 1983; even now the area has not been stabilized.

1990-2009: Semi-commercial agrarian systems

This period saw major social, political, and economic changes in the country. Among them the decentralization and empowerment of community to make decisions at local level gradually changed the way people managed their farms and resources. While people were made responsible to manage natural resources, government took up infrastructure development like building roads, irrigation schemes, schools and hospitals. With modernization and introduction of television, internet and mobile phones, the need to generate income from farming became a primary objective. Depending on the location, communities started specialized farming targeting the market. Another fundamental development during this period

was the democratization of the governance and involvement of local population is decision-making processes.

The south facing slope of Kengkhar is best suited for cultivating mandarin orange. The traders market oranges from Kengkhar in Pemagatshel. With the production potential and marketability of orange, DoA distributed free orange seedlings to the farmers. During 1990 almost all households received 5-10 seedlings to plant in their homestead. With the promotion of citrus, woodcraft and citrus became the principal livelihood sources for the *kengkharpas*. Even today, the lack of a motorable road has not deterred the people to painstakingly take orange in horseback to Pemagatshel and Mongar where they fetch substantial income. A major blow to the drinking water came in 1998 when the Mogola land slide completely washed the water source and pipes. With the land slide in Mogola and Rotpari, people had to go back to the natural spring ponds which were only used for livestock. With declining spring discharges, the water became a scarce resource as local farmers, government establishments and students had to depend on the same source. In 2002, agriculture research initiated rain water harvesting, wherein people constructed large tanks lined with plastic sheets to harvest rain water and people were trained on roof water harvesting in plastic jars. As a key development need for the community, Mongar district helped community to tap water from Larjap which is 17 km away. Due to its length and the course it follows along the ridge, the scheme was irregular with frequent breakdown putting pressure on people for maintenance. This massive investment did not ease the water problem and once again people had to go back to their old spring ponds. The democratic process initiated in 2008 provided an opportunity to people to collectively seek support from research and development agencies to resolve the issue. In 2009 the research centre in Wengkhar (near Mongar district town) helped the community to build concrete tanks to collect spring water and share it among the tanks by linking them in a network. This effort has also helped people to collectively restore the catchment areas for respective spring ponds and manage it sustainably. With the dwindling water resource, people of Kengkhar had expanded their practice of upland cropping and citrus have become a definite saviour for them which generates substantial household income.

Sequences of agrarian systems in *Kengkhar: Gradual agrarian system change*

The pace at which the transformations of the agrarian systems in Kengkhar occurred over the last 6 decades is spectacular. Prior to the 1950s, in the midst of primary forest, people practiced shifting cultivation and reared large herds of cattle. After government initiated official enumeration of population and registered the land they tilled, people gradually started sedentary farming using local varieties and traditional practices. The progression from subsistence farming to semi-commercial farming primarily happens to satisfy the social needs (Trébuil, 1989) influenced by the changing social, ecological, economic and political environment.

The transformations in Kengkhar were gradual (Table 2). In the early 1950s when the national level registration of citizens was done, elders narrate the presence of scattered households in most gentle slopes close to the natural spring ponds. In the middle of thick mixed-broadleaved forest there used to be 10-12 open space where people built houses and did farming. The practice of slashing and burning large tracks of forest during January to April was common. Now in his 70s, an elder respondent expressed with excitement the blazing fire line spread he watched at night. As the productivity of shifting cultivation was low, farmers looked for fertile patches in the forest, cleared and did farming there. Moving around with herds of cattle, everyone produced enough to sustain their livelihood. With nationalization of forest and land reform policy, the operational space for the community drastically reduced, and they gradually started cultivating their designated plots with low yielding traditional crop varieties. As the productivity of land was low and access to modern technology limited, people expanded the woodcraft trade and currently around 80% of households depend on woodcraft for their livelihood. With the small boom of the woodcraft industry linked to the expanding tourism industry at the national level, the major effect has been over harvesting of trees from the nearby forest. Opening the forest area in such terrain has accelerated drying of spring ponds and in some fragile areas land slides washed away spring ponds. As upland crops like maize and millets yields were low, with the support of the Department of Agriculture they introduced mandarin orange during the early 80s, which has now become the principal cash crop in Kengkhar. Currently 83% of households grow orange in areas ranging from 0.1 to 0.8 ha per household. Although there is no road connection to Kengkhar, yet people tirelessly bring their orange on mules to Mongar and Pemagatshel markets. Apart for economic benefit from orange, extension officials in the area say that orange plants have helped in increasing the tree cover. With the two principal sources of income, people now operate a semi-subsistence farm all striving to produce surplus for market. In the early 2000s, when the government decided to develop a major North-South national highway between Gyelposhing and Nanglam[6] (GNHC, 2008a) which passes along the Kurichu river at the lowest reach of Kengkhar, the community submitted a petition to the District requesting a farm road. Subsequently the area development project[7] agreed to support its construction in the 9th plan (2002-2007). As the construction of the national highway got delayed by 2-3 years, the construction of the farm road could only start in 2009. The success of citrus production and the established market for woodcraft are boosted with the approval of road. In fact since 2000, orange plantation on a small scale was taken

6 Nanglam is a Sub-district of Pemagatshel district and is an important town connecting to Assam in India.

7 An area development project under the MoAF – Agriculture Marketing and Enterprise Promotion Program (AMEPP) sponsored by the International Fund for Agriculture Development (IFAD) support most agriculture development activities in the Eastern region (6 districts in the East).

up by all households. There is one progressive farmer, who has devoted most of his area into a commercial nursery for citrus and *Boehmeria regulosa* (tree species preferred for making top quality *palang*-cask).

Table 2. Sequence of agrarian systems in Kengkhar, East Bhutan.

AS Variable components	1970		2000
	Subsistence	**Semi-subsistence**	**Semi-commercial**
Ecological events	Predominantly mixed-broadleaf forest with patches of grazing land and shifting cultivation plots	Conversion of forest areas into dryland fields. Shifting cultivation continue to exist. Many natural springs dry up	Land slides in 3 sites, forest density drastically reduced
Means of production	Local varieties, manual tools, traditional methods, burning of forest debris	Local and few improved varieties, farmyard manure, manual tools, draught animals	Mostly local with few improved varieties of citrus, maize and vegetables, farmyard manure, tools, draught animal
Techniques applied	Slash and burn in dryland fields, long fallows	Slash and burn with short fallow, monocropping of maize, fruit plantations	Double cropping of maize, citrus orchards and vegetable in dryland
Production	1 crop of maize (low yield) and millets (fox tail, and finger millets), supplemented with wild tubers and vegetables	Maize, citrus, millets and vegetables	Maize, potato, citrus, beans, chilli, mustard and radish
Demographic pressure	24 inhabitants/Sq km (12 HH estimate by village elders)	60 inhabitants/Sq km (30 HH in 1996)	104 inhabitants/Sq km (52 HH in 2009)
Marketing conditions	Bartering, family exchange, sell small amount of vegetable and fruits in the village		Use of mules to transport oranges, vegetables and wood crafts to Mongar and Pemagatshel

AS Variable components	1970		2000
	Subsistence	**Semi-subsistence**	**Semi-commercial**
Farm supplies (inputs, equipment)	Forest litter and compost carried manually/mules, farm tools locally made by village craftsman	Inputs supplied by District agriculture extension	Farm yard manure, improved seed supplied by extension staff, tools purchased from Samdrupjongkhar or Mongar
Rural credit patterns	No monetary credit system, exchange of input with labour		Agricultural credit available from BDFC
Land tenure patterns	Shifting cultivation plots self managed, user rights for grazing land	Large land holding by early settlers while small holding of resource poor farmers	
Labour market	Family labour, collective work in slashing and burning	Family labour still dominates; rarely wage labour from within community	
State interventions	Introduction of land ceiling, land grants to those landless and resettlement	Technical advice and material support from Agriculture Extension. Extension office in block. Drinking water supply	Subsidy, marketing support, credit and institutionalization of collective, construction of water supply and tanks
Farmer income, productivity	Non-monetized production, self sufficiency	Maize production predominantly subsistence, surplus commodities usually exchanged or bartered	Maize production predominantly subsistence, citrus, potato and vegetable for market
Extent of farm differentiation	Homogenous	Medium	Medium

CONCLUSIONS

The study distinctly brings out the gradual transformation of the farming systems in remote communities. For instance it took more than 15 years for all farmers to make the change. While the market demand for wooden mask, cask, altar, and late season citrus from Kengkhar is high, the lack of road and reduction of porters are deterrent to shift over a semi-commercial system. Although gradual the trend is picking fast, as government has approved a 5 Km farm road from Jimjurung to Tongla from where it is gentler and takes only 3 hours on foot to reach Kengkhar.

It is evident that accessibility to information, road, livelihood sources and external inputs/services has been a driving factor for the transformation. When farmers are not confident on the outcome of development efforts, they continue to maintain old practices. Some glaring examples are (i) 63% of the farmers still practice shifting cultivation despite the ban introduced in the 1980s and exclusion of this land use type in the record from 2007, and (ii) the presence of wooden trough next to the natural spring pond. The analysis and lessons of past agricultural transformations provide a prospect for application of a broad-based and all-inclusive research approach. Broad based as it should encompass all issues arising from the renewable resource in question and inclusive to include all stakeholders within the context.

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An analysis of rice varietal improvement and adoption rate by farmers in Bhutan

Mahesh Ghimiray[1]

ABSTRACT

Rice is an important food crop in Bhutan. However, the domestic production meets only about half of the national annual requirement of about 130,000 MT. The government aims to attain a higher (65%) self-sufficiency level in rice by increasing production through the use of high yielding varieties. This paper provides an insight into the history of rice variety development and the chronology of variety releases in the country. It also provides a summary of rice production systems and tracks productivity growth from late 1980s to 2010. National rice yield increased from 1.53 t/ha in 1989 to 3.18 t/ha in 2010. Since 1988, 23 rice varieties have been developed and released in Bhutan for the entire cultivation domain ranging from high to low-altitudinal zones. Levels of adoption of modern varieties by altitude zone were estimated by eliciting opinions from rice experts. A household survey was concurrently conducted to validate results of the expert estimates. Results of the expert elicitation showed that modern variety adoption at the national level was 53% which was slightly higher than 42% obtained from the household survey. Estimates of cultivar-specific adoption level showed a clear delineation of modern varieties grown in the different altitude zones. Khangma Maap, IR 64 and BR 153 were the most popular varieties grown in the high, mid and low altitude zones, respectively.

KEY WORDS: Modern varieties, Variety introduction, Breeding, Adoption rate, Expert estimation

INTRODUCTION

The cultivated area in Bhutan is only about 2.93%, including both wetland and dryland. Rice is indispensable in the Bhutanese culture, tradition, religion and farmers' livelihoods. More than 69% of the population is engaged in farming with rice and maize as the main crops. Although rice is not the largest produced cereal in the country, it is the most widely consumed cereal. The per capita consumption of rice is computed at 144 kg milled rice per year (PPD, 2010). Rice is grown in 22,550 ha (DoA, 2010) with a total production of 71,637 MT of rough rice. The national average rice yield stands at 3.18 t/ha. Domestic production of rice has not been able to meet the demand due to low productivity. The domestic production

1 RNRRDC, Bajo, Wangduephodrang; mghimiray@gmail.com

of rice meets only about 48% of the total requirement. The deficit is met from rice imports amounting to over 58,000 MT per annum from India. The insufficiency in rice stems from a number of factors such as limited wetland, use of low yielding traditional cultivars, low use of plant nutrients from inorganic fertilizers (9-11 kg of plant nutrients per ha) and limited irrigation water supply.

MATERIALS AND METHODS

The main objective of this paper is to analyze rice research and development that has taken place after R & D was started in the early 1980s. The focus of the paper however is on rice variety development and the spread of new varieties in the country. Literature reviews and desktop research were used to analyze and document the history of rice variety development. The technical annual reports of RNR RDC Bajo and other RDCs were the main sources of information. Variety release records provided the listing of officially released rice varieties for different rice agro-ecozones.

To determine the adoption rate of rice varieties by farmers, two different methods were employed. First, an expert panel to elicit the spread and adoption of modern rice varieties in Bhutan was organized in July 2011. Expert panel estimation is a quick and easy way for varietal adoption and diffusion. This approach is particularly relevant in a small system with limited resources such as in Bhutan. A total of 12 local experts participated in the meeting. They comprised of rice breeders (6) from different research centres, extension staff (3) of the Department of Agriculture, agronomist (1), seed expert (1) from the national Seeds Centre and one farmer representative. The meeting was facilitated by an expert from IRRI. Two sets of forms were used to gather information. The first form collected information on the percentage area grown to 10 top rice varieties and summarized the overall adoption rate of HYVs versus traditional varieties. The other form elicited information by rice agro-ecologies: high altitude (>1800 m), mid altitude (800-1800 m) and low altitude (<800 m) as commonly accepted altitudinal categorization in the country. Within an altitude zone, most popular varieties were also enlisted with their percentage area.

Second, a household survey was conducted to validate results of the expert panel estimates of varietal adoption. Eight main rice producing districts across altitudinal agro-ecologies were identified for the field work. This included Thimphu and Paro in the high altitude zone, Wangdue, Punakha, Trashigang and Monggar in the mid altitudes and Sarpang and Samtse in the low altitude region. According to RNR Stats 2009, the coverage of rice districts from where the samples were drawn added to 59% of the total rice area. Of the districts sampled, coverage in the high, mid and low altitude zones was 15%, 51% and 34% respectively. A multistage random sampling method was used, with 4 blocks (a group of villages) from each district, 3 villages from each block and 3 households from each village. This gave a total

sample size of 288 households. A standard questionnaire was developed and used. Data entry, validation and analysis were done using MS Excel jointly by RDC Bajo and IRRI. The data collected from the survey included: general information on the interviewee (gender, education level, land holding size etc), cultivation of improved varieties (name of the varieties, seed source, area grown), traits of the improved varieties, pest resistance), inputs used (fertilizers, herbicide) and some aspects of rice marketing.

RESULTS AND DISCUSSIONS

Rice production systems

Rice is grown from tropical lowlands (200 m) in the south up to elevations as high as 2700 m in the north. Because of Bhutan's rugged topography, rice fields are generally terraced. Rice environments are broadly grouped into three altitude zones which also reflect temperature regimes. The high altitude zone, also referred to as warm temperate zone, covers rice areas from 1,600 m and above. Low temperature at early vegetative stage of the rice crop characterizes this environment. Around 20% of the rice areas fall under this zone. The mid altitude zone which accounts for 45% of the rice areas has an elevation of 700 m to 1600 m. Its sub-ecologies are the dry and humid sub-tropical environments, the latter receiving more rainfall than the former (Javier, 2007). The remaining 35% is the low altitude zone (200 m – 700 m) concentrated in the southern part of Bhutan and also referred to as the wet sub-tropical zone. Rice agro-ecological zones are tabulated below.

Table 1. Rice agro-ecological zones of Bhutan.

Agro-eco zones	Altitude (m)	Rainfall (mm)	Districts	Major issues
Warm Temperate	Above 1600 up to 2700	650-850	Paro, Thimphu, Ha, higher altitude of Punakha and Wangdue and parts of other districts	Rice blast Cold sterility
Dry Subtropical	Between 700 up to 1600	850-1200	Wangduephodrang Punakha, Trongsa, Trashigang, Mongar, Lhuentse	Rice blast
Humid Subtropical	Between 700 up to 1600	1200-1500	Tsirang, Dagana, parts of Trashigang, Zhemgang and Chukha	Rice blast Sheath blight Poor soils

Agro-eco zones	Altitude (m)	Rainfall (mm)	Districts	Major issues
Wet Subtropical	Below 700	4000-5000	Samtse, Sarpang, and Samdrupjongkhar	Fungal diseases Insect pests Poor soils Lack of irrigation

Production and productivity trend

Table 2 summarizes data on rice area, production and productivity from 1989 to 2010. The area cultivated to rice ranged from 18432 ha in 2002 to a maximum of 27026 ha in 2006. Reasons for such a variation in annual cultivated area include lack of irrigation, farm labor shortage and wild animal depredation. Overall, the productivity has increased, so has the total rice production. From only 39790 MT in 1989 the total rice production has increased by 80% to reach 71637 MT in 2010. Research and development on rice has attributed to this increased production as improved rice technologies are adopted by farmers. The national average yield has risen from 1.53 t/ha in 1989 to 3.18 t/ha in 2010. The main factors contributing to the gain in productivity are the use of rice HYVs, improvement in crop management such as better land preparation, weed control and fertility management (Shrestha, 2004). It is estimated that HYVs outyield traditional varieties by at least 27% under similar rice growing conditions.

Table 2. Rice acreage, production and yield in Bhutan, 1989-2010.

Year	Area (ha)	Rough Rice Production (MT)	Grain Yield (t/ha)
1989	26010	39790	1.53
1990	26304	59449	2.26
1996	23777	65576	2.76
1997	23679	63065	2.66
1999	19374	44686	2.30
2000	18683	37868	2.03
2002	18432	37867	2.03
2003	19480	45805	2.35
2004	18634	54325	2.92
2005	24983	67606	2.71
2006	27026	74380	2.75

Year	Area (ha)	Rough Rice Production (MT)	Grain Yield (t/ha)
2007	27024	74438	2.76
2008	19124	77314	4.04
2009	23443	65763	2.81
2010	22550	71637	3.18

Rice varietal release patterns

In line with the Royal Government's policy of self-sufficiency in rice production, the introduction of modern rice varieties was begun in 1982 following the establishment of the then Centre for Agricultural Research and Development (CARD), now renamed as RNR Research and Development Centre at Bajo. Varieties and breeding lines from regional and international germplasm evaluation programs were tested for their adaptability and suitability to the Bhutanese agro-climatic conditions. Such an effort has resulted in the identification and release of 15 improved rice varieties, introduced from elsewhere, for various recommendation domains (Table 3).

Due to its uniqueness and specificity of growing conditions, rice varieties introduced from elsewhere often fail especially in the high and mid altitude zones. To overcome this problem and also to assimilate desired genes in Bhutanese local varieties for blast tolerance and high yields, a cross breeding program was started in 1995 with IRRI. The program has been highly successful and so far 8 rice varieties which combine genes for blast resistance, high yields and culinary traits (red color, medium amylose) have been released (Table 4).

Table 3. Introduced and released rice varieties

Designation	Local names	Year of release	Recommended Altitude zone (m)
IR 64	IR 64	1988	600-1600
Milyang 54	Milyang 54	1989	600-1600
IR 20913	IR 20913	1989	600-1600 Below 600
No 11	No 11	1989	Above 1600 600-1600
BR 153	BR 153	1989	Below 600
BW 293	BW 293	1990	Below 600

Designation	Local names	Year of release	Recommended Altitude zone (m)
Barkat	Barkat	1992	600-1600
Chummrong	Khangma Maap	1999	Above 1600
Khumal 2	Wengkhar Rey Kaap 2	2002	600-1600
Khumal 6	Wengkhar Rey Kaap 6	2006	600-1600
Paro China	Jakar Rey Naab	2006	Above 2600
APO	Bhur Kambja 1	2010	Below 600
IR 70181-5-PM1-1-2-B-1	Bhur Kambja 2	2010	Below 600
IR 72102-3-115-1-3-2	Bhur Raykaap-1	2010	Below 600
Karjat 3	Bhur Raykaap 2	2010	Below 600
OR 367-SP11	Wengkhar Reykaap 1	2010	Below 600

Table 4. Locally bred and released rice varieties

Parents Crossed	Local names	Year of release	Recommended Altitude zone (m)
Local Maap x IR64	Bajo Maap 1	1999	600-1600
Local Maap x IR64	Bajo Maap 2	1999	600-1600
Paro Maap x IR41996-118-2-1-3	Bajo Kaap 1	1999	600-1600
Bja Naab x IR41996-118-2-1-3	Bajo Kaap 2	1999	600-1600
YR3825-11-3-2-1//YR3825-11-3-2-1/Barkat	Yusi Rey Kaap1	2002	Above 1600
Suweon 359//IR41996-118-2-13/ Thimphu Maap	Yusi Rey Maap1	2002	Above 1600
Akiyutaka / Nam	Yusi Rey Kaap2	2010	Above 1600
Akiyutaka / Rey Maap	Yusi Rey Maap2	2010	Above 1600

The first modern rice variety to be officially released in Bhutan was IR 64 in 1988. This variety is still popular among farmers in the mid-elevation (600-1600 m) areas

for its high grain yield and cooking quality (medium amylose content) although a gradual breakdown of resistance to leaf and panicle blast has been recorded in recent years (Ghimiray, 2008). In 1999, four varieties were released of which only one (BR 153) was intended for the low altitude zone. It may be noted that the mid altitude zone was the focus of rice research and development in the 1980s and beginning of 1990s primarily because agricultural research started in this zone when CARD was created by the Ministry of Agriculture. In 1990, one more rice variety (BW 293) was released for the low altitude zone, however, this variety did not gain any popularity due to its short plant stature. It was subsequently denotified by the Variety Release Committee.

Rice double cropping in the mid altitude zone was introduced in the late 1980s and Barkat was released as a first crop variety in rice-rice sequence. After 1992, a long hiatus was observed in national releases until 1999 when five varieties were released. Of those five varieties, only one (Khangma Maap) was an introduction and the rest were all products of cross breeding using Bhutanese local varieties as parents for the first time in rice research history. Two more locally bred varieties (Yusirey Kaap1 and Yusirey Maap 1) which incorporated blast resistance genes in the native varieties were developed and released in 2002.

In the low altitude zone essentially a single variety (BR 153) was available for farmers for a long time. A large area (>60%) in the low altitude zone is rainfed, hence drought tolerance is an essential trait. To fulfill this need, two drought tolerant varieties (Bhur Kambja 1 and 2) were released in 2010 for the first time in the country. Three more varieties for the irrigated ecosystem were also released in addition to two more blast resistant varieties (Yusirey Kaap 2 and Maap 2) for the high altitudes. Released rice varieties have diverse genetic background (Javier, 2007) which is an important consideration in variety development.

Rice adoption rate

The results of the expert elicitation showed that MV adoption at the national level was 53% (Table 5). When compared with the findings of the study conducted by Shrestha (2004), adoption increased by 18% from 35%. The major expansion has taken place in the low-altitude southern belt where improved varieties are being actively promoted by the government. New varieties suited to this region have been developed and promoted. The lowest level of expansion is in the mid-altitude zone. The 2002 study also indicated that MVs are already widely adopted in the high-altitude zone and there have been further increases in the adoption of MV in this zone.

Table 5. Expert panel estimate of area under HYV

Zone	% share in total rice area	Expert estimate of area under HYV in 2010 (%)	Area under HYV based on a previous study in 2004 (%)
High	20	80	66
Mid	45	40	38
Low	35	55	17
All	100	53	35

Estimates of cultivar-specific adoption level derived from expert panel are presented in Table 6. A clear delineation of varieties grown in the different domain can be observed. Experts were able to identify the popular varieties grown in the different zones.

Table 6. Cultivar-specific adoption (%Area)

Varieties	Expert estimates		
	High	Mid	Low
Khangma Maap	50	0	0
Yusi Rey Maap	23	0	0
Yusi Rey Kaap	13	0	0
No 11	3	0	0
Jakar Rey Naab	3	0	0
IR 64	0	50	0
Wengkhar Rey Kaap	0	20	0
Bajo Maap	0	10	0
BR 153	0	0	70
Bhur Rey Kaap	0	0	10
Bhur Kamja	0	0	6
Other MVs	8	20	14

The varieties recommended by the Department of Agriculture and cultivated by farmers are specific to a given altitudinal zone. In the high altitude zone, Khangma Maap is the pre-dominant variety covering 50% area. This is followed by Yusi Rey Maap (23%) and Yusi Rey Kaap (13%). Other modern varieties grown are No 11 and Jakar Rey Naab. Khangma Maap is a red grained variety introduced from

Nepal and is known for its resistance to blast and cold tolerance. In the mid altitude zone, IR 64 is the most popular variety with 50% area coverage. Other varieties include Wengkhar Rey Kaap (20%) and Bajo Maap (10%). The low altitude area is dominated by BR 153 (an old variety from BRRI, Bangladesh) covering 70% area. A recent release for the low altitude belt, Bhur Rey Kaap (10%) and a rainfed variety Bhur Kambja (6%) are gaining popularity. Due to porous border with India, many HYVs (14%) from across the border are also grown by farmers. Overall, the most popular rice varieties are Khangma Maap, IR 64 and BR 153 in the high, mid and low altitude zones respectively.

The household survey was conducted in eight main rice districts across altitudinal rice ecologies to validate results of the expert panel estimates. A comparison of the results as shown in Table 7 indicates that the experts' perception of area grown to modern varieties matches well for the high and low altitude zones but not for the mid-altitude zone. The greater discrepancy for the mid-altitude zone probably is the result of expert panel composition which had inadequate representation of experts from this zone. This highlights the importance of ensuring that the expert panel includes people knowledgeable about specific zone as a way of reducing possible biases.

Table 7. Comparison of expert estimates and household survey results (%)

Zone	% share in rice area	Expert Estimate	Household Survey
High	20	80	83
Mid	45	40	19
Low	35	55	46
All	100	53	42

A comparison of cultivar-specific adoption estimated through expert panel and through household survey is insightful (Table 8). There is an apparent demarcation of varieties grown in the different altitude zones. Except for Wengkhar Rey Kaap and Sorbang in the mid-altitude zone, and IR 8 in the low-altitude zone, estimates of the adoption are close to the estimates obtained in the household survey.

Table 8. Cultivar-specific adoption (%Area)

	Expert estimates			Household survey			
	High	**Mid**	**Low**	**High**	**Mid**	**Low**	**All**
Khangma Maap	50	0	0	39	8	0	15
Yusi Rey Maap	23	0	0	28	0	0	10
Yusi Rey Kaap	13	0	0	2	0	0	1
No 11	3	0	0	19	8	0	8
Jakar Rey Naab	3	0	0	9	0	0	3
China 7	0	0	0	2	0	0	1
Janaam	0	0	0	2	0	0	1
IR 64	0	50	0	0	49	0	8
Wengkhar Rey Kaap	0	20	0	0	2	2	1
Bajo Maap	0	10	0	0	13	0	2
Sorbang	0	0	0	0	14	0	2
Zhung Bara	0	0	0	0	4	0	1
Bajo Kaap	0	0	0	0	2	0	0
Tsepo Bara	0	0	0	0	1	0	0
BR 153	0	0	70	0	2	57	28
Bhur Rey Kaap	0	0	10	0	0	13	6
Bhur Kamja	0	0	6	0	0	4	2
IR 8	0	0	0	0	0	13	6
IR 72102	0	0	0	0	0	5	2
Jaya	0	0	0	0	0	2	1
Pussa	0	0	0	0	0	2	1
IR 20913	0	0	0	0	1	1	0
Mansara	0	0	0	0	0	1	0
Radha	0	0	0	0	0	1	1
Other MVs	8	20	14	0	0	0	0

Overall, there was a good match between the expert estimates (53%) and the results of the household survey (42%) on the adoption of modern rice varieties. One problem that emerged was the low (19%) adoption rate from the household survey in the mid elevations compared to 40% estimate by panel experts. The mid altitude

zone has the largest share (45%) of the rice area and the sampled area may not have been adequate. A relook at the sample size and the data collected will be useful.

Within varieties, the estimation from the household survey for Wengkhar Rey Kaap was low (2%) as against experts' view of 20%. This variety is confined to the eastern region of the country where only two districts were sampled and this may not have captured the entire spread of the variety. In the low altitude belt, the household survey captured many more modern varieties (IR 8, Jaya, Pusa, Mansara) than the experts thought of. There is a varietal inflow from across the Indian border and it is common to find farmers adopting such varieties even if they are not officially released in the country.

CONCLUSIONS

Rice is the most important food crop grown in Bhutan from about 200 m to an elevation of 2700 m in four major agro-ecological zones ranging from warm temperate to wet subtropical region. In 2010, rice was grown in 22550 ha producing 71637 MT of rice with an average productivity of 3.18 t/ha. The total domestic production met only 48% of the national requirement in 2010.

One of the ways to increase rice production in the country has been to develop HYVs for all the rice growing environments. Rice research and development started in 1982 when CARD was established and technical collaboration with IRRI formalized in 1984. Rice variety development began with introductions mainly from IRRI in the 1980s and the evaluation and adaptation to local growing conditions. Concurrently, a rice breeding program was also initiated to genetically improve the local varieties for grain yield, disease tolerance and culinary traits. Official release of rice varieties started in 1988 with IR 64 as the first variety to be released. So far, a total of 23 rice varieties have been developed and released by the rice research program. Of the total, 15 varieties are introductions and 8 have been developed locally. The varieties cover the entire cultivation domain ranging from high, mid to low altitudinal zones.

An adoption study in 2004 showed that improved rice varieties covered 35% of the total area. To update the data on varietal spread, two more studies were commissioned in 2010. Results of the expert elicitation showed that modern variety adoption at the national level was 53%, an increase of 18% from 2004. The low-altitude wet sub-tropical zone saw a major expansion of variety development and promotion activities, whereas the mid-altitude zone reached almost a saturation point. The household survey results showed an overall adoption rate of 42%, slightly lower than the expert estimate. Rice varieties are specific to altitudinal regimes. In the high altitudes, the most widely adopted varieties were Khangma Maap (39%) and Yusi Rey Maap (28%) according to the household survey. IR 64 with 49% adoption

rate and Bajo Maap (13%) were popular varieties in the medium altitude zone. In the low altitude belt, BR 153 (57%) was predominant followed by Bhur Rey Kaap with 13%. Overall, a good progress has been made in rice research and development considering the limitations of resources in the system.

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Assessment of blast resistance on rice varieties in Bhutan

Tashi Uden[1]

ABSTRACT

Rice blast is known to a serious problem in rice growing areas; the outbreak of rice blast disease in Bhutan in 1995 affected all rice growing areas. This study was conducted in six locations in Punakha, Thimphu and Paro Dzongkhags using trap nursery boxes to determine blast resistances among local and released rice varieties. Twenty five traditional and improved rice varieties were grown in the nursery box. The boxes were placed in farmers paddy fields when rice seedlings were at three to four leaf stages, and at least 30 plants per variety were analyzed for blast resistance and severity per location. Most varieties were infected by blast in one mid-altitude nursery and two high altitude nurseries. There was no disease incidence in one of the high altitude site. A high level of heterogeneity in resistance was detected within and among varieties. Most of the traditional varieties including IR 64 and No.11 had mixed reactions. Susceptible varieties were affected wherever the environment was conducive. Recommendations were formulated to improve composition of trap nursery for elaborate and meaningful evaluation of varieties for resistance and diversity of pathogen population. Some critical research needs are recommended to better understand the epidemiology of blast disease especially with regards to role of seed and straw as initial inoculums.

KEY WORDS: *Rice blast, Resistance, Susceptibility, Trap nurseries,*

INTRODUCTION

In Bhutan, rice blast disease outbreaks in 1995 caused loss of 1099 metric tons of milled rice from the valleys of Punakha, Wangdue, Thimphu and Paro (Ghimiray *et al*., 2008). It affected mostly traditional cultivars in the high (1800–2600m) and some parts of mid altitude (1200–1800m) rice areas. The disease was reported from field where irrigation water enters the field, shady and where free circulation of wind is absent. In the high altitude, rice blast is not observed in nurseries but especially in transplanted fields after tillering.

There is very little information on blast disease resistance of traditional and improved released varieties cultivated in Bhutan. The only tests for disease resistance for a few varieties have been conducted at International Rice Research Institute (IRRI) with Philippine blast isolates (Chhetri, 1992) but the results of such tests are of

1 National Soil Service Centre, Semtokh; tashiu@yahoo.com

little relevance to Bhutan because of likely genetic differences in the pathogen populations and the growing environment between the Philippines and Bhutan. Thus, assessment of the relevant genetic diversity within Bhutanese germplasm is important if they are to be used as parent material for varietal improvement.

Therefore, the study was carried out to determine if resistances to rice blast are available in locally grown cultivars that could be of used for resistance breeding.

MATERIALS AND METHODS

The study was conducted in six locations covering Punakha (Kabesa & Goenshari), Thimphu (Genekha & Khasadrapchu) and Paro (Tshendona & Bondey).

Twenty five rice varieties were raised in 18 wooden boxes with internal dimension of 50x45x12cm^3. The varieties that had germination percentage below 80% were retested to ensure uniform plant population in wooden boxes. Seedlings raised in wooden box were thinned to 10 per variety and placed in field at three to four leaf stages. The experimental boxes were placed in farmers' field coinciding with time of tillering stage of paddy in farmer's field. The *Zechum* variety collected from high altitude area was used as susceptible check and to attract blast inoculums in nursery box

Fig. 1: Experimental box outside green house

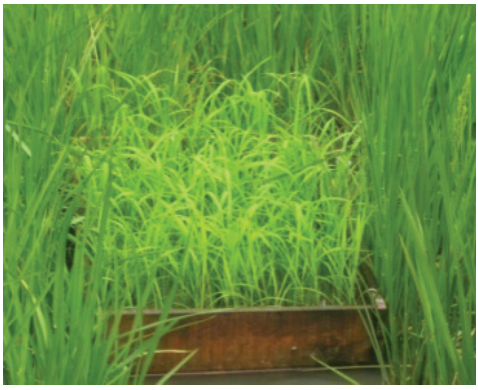

Fig. 2: Experimental box in farmers' field

Blast disease was observed fortnightly after the placement of nursery boxes in fields. Each plant in nursery box were examined and scored for infection based on IRRI (1998) Standard Evaluation Scale. Leaf blast severity based on the % leaf area covered by lesions was estimated visually with the aid of a pictorial chart for estimating blast severity in field (IRRI, 1996).

Data was analyzed using SPSS 16 package. There was no uniform resistant or susceptible reactions of varieties tested, reaction index was used to calculate reactions of varieties to blast disease as: The percent R (resistant), MR (mixed reaction), and S (susceptible) were multiplied with corresponding assigned values: 1 for R, 2 for MR and 3 for S reactions, respectively and their sum product, divided by 100, was used as resistance index. The index could thus vary between 1 (all plants R) and 3 (all plants S). If one allows for 30% of the susceptible plants to escape infection, the index reduces to 2.4 ([70 x 3 + 30 x 1]/100). Allowing for some MR reactions in addition, a resistance index above 2.2 may therefore be interpreted as a generally susceptible reaction which cannot be distinguished with our testing conditions from a mixtures of some resistant with many susceptible plants. If, on other hand, 90% of the plants are resistant with only 10% (i.e. 3 out of 30 plants, e.g.) susceptible, the index is 1.2 ([10 x 3 + 90 x 1]/100).

RESULTS AND DISCUSSIONS

Occurrence of blast in experimental nurseries

Blast occurrence in the nurseries differed greatly between locations. In Thimphu locations, blast was present in Genekha and not present in Khasadrapchu; even susceptible check (Zechum) was not infected at Khasadrapchu site. Information from Khasadrapchu site, therefore, is not included in the analysis. In Punakha and Paro, blast was present in all the locations. The mean number of varieties attacked causing distinct susceptible reaction varied among locations with the highest number of varieties attacked in the high altitudes locations at Genekha and Bondey (3S each, Table 1) on high altitude varieties, and mid altitude site at Rimchu 1 on international differential (3S, Table 3). None of the varieties from mid altitude in the experimental nurseries showed distinct susceptible reactions, although some showed mixed reactions (Table 2).

Reactions of high altitude varieties

Zechum, a land race from high altitude showed mostly susceptible reaction at all locations except at two locations (Table 1); *Dumja*, a landrace from Paro showed susceptible reactions at two locations, mixed reaction at three locations and resistant reaction in one site. Two varieties from high altitude (*Guojing 4 and Chumroo*) were mostly resistant at all locations, except at Rimchu where some plants showed mixed reaction. *Rice No 11* and *Paro China*, that are very popular and widely cultivated in high altitude showed clear susceptible reaction at some locations whereas *Gyemja* was susceptible only at one site (Table 1).

Table 1. Reactions of varieties from high altitude to blast disease at different locations

High altitude varieties (1800-2600 m)	Locations				
	Rim 1	Rim 2	Genekha	Bondey	Tsendona
Zechum	S (2.4)	S (2.23)	S (2.53)	S (2.6)	MR (2.2)
Dumja	S (2.4)	MR(2.2)	MR (1.6)	S (3)	MR (2.1)
Rice No 11	MR(2.1)	S (2.3)	MR (1.7)	S (2.6)	MR(2.2)
Paro- china	R (1)	R (1)	S (2.3)	MR(1.2)	MR (1.2)
Gyemja	MR(1.5)	R (1)	S (2.5)	R(1)	R(1.1)
Guojing 4	MR (1.2)	R (1.1)	R (1)	R (1)	R (1)
Chumroo	MR (1.6)	R (1.1)	R (1)	R (1)	R (1)
Total Susceptible reaction (S)	2	2	3	3	0

Figure in parenthesis are reaction index (<1.1 is Resistant (R); 1.2-2.1 is Mixed Reaction (MR); >2.2 is Susceptible(S)

Reactions of mid altitude varieties

Among varieties collected from mid-altitude, improved varieties IR 20913, Bajo Maap 1 and BK-1 showed uniform resistant reactions at all locations (Table 2). For other varieties from mid altitude, reactions are mostly resistant and mixed reactions. IR 64, an improved popular variety was uniformly resistant but showed mixed reactions in two locations.

Table 2. Reactions of varieties from mid altitude to blast disease in different locations

Mid altitude landraces[1] and improved varieties (1200-1800 m)	Locations				
	Rim 1	Rim 2	Genekha	Bondey	Tsendona
Nabja[1]	R (1.1)	MR(1.6)	R (1)	R (1)	R (1)
Tan tshering[1]	R(1)	MR(1.2)	R (1)	R (1)	R (1)
Karjet[1]	R (1.1)	MR(1.2)	R (1)	R(1)	R (1.1)
IR-64[2]	R (1)	MR(1.3)	MR (1.3)	R (1)	R(1)
IR-20913[2]	R(1)	R (1)	R (1)	R (1)	R (1)
BK-1[2]	R(1)	R(1)	R(1)	R (1)	R (1)

Mid altitude landraces[1] and improved varieties (1200-1800 m)	Locations				
	Rim 1	Rim 2	Genekha	Bondey	Tsendona
BK-2[2]	R (1)	MR(1.2)	MR(2)	R (1)	R (1)
Bajo Maap 1[2]	R (1)	R (1)	R (1)	R (1)	R (1)
Bajo Maap 2[2]	R(1)	MR(1.3)	MR (1.3)	R (1)	R (1)
Macha Pachery[2]	MR(1.3)	R (1)	MR (2.1)	R (1)	R (1)
B2983 B[2]	R (1)	MR(1.3)	MR (1.6)	R (1)	R (1)
Khangma Maap[2]	R (1.1)	MR(1.2)	R(1)	R (1)	R (1)
Total susceptible reaction (S)	0	0	0	0	0

Figure in parenthesis are reaction index (<1.1 is Resistant (R); 1.2-2.1 is Mixed Reaction (MR); >2.2 is Susceptible(S); [1]Commonly cultivated land races in mid altitude (Punakha and Wangdue) rice growing areas; [2]Improved varieties released by RDC-Bajo

Reactions of IRBL differentials

Four IRBL differentials (IRBL a-A, IRBL-K60, IRBL G-C, IRBL 1-F5) showed at least one susceptible reaction, and two IRBL differentials (IRBL 5-M and IRBL 2-F4) did not show any clear susceptible reaction at all the locations, and the IRBLa-A showed susceptible reaction in three out of six locations (Table 3)

Table 3. Reactions of IRBL differentials to blast disease at different locations

International differentials	locations				
	Rim 1	Rim 2	Genekha	Bondey	Tsendona
IRBLI-F5	S (2.6)	MR(2.2)	R (1.0)	MR (2)	MR (1.4)
IRBLG-C	MR(2.1)	S (2.7)	MR (1.6)	R (1.0)	MR (1.5)
IRBL-K60	S(2.3)	MR(1.8)	MR (1.7)	S (2.7)	MR (1.9)
IRBL2-F4	MR(1.4)	MR(1.2)	MR (2)	R (1.0)	R (1.0)
IRBL5-M	MR(2.1)	MR(1.7)	MR (1.6)	R (1.4)	MR (1.3)
IRBLa-A	S (2.3)	S (2.2)	MR (1.4)	S (2.9)	MR (2.0)
Total susceptible reaction (S)	3	2	0	2	0

Rim 1= Upper Rimchu. Rim 2 = Lower Rimchu; Figure in parenthesis are reaction index (<1.1 is Resistant (R); 1.2-2.1 is Mixed Reaction (MR); >2.2 is Susceptible(S)

Severity of leaf blast in the experimental nurseries

Mean leaf blast severity (% leaf area affected) of 25 varieties in nurseries were compared and analyzed with Duncan's Multiple Range Test (DMRT) at 95% confidence level (Table 5). Zechum, Dumja and IRBL G-C were most severely affected (% mean severity ranged from 15.68%-18.55 %). Two varieties from mid altitude (IR-20913 and BK-1) were not infected. For other varieties from mid altitude mean disease severity ranged from 0.01 to 2.15 %.

Table 4. Mean leaf blast (MLB) severity of rice varieties tested in six locations

Varieties	MLB severity	Varieties	MLB severity	Varieties	MLB severity
IR-20913	.0000[a]	IR-64	1.89[abc]	Chumroo	5.56[c]
BK-1	.0000[a]	Bajo Maap-2	1.98[abc]	Paro-china	10.50[d]
Nabja	.0111[a]	BK-2	2.15[abc]	IRBLI-F5	10.82[d]
Karjet	.0500[a]	Rice No 11	3.58[abc]	IRBL5-M	11.00[d]
Tan Tshering	1.11[ab]	IRBL2-F4	3.63[abc]	IRBLa-A	11.76[d]
Bajo Maap-1	1.12[ab]	Macha Pachery	4.50[bc]	IRBLKP-K60	12.97[de]
B2983 B	1.23[abc]	Gyemja	4.61[bc]	IRBL G-C	15.68[e]
Khangma Maap	1.66[abc]	Guojing-4	5.30[bc]	Dumja	18.11[ef]
				Zechum	18.55[ef]

Means followed by same upper letter are not significantly different from each other (p <0.05) DMRT

Site conduciveness for blast disease

Upper Rimchu has highest amount of disease (20.50 %) that is significantly different from all other locations (Table 6); Genekha is the second most conducive site (10.51 %), and least conducive site is Khasadrapchu where none of varieties were affected by blast disease.

Table 5. Comparison of Mean blast disease severity (%) in six different locations

Location	Means disease severity
Khasadrapchu	0.00[a]
Tsendona	0.63[a]

Location	Means disease severity
Bondey	1.07[ab]
Lower Rimchu	2.81[b]
Genekha	10.51[c]
Upper Rimchu	20.50[d]

Means followed by same upper letters are not significantly different from each other (p<0.05), DMRT

Discussion

Heterogeneity of varieties

This study suggest that in Bhutan rice varieties have evolved differently in different ecological zones and have acquired inter and intra population diversity with levels of blast resistance generally higher in varieties from the mid and low altitudes than in varieties from the high altitudes. Similar landrace diversity has been observed in Pearl millet populations in Africa in their resistance to Downy mildew (caused by *Sclerospora graminicola*. Sacc.) (Quendeba *et al*., 1995), and in resistance in wheat, oat and barley populations to different rust pathogens of these crops in Israel (Browning, 1974).

Observation of different lesion types on different plants of same variety could be due to inadequate infection success or to genetic variation in host, as near-isogenic lines (IRBL differentials) and introduced improved varieties (BK 1, IR 20913, Bajo Maap 1) were generally found to be uniformly susceptible or resistant, while populations of Bhutanese varieties were variable in resistance to the same pathogen population. From this it is reasonable to conclude that at least part of the variability in reactions within the Bhutanese materials was due to intra-varietal diversity for blast resistance. It could also be due to the fact that farmers in Bhutan do not select for uniformity in resistance. The only selection they do is seed size and weight. It is difficult to state reason as to why they do not select for resistance. It may be that they are not aware of concept of resistance. Few plants damaged in their field do not worry farmers. The present seed storage conditions are also likely to contribute to mixing of seed unknowingly.

Environmental effects on selection for resistance

Variation in climate and soil have direct and indirect effects on host diversity, and landraces of agricultural crops have developed under natural selection exerted by climatic and other stress conditions in the region of origin together with more or less conscious selection by the farming community (Fischbeck, 1997). By providing more or less conducive conditions for disease, climate and soil may also affect

host-pathogen interactions and the evolution of resistance/virulence. For example, Trutmann *et al*. (1993) assessed the amount of resistance in beans to anthracnose caused by *Colletotrichum lindemuthianum* in local farmer's mixtures using farmers bean seed collected from three different altitudes. Their studies showed that a large percentage of varieties in traditional mixtures had resistance to *C*. *lindemuthianum* and percentage of resistance in mixtures increased greatly with altitude and prevalence of anthracnose.

Absence of blast disease at Khasadrapchu site may be due to unfavorable conditions such as lack of accumulated dew period and optimum temperature that are essential requirement for successful infection. For sporulation and infection of blast pathogen, long dew period more than 16 hrs and temperature around 20-25 ^{0}c are required (Ou, 1985).

Mid altitude nursery at Rimchu has highest amount of disease affecting highest number of varieties in nursery. The varieties (e.g. *Tan Tshering and Nabja*) selected from same rice growing environment (mid altitude) are not attacked in the nursery in mid altitude. This suggests that blast pathogen is always present in mid altitude where the environment is favorable throughout the season but due to continuous selection pressure by pathogen resistant hosts is also selected. These observations also show that selection for resistance occurs in environments which favor pathogen populations and selection is occurring especially at the seedling stage where susceptible seedlings are killed.

IR 64 is generally resistant to blast in Philippines but IR 64 collected from RDC Bajo was found susceptible to blast in some sites. The observed susceptibility could be due to pathogen adaptation or to contamination of seed in the farmer seed storage. No. 11 was introduced from Japan in 1970s because of its cold adaptation and high yield. However, in 1995 when there was blast epidemic No. 11 was affected in some places in Punakha. Such variation in reaction suggests that variety is no longer pure as originally introduced and increasingly becoming adapted to local conditions. Some form of seed mixing may also be taking place in field and in farmer's store.

Usefulness of nursery box screening

It is possible that disease expression measured in nursery box may not be representative of that experienced in bigger field. Differences in growth conditions in nursery box and field may also affect susceptibility. However, infield disease avoidance or escape resistance also operates, thus if plants are unlikely to encounter disease in field, classifying the plant as susceptible based on forced contact with pathogen in nursery box may not be ecologically relevant. For efficient identification of varietal resistance both screen house test and field evaluation should be used together but evaluated separately (Ezuka 1972). Thinlay *et al*. (2000) found, for

example, LTH NIL (F145-2) resistant in nursery box in screen house but it was attacked in two field locations in mid altitudes of Bhutan, which supports argument that both methods of screening are indispensible.

The resistances identified in Bhutanese varieties are seedling resistances only. Field observation indicated that variety such as *Zechum* from high altitude that had been susceptible in seedling stage in greenhouse were also susceptible during later growth stages in the field. On other hand, seedlings of *Tan Tshering* from mid altitude were resistant in nursery box and in field as adult plants.

CONCLUSIONS

The considerable variation in resistance of Bhutanese rice varieties and site conduciveness to blast disease presents an enormous opportunity for resistance varieties selection. This opportunity has not been explored in the past as rice varietal improvement was made mostly through introduction of germplasm. Therefore, below we provide an outline for an approach for the improvement of resistance to blast within Bhutanese varieties that are already adapted to specific target environments, in this case the high altitudes.

Among high altitude varieties there are some fairly resistant varieties, e.g. No. 11, *Chumroo*, and *Guojing* 4, that can be used as donor for resistance genes for use in the high altitudes. Environmental conditions under which the varieties are grown need to be carefully determined by talking to farmers and observation. The farmer who owns the variety is requested to prevent destruction of the crop by cattle or wild animals. At the time of harvest, healthy single panicles from different parts of the field should be collected and stored separately. A bulk sample should also be collected.

Selection has to be done by inoculation under controlled conditions together with field screening. If the target for deployment of such variety is in the high altitude where neck/node blast is more important than leaf blast then screening has to include the whole growth cycle to select for resistance to neck/node blast in addition to leaf blast. When performance of a selected parent is satisfactory the next stage is seed production and crossing with a suitable matching parent. For the high altitudes, the matching recipient parent must possess characteristics similar to the donor parents to prevent problems of infertility and adaptation. The progeny of crossed material should be monitored for resistance and other characteristics. This process will involve considerable time before release of materials to farmers.

However, in contrast to introduced varieties, materials developed in the manner outlined above are more likely to be acceptable in taste and straw production to

the local growers. In addition, such germplasm should allow for the continuous adaptation and admixing of local materials thus insuring at least some degree of preservation of local germplasm rather than indiscriminate replacement by introduced alien varieties and subsequent loss of genetic resources. Trap nurseries are useful as means to check seedling resistance of important commonly cultivated varieties in different places and monitor change in the virulence of pathogen populations over space and time. As rice improvement programs accelerates and when new varieties are released it is important to monitor the pathogen populations in the fields where released varieties are cultivated. For this purpose trap nurseries method offer best option to monitor changes in virulence of the pathogen population because in Bhutan it is often difficult to raise field nurseries due to unavailability of land in farmers field. Trap nurseries can be raised in wooden boxes which can be transported easily provided it is not very heavy; however, the optimal composition of varieties for the trap nurseries should be worked out.

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Assessment of marigold as a trap crop and insecticide in reducing fruit borer (*Helicoparva. armigera*) incidence on tomato crop

Phuntsho[1]

ABSTRACT

To assess the effectiveness of marigold as a trap crop and insecticidal spray in borer incidence reduction, an experiment was conducted in farmer's field in Masangdaza village. Result showed mean larval incidence in control the highest and was significantly different from insecticidal(Malathion 50EC) spray ($p<0.05$) Mean number of borers recorded per marigold flowers was 3.4 out of which the mean numbers of flowers per plant was 36.3. Significant difference in mean fruit damage was observed between control and marigold and sprays with $p<0.05$. There was no significant difference between marigold and malathion sprays. Highly significant difference ($p>0.05$) in mean yield per plant between control and marigold was observed. Results found that marigold is a good trap crop and can reduce the use of insecticides. Therefore, this study focused on comparing borer incidence in tomato plants where marigold was planted as trap crop against the use of insecticide. To create awareness of the farmers on their problem, the study was conducted in farmer's field in Saling geog, Mongar Dzongkhag.

KEY WORDS: Tomato, Fruit borer, Marigold, Trap crop, Insecticidal spray, Incidence, Yield.

INTRODUCTION

With the growing Bhutanese urban population, the demand for tomato has increased. Thus, large volumes of tomatoes are imported from India. Import figure of horticulture data-base (DoA, 2004-2009), showed an import volume of 1,605.12 and 1,998.77MT respectively. Looking at this import trend, tomato has a very high potential and good market and is a promising crop for rural income generation. While the import volume and value increases, there is a potential domestic as well as export market in India during off season. However, tomato production is mainly constrained by the incidence of fruit borer (*H. armigera*). It is claimed to be one of the most destructive pests causing huge yield losses by boring in the tomato fruits and rendering them unmarketable. Yield losses due to this destructive pest in India ranges from 5-85% (Hussain and Bilal, 2007). In Bhutan, to address this problem,

1 RNRRDC, Wengkhar; khengphuntsho@yahoo.com

insecticides are generally being used but it is not in keeping with government's policy of using clean agriculture practices and advocating organic farming practices.

Studies in other countries show that use of trap crops like marigold (*Tagetes erecta*) help to reduce the incidence of this pest (Hussain and Bilal, 2007). Type of marigold used for the experiment is tall African marigold (*Tagetes erecta*) known as *Seyshey metho* in Dzongkha and *Sai Patri in* Lhotsham (Grierson and Long, 2001). Use of trap cropping technology through use of marigold is a small component of organic practice of pest management, yet it is more holistic and a noble approach of sustainable agriculture farming. Therefore, this study focused on comparing borer incidence in tomato plants where marigold was planted as trap crop and chemical control of pest by the use of malathion. To create awareness of the farmers on their problem, the study was conducted in farmer's field in Saling geog, Mongar Dzongkhag.

MATERIALS AND METHODS

Field experiment was conducted in Masangdaza under Saling geog in Mongar located an altitude of 780 m a.s.l. Complete randomized design (CRD) with three treatments in three farmers field as replication was used. A plot size of 3.0m x 4.0m was used to plant 25 tomato seedlings.

Marigold seedlings were raised in the month of June followed by tomato in July to synchronize flowering. Five beds of 0.5m x 4.0m were prepared leaving 0.3 m gap. 20 days old tomato and 45 days old marigold seedlings were simultaneously transplanted in the field. Row to row and plant to plant distance for tomato was maintained at 75cm and 50cm respectively. For marigold plant to plant distance of 30 cm was maintained. Spray was done during third week of September after the onset of fruiting, a week prior to observation and data recording. The insecticide used was Malathion (50 EC) at the rate of 2ml/litre of water.

Data on larval incidence, fruit damage and yield per plant were collected. 5 plants were randomly selected and tagged for observations. Data analysis was done using one way ANOVA (SPSS 16). The treatment effect was tested and compared using multiple comparisons on Post Hoc (DMRT).

RESULTS AND DISCUSSIONS

The table 1 below gives the effect of different treatments on mean larval incidence, fruit damage and yield.

Table 1. Effect of different treatments.

Treatments	Mean Larva incidence/plant	Mean Fruit damage incidence/plant	Mean Yield/ plant
Insecticide spray	0.73	1.8	1864.7
Marigold	0.93	2.1	1829.4
Control	1.53	3.93	1351.5

The results showed that mean larval incidence in tomato treated with marigold and insecticide were less compared to Control treatments. (Fig.1). There showed significant difference ($p<0.05$) between control and insecticide spray in mean larval incidence. However, there was no statistical significant difference ($p>0.05$) in mean larval incidence between control and marigold treatment, and between marigold and insecticide treatment. Result showed significant ($p<0.05$) difference of mean yield per plant between control and marigold, control and insecticidal sprays. Significantly higher yield was shown in insecticidal sprays. Result also revealed that there was no significant difference between marigold and insecticidal sprays ($p>0.05$) where ($p=.751$).

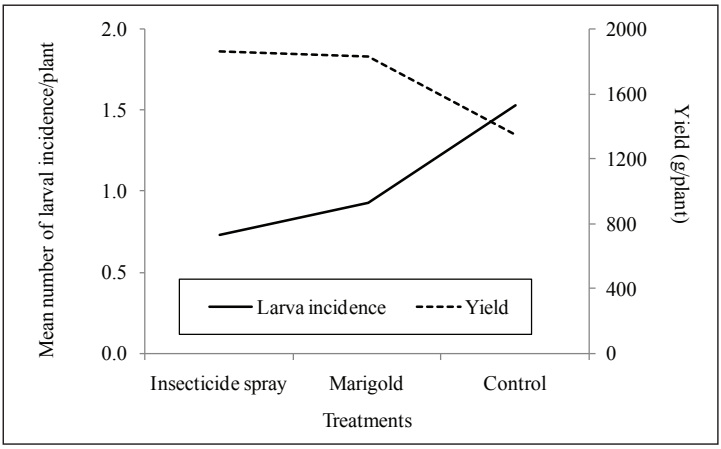

Fig. 1: Effect of larval incidence with yield

Effect of fruit damage incidence with yield

Treatment of marigold (trap crop) showed significantly less fruit damage compared to control (Figure 2). Significant difference ($p<0.05$) of mean fruit damage was observed between control and insecticidal sprays ($p=0.037$). Mean of damaged fruits between marigold and sprays revealed no significant difference since at $p=0.693$ (Figure 2). Low fruit damage incidence and high yield was observed in the

two treatments (marigold & insecticide) (Figure 1). Contrary to the treatments, the control showed high larval incidence and low yield (Figure 1).

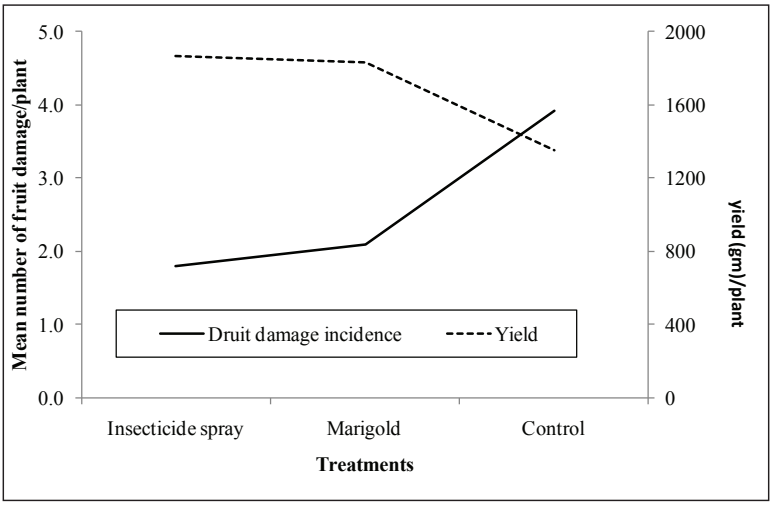

Fig. 2: Effect of fruit damage with yield

Discussion

The success of use of marigold (*Tagetes erecta*) as trap crop for the management of tomato fruit borer is very much known in India. Moorthy and Kumar (2004) reported that many tomato farmers grow marigold around the crop and also market the marigold flowers. Srinivasan *et al*. (1994) also evaluated the possibility of using okra, field bean, pegionpea, sunflower, maize and tall African marigold as trap crops for the management of fruit borer (*H.armigera*) on tomato. Their result indicated that, use of tall African marigold afforded maximum reduction of both eggs and larvae of *H.armigera* in the intercropped tomato with a consequent reduction in the number of bored fruits. They reported that use of other crops as trap crops were found ineffective because they were less preferred and also because in these crops, did not synchronize flowering with tomato . Hussain and Bilal (2007) during their study on use of marigold as the trap crop on different planting combinations reported to have observed marked difference between sole crop and intercropped marigold with tomato (p=0.05). Gundannavar *et al*. (2007) during their study on *H. armigera* management on chili, revealed that population density of fruit borer at different intervals of 70, 85 100 and 115 days after transplanting was significantly less in marigold treated as a barrier crop around each plot.

The result of the present study reveals that use of marigold was as good as the use of insecticide which is not in line with the policy of using clean agricultural practices. Therefore the usefulness of marigold as trap crop as shown by this experiment is in line with the similar studies carried out in India.

Ragunathan (2001) reported that economic threshold level (ETL) of borer for plant is one larva or one damaged fruit per plant. Surulivelu and Kanan (2003) also mentioned that the economic threshold level for *H. armigera* is one larva per plant or 5% damage of fruiting bodies. In control, mean of damage fruit per plant has crossed the economic injury level of one damaged per plant as per the above mentioned literature. However, in the case of two treatments (chemical and marigold), it was observed that both economic threshold level and economic injury level were not crossed.

However, use of malathion as an effective means for control of *H. armigera* as shown in the present study is not in keeping with government's policy of advocating organic farming practices. Tay *et al*. (1984) in Jipanin *et al*. (2001) reported that use of agro-chemicals is associated with numerous problems such as accidental poisoning to man, upset of natural environment balance and toxic residues that are hazardous to health and the environment. Treatment of marigold which was found effective as compared to control is found useful and compatible with strong government policy of organic agriculture farming practices.

Other attributes of marigold use as a trap crop enables to serve as a sink for other insect such as thrips and aphids. Observation of large numbers of thrips and aphids inside the marigold flower gave the clear evidence on efficiency and effectiveness of marigold as a trap crop apart from attracting fruit borer. Skinner (2009) stated that thrips are being attracted to the marigold flower much ahead than on the main crop and therefore helps growers to save time and money by planting marigold as an indicator plant for early detection. Thus use of marigold as trap crop demonstrated as an effective tool for the pest management thereby proving sustainable, ecologically and environmentally sound, and socially acceptable for the Bhutanese farmers.

CONCLUSIONS

This study compared the effect of marigold as trap crop and chemical sprays against the borer and tried to confirm the general claim that marigold is very useful as a trap crop for tomato fruit borers management. Larval incidence, damage incidence and yield parameters were used to assess the potential of marigold as trap crop. Low larval incidence and high yield was observed in the two treatments (Marigold & insecticide) compared to the control. The study concluded that use of marigold as trap crop showed significant yield increase and low larval incidences. Contrary to the marigold and malathion spray treatments, the control showed high larval incidence and low yield. This study found that marigold used as a trap crop is as effective as malathion thus indicating marigold to be a good trap crop. Hence, Marigold trap cropping has the potential to reduce the use of insecticides (Malathion) which is in line with the promotion of clean agricultural practices. However, for further

validation of the findings, it requires similar investigation during spring season with similar experimental design, treatments and conditions.

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Economics of mechanizing rice cultivation at RNRRDC Bajo

Yeshey[1]

ABSTRACT

Rice production is the livelihood of 69% of Bhutanese farmers. Currently rice is cultivated in 56375 acres with a national productivity of 1271 kg/acre (RNR Statistics, 2010). The quantity produced (7,637MT) is not adequate to meet the requirements of the people and therefore a substantial amount (58000 MT) is imported from India. Bhutanese rice production therefore, still needs to be increase to feed the expanding population. However, rice cultivation being labour intensive, increasing rice production with labour shortage as nationwide problem is challenging. The scarcity of manual labour and the drudgery require alternative sources of power to carry out rice production and to make rice cultivation an attractive job to the educated youth in general. In addition since rice is an important crop in Bhutan, it is important to study how best the rice production could be made more economical and profitable to the rice farmers. This study was therefore, conducted on-station at RDC Bajo in 2011 with the objectives to quantify inputs such as labour, machineries and other material inputs in mechanization of rice cultivation and to determine the cost of rice production. The results showed that the total production costs (Nu/acre) of rice through mechanization is Nu. 45944. Similarly labour use (man-days/acre) of rice production is 121 man-day/acre with a cost of production of rice Nu.14/ kg. Since similar study for traditional/manual method of rice production was not done parallel, it is difficult to draw any conclusive recommendations at this stage. Given the fact that rice is facing competition from cheaper imports, this study will be continued with a parallel study on traditional/manual rice production method to devise an appropriate strategy for making rice production more economical and attractive.

KEY WORDS: Rice, Labour, Drudgery, Partial Mechanization, Costs

INTRODUCTION

Rice cultivation in Bhutan is very important for the farmers culturally, traditionally and religiously. Currently rice is cultivated in 56375 acres with a national productivity of 1271 kg/acre (RNR Statistics, 2010). During the last 7 years rice area has increased from 46585 in 2004 to 56375 acres in 2010 with productivity

1 Renewal Natural Resources Research and Development Centre, Bajo, Wangduephodrang, DoA, Ministry of Agriculture and Forests (yesheyrcb@yahoo.com)

increase from 1166 to 1271 kg/acre in 2010 (RNR, Statistics). In tandem with the growing population rice production needs to be increased in the future.

With depleting natural resources, deteriorating soil health, poor input use efficiency and increasing cost of production, increasing rice production is an uphill task. In the past increase in rice production seemed to have been achieved mainly from increase in cultivation area, introduction of high yielding varieties and application of fertilizer inputs. Rice cultivation mechanization is one critical input that will facilitate timely completion of operations and thereby saving labour and increasing the productivity and profitability. However, more than in most countries, Bhutanese agriculture depends mostly on manual labor and animal power. Rice cultivation in many parts of Bhutan is still associated with drudgery.

According to a survey report, there is a glaring mismatch between household labour availability and requirement. While the mean total full time labour available is 3, the mean total labour requirement is 4.27. In addition, of the total 298 households interviewed during the survey, 50 percent reported a "decrease" in labour availability over the years (Yeshey, 2001). The scarcity of manual labour and the drudgery require alternative sources of power for rice production. High labour demand during different rice cultivation operations often adversely affects timeliness of implementation. Machines and tools could easily replace manual labour bringing advantages such as timely cultivation, increased production and minimize cost of production. To address the labour shortage issue in rice production, this study was planned to quantify inputs such as labour, machineries and other material inputs in mechanization of rice cultivation and determine the cost of rice production.

MATERIALS AND METHODS

Trial site and seed treatment

The trial was conducted on-station at RDC Bajo from May to November 2011 and was implemented in collaboration with the regional Agriculture Machinery Centre (AMC) Bajo. Rice varieties, Bajo Maap I and II were cultivated. Seeds of these varieties were cleaned and selected manually using specific gravity selection method with salt water followed by seed treatment using hot water at 60^{o}C for ten minutes for disinfection of the seeds. Pre-germination of the seeds was done by soaking the seeds in cold water with 20^{o}C until the seeds sprouted.

Nursery establishment and management

For tray nursery establishment, red virgin soil was collected from Lobesa. Soil clods were broken down manually and sieved using a mesh of 4 – 5 mm. Before putting soil in the trays, trays were covered with news papers to block the roots. Then the sieved soil was put in the trays on which the sprouted seeds were evenly sown at

the seed rate of 100 gm per tray. The trays were dipped in water until fully saturated after which the water was drained completely. The trays were then kept inside the green house until germination. Once the seedlings reached 2.5 leaf stage, the trays were transferred outside in a properly leveled ground to acclimatize seedlings to the open air. Watering was done as and when required until the seedlings were transplanted. Twice trimming of the seedlings was done to maintain the height with age.

Land preparation and soil nutrient application

FYM was applied at the rate of 2000 kg/ac and incorporated during pre-irrigation ploughing. All the research plots were ploughed thoroughly using farm tractor after wheat was harvested. Cleaning the bunds, digging the corners and terrace edges was done manually and flooded the fields thereafter. Power tiller was used for rotovating to puddle and level the plots. After puddling, leveling, burying the weeds, digging the corners and edges, repairing and plastering the bunds was done manually. Water was drained out slightly to maintain the level as required. Recommended rates of chemical fertilizer (32:20:8 NPK kg/ac) was applied. All of P and K were applied as basal dressing while N was applied in two splits; half as basal dressing and the other half as top dressing at tillering stage (25 DAT). The field was kept 24 hours to let the mud get set before transplanting.

Transplanting and weed management

25 days old seedlings were transplanted using two-line rice transplanter. After transplanting the seedlings, irrigation was applied as and when required. Four days after transplanting, to control weeds butachlor 5G was applied at the rate of 1.5 kg active ingredient per hectare. One time weeding was done 30 days after transplanting. Weeding was done using manual rotary weeder. *Potomogaton distinctus* (locally called as *Shochum)* was the most noxious weed in the field. The uprooted weeds were carried out of the field manually to control their spread. Grass cutter was used for cutting grasses on the bunds and field surrounding. This was done only once during the whole rice season (after rice transplantation until harvesting).

Harvesting and threshing

Before rice harvesting, crop cut was taken to estimate the total production from the mechanized area. Then the boarder harvesting was done manually. Finally reaper was used for harvesting the whole area and threshing was done with power thresher.

Types of farm machineries used for the trial

Farm machineries used for this study were farm tractor, power tiller, rice transplanter, manual rotary weeder, grass cutter, reaper and power thresher. For nursery establishment except the use of tractor for transporting red virgin soil from Lobesa, the rest of the activities were carried out manually. Similarly other operations such

application of soil nutrient inputs and cleaning, repairing, plastering of bunds and digging terrace corners and edges were done all manually. Our mechanization thrust has therefore, been towards rice cultivation operations such as land preparation, transplanting, harvesting and threshing which require the most labour inputs.

Data Analysis

Cost of inputs used in the trial was calculated based on the current market prices. Since the land where the trial was conducted is owned by the centre, under the fixed cost of the land, only land tax was included for calculation of the total cost of rice production. Similarly machines used for the trial were owned by the centre and therefore the depreciation of the machineries was used instead of hiring charges. Depreciation of the machineries used was calculated using the hourly ware and tear value based on the actual priced paid for each farm machine and its life span. Labour input cost was calculated using Nu.300/per day. In Punakha-Wangdue Valley during peak rice transplanting time, hire labour wages goes as high as Nu. 400/per day with 4 meals.

RESULTS AND DISCUSSIONS

Mechanization level of rice cultivation

The major operations in rice cultivation and percent mechanization of each operation for the trial are presented in Table 1. The proportion of the time was calculated based on the total time taken for each operation.

Table 1. Major operations in rice cultivation and percent mechanization of the operations

Red soil collection and preparation	Nursery keeping & management	Soil nutrient application	Pre-irrigation ploughing	Clearing bunds, digging corners and field edges	Puddling and leveling	Transplanting	Grass cutting	Weeding	Harvesting	Threshing
20	**00**	**00**	**100**	**00**	**90**	**100**	**100**	**50**	**95**	**100**

Data source: Field trial 2011

While certain operations are fully mechanized, there are some operations which are done purely manual. This is mainly because of the nature of the work that did not allow for mechanization. For instance cleaning bunds, digging field corners and edges have to be done manually.

Comparative labour, material and machine costs in rice production

In rice production, the main cost is the labour cost followed by material and the machinery costs (Figure 1). Since the trial was conducted on-station and the field is owned by the centre, for the fixed cost of the land, only land tax is included in the calculation of the total cost of production and it is very minimal compared to others costs. The result indicates that, even under mechanization of rice cultivation, the cost of labour is very high compared to other costs.

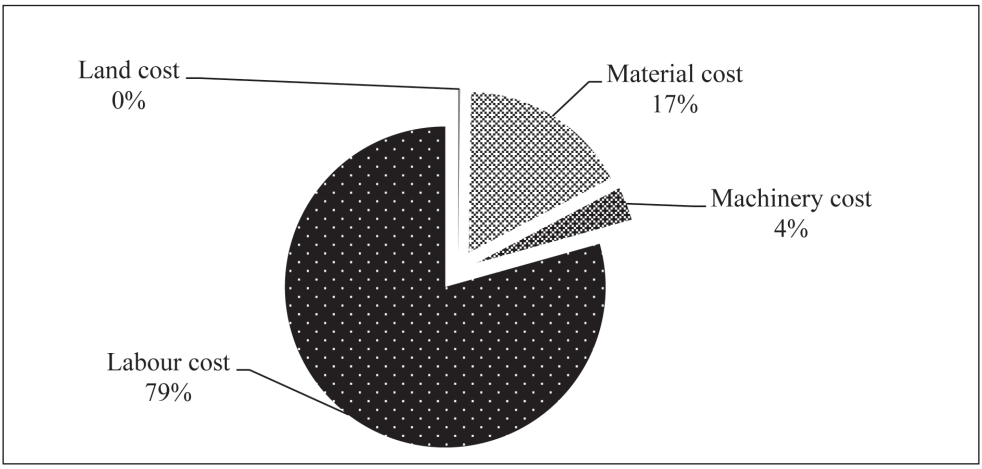

Fig. 1: Percent costs of different factors in rice production

High labour cost even under mechanization of rice cultivation is because of the nature and operation costs of certain activities. For instance, the cost of nursery is the highest followed by threshing (Figure 2). Nursery operation includes collection of red soil, soil preparation, preparing the trays, packing soil, wetting the trays, sowing seeds and covering, taking out the trays from green house to outside in the open ground after germination, watering and trimming the seedlings which are all done manually. Soil preparation includes breaking the clods and sieving which is found to be another tedious manual work.

Among all the activities in the nursery operation, only seeding is said to be possible for mechanization. Thus simplification of nursery establishment and management is one area that needs more research and development study to minimize the labour cost.

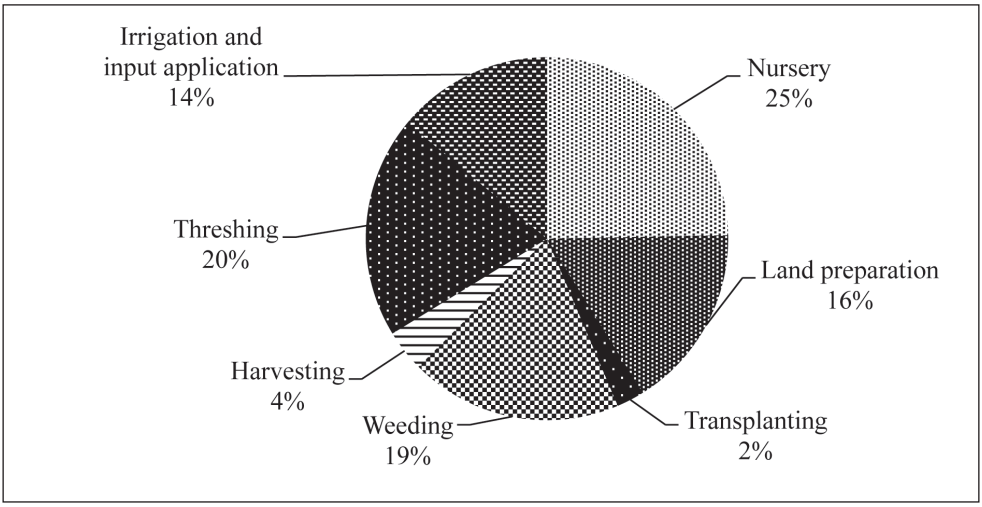

Fig. 2: Percent labour costs for different operations in rice cultivation

Similarly during threshing time, there are two manual transportation works, the transportation of the harvested paddy from the field to the threshing area and then the transportation of threshed grains from the threshing area to the store. Before transporting paddy from field to threshing area, labour is required to collect paddy and stack into big bundles for transportation to the threshing area. There are also labour required to clean the threshing area, collect and remove straw from the threshing area, change the grain collection bag as and when it get full and finally packing for transportation to the store. Labour input cost in these operations can be reduced only through setting the threshing machine inside the field for reducing the paddy transportation distance and then power tiller to transport the grain.

The next high labour cost is for land preparation. Under this operation, only pre-irrigation ploughing, puddling and leveling are mechanized. Other tedious activities like cleaning, repairing, and plastering the bunds, digging field corners and the edges where machines could not reach are all done manually. Furthermore, under mechanized transplanting, the field has to be very clean without any debris and well-leveled. Additional labours are required to help in manual leveling and burying of debris.

One major rice cultivation operation not fully mechanized is weeding which is the next highest labour input cost in rice production. Weeding was done using manual rotary weeder and then removing out the uprooted weeds from the field. The operation was almost similar to hand weeding and thus the cost became high.

Among the costs of the inputs, cost of the farmyard manure is the highest followed by fertilizers and the plastic trays (Figure 3). Use of farmyard manure, fertilizers and butachlor are enviable in optimizing rice productivity. However, cost of plastic trays may be able to reduce as research elsewhere showed that seedlings raised on a one-inch thick soil bed put on the plastic sheet are suitable for transplanting by machine (Rajendra, 2009). Similar study should be done to reduce the material cost in the nursery for promoting mechanization for rice cultivation.

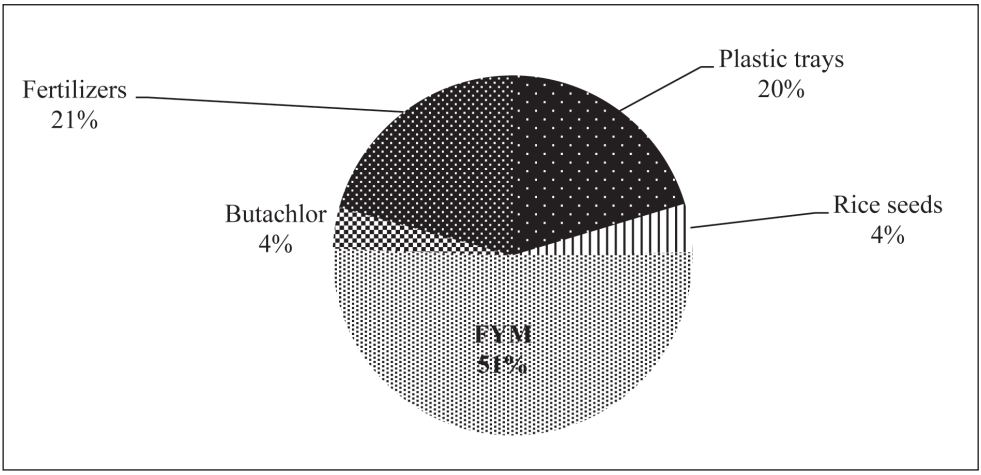

Fig. 3: Percent costs of different inputs in rice production

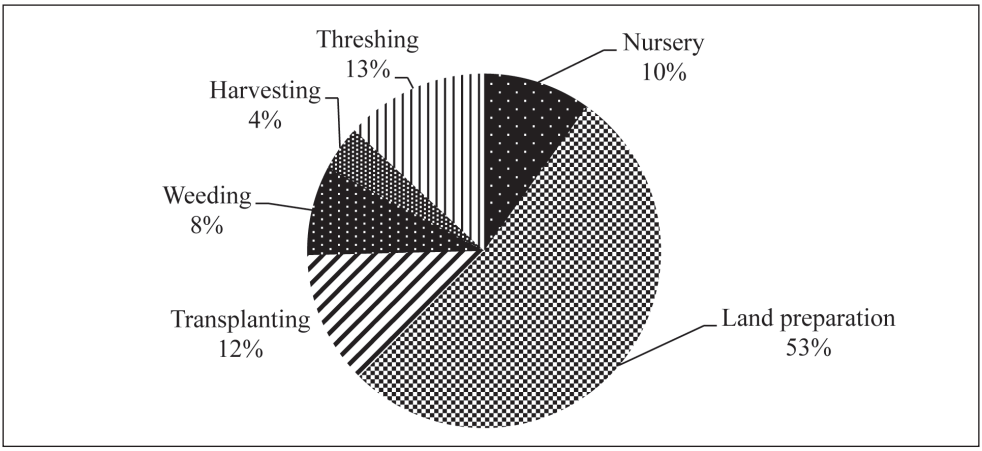

Fig. 4: Percent costs of machineries for different operations in rice production

Among the costs of the machineries, the highest is for land preparation, followed by threshing and transplanting. Given a farmer owns all the farm machines, it is likely that mechanization in rice cultivation will increase in future to response to labour

shortage as mechanizing transplanting, harvesting and threshing has drastically reduced the labour cost without much machinery cost incurred (Figure 4). However, if a farmer has to hire all the machines, the cost of machinery input is likely to increase and thus the cost of production will go up simultaneously.

Production Costs

Since the trial was conducted on-station and the centre owns the land where the trial was conducted, land tax was included in the calculation. Similarly for the machines, since the centre owns all the machineries, instead of the hiring charges, value for wear and tear and the fuel costs were used in the calculation.

The total production costs (Nu/acre) of rice through mechanization is Nu. 45944. Similarly labour use (man-days/acre) of rice production is 121 man-day/acre. According to a study done on the economics of rice production for the West Central region in 2005, the total production costs of rice for Punakha and Wangdue are Nu. 22448 and Nu. 20675 per acre respectively. The labour input (man-days/acre) of rice production are 132 man-day/acre in Punakha and 152 man-days/acre in Wangdue. While it is not fair to compare the findings of this study with the results of the study done earlier (some 8 years ago) because of the differences in the method of the study carried out, the changes in the costs of labour and material inputs, but it might help us to make some comparative analysis with due consideration of the differences between the two studies.

Among the specific operation in mechanization of rice cultivation, the highest labour use is for nursery followed by threshing, weeding and land preparation (Figure 5).

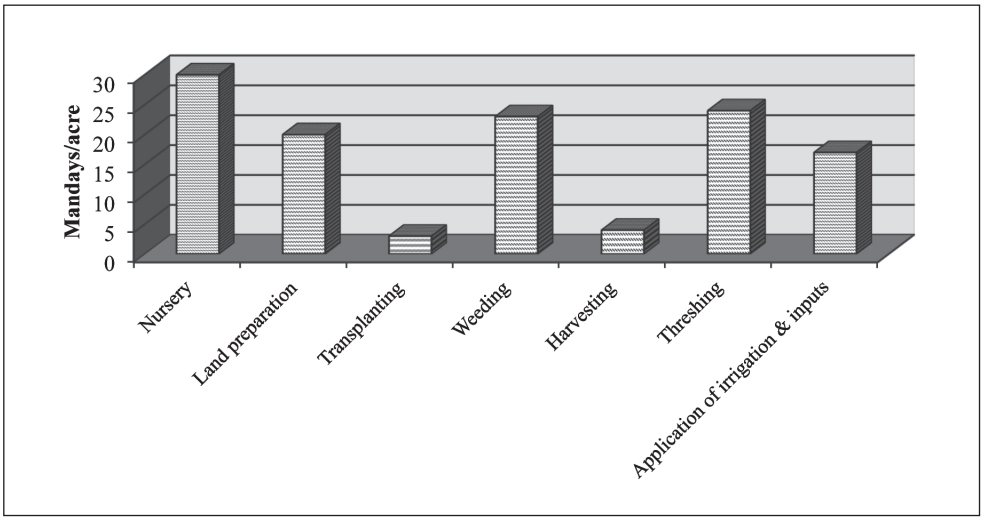

Fig. 5: Mandays for specific operations under mechanization of rice cultivation

Table 2. Total costs of rice production

I	**FIXED COSTS**	**Nu/Area**
		1 Acre
1	Land (Tax only)	100
2	Depreciation of tractor plus cost of fuel for nursery	151.38
3	Depreciation of tractor, power tiller plus fuel cost for land preparation	806.96
4	Depreciation of transplanter plus fuel cost for transplanting	186.4
5	Depreciation of rotary weeder, grass cutter plus fuel cost for weeding	124.94
6	Depreciation of reaper plus fuel cost for harvesting	63.76
7	Depreciation of power thresher plus fuel cost for threshing	200.7
8	Cost of nursery trays with three years of life span	1600
	TOTAL (Nu)	**3234.14**
II	**VARIABLE COSTS**	
1	Total input cost (FYM, fertilizers, weedicide, and seeds)	**6260.1**
III	**Labour/agronomy costs**	
1	Nursery establishment and management	9000
2	Land preparation (ploughing, puddling and leveling)	6000
3	Transplanting	900
4	Weeding (weeding and surrounding grass cutting)	6900
5	Harvesting	1350
5	Threshing (processing, cleaning, transportation)	7200
6	Irrigation and input application (FYM, fertilizers and weedicide)	5100
	TOTAL (Nu)	**36450**
IV	**Grand total cost of rice production (I + II + III)**	**45944.2**
V	**BENEFITS**	
1	Income from the sale of rough rice	64000
2	Income from the sale of rice straw	8400
3	**Total benefit**	**72400**
4	**Net benefit (Total benefit - Total cost)**	**24855.76**

I	FIXED COSTS	Nu/Area
		1 Acre
VI	**Cost of production of rice**	
1	Total Net Costs (excluding the land tax)	45844.2
2	Divided by quantity of main product	3200
3	**Cost of Production (Nu/kg)**	**14.3**

Data source: Field study in 2011

The cost of rice production, the fixed costs, the variable costs and the costs of the agronomy is presented in Table 2.

Among the major rice cultivation operations under mechanization for rice production, the cost of nursery is the highest followed by threshing, weeding and land preparation (Figure 6).

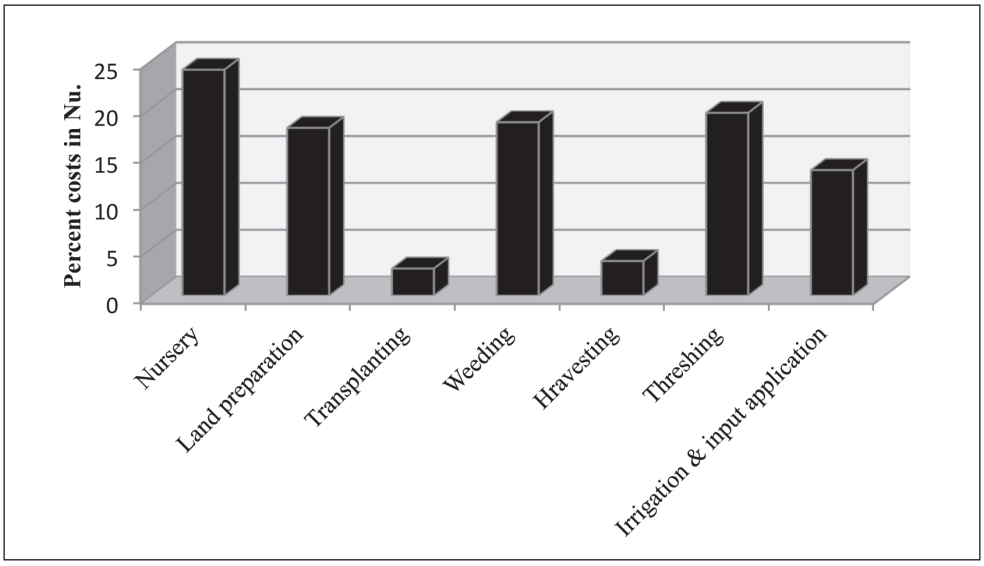

Fig. 6: Percent costs of different operations in rice cultivation under mechanization

Reducing the costs of nursery and weeding operations will make mechanized rice production more profitable. The domestically produced rice fetches higher price in the market, whereas the imported rice is cheaper. Furthermore although, rice is not the largest produced cereal in the country, it is the most widely consumed. Therefore, generating technologies to make rice production more economical and profitable to the rice farmers is an important research and development area.

CONCLUSIONS

The total production costs (Nu/acre) of rice through mechanization is Nu. 45944. Similarly labour use (man-days/acre) of rice production is 121 man-day/acre and the cost of production is Nu. 14 per kg of rice. It is difficult to say whether the production cost is high or low as there is no parallel study done for traditional/ manual rice cultivation method to compare the results.

There is a high use of labor in rice production even under mechanization of rice cultivation. Among the rice cultivation operations under mechanization, nursery, threshing and weeding required higher labour input. This suggests that future research and development in the mechanization of rice cultivation should gear towards generating technologies to reduce the cost of labour in nursery, threshing and weeding.

Labor has become scarce and expensive (Nu. 300 per day in addition to 3 - 4 meals). In such a scenario, making rice cultivation a less labor intensive exercise through the use of farm machines can reduce the drudgery. Labour requirement in transplanting, harvesting, grass cutting and land preparation are reduced drastically under mechanization. Besides this, labor costs for threshing can be cut down if threshing is done in an area where the transportation of paddy is easier and faster.

The conclusion drawn from this study is that, while the costs of certain rice cultivation operations are found to be very low, there are some operations which need further studies to generate technologies to reduce the costs.

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Long term study on potato-maize based farming system as managed by the farmers of Eastern Bhutan

Yeshey Dema[1], Karma Dema Dorji[1], Tshering Pem[1] and Ngawang Tenzin[1].

ABSTRACT

To build up a database on the soil nutrient status of the country from the major potato-maize based farming systems of eastern Bhutan, soil samples were collected every after 2-3 years. The yield of potato and maize is reported to be decreasing over the years. The chemical fertilizers applied to potato and maize account to only urea, suphala and to a small extent Single Super Phosphate (SSP) while no Muriate of Potash (MOP) is applied and therefore an imbalance in the nutrient application rate. The farmyard manure application is decreasing over the years due to the decrease in cattle head which is contributed by farm labour shortage. The soil organic matter content is decreasing though the other soil properties such as the available P and K have not changed much over the years though the P and K contents in the soil is still very low. The soil pH has remained almost constant within the medium range except for few areas dropping to very low values.

KEY WORDS: Potato, Maize, Geog, Dzongkhag, FYM (farmyard manure), fertilizers, urea, suphala, SSP, MOP, nutrient, survey, yield, soil.

INTRODUCTION

Potato and maize intercrop is the major crop grown by the farmers of Eastern Bhutan. Potato is grown throughout Bhutan as a major source of cash income and also for consumption while maize is mostly grown for consumption in the East. Potato is normally cultivated from December to January which is followed by maize about a month later. It is cultivated in the country at an elevation ranging from 1800-3000 m.asl (Roder *et al*, 2008). In 2009, the potato yield from Trashigang Dzongkhag was about 2.6 tac^{-1}, Monggar about 2.34 tac^{-1} and Pema Gatshel about 3.97 tac^{-1} of the country's average yield of 3.8 tac^{-1}. The total production for the country was about 46,161 t. The total maize yield was about 1.07 tac^{-1} for Trashigang, about 1.3 tac^{-1} for Monggar and 0.94 tac^{-1} for Pema Gatshel (Agriculture Statistics, 2009). Farm yard manure and mineral fertilizers especially Urea (46% Nitrogen containing fertilizer), Suphala (NPK complex containing 15% each) and SSP (16% Phosphorus containing fertilizer) are usually applied by the farmers in varying quantities and combinations. Normally, urea is applied as a topdress to maize while Suphala is applied as a basal dose in potato. Few farmers also apply urea and SSP as a basal dose in potato.

1 National Soil Services Centre, DoA, Semtokha; yeshey.dema@gmail.com

Potato can be grown in most soil types though the greatest productivity is from deep, loose, crumby and well aerated soils. Potatoes have low tolerance to water logging and therefore do not do well in heavy clayey soils. However, on the other hand, coarse textured soils lack both nutrient and water holding capacities.

The objective of this study is basically to build up a database on soil nutrient status of the major crops in the country as managed by the farmers. This paper tries to compares/presents the soil results from the subsequent soil samplings.

MATERIALS AND METHODS

Description of the Study Area

A field survey/study was conducted in the eastern part of Bhutan in Monggar, Trashigang and Pemagatshel Dzongkhags. Soil samples were collected along with the information on farmers' soil fertility management practices using a structured questionnaire format. The first and second batches of samples were collected in 2002 and 2008 respectively and the third batch would be collected in 2011 after the potato harvest. Though potato-maize is cultivated throughout eastern Bhutan, the most intensively cultivated geogs were selected for the study. In this study a total of seven geogs viz. Kanglung, Khaling, Thrimshing and Yangneer (Trashigang Dzongkhag), Drametse geog (Monggar Dzongkhag) and Nanong and Zobel (Pema Gatshel Dzongkhag) were selected based on the list prepared by the respective Extension Agents of these geogs.

In Drametse geog, the sampled villages are located at an altitude range of 1491 – 2315 m. asl while in Trashigang Dzongkhag, the sampled geogs are located at an altitude range of 1040 – 2935 m.asl and the sampled geogs of Pema Gatshel at 1674 – 2360 m. asl. The majority of the plots under this study area are situated on slopes ranging from very flat to more than 38^{o} slopes. In Drametse geog and the four geogs under Trashigang Dzongkhag, the majority of the plots are north easterly facing while it is north and north-west facing for the two geogs under Pema Gatshel Dzongkhag.

Field survey

The National Soil Services Centre (NSSC) under the Ministry of Agriculture and Forests, collected about 690 soil samples from these seven geogs. Soil samples were collected from those fields where potatoes were cultivated in more than 1 langdo (1 langdo =1350m^2). One composite soil sample from a minimum of 8-10 subsamples were collected from one field. Soil samples were collected from a plow depth (20cm) using a soil auger and analyzed at Soil and Plant Analytical Laboratory (SPAL) under NSSC. Aspects, slope, altitude and GPS readings were taken from these areas.

Statistical Analysis

The analytical soil results were analyzed using SPSS 16 for windows. Descriptive statistics of SPSS was used to calculate mean, minimum and maximum values of quantitative traits. Microsoft Excel spreadsheet was also used to present the soil properties chart.

RESULTS AND DISCUSSIONS

This report presents the findings of soils under potato-maize cultivation from eastern Dzongkhags over a period of 6 years from 2002 to 2008. The general observations as recorded during the survey are presented in the first half followed by the soil analysis result in the second half.

Sample households

In this survey area a total of 202 households from 20 villages under 7 geogs covering 3 Dzongkhags were sampled. The number of respondents from each village varied from 3 to 22 households.

Crop yield

In all the sampled villages, potato is intercropped with maize. It is reported that under favorable growing conditions and crop management, potato yield can vary form 16- 20 tac^{-1} though on an average, the yield can be about 7-8 tac^{-1} (FAO). The average potato yield of the east in 2002 and 2008 were 5.23 tac^{-1} 3.78 tac^{-1} respectively. The highest potato yield was reported from Nanong geog under Pema Gatshel while the lowest yield was reported from Thrimshing geog. In general there is a decreasing trend in potato yield over the years.

According to Perrenoud (1993), a crop yielding 37 t ha^{-1} removes 113 kg N, 45 kg P_2O_5 and 196 kg K_2O per hectare. At very high yields, nutrients removal in tubers is very elevated: for example, in an irrigated field of Central Washington of commercial potato cv. *Russet Burban*k, yielding 79 t ha^{-1}, N, P and K accumulation in tubers was 282 kg N ha^{-1}, 92 kg P_2O_5 ha^{-1} and 384 kg K_2O ha^{-1} (Fageria et al, 1997).

Potato crop is a heavy remover of soil potassium and is the nutrient taken up in the greatest quantity whereby the tubers remove 1.5 times as much potassium as nitrogen and 4-5 times the amount of phosphate (Perrenoud, 1993). Therefore, potato is regarded as an indicator crop for K availability because of the high K requirement (Roberts and McDole, 1985).

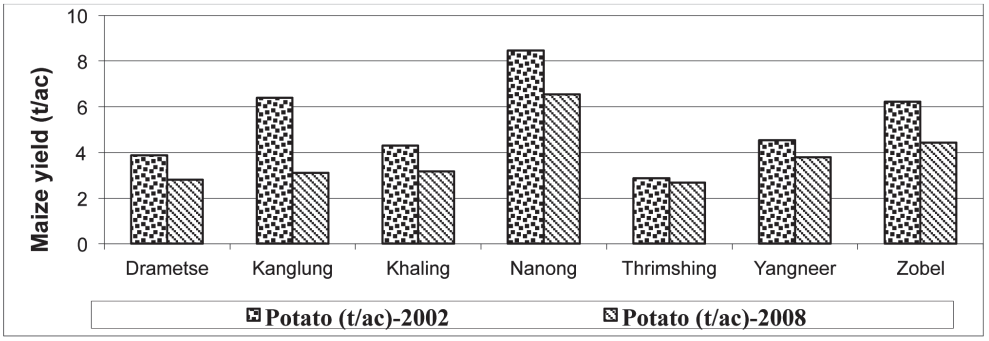

Fig. 1: Potato yield (tac^{-1}) from seven geogs of East.

The average maize yield from these geogs is reported to be about 1.64 t ac^{-1} (2002) and 1.48 t ac^{-1} (2008). For most of these geogs, there is decrease in maize yield over the years while there is a slight increase in maize yield in Kanglung, Nanong and Zobel geogs. This decrease in yield was attributed mainly to damage by wild animals.

An average maize crop yielding 9.5 t ha^{-1} would remove about 129 kg N, 71kg P_2O_5, 47 kg K_2O per hectare by the grains while the stover removes about 62 kg N, 18 kg P_2O_5 and 188 kg K_2O per hectare (Barber & Olson, 1968).

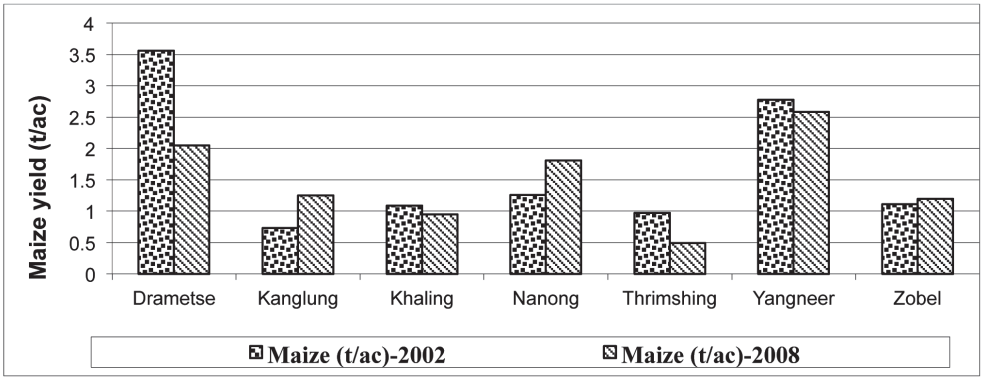

Fig. 2: Maize yield (tac^{-1}) from seven geogs of East.

Soil fertility management practices (farmers' or recommended?) Farm yard Manure (FYM)

From the survey, it was reported that all the farmers apply farm yard manure (FYM) to their fields prior to potato sowing. The average FYM application rate for these geogs is about 9.79 tac^{-1} and 8.16 tac^{-1} for 2002 and 2008 respectively. The highest application of FYM is reported from Nanong geog under Pema Gatshel Dzongkhag (18.67 t ac^{-1}) in 2008 which is an increase from 17.9 tac^{-1} in 2002. The lowest rate

of FYM application is reported consistently from Khaling geog. In general there is a decrease in FYM application rates from 2002 to 2008 (Drameste geog, from 16 to 11 t ac^{-1} respectively; Yangneer from 12 to 4 t ac^{-1}; Zobel from 11 to 9 t ac^{-1} and Thrimshing from 5 to 3 t ac^{-1} respectively). In all these geogs, the decrease in FYM application is consistently reported to be due to decrease in cattle number which is further attributed to farm labour shortage.

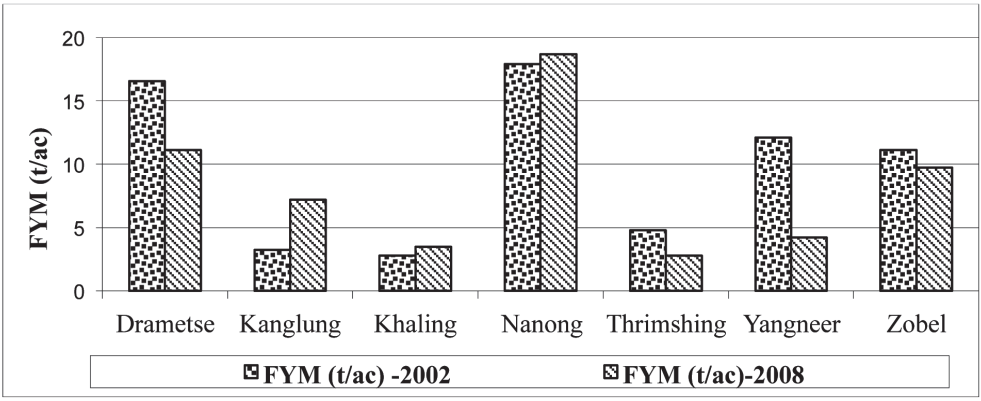

Fig. 3: FYM application rate (tac^{-1}) from seven geogs of East.

Mineral fertilizers application trend in Bhutan

Though the first mineral fertilizers were imported in the early 1960s, the actual input was operational only in the mid 1980s (Norbu, 2001). The national fertilizer distribution in terms of plant nutrients (NPK) is about 3:1: in early 1990s to 8:1:1 (2002) and 7:1:1 (2008) and this ratio has not changed or improved over the years, though the desirable ratio is about 4:2:1 (Sharma 1999). There is a clear indication of the preference of nitrogenous fertilizer (urea in particular) over other fertilizers by the farmers of Bhutan. However, the overall import of fertilizers has also remained almost constant at about 3000 tons since the last ten years.

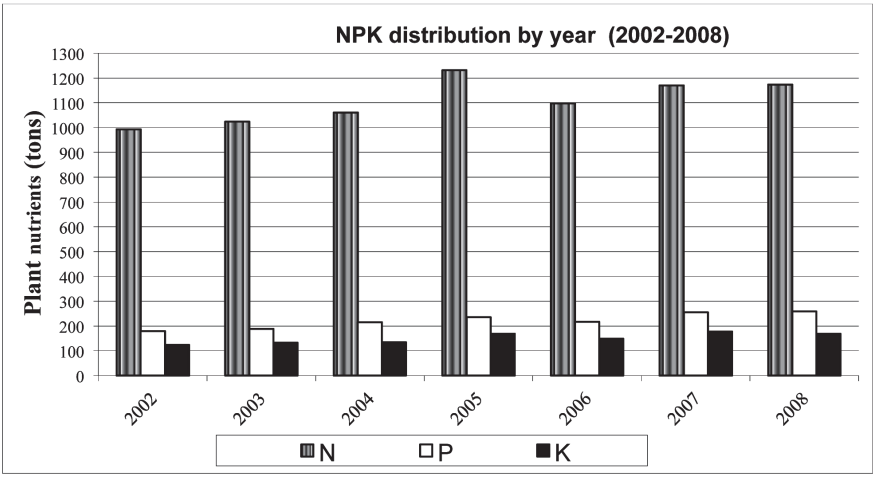

Fig. 4: NPK distribution by year at the national level.

Mineral fertilizers application by the farmers

In all the sampled geogs, almost all the farmers apply mineral fertilizers in addition to FYM in potato and maize in varying rates. It was reported that though suphala is applied as a basal dose to potato, urea is applied as top dress to maize. Few farmers of Kanglung geog also apply SSP (Single Super Phosphate) in combination with urea as basal dose to potato in the ratio of 1:2 (Urea: SSP)[2]. In Yangneer geog, about two farmers apply small quantity of SSP to potato. In all the 7 geogs, no MOP (Muriate of Potash) a potash containing fertilizer other than Suphala (15-15-15 NPK) is applied.

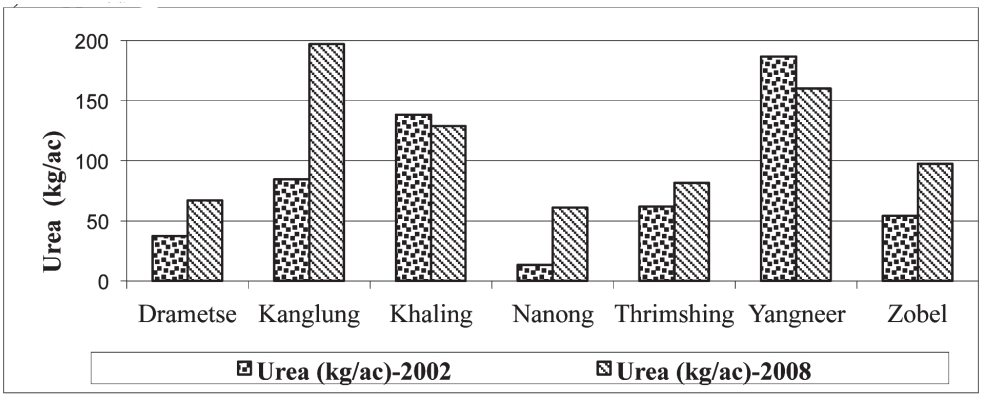

Fig. 5: Amount of Urea applied to potato- maize (tac^{-1}) from seven geogs of East.

2 Farmers reported that it is based on the BNPP training and recommendations in 1980s.

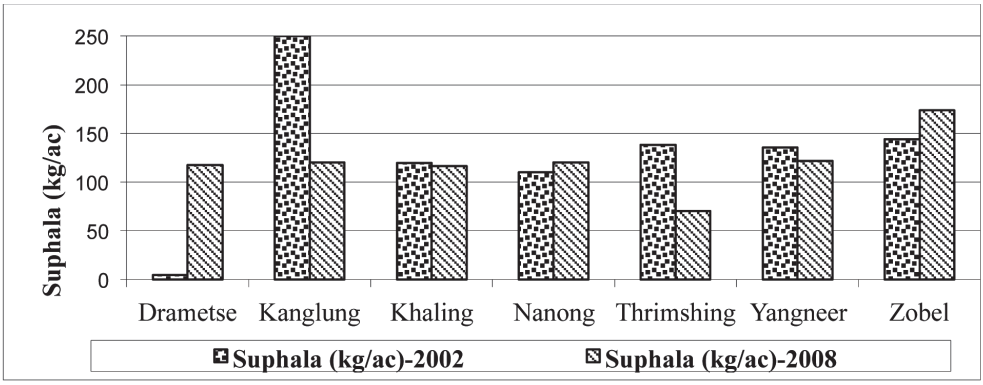

Fig. 6: Amount of Suphala applied to potato- maize (tac^{-1}) from seven geogs of East.

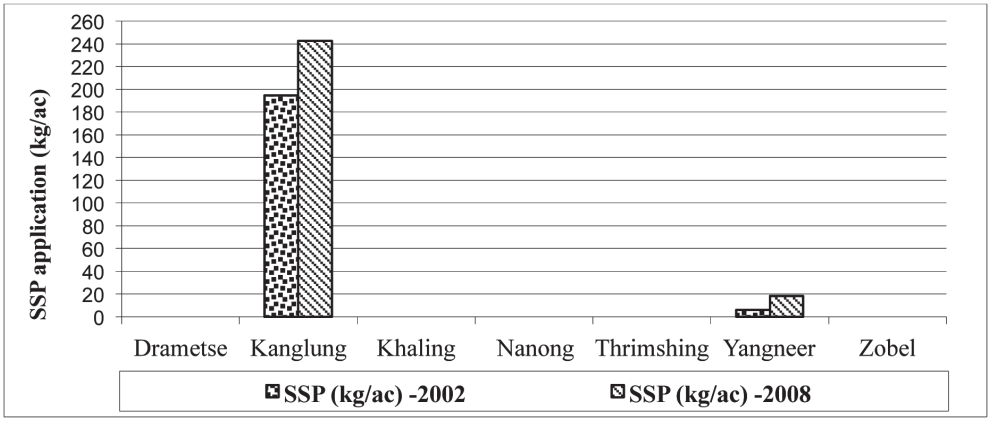

Fig. 7: Amount of SSP applied to potato- maize (tac^{-1}) from seven geogs of East.

The average Urea application from the east in 2002 was about 101.7 kgac^{-1} (i.e 38.14 kgac^{-1} to potato as basal dose and about 63.6 kgac^{-1} to maize) which is equivalent to 47 kgac^{-1} N. The average Suphala application from the 7 geogs of east was about 120 kgac^{-1} which is equivalent to 18 kgac^{-1} NPK nutrients. Therefore in total, the average nutrient content from these three fertilizers would amount to 65:18:18 kgac^{-1} NPK. This amount of nutrient application by the farmers of the east is less than the NSSC recommendation rate[3] except for N which is slightly higher than the NSSC rate, however for Kanglung geog, the NPK application rate is 65:49:18 (higher for N and P and low for K in comparison to NSSC recommendation rate) where the average SSP application is 195 kgac^{-1} contributing about 31 kgac^{-1} P.

3 NSSC recommendation rate for potato (East) is 40:32:32 kgac^{-1} NPK

For the 2008, the average urea application from the east is about 113.21 kgac^{-1} which is equivalent to 52 kgac^{-1} N nutrient. The average suphala application rate is 120 kgac^{-1} which is equivalent to 18 kgac^{-1} NPK nutrient. Though the average suphala application rate has not changed over the years, Kanglung and Thrimshing geogs have seen a decrease in suphala application rates while there is an increase in Drametse geog from practically nil in 2002 to about 118 kgac^{-1} in 2008. Therefore the average NPK rates of these geogs works out to be 70:18:18 kgac^{-1} NPK nutrients. As in 2002 only Kanglung geog applied SSP (240 kgac^{-1} SSP which supplies 38 kgac^{-1} P nutrient).

The average ratio of N:P:K use in potato for these geogs for both 2002 and 2008 is about 4: 1: 1 which indicates an imbalance in nutrient use. This imbalance is almost consistent with the national fertilizer consumption data where the most preferred fertilizer is urea (Figure 4).

Soil analysis results

Potatoes can be grown on most soils. For potatoes to do well, the minimum soil pH requirement is 5.5. Alkaline conditions can adversely affect skin quality and as in any other crops, highly alkaline conditions can induce micronutrient deficiencies.

On an average, the pH of the soils has not changed much over the years as the average pH ranges has remained constantly within the medium ranges (63% and 64% respectively for 2002 and 2008) though there is a gradual shift towards the low pH values over the years in few pockets of villages. However, the OM% has drastically decreased over the years (about 60% and 39% of the samples had high and medium OM values in 2002 compared to only about 60% within the medium range and the rest in the low range in 2008). This decrease in OM% could also be due to the decrease in FYM application over the years. In general, the available P and K of these soils have not changed over the years and most of the soils have consistently remained within the low to very low P values. In such conditions, it is advisable to apply P and K containing fertilizers to get good yield. The CEC and the BS% of these soils have also not changed over the years with more than 50% of these soils in the low range.

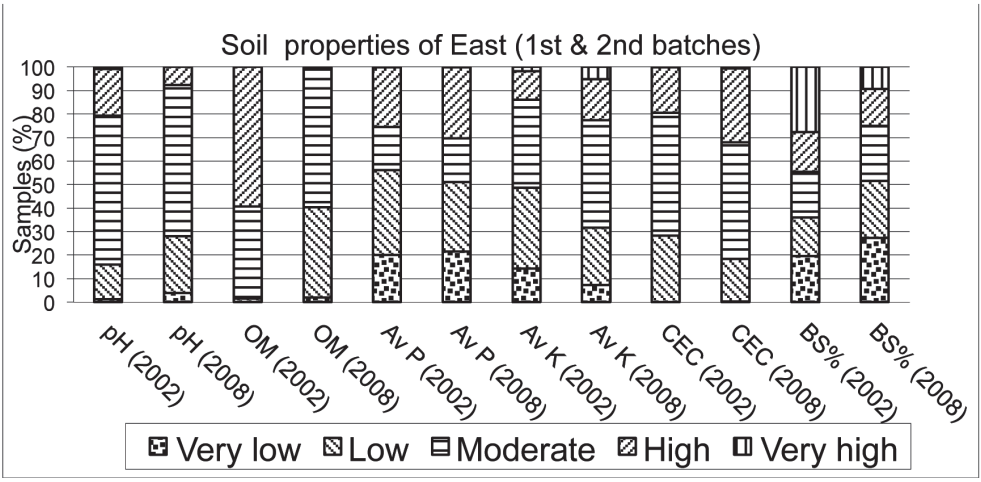

Fig. 8: Soil properties from the seven geogs of East.

CONCLUSIONS

The farmers of eastern Bhutan cultivate potatoes as a source of income. Maize is intercropped with potatoes which are usually sown about a month after potato plantation. In-organic fertilizer such as suphala (NPK complex) is applied to potatoes as a basal dose while urea is applied as a top dressing to maize. Though potatoes are considered to be good extractors of soil potassium, no potassium containing fertilizers such as MoP (other than suphala) is applied by the farmers. Continuation of this management regime will mean that it will be difficult to increase potato- maize yields without the risk of depleting soil nutrient stocks, particularly of K and P. Both the potato and maize yield is lower than the FAO figures. This implies that there is potential for increasing the yields with proper management practices. In general, the pH of these soils under potatoes has remained within the favorable, medium range while the OM content is decreasing over the years. In most of these soils, the P and K content are low indicating the need to apply more P and K containing fertilizers to get good yield.

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Potential tea cultivars for organic green tea production at Samcholing Bhutan

Bal Bahadur Rai[1]

ABSTRACTS

Tea is one of the most commonly served and consumed beverages next to water. Among many types of teas, green tea is one that is gaining increasing popularity in the world market and even in Bhutan. Small plantation of green tea exists in Samcholing village of Trongsa with the two different cultivars (Camellia sinensis variety sinensis and Camellia sinensis var assamica).The study was conducted at Samcholing village of Drakteng gewog, Trongsa to estimate yield per plants of both the cultivars and assessing the quality green tea based on sensory survey of both tea cultivars i.e. (taste, colour and aroma). The results indicated that there was no specific preference based on colour, aroma, and taste between the two tea cultivars by the respondent. This indicates that farmers can grow either of the two cultivars depending on availability of planting materials. However, based on the fresh yield production Camellia sinensis variety sinensis yielded 28% higher than Camellia sinensis var assamica. Therefore, it is recommended that Camellia sinensis variety sinensis may be promoted for commercial plantations to produce organic green tea at Samcholing, Trongsa Bhutan.

Key words: Green Tea, *Camellia sinensis*, Samcholing, Natural antioxidants, Polyphenols, Cultivars, Processing.

INTRODUCTION

Tea plantation in Bhutanese agriculture system is relatively new although some tea bushes are seen sporadically. Bhutan's policy on organic agriculture production very well supports the venture of tea plantation at Samcholing village, Drakteng geog of Trongsa dzongkhag for Organic tea production with the advent of Focused Village Rural Development Project in 2009 NOP (2006).

Tea plant belongs to family *Theaceae*, genus *Camellia* and species *Camellia sinensis* and its binomial name is *Camellia sinensis*. There are two major varieties of tea that are popular in the world; viz; (i) *Camellia sinensis var. sinensis* (L.) Kuntz and (ii) *Camellia sinensis var. Clonal assamica* (Masters) Kitam. *C. sinensis var sin*ensis

1 CoRRB, MoAF, Thimphu; raibb@yahoo.com

originated in China has narrow and small leaves and *C. assamica var assamica* that was originated in India, has relatively wider and bigger leaves (Loeshwar, 1997). There are many types of teas viz; Black tea that is fermented, Olong tea and Yellow tea that are semi-fermented, and Green teas that are not fermented. According to Ziss and Braber (2001) all types of teas viz, Black tea, Yellow tea, Olong tea and Green tea are processed from the same plant but adopting different methods of processing makes them different brands of teas.

Since commercial tea plantations are new in Bhutan, research on the potential cultivars is necessary. There are two cultivars of Camellia species (*C. sinensis* and *C. assamica*) and both are presently used for processing organic green tea, but it is not confirmed which one of the two variety is the most preferred by the consumers. Therefore, the study was conducted to identify the most preferred cultivar out of two existing tea cultivars, based on sensory test and production potentials.

MATERIALS AND METHODS

The field work was done at Samcholing village, under Drakteng geog in Trongsa Dzongkhag. Two farmers cultivating two different cultivars of tea plants viz, (*C. Sinensis* and *C. assamica*) in 2 acres of plantation were selected as the principle respondents. In both the fields 10% of tea plants were tagged with the help of computer assisted random selection. First three leaves from tagged plants were manually harvested three times at an interval of one month. Emphasis on 3 terminal leaves while plucking was emphasized as plucking more leaves per pick would lead to cramping of leaves in the fist and deteriorate the tea quality (Miyagishima, *et al*., 2010). Fresh weight of the harvested leaves was measured in digital weighing machine along with it moisture content, using moisture meter (Indian brand MMC 200). Leaves from both the cultivars were processed separately based on methods proposed by Kim (1998). The final product in 1gm sachet was used in conducting sensory taste (Lin, 2010). The sensory taste (colour, aroma and taste) of tea samples were carried out with 200 Nos of green tea drinkers at multi-locations of Trongsa and Thimphu. Responses were collected using structured data sheet. Data was analyzed using Wilcoxon signed-ranked test in STATA/1C10. The yield data from both cultivars were also compared to evaluate their production potential.

RESULTS AND DISCUSSIONS

Three consecutive crop cut data was analyzed using excel spreadsheet 2007, to compare the yield of two cultivars as presented in figure 1 and compared the results of sensory test for both the tea samples using Shapiro-Wilkinson test (Stata /1C 10).

The comparison of yield from the multi harvest data provides the preference of cultivar based on the production potential. While the sensory taste of based on

colour, aroma and taste of the green tea provides the information on the preference of green tea by the respondents. It shows that the yield of *C. sinensis* is consistently higher in all three harvests resulting an average of 28% higher yield in comparison to *Camellia sinensis var assamica*.

Although, both the tests adopted for undertaking this study have its own weakness as it has no laboratory investigations. It also focused to a very small respondent population to get their views.

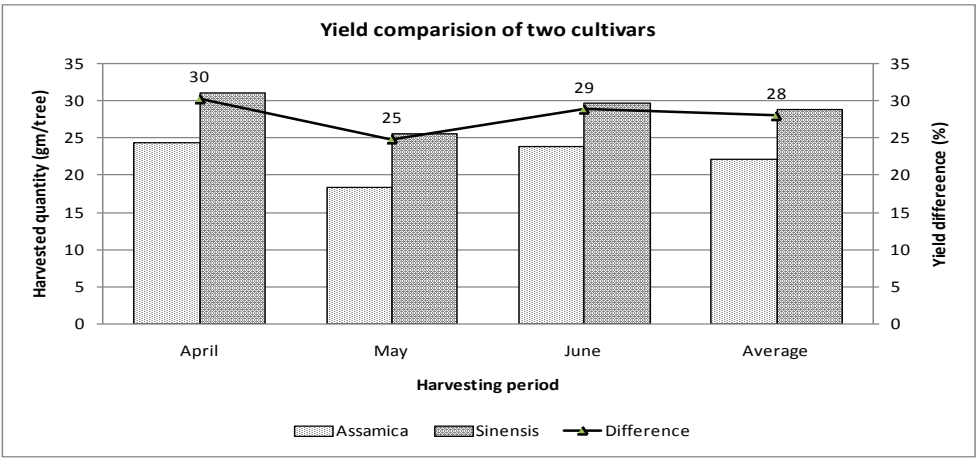


Fig. 1: Yield comparison of *C.assamica* and *C. sinensis*

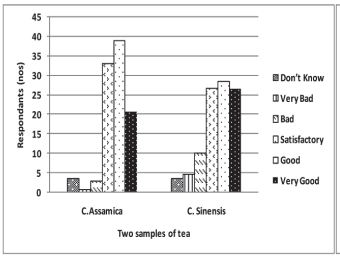
Shapiro-Wilkinson test (Stata /1C 10) was also performed to find out if the data are normal, to decide the test to be adopted for analyzing the data. The data in the dependable variables were checked numerically and found that *p* values were < .05 as represented in Table 1.

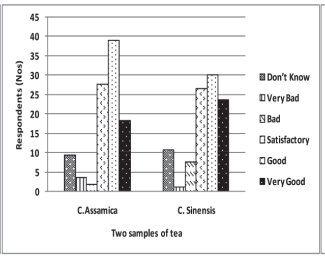
Table 1. Shapiro-Wilkinson test for normal distribution of data

Variable	Observations (No.)	P value
Camellia sinensis var *sinensis* (colour)	*200*	*0.0000*
Camellia sinensis var assamica (colour)	*200*	*0.0001*
Camellia sinensis var sinensis (aroma)	*200*	*0.0000*
Camellia sinensis var assamica (aroma)	*200*	*0.0000*
Camellia sinensis var sinensis (taste)	*200*	*0.0000*
Camellia sinensis var sinensis (taste)	*200*	*0.0001*

p values in Table 1, are highly significant ($p < .05$) indicating that the dependant variables are not normal. Hence, t-test or ANOVA were inappropriate to analyze such kind of dependable variables. Therefore analysis of such data has to be analyzed using non-parametric tests such as Wilcoxon signed-ranked test and Wilcoxon paired test (Gomez and Gomez, 1984).

The results of sensory test based on (colour, aroma & taste) was performed (Figure 2, 3 & 4). The study showed that *Camellia sinensis var assamica* performed better in all three aspects (colour, aroma & taste).





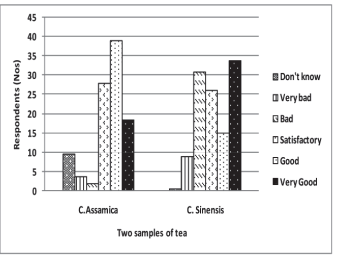


Fig. 2 Colour differences **Fig. 3: Aroma differences** **Fig. 4 Taste differences**

However, to decide and conclude scientifically, a statistical test was performed using Wilcoxon signed-rank test (Table 2). It was observed that there was no significant difference between the two cultivars (Table 2).

Table 2. Scientific anlysis using *p* value (Wilcoxon test)

Tea samples and parameters of difference	*p* value
Camellia sinensis var sinensis (colour) *Camellia sinensis var assamica (colour)*	0.0619
Camellia snensis var sinensis (aroma) *Camellia sinensis var assamica (aroma)*	0.4182
Camellia sinensis var sinensis (taste) *Camellia sinensis var assamica (taste)*	0.1537

However, Li, *at al*.,. (2009) concluded in his study on 'varieties preferred for production of green tea', that *Camellia sinensis var. sinensis* was relatively preferred for green tea over *Camellia sinensis var assamica*. According to Ziss and Braber (2001) all types of teas viz, black tea, yellow tea, olong tea and green tea are processed from same plant but different methods of processing makes the different brands of tea.

Unachukwu, *et al*., (2010) cited that Chinese and Japanese green tea are usually processed from *Camellia sinensis* var *sinensis* while black teas are made from *Camellia sinensis* var *assamica* According to Lin, (2010), the external factors viz, taste, colour and aroma of tea differs from the method it is processed and even the brewing methods adopted. He has also written that the temperatures of tea brewing water and the duration of steeping influences the tea colour, aroma and taste.

There was no significant difference noted between the two different teas, that could be associated with differences research methodology adopted. Matsumoto, *et al*, (2002) used phenylalanine ammonia-lyase (PAL) DNA test and Ujihara, *et al,* (2009) used six simple sequence repeat markers analyzed by capillary sequencer methods for analyzing the biochemical components of the two teas. While in this study used sensory methods and production potential of two tea cultivars was adopted.

CONCLUSIONS

The study found that there was no specific preference between the two existing tea cultivars (*C. sinensis* and *C.assamica)* presently grown at Samcholing based on the sensory test. However, three consecutive harvest and yield comparison of these two cultivars shows consistently higher yield in *C. Sinensis*. Although the higher yield observed in *C. Sinensis* could be contributed due to better farm management practice of the farmer growing this C. Sinensis.

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Production evaluation trial of improved rice cultivars in Dagana and Tsirang

Sangay Tshewang[1], Sonam D. Dorji, Nidup Zangmo, and Tenzin

ABSTRACT

Rice is an important cereal in Bhutan providing food and other daily requirement to the national populace. The national average yield, however, remain low at 3.1 t ha^{-1} owing to numerous circumstances with some being poor adoption of improved varieties, inadequate nutrient and poor agronomic management. Given the low productivity in Tsirang and Dagana, an on-farm evaluation of improved rice varieties was conducted to assess the production potential. The introduced cultivars significantly ($p \leq 0.05$) gave more productive tillers and higher grain yield than the local varieties. The grain yield advantage to be realized through adoption of the improved varieties could be as high as 50% as compared to the traditional varieties. The study indicates the feasibility and opportunities of these improved varieties in similar agro-ecological areas to elevate the rice production at both household and national level.

Key Words: Rice, Grain yield, Productive tillers

INTRODUCTION

Rice (*Oryza sativa* L.) is an important cereal in Bhutan, and Royal Government accords high priority to increase the domestic production to attain food self sufficiency. Despite the support, domestic production never fulfilled demand, and it is estimated that 50% of the annual rice requirement is still imported (Ghimiray *et al*., 2006). The latest statistics indicated that the total rice production was 71,637 t from an area of 22,500 ha averaging 3.1 t ha^{-1} (DoA, 2011). The productivity, however, is still lower than the regional (Asia) productivity of about 4.9 t ha^{-1} under irrigated conditions (Pandey and Pal, 2007). Some of the contributing factors to national low productivity are: poor agronomic management and crop husbandry, limited use of inorganic fertilization, pests and diseases problems, and low and/or poor adoption of high yielding varieties. Comparing the current yields in the research stations to the low yields in the farmers' fields, there exists opportunity to increase the production.

1 Renewable Natural Resources Research and Development Sub Centre, Tsirang; sangay128@gmail.com

Rice is one of the main crops in Tsirang and Dagana Dzongkhags. Tsirang shares about 8% and 5% of national area and production respectively while Dagana's contribution in area and production are 8% and 6% respectively (DoA, 2011). The two Dzongkhags produce one of the lowest productivities of about 2.3 - 2.4 t ha^{-1} (DoA, 2011) despite having considerable rice areas. The circumstances contributing to this low productivity are unknown but these two humid districts were encountering constraint of not having appropriate high yielding improved varieties. It is often suggested that productivity could be increased through introduction of high yielding varieties, improved crop husbandry, and adequate inputs such as inorganic fertilizers particularly for the improved varieties (Dobermann and White, 1999; Fan *et al*., 2005). The main objective of this study therefore was to determine whether improved rice varieties could adapt to local environmental conditions of these two districts, and how would farmers perceive the new varieties. The increase of rice productivity through identification of suitable high yielding varieties in attaining the food security was the ultimate aim.

MATERIALS AND METHODS

Experimental site and soil

The trial was conducted during 2011 rice season in Drujeygang and Goshi in Dagana, and Sunkosh in Tsirang. The trial fields were located within an elevation of 1200-1300 m except Sunkosh which was 650 m. The general characteristics of soil in the test sites were sandy loam to loam (National Soil Service Centre, 2009).

Trial design and treatment

An informal discussion on currently available varieties and farmers' methods of crop husbandry was made with the farming communities. Except Sunkosh, none of the other sites have ever tested improved rice varieties. Given the undulated topography and fragmented small terrace which challenged randomization and replication, the trial was laid out in a single observation plot. The design in Drugeygang was of Baby trial design 1 where a single new variety is compared with farmers' check, while in Sunkosh and Goshi it was Baby trial design 2 where two new varieties are compared between themselves and the local check as described by Witcombe (2002). An analysis of variance was carried out by statistical software R (R Development Core Team, 2010) to compare the treatment means. Different released rice varieties according to the recommended altitude were tested (Table 1).

Table 1. Recommended agro-ecology of different tested improved rice varieties

Variety	Recommended altitude (m)	Crop	Releasing agency	Test site
Bajo Kaap 2	600-1500	Main Single	RNRRDC Bajo	Drugeygang
Wengkhar Rey Kaap 2	600-1500	Main Single	RNRRDC Wengkhar	Goshi
Wengkhar Rey Kaap 6	600-1500	Main Single	RNRRDC Wengkhar	Goshi
Bhur Rey Kaap 2	< 700	Main Single	RNRRDC Bhur	Sunkosh
Bhur Kambja 1	< 700	Main Single	RNRRDC Bhur	Sunkosh

Crop management practices

The land preparation including ploughing, puddling and leveling were done by respective farmers as usually practiced. Nursery was sown in May - June under the wet bed method, and transplanted after 30-40 days depending on the irrigation. In contrast to their normal custom with traditional varieties, transplanting of 2-3 seedlings per hill was suggested which most of the farmers followed. The crop was harvested in October - November taking about 140-150 days from transplanting to maturity.

No specific recommendation on organic fertilization was made as farmers normally have a custom of basal application of farm yard manure or cattle tethering before puddling. However, farmers faced shortage of organic manure and did not apply in this season. Chemical fertilizers of 70 kg N ha^{-1}, 40 kg P_2O_5 ha^{-1} and 20 kg K_2O ha^{-1}, a rate recommended by National Soil Service Centre (2009), was suggested. Additional recommendation was to apply 50% of N, and whole P and K during final day of land preparation, and remaining 30% and 20% N at mid tillering (30 days after transplanting) and panicle initiation (60 days after transplanting) respectively. However, none of the farmers applied the recommended dose and most common rate of application was 100-125 kgs of Suphala (16:16:16) ha^{-1} as basal dose. All farmers reported of top dressing 20 kg N ha^{-1} after 40-45 days of transplanting in the form of urea to improved varieties.

Data collection

Average productive tillers $hill^{-1}$ and plant height were determined from ten hills and plants respectively through random sampling. For productive tillers, a panicle bearing more than 5 filled spikelets was considered as effective while plant height

was measured from base of plant till tip of panicle or flag leaf whichever the highest. The grain yield was estimated from the crop cut using a quadrant of 3 m x 2 m with grain moisture content adjusted to 14%. Each crop cut was considered as a replicate, and every precaution was taken to avoid the border rows and be the representative of the general field. At harvest, both the cooperative and non-participating farmers (neighbours) were engaged in the field exercise and the yield measurements to assess the improved varieties participatory.

RESULTS AND DISCUSSIONS

Results

There was a significant difference ($p \leq 0.05$) in grain yield and the productive tillers between the treatments in all the locations (Table 2). Plant height also differed significantly except at Drujeygang. The introduced improved varieties yielded more than 50% of their local counterparts. Similar trends could be observed in the productive tillers per hill.

Table 2. Plant height, productive tillers and grain yield of seven cultivars at different locations

Site	Variety	Plant height (cm)	Productive tillers hill^{-1}	Grain yield (t ha^{-1})
Drugeygang	Bajo Kaap 2	78 a	8 a	4.4 a
	Attey (traditional)	80 a	5 b	2.6 b
p value		0.88	< 0.05	0.05
Goshi	Wengkhar Rey Kaap 2	105 ab	6 ab	4.7 a
	Wengkhar Rey Kaap 6	98 b	7 b	4.1 a
	Attey (traditional)	114 a	4 a	2.3 b
p value		< 0.05	< 0.05	< 0.05
Sunkosh	Bhur Rey Kaap 2	114 a	13 a	5.5 a
	Bhur Kambja 1	119 a	11 a	4.0 c
	IR 64*	78 b	6 b	2.4 b
p value		< 0.05	< 0.05	< 0.05

Means followed by the same lowercase letter within the columns do not differ significantly by 95% confidence interval at $p \leq _{0.05}$.

*Though improved, it is considered as local in the current study as farmers were cultivating since last 10 years.

Discussions

The grain yields of all the improved varieties in the current on-farm were lesser than what is usually obtained in the research station. Bajo Kaap 2 in the station yields about 8.6 t ha^{-1} (RNRRDC Bajo 2006) while Wengkhar Rey Kaap lines produce an average yield of 6.4 t ha^{-1} (RNRRDC Wengkhar 2010). Similarly, the low altitude varieties Bhur Rey Kaap 2 and Bhur Kambja 1 yields between 5-6 t ha^{-1} (RNRRDC Bajo 2009). The improved varieties, however, yielded higher than the local cultivars (Table 2) indicating its potentiality in grain production. The stations' yields are usually higher than the farmers' because of timely agronomic practices such as effective weed control, pests and diseases control and optimum fertility management. Traditional cultivars on the other hand are low yielder but produces stable yields even under unfavourable conditions (Saito *et al*., 2006).

A contributing factor to the current low yield from these improved varieties could be due to inadequate supply of nutrient either through chemical or organic source thereby hindering the expression of true genetic potential. The amount of inorganic nutrition in the current study had been minimal as compared to the recommended dose. On the other hand improved varieties are highly responsive to chemicals fertilizers, and this inorganic input will be imperative in enhancing the production especially in areas with improved cultivars (Yadav *et al*. 1998). Thus, demonstration of recommended integrated nutrient management needs to be a component of the future on-farm production trials particularly with those of modern varieties. The yield benefits of local cultivar through inorganic fertilization was not assessed as Saito *et al*. (2006) reported insignificant yield advantage of local cultivars through chemical fertilizers. Farmers also do not apply any inorganic fertilizer to their local varieties.

The participating farmers, as with others, had a diversity of preferred traits both in agronomic and grain quality. All farmers in the test sites would invariably prefer a tall variety with the expectation of higher biomass to feed their livestock during off season. Livestock is an integral component of Bhutanese agriculture and crops' residues are fed to cattle during the winter season (Young 1991). It was, however, discussed that higher tillering capacity from the improved varieties would compensate the short stauterness of the tested improved cultivars. It was unfortunate in the current study that tillering was low which may have resulted from poor or inadequate crop husbandry.

The cultural and social customs also determine the preference of varieties. For example, farmers from Drujeygang would prefer a red pericarp cultivar while other

farmers would opt for a white variety. The research and extension therefore should clearly understand such preference as it will play a vital role in dissemination of new varieties.

CONCLUSIONS

These trials suggest that higher rice yield can be achieved through adoption of improved mid and low altitude rice varieties. Farmers' preference for the varieties varied depending on the location. There is a need to demonstrate the Integrated Nutrient Management practices to maintain or improve the soil fertility for long term sustainability. Future research is needed to evaluate these cultivars in wider non-tested or remote rice growing areas in Tsirang and Dagana from food security perspective.

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Socio-economic assessment of roadside marketing of agricultural commodities along Thimphu-Tsirang highway

Tanka Maya Pulami

ABSTRACT

Agricultural production in rural communities is the principal source of household income. As the demand for agriculture commodities increase, its marketing is often a problem for the small farmers. This study was initiated with the objectives of assessing different agricultural commodities handled by roadside stands along the Thimphu–Tsirang highway; study their contributions to household income and document the potentials and constraints. Data were collected through personal interview from 60 farmers who sell agricultural commodities along the highway at three strategic sections (Thinleygang –Metsina, Yusipang-Hongtsho and Tshokona-Burichu Dovan) and 12 key informants. Major agricultural commodities sold are cucumber, bean, chili, leafy greens, cole crops, apple, orange, passion fruit and guava and processed products like roasted maize, mekhu and dollay pickle. Thinleygang -Metsina (Punakha) highway vendors had the highest average income of Nu. 62570 while at Yusipang-Hongtsho (Thimphu) the average income was Nu. 45710 and Tshokona-Burichu Dovan (Tsirang) had the lowest average income of Nu. 34030. Roadside marketing of agricultural commodities has significant contribution to the household income (24%) in comparison with other source of income. Major problems were unavailability of marketing facilities, packaging materials and low production.

Key Words: Roadside marketing, Agricultural commodities, Household income

INTRODUCTION

Agricultural marketing is important to all farm enterprises, regardless of the product, place, people or scale of the business enterprise. According to Mandoza & Rosegrant (1995), agricultural marketing systems in most developing countries have a highly atomistic production site consisting of widely dispersed and numerous smallholder producers of perishable crops. The 69% of Bhutanese population depending on agriculture is categorized as small holders with only 3.4 acre of average land holding (Tobgay, 2005). The small farm holding and scattered settlement results in

1 RNRRDC, Bajo, Wangduphodrang; tmpulami@yahoo.com

highly dispersed small producers making it difficult in introducing better methods of cultivation and organizing marketing. Lately agriculture has diversified in Bhutan from the shift in production from low-value staple crops such as rice and maize, into higher value commodities such as fruits, vegetables and medicinal plants (MoAF, 2010). However, these commodities require immediate disposable due to their perishable nature and short shelf life but farmers have only option to dispose/sell their commodities either at weekend markets or at farmers market, which might deteriorate the quality due to over maturity or during the transport. As such, roadside marketing flourish an ideal place to sell their produce.

Despite the low production volume, farmers have to trade their agriculture production to generate income to meet household expenses. With the gradual transformation from subsistence farming to semi-commercial agriculture in peri-urban areas, marketing of farm produces has assumed greater importance in recent years. Since late 1990s, there has been sudden rise in numbers of road-side stalls along the national highways, and the trend is gradually spreading across the country. Although the commodity and volume handled are limited and small, such marketing systems have positive impact on local agricultural production and household income. However, in absence of legal framework and proper infrastructure these marketing channels are not formalized. It is assumed that a comprehensive study of the existing road-side marketing can form as a basis for developing future strategies for promoting commercial farming.

This study was initiated with the objectives of assessing the various types of agricultural commodities handled by roadside stands along Thimphu–Tsirang highway since it has the intensive movement and plying of vehicles, the locality adjacent to the highway has become potential for roadside marketing of agriculture produce. The study also intended to analysis the household income contributions and documents the potentials and constraints of roadside marketing.

MATERIALS AND METHODS

The study was conducted along the Thimphu-Tsirang highway (Figure 1) stretching the length of approximately 165 kilometers where the movement of vehicles has increased creating opportunities for local farmers to sell their farm produce and generate significant income. The study area was divided into three strategic sections, for instance (i) Yusipang-Hongtsho in Thimphu dzongkhag, (ii) Thinleygang -Metsina in Punakha dzongkhag and (iii) Tshokona-Burichu Dovan in Tsirang dzongkhag. Data were collected from 60 farmers, and to make the comparative studies 20 from each section were randomly picked who were engaged in roadside marketing using semi-structured questionnaires. In addition, information on marketing strategy, policies and potentials were collected from 12 key informants

Fig. 1: Map showing study locations

representing Bhutan Agriculture Food Regularity Authority (BAFRA), Dzongkhag Agricultural officers (DAO), Dzongkhag Municipal & geog extension through informal discussions. Marketing data were collected from August-October, 2011 as it is the pick season for roadside vending of agricultural commodities. Yield and income data were collected for one year (2010). Data was analyzed using descriptive statistics, comparative groups, Analysis of Variance (ANOVA) and correlation (SPSS 16.0). Graphs and chart were developed using Microsoft EXCEL. Responses from key informant survey were used to generate Strength, Weakness, Opportunity and Threat (SWOT) of roadside vending.

RESULTS AND DISCUSSIONS

Profile of the respondents

The general profile of the respondents participated in the survey is presented in Table 1. The study found that the female are mainly involved at the roadside marketing of RNR produces which counted to 81.7% of the total respondents. As mentioned by Kulemeka (2011), females are usually involved in roadside marketing of fruits and vegetables; charcoal and fire wood in most African countries. Similarly, the study reveals that although there is not much gender disparity in Bhutan, women are mostly involved in vegetable production and roadside marketing while male are involved in more labourious works.

Table 1. Respondents socio-demographic characteristics

Profile	Yusipang-Hongtsho		Thinleygang -Metsina		Tshokona-Burichu Dovan	
Gender	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**
No of respondents	18	2	17	3	14	6
Literate	7	0	4	1	3	2
Illiterate	11	2	13	2	11	4

Profile	Yusipang-Hongtsho		Thinleygang -Metsina		Tshokona-Burichu Dovan	
Gender	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**
Age <20	1	0	0	0	0	0
Age 20 to 50	16	1	12	2	11	6
Age> 50	1	1	5	1	3	0

Major agricultural commodities sold at roadside

The diversity of vegetables and fruits sold in the study areas vary at different locations. In Thinlaygang-Mitsina, the major agricultural commodities sold are saag, cucumber, beans, chili, broccoli, leafy greens, oranges, passion fruits, guava, and pear. Mostly summer fresh vegetables (cole crops) are sold at Yusipang. They fetch good prices for vegetables as it has advantages of being off season crops when there is no supply of cole crops from India and also having advantage of being near to the capital city where people can afford to pay higher amount of price. However, in Hongtsho majority of the households sells apple and walnuts. Although most of the summer vegetables are also grown in Hongtsho but farmers prefer to take the produce directly to weekend market or to middleman in bulk. There is more diversity of agricultural commodities sold in the Tsirang highways yet the quantity they handle is relatively lower. The main commodities sold at Tshokona-Burichu Dovan section are *dollay,* saag, cucumber, pumpkin, ginger, chili, beans, oranges, banana, passion fruits, guava and pear. Besides lime, mango, pine apple, papaya, passion fruits and sugarcane are also sold in small quantities.

Some value added products are also available in the surveyed areas like roasted maize, *mekhu* and pickles in different locations. Among the commodities sold at the roadside, "roasted maize" is the specialty in Thinlaygang and *mekhu* (rice chapatti) in Metsina. In Tsirang *Dollay* pickle is the main processed product that farmers sell at roadside.

Table 2. Major agricultural commodities marketed at Thimphu-Tsirang highway, 2010

Commodities	unit	Tshokona-Burichu Dovan		Thinleygang-Metsina		Yusipang-Hongtsho	
		Quantity	Rate (Nu)	Quantity	Rate (Nu)	Quantity	Rate (Nu)
Chili	kg	36.1	62.1	208.9	51.8		
Beans	kg	19.2	22.5	111.1	36.4	32.1	47.1
Saag	bundle	114.2	6.3	280.0	9.8	194.6	16.7
Tree tomato	kg	32.0	142.1	57.2	97.8		
Broccoli	kg	35.0	46.0	175.0	21.3	157.7	37.1
Cauliflower	kg	47.5	10.0			124.5	50.5
Cucumber	number	107.9	20.0	178.2	24.3		
Radish	kg	20.0	20.5	217.5	17.5	78.3	16.3
Cabbage	kg	50.0	20.0			170.9	16.5
Orange	no	9400.0	2.8	2500.0	2.5		
Apple	kg					2336.9	51.5
Banana	dozen	175.2	36.7				
Passion fruit	no	1664.3	1.9	258.3	3.2		
Guava	no	1362.0	3.1	400.0	2.2		
Pear	kg	90.0	15.6	86.7	34.2		

Income generation from roadside marketing

The average income (Table 3) earned from roadside marketing of agricultural commodities in 2010 is computed at Nu.47440.0 (*SD*=41167.1). There is high variation of income because of highly dispersed minimum and maximum income earned because of the types of produce and also the quantity of the produce the handle. Comparative analysis shows that Punakha has the highest earning from roadside marketing with the average of Nu. 62570.0 (*SD*=39684.8). This is attributed due to selling of *mekhu* and roasted maize which has maximum profit margin. Besides, Thinlaygang-Mitsina farmers also sell lot of fresh vegetables resulting to highest average income. Although farmers has to buy ingredients required to make *mekhu* (oil and firewood), yet the profit margin gained from the sale of *mekhu* is significant. According to Dunn (1995), "Rural entrepreneurs look for opportunities

to 'add value' to the products they sell and thus increase their profit potential. Value can be added through processing, it can also be added by providing various services or experiences with the product". Profit potential is increased when an ordinary raw commodity is converted into a unique product or experience. Farmers in Yusipang-Hongtsho highway average income earned was Nu. 45710.0 (*SD*= 42381.9) from roadside marketing. In contrary, Tsirang has the lowest average annual income per households from roadside marketing which is computed at Nu. 34030.

Table 3. Average income (Nu) earned from agriculture produce, 2010

Dzongkhag	N	Mean	*SD*
Punakha	20	62570	39684.8
Thimphu	20	45710	42381.9
Tsirang	20	34030	38183.8
Total	60	47440	41167.1

Lloyd, *et.al*, (1995) stated that "the location of a roadside stand can greatly influence its profitability. The more successful stand sites are located near customers and are easily visible from the road". For example, if a stand is close to a city then the average weekly sales will be higher than the stand that is in a rural area, especially if the road is a busy. Comparatively Tsirang highway has more diversity of commodities to sell compared to Punakha and Thimphu, yet the average annual income is lower than in other areas as the quantity handled are less. It is also assumed that the differences are due to less number of vehicle plying on the highway and reduced number of customers. Whereas Punakha highway is at the centre of the route with more vehicles on road, exposed to higher population which enable farmers to sell and earn more income in this location.

Proportion of income from roadside marketing to household annual income

The survey indicates that roadside marketing has significant contribution in income generation to the households (Fig 2). At Thinlaygang-Mitsina area, it contributes 38.8% of the total average annual income per household. In case of Yusipang-Hongtsho, it contributes 20.2% of the total average annual income to the household because most farmers directly sell vegetables in bulk to Thimphu weekend market and potatoes to Phuntsholing auction yard, consequently earning more income from other means of marketing than the roadside marketing. The main source of income in this area if from non-farm (M=24000.0) activities, where the income for the household is derived from the salary earned by some of the household members working as government servant, business and private businesses.

Correspondingly in Tsirang, roadside marketing contribution is lowest as farmers responded that although they have horticultural commodity especially mandarin

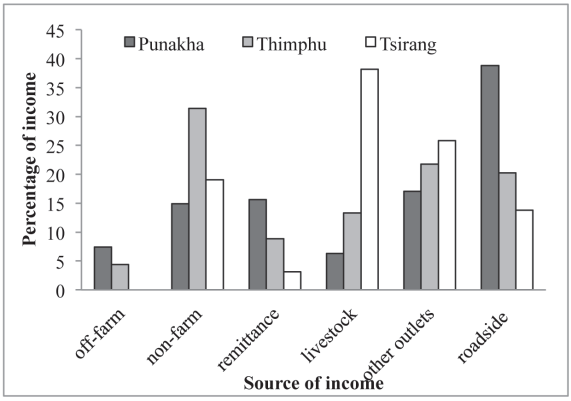

Fig. 2: Sources of household income

(orange) but this commodity is directly contracted out to the contractors from where they earn substantial amount for the household. The maximum income generating commodity in Tsirang is from the sale of livestock and its products (eggs and broiler).

The income earned from roadside marketing had significant correlation to total annual income $\chi^2_{(59)} = 0.59$, p=.00 and it proves that with increase in income from roadside marketing will directly increase the total household income.

Reasons for roadside marketing

Farmers at Yusipang-Hongtsho area produce agricultural commodities in larger quantities, they prefer to sell at the roadside, but at times they take their produce to the weekend market or sell directly to the middleman when they are engaged with other farm works. For respondents in Punakha highway, it was found not much difference in the variation pattern of percentage distribution on the reasons for marketing fig 3. Likewise in Tsirang highway, majorities (50%) of the respondent do roadside marketing for more cash income, 40% respondents reported that their produces are in small quantities to be taken to weekly market or sell in bulk to the middleman; therefore they sell the produces on roadside during all week days. Only 10% reported that the weekly market is far for them to take their produce and had opted to sell at the roadside.

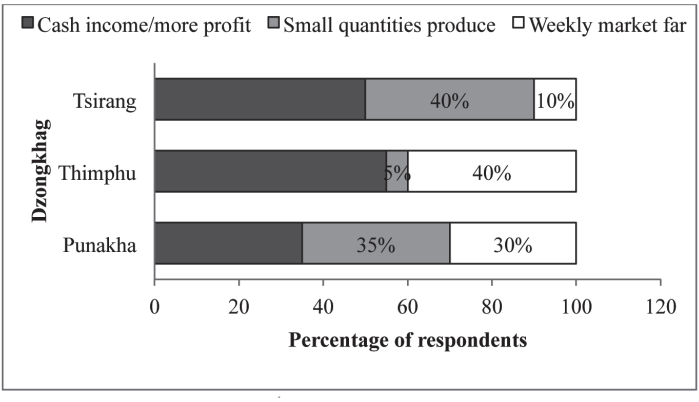

Fig. 3: Reasons for roadside marketing

Trend of roadside marketing

In Bhutan, roadside marketing had picked up recently since late 1990s as one of the marketing strategy for agriculture commodities. However, the trend on numbers of road-side stalls along the national highways is rapidly increasing, although the commodity and volume that the farmers handle are limited and small, yet such venture has some impact on maximizing local agricultural production. The survey concluded with the categorization of roadside marketing farmers and their trend in business set up into three categories: a) The early starters who started the business between the year 1994 to 2000; b) middle starter from 2001 to 2005 and c) recent starter from 2006 to 2011.

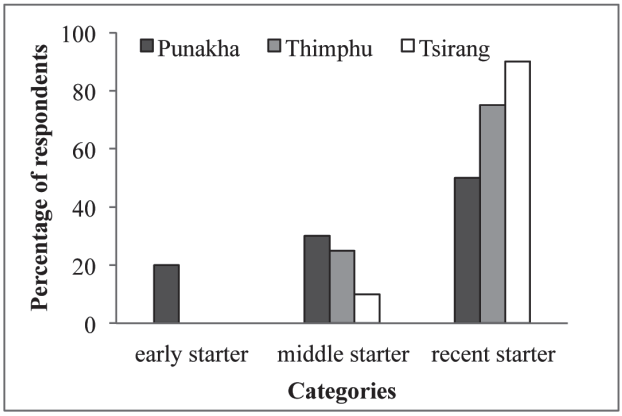

Fig. 4: Trend of roadside marketing

It was found that 20% of the respondents fall under the early starter category that had started the roadside marketing at Metsina in Punakha. Later between the years 2001 to 2005, the roadside marketing was started in all the three dzongkhags with nominal vendors. Eventually from 2006 onwards, there has been incremental increase in roadside marketing selling diverse RNR produces (Figure 5). The incremental increase in number of roadside vendors over the year is attributed by observing and learning from progressive farmers and adopting the system.

The study finding indicates that in general the trend in quantity and income from roadside markets has increased significantly over the span of time and it applies to all the locations. Proportionately 67 % of respondents reported that they have increased their business and it is credited due to the increased number of vehicles plying on the highway correspondingly increasing the number of buyers/customers (Figure 6) while 20% respondents reported that their roadside marketing of produces had remained same over the years. However, 13% respondents claimed that their business has decreased which is attributed due to increase in number of vendors at the particular location, creating competition in selling same types of commodities and decrease in sales.

The system of roadside marketing is not upto the standard considering the infrastructures, facilities and location of the stalls, the survey attempted to understand

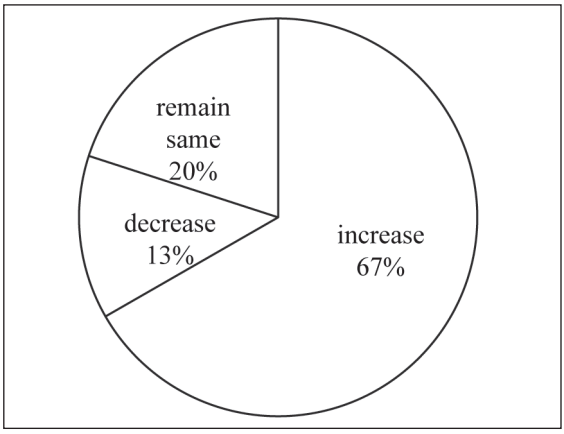

Fig. 5: Roadside business trend

respondents views on future improvement of the marketing system. In general majority of the respondent were for improving the roadside marketing system as shown in Fig 7. It will enable them to facilitate marketing and display more quantities and qualities of produces. On average, 77% of the respondents sought to have better roadside system to attract costumers and earn more income. Whereas 13% responded that it will not make much difference and would like to continue with the same system since the do not have adequate land and labour to intensify and diversify their produces.

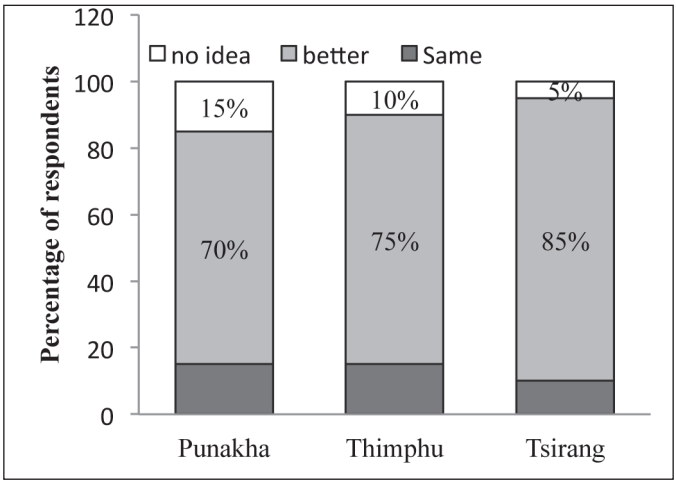

Fig. 6: Views on roadside marketing system

The study resulted average post harvest loss of 11.59% (SD=4.5). There was no significant difference of percentage of post harvest loss of fruits and vegetables sold at the three locations $F(2,57) = .005$, $p = .995$. Post harvest loss of horticultural produces in developing countries is 20-50% (Sudheer and Indira, 2007). In contrary, the survey result showed that the post harvest loss in our context is much lesser compared with many other studies conducted worldwide. It would be because produces are sold fresh without much handling as compared to other market outlets.

Major problems and constraints in roadside marketing of agriculture commodities

In absence of the policy on roadside vending of agricultural produces farmers encounter numerous difficulties in operating the roadside stalls.

Agricultural production system is considered as labour intensive, it demands labour right from the land preparation till marketing. From the total sample of this study, 21.67% of the respondents reported of having labour shortage in initiating this roadside business and the distributions of labour shortage among the locations do not vary much.

The other associated problem was less land holding and production where 13.33% of the respondents have less land holding resulting to low production from the available unit of land. As a result, farmers cannot increase produces for roadside marketing even if they intend to. The responded also reported that most of the commodities sold at roadside are local varieties which has low yield. Wild animal damage was one of the major problem ranked by the farmers of Thinleygang, where 30% of respondents (N=20) claimed having wild animal damage.

From the total survey sample, 90% of the respondents reported having problem of selling the produce in open areas. From this proportion, 58% ranked it as the most important problem for roadside marketing. Although 28.3% of respondent have marketing shed but it was reported that they do not serve the purpose and meet the standard. With such temporary shed, it is difficult to keep away from rain during monsoon and to accommodate their produces for marketing. Particularly, in Thinlaygang areas farmers have reported difficulty of roasting maize during raining season. As an alternative, farmers built temporary sheds during the season and are removed after the season is over.

Especially for efficient roadside marketing it is of primary importance to have some basic facilities like toilets, garbage bin, store house and supply of drinking water both for the customers and sellers. However, such facilities seldom exist in the system. The survey found that 39.8% of respondents have problem of these facilities. Discussion with officials from Municipal Corporation and Roads Department, it was noted that improper disposal of garbage is increasing and has become one of the main problems for roadside marketing. Both the sellers and buyers dispose their garbage nearby the stalls which present an unhygienic site and in the long run it might lead to environmental pollution, also it create unpleasant sight for the people travelling along the highway especially the tourist.

Except in few locations there is no designated place in most places for the people to sell their produce. Such system might cause risk to both the sellers and the customers. As such, this study attempt to gain farmers point of view and found that 26.67% of the respondents have problem in finding appropriate place for displaying their produce and sell at roadside. Usually such businesses are found located on the sharp turns and on congested area of the highway, therefore, there is objection from authorities like Department of Roads and Traffic police to avoid risks while

the travellers park their vehicle and purchase the produce. In totality 13.33% of the sample respondents reported of having problem for product development since it is labour intensive and time consuming. In Thinlaygang, farmers have problem of inadequate firewood for maize roasting and it is difficult to get firewood permit from forest office since farmer has fixed volume of firewood allocated per year.

The other difficulty reported was the unavailability of proper packaging materials (jars, bottle, containers etc.) for pickling. Presently farmers' use all forms of containers (plastic bottle, jars, bottle etc.) to package pickles, these forms of packaging is not hygienic as the containers are not sterilized. Although farmers gain high economic returns from selling pickles yet appropriate technology intervention is required to improve the quality of the produce.

One of the policy objectives of the RNR sector for the 10th five year plan is to transform subsistence agriculture to small scale commercial agriculture without compromising food security (RGoB, 2009). Considering the widespread operations of road-side marketing that contribute to household income and local horticultural production, it is one of the initiatives to fulfill the objective with the intervention of good policy strategy. Infrastructural support in terms of construction of proper permanent or semi-permanent marketing shed at strategic locations will immensely benefit larger group of small farmers whose main source of income is from farming and roadside marketing. The other areas of concern on the environmental issues, is to educate the vendors on environmental degradation and spoilage of scenic beauty due to their current practice of waste disposal. Providing waste collection bins would improve the cleanliness of these areas. Furthermore, for the convenience of both the travellers and sellers, basic facilities like toilets and drinking water supply at strategic location is found to be of immense necessity along the highways. Some of the striking products that gain customers and travelers attention are on the roasted maize at Thinleygang area and *mekhu* at Metsina. The trends in sell of these products are increasing over the years. However, it was reported by farmers that for both roasting maize as well as frying *mekhu* it requires huge amount of firewood and labour. Considering the scenario, finding an alternative means of roasting maize and frying *mekhu* such as introduction of maize roasting machines and electronic frying cookers will reduce the drudgery as well as the negative effect on environment.

The processed products such as *mekhu*, pickles and some other processed foods were observed to be not hygienically processed. Discussion with The BAFRA officials confirmed that the products do not meet the standards. Moreover these farmers need to be aware that customers are increasingly becoming more and more health and cleanliness conscious these days. Therefore, one of the recommendations of this study is to provide training on hygienic handling of these products to the roadside vendors. Together with the hygienic processing, it is also important to uplift the quality of the products that the farmers sale at roadside through value addition.

SWOT analysis

Despite the problems the roadside marketing has definite advantages. To garner better understanding of the strength, weakness, opportunities and threat of roadside marketing of agricultural produces, SWOT analysis was used.

a. Strengths

- Convenient for farmers to sell their produce afresh as per their own price.
- Good source of income for small farmers
- Reduces transportation costs and post harvest losses.
- High economic returns of produce from farm gate.

b. Weakness

- Poor hygiene, no proper packaging and levelling.
- No fixed rate for any commodities. Fluctuation in produce price within farmers.
- Poor marketing system as there is no proper marketing facilities.
- No proper dump sites for garbage/ wastes so litter the environment.

c. Opportunities

- With increasing number of vehicle movement on the highway, it will result to increase numbers of customers.
- People becoming more conscious about health and healthy foods will encourage purchasing local produces.
- Farmers can make good income with improved marketing systems along the roadside, thereby making possibilities to extension of marketing systems along the roadside.

d. Threats

- Roadside marketing is informal business with no proper policy and legal support, sustainability is a question.
- Chances to discourage and discontinue such marketing system upon the objections of concerned road authorities.

CONCLUSIONS

In most of the developing countries, roadside marketing provides an immediate means for income generation to the small scale farmers. As the need for cash at household level for purchase of household goods, medicine, educating the child has tremendously increased in Bhutan, there is rapid upsurge of roadside vending of agricultural produces. This is also attributed to the road transport network system prevailing in our country, where the traffic is not congested and customers have time to grab few fresh vegetables and fruits as they travel.

The study findings reveal that roadside marketing has positive impacts on the socio-economy of the households and their livelihood. It was found that there is significant contribution from roadside marketing to the people of the three selected study locations (Yusipang-Hongtsho, Thinleygang -Metsina and Tshokona-Burichu Dovan).

In addition to the economic benefit small farmers derive from the marketing and brisk employment it provides, the study found that farmers encounter various problems in production and marketing that includes infrastructural support, post harvest, processing and packaging, transporting, environmental and most importantly absence of policy and legal support for continuity and sustainability of such marketing system in the country. Yet with all those bottlenecks, farmers are still managing to continue as it greatly contributes for their livelihood.

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Traditional chilli pepper diversity: Farmer's perception on its decline in western Bhutan

Laxmi Thapa[1]

ABSTRACT

Phenonotypic charateristics of diverse chili peppers in Bhutan is perceived to be declining. This is further aggravated by absence of basic information on the diversity of chili Pepper. Study was conducted to document the diversity and perception on decline of traditional chili pepper with the help of semi-structured questionnaire survey of 133 households in Chhukha and Paro Dzongkhags. The study confirmed the presence of 19 varieties of chili pepper out of which 13 were found to be traditional varieties. Six local varieties such as Payee, Sha, Dallae, Begup, and Pakshikha ema were most popularly cultivated. Result indicated that there is no decline in the cultivation of traditional chili pepper however, significant changes in phenotypic characteristics of the varieties have been observed. Perceptible change in the phenotypic characteristics of Sha, Payee and Begup ema in western Bhutan was recorded. The study highlights the need to conduct comprehensive phenonotypic charaterization of our valuable traditional chili pepper .

***Key words**: Chili, Diversity, Varieties, Pepper,Ttraditional, Phenotypic cheracteristics*

INTRODUCTION

Chili pepper (*Capsicum* spp.) is one of the most important cash crops for Bhutanese farmers and is an indispensible ingredient of the Bhutanese cuisine. All Dzongkhags (Districts) in Bhutan grow chili pepper with an annual production of chili estimated at 6,696 metric tons from an area of 6985 acres (DOA, 2010).

Traditional varieties include the cultivars farmers have been growing over many years. Several location specific varieties of chili peppers have been observed in Bhutan. Tshering *et.al*., (2010) reports existence of nine traditional varieties of chili pepper namely *Sha Ema, Begup Ema, Dogep Ema, Urka Bangla, Pakshika Ema, Dallae Khorsani, Rangi Khorsani, Janmara Khorsani and Zeray Khorsani*. These varieties are important as genetic and cultural resources. Although several chili pepper varieties have been noticed there is no comprehensive study undertaken to document the diversity of chili pepper in Bhutan.

1 Research Officer, RNR RDC, Yusipang; latithapa@gmail.com

The Ninth horticulture research coordination meeting (2008) deliberated on the declining (degenerating) phenotypic characteristics (observable characteristics) of the traditional chili varieties. To date no documentation of concrete steps taken are available. This possibly could lead to the loss of important germplasm. Perception of farmer can differ from that of development workers. A clear understanding of farmer's perception is felt necessary for formulating clear guidelines for future research agenda on the conservation of traditional chili pepper varieties.

Therefore, this study was conducted to document the chili pepper diversity and farmer's perception on the decline of phenotypic characteristics of traditional chili pepper in Western Bhutan.

MATERIALS AND METHODS

The study was conducted in two Dzongkhags (Paro & Chhukha) of western Bhutan. Field survey was conducted during August and September 2011. Using the secondary data (RNR statistics 2009) Paro with maximum area under cultivation and Chhukha with high, mid and low altitude agro-climatic condition were selected to capture the maximum diversity.

A purposive multi-stage sampling was used. Three chili pepper growing Gewogs in each Dzongkhag were selected. From each of the six gewogs, two villages were selected as the survey sites (Table 1).

Table 1. Study sites by dzongkhag, gewog and villages

Dzongkhag	Gewog	Villages	Altitude (m. asl.)	No.of respondents
Chhukha	Bongo	Pakshikha	1320	15
		Meritsimo	1330	8
	Sampheling	Alley	250	9
		Dungena	300	10
	Chapcha	Chapcha	2300	11
		Paga	2413	12
Paro	Lungney	Woochu	2030	15
		Bondey	2080	10
	Tshento	Tsenzi	2050	10
		Nyamzi	2250	13
	Dogar	Tshongkha	2280	10
		Lomikha	2280	10
Total (n)=	6	12		133

Household survey was carried out using pre-tested and semi-structured questionnaire. The questionnaire consisted of both open-ended and closed. The questions consisted of two major parts: i) chili varieties and its characteristics, and ii) the perception on decline. Using the 30% HHs sampling 68 HHs and 65 HHs were sampled for interviews in Paro and Chhukha, respectively. In total, 133 interviews were made.

Field observations on varieties of chili grown and its characteristics were made during the household visits in the farmstead. All the varieties listed in the report are in local names.

Data was entered in MS excel and analyzed using SPSS (Statistical Package for Social Sciences (Version 16). For qualitative data to perform non-parametric test, descriptive statistics was used. Descriptive statistics was performed to calculate frequency, percentage, minimum value, maximum value, mean, standard deviation and for cross tabulation for associations. Chi-square goodness of fit test was performed for the important chili type.

RESULTS AND DISCUSSIONS

Chili pepper diversity

Of the 19 different varieties cultivated in Chhukha and Paro 13 are traditional varieties (Table 2). It is, however, not clear to which species these belong to, since the names indicated are local names. Phenotypic characterization only will confirm whether these are different or different names for the same varieties.

Table 2. Top five traditional varieties cultivated in Chhukha and Paro Dzongkhags

Sl/no.		Frequency	Percent
1	Begup ema	30	11.9
2	Dallae Khorsani	32	12.6
3	Pakshikha	20	7.9
4	Payee	54	21.3
5	Sha ema	35	13.8
Rest	Capsicum, Chapcha local, Dogup ema, Indian ema, Janmara, Japan ema, Lamchey, Madhisay, Rangay, Saili, Super solo, Thadray, Yangtse and Zeray Khorsani		≤ 5.5%

The varieties which are not traditional are capsicum, Indian ema, Japan ema, Super solo, Madihsay and Lhamchey. Dzongkhag wise data point to the cultivation of 15 different chili types in Chhukha and eight different chili types in Paro (Fig. 1).

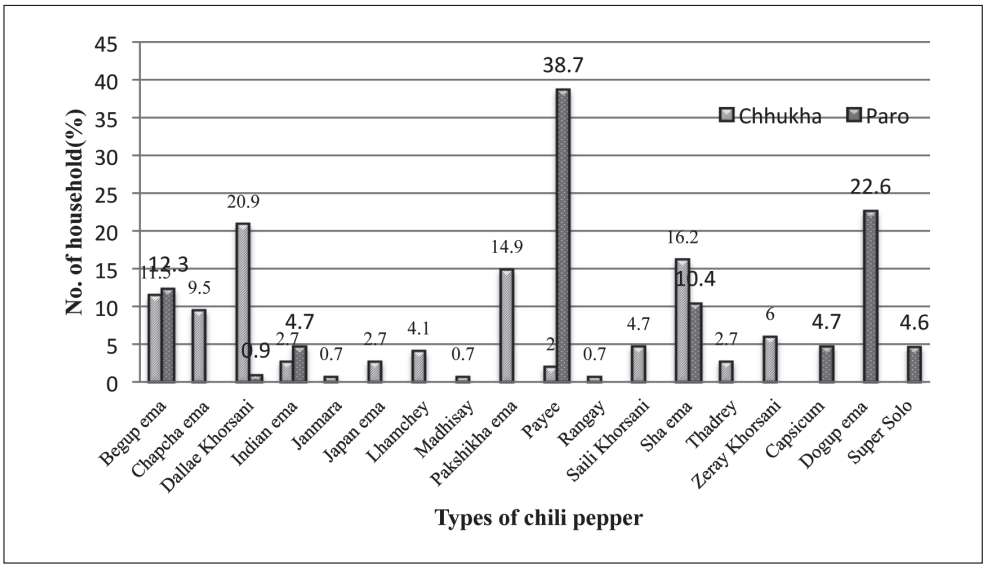

Fig. 1: Chili Pepper grown in Chhukha and Paro Dzongkhag.

Pakshikha ema, Urka Bangla and Dogup ema are believed to be typical to Bhutan (Tshering *et al*., 2010). The RNR RDC Wengkhar has characterised Urka Bangla (Yangtsi ema) and that of Dogup ema can be found in Choden's book titled "Chili and cheese", 2008 but no location is specified. Both of this literature has mentioned Urka Bangla and Dogup ema as *Capsicum annuum*. Tshering *et al*., (2010) provided the general information on the area of production of Dogup ema as western part of Bhutan but no specific location. This study found that Dogup ema is cultivated by the farmers of Dogar Gewog in Paro.

Pakshikha ema is another distinct variety and is said to have special taste and fetches higher price than any other varieties at the Gedu market. Payee and Dogup ema are distinctive varieties. Respondents from Paro indicated that the local cultivar Payee (Parop ema) has distinct characteristics with short (thumb size) length and width (Annexure 1). Chili that gets wrinkled when fresh or dried fetches premium price. Two such varieties are the Begup ema and Japan ema. The former one is said to get wrinkled characteristics during the fruiting season while the latter gets wrinkled after the fruit is ripened and dried.

Maximum number (35%) of respondents reasoned good taste for retaining the traditional varieties. Other reasons cited were high market price (24%) and easy access (17%) to seed and seedlings. Mild pungency and soft fruit skin were associated with good taste.

Other reasons cited were: resistance to pest and diseases, good drying quality, unavailability of other potential varieties, crop adaptability, assurance in production and ease of working with traditional varieties. These characteristics of traditional varieties need to be validated further for future research on conservation, utilization of desirable characteristics and varietal development.

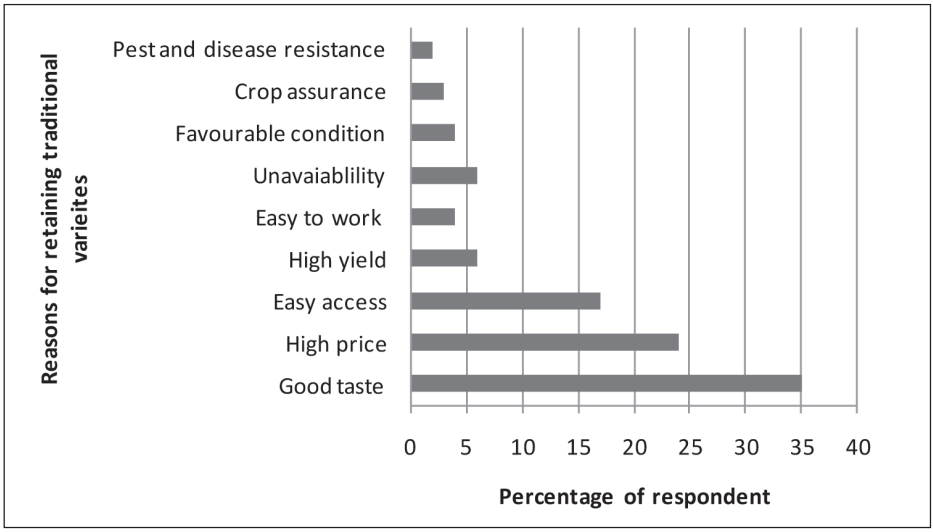

Fig. 2: Reasons for retaining Traditional Varieties

Perception on phenotypic change

The result of the test performed with two level of variable (i) change and (ii) no change and Chi-square goodness of fit test performed on each of the six popular chili types is presented below.

Table 3. Farmer's perception on phenotypic change of six popular chili types

	Perception of respondents			
Chili type	**There is no change**	**There is change**	**Chi sq.**	**P-value**
Begup(n=24)	3	21	13.5	0.0002
Dogup(n=9)	3	6	1	0.317
Dollae(n=28)	14	14	0	1
Pakshikha(n-20)	10	10	0	1
Payee(n=47)	13	34	9.38	0.002
Sha ema(n=27)	5	22	10.7	0.001

n= number of respondents

The results indicate that there is significant difference in three chili types (Begup, Payee and Sha) between the proportion of those who think there is change and those who don't (Table **3**). Conversely, there was no significant difference with Dogup, Dollae and Pakshikha. Therefore there is perceptible change in the phenotypic characteristics of Sha, Payee and Begup ema in western Bhutan.

The perception of the researchers corresponds with those of the farmers concluding that there are changes in the phenotypic characteristics of traditional chili pepper although these changes are specific to varieties.

It is important to document the evidences leading to the changes in the phenotypic characteristics. Data on farmer's opinion was thus collected to record such evidences. While majority (28%) of the respondents had no idea for the occurrence of change in phenotypic characteristics, 16% attributed it to seed mixture and repeated use of same seeds and another 6% reasoned it to be due to introduction of new variety. The change attributed to crop management, pest and diseases remain to be studied.

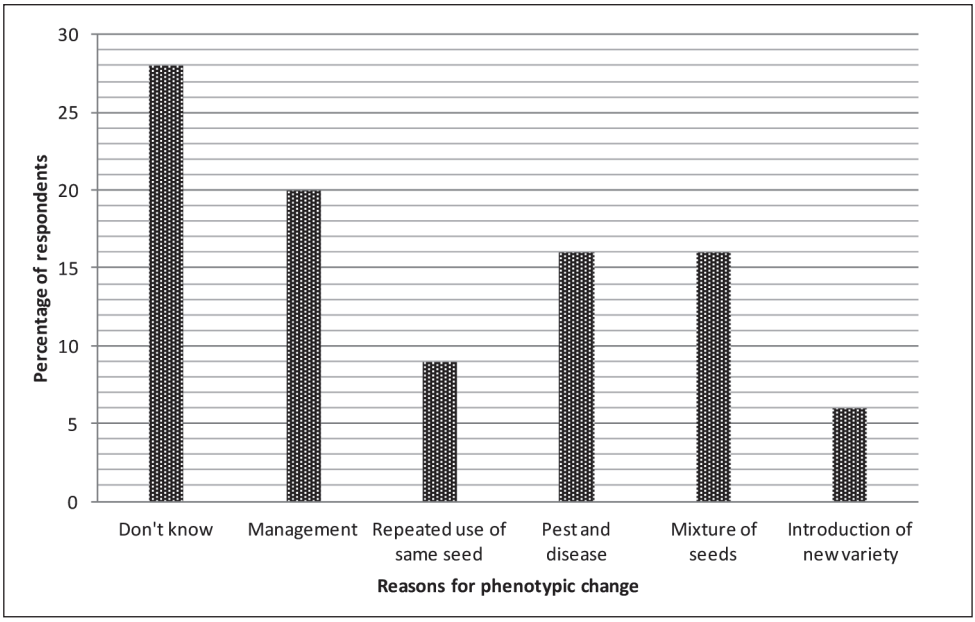

Fig. 3: Reasons for change in phenotypic characteristics

Perceptions on decline in cultivation

Using direct yes or no questions, information on the respondents' perception on the decline of cultivation is reported for six traditional varieties.

Table 4. Farmer's perception on decline in cultivation of six popular traditional chilli.

Chili Types	Respondents perception on decline of cultivation			
	There is decline	There is no decline	Chi Sq.	P-value
Begup (n=30)	5	25	13.33	.001
Dogup (n=13)	1	12	17.28	.001
Payee (n=50)	10	40	41.3	.001
Sha ema (n=33)	7	26	27.48	.001
Dollae (n=23)	8	15	3.16	.180
Pakshikha (n=20)	7	13	1.8	.206

n=number of respondents

The result indicates that there is significant difference in the proportion of those who think there is no decline and those who think there is decline in cultivation in four variety (Table 4). Highly Significance difference was found in Begup, Dogup, Payee and Sha ema indicating that there is no decline in the cultivation of these four important traditional chili varieties. No significant difference was found in two varieties (Dollae and Pakshikha) which could mean that the cultivation of these two varieties have remained same.

CONCLUSIONS

The study revealed that the cultivation of diverse traditional varieties of chili pepper in Chhukha and Paro. Such practices are important for conserving the important genes of our traditional varieties. The study found that popular traditional chillies varietes (Parop ema, Pakshikha ema & Begup ema) has not been studied in terms of characterization and conservation. It is evident that there is no decline in the cultivation of traditional chilli pepper varieties. Dependency on traditional variety is mainly associated with good taste, good price and easy access to seed and seedlings.

Farmers perceive that change in the phenotypic characteristics of traditional chili pepper varieties is taking place. Phenotypic changes are evident in Sha ema, Begup and Payee. The study highlights the need to conduct comprehensive phenonotypic characterization on these traditional varieties of chili pepper immediately.

The result of the study is based on data from only two dzongkhags and 133 respondents; a larger sample is required in order to represent the holistic data. Therefore further study in other dzongkhags is required.

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Annexure 1. Six important traditional chili Pepper found in Chhukha and Paro Dzongkhag.

	
Capsicum chinense *Local Name:* Dallae Khorsani *Location found;* Dungena, Alley, Pakshikha, Meritsimo *Fruit Characteristics:* Round (around 2cmx2 cm) *Pungency:* Very Pungent	***Capsicum annuum*** *Local Name:* Sha ema *Location found:* Paro,Chapcha *Fruit Characteristics:* Slightly triangular with blunt sunken blossom end(6cmx10cm) *Pungency:* Mild
	
Capsicum sp. *Local Name:* Payee (Parop ema) *Location found:* Namji, Tshenzi, Lomikha, Bondey *Fruit Characteristics:* Smaller and thinner than sha ema with length of thumb (5.7cmx1.8cm) *Pungency:* Mild.	***Capsicum annuum***. *Local Name:* Dogup *Location found:* Lomikha,Tshongkha *Fruit Characteristics:* Long, blocky shape with pointed blossom end(13cmx2cm) *Pungency:* Mild

	
Capsicum sp. *Local Name:* Pakshikha *Location found:* Pakshikha, Meritsimo *Fruit Characteristics:* Slender short fruit with pointed blossom end (7cmx1cm). Fruit grow uprightly. *Pungency:* Strong	***Capsicum annuum***. *Local Name:* Begup *Location found:* Chapcha, Paga, Tshongkha, Bondey, Tsenzi *Fruit Characteristics:* Long slender fruit with pointed blossom end. Wrinkled fruit when fresh and dry (13cmx2.2cm).

Forestry

Canopy-size, diameter and height relationship in trees of College of Natural Resources campus

Jigme Tshelthrim Wangyal[1]

ABSTRACT

In this study, the relationships between canopy–width, trunk girth and total tree–height of the Pinus roxburghii, Ficus auriculata , Jacaranda mimosifolia , Cupressus corneyana, and Albizia gamblei tree species growing in the College of Natural Resources located in Lobesa, Punakha Dzongkhag were examined. Five trees of each species which are notably free from obvious anthropogenic disturbances were selected for the study. Regression analyses of the data indicate that there are linear relationships between crown width, height and trunk size of all species. A perfect linear relationship was observed between canopy width and girth at breast height (GBH) of Pinus roxburghii, Ficus auriculata and Jacaranda mimosifolia with the exception of Cupressus corneyana and Albizia gamblei. The relationship between canopy–width and tree–height appeared linear in Ficus auriculata and Jacaranda mimosifolia where as the relationship between GBH and tree–height appeared to be linear in all other four tree species studied with the exception of Cupressus corneyana. The results are discussed in the context of their adaptive significance for their growth in artificial plantations.

Keywords: Canopy, GBH, Tree height, Linear relationship

INTRODUCTION

Trees exhibit substantial variations and flexibilities in their pattern and size of crowns, height and trunk diameters (Kuppers, 1989; Givnish, 2002; Vincent & Harja, 2008) which are regulated by hereditary developmental trend, which may in turn be altered by the surroundings where the trees grow (Arzai & Aliyu, 2010). The height of the tree and its size of the canopy is important in a tree as the photosynthesis rate would depend on the amount of light the crown intercept (Midgley, 2003; Russel *et al*., 1989). Investments in height of trees improve access to light but incur cost in construction of stem (Falster & Westoby, 2003). Trees grow tall where resources are abundant, stresses are minor, and competition for light places a premium on height growth (Koch *et al*., 2004). In general, natural selection favour trees that receive more amount of light, but that depends on the amount of light that falls on the tree species.

1 College of Natural Resources, Royal University of Bhutan; jigmewangyal@gmail.com

King (1990) found that natural selection tended to favour trees that grow high quickly. Hence, competition for light is often important in groups of trees for their survival. A mathematical model has demonstrated that higher tree intercepts more light during the course of the day (Jahnke & Lawrence, 1965). The trunk diameter also has adaptive significance to a tree in that bigger trunk can withstand larger forces that act on it (Arzai & Aliyu, 2010). These forces according to Fraser (1962) are the tree weight and the drag exerted on it by wind. Alexander, (1970) found wind to be more important than weight in deciding the necessary thickness of trunk for a tree.

The objective of this study was to investigate the relationship between canopy–size, height and trunk diameter amongst five tree species growing in the College of Natural Resources campus and to decide the implication of these relationships on adaptation of the trees.

MATERIALS AND METHODS

Five species each of *Pinus roxburghii*, (Sargent), *Ficus auriculata* (Loureiro), *Jacaranda mimosifolia* (D. Don), *Cupressus corneyana* (Carriere), and *Albizia gamblei* (Prain) trees were selected for the study. All trees chosen had their parts intact as they were picked up from the areas with very little disturbed from anthropogenic factors. Debarked, diseased and disturbed trees were avoided. The following parameters were measured on each tree:-

Canopy Size

Considering the time shortage, the principle of least work (Monteith, 1981) was used for measuring the canopy–size of the trees chosen for the study. Every tree was looked at from all sides to find out the side where the crown was broadest. The distances between the two extremely short and long ends of the canopy were then marked by setting up two range poles and using measuring tape, the distance noted as canopy size in meters, after which an average was taken to obtain the size of the canopies.

Tree Girth (GBH)

Tree girth was considered as the girth at breast height (GBH). The GBH of the trees were obtained by measuring the girth at breast height (at a distance of 1.3m) from the ground in meters.

Total Tree Height

Depending on the position, the tree height was measured by direct or indirect methods. Felled tree heights are measured directly with tapes or graduated poles

while for standing trees indirect methods are used as tips are often inaccessible. According to King (1990), climbing on the tree to obtain heights with tape or graduated pole is dangerous. Spiegel relaskop that have three height scales (20m, 25m and 30 m) on the standard metric version was used to obtain the heights of the trees as follows.

Measurements of the desired horizontal distances from the base of the tree to a location where the required point (e.g. tree tip) can be seen were identified and necessary readings taken. Sighting was done at the required point, while holding the break button to allow the scales to freely rotate. Once the scale was settled, readings of the appropriate heights were taken first at the crown tip. Then sighting was done to the base of all the trees. The addition or subtraction of the reading at the tip of the crown and at the base of the tree gave appropriate heights.

Statistical Analysis

A regression analysis was conducted to measure the nearness of the apparent linear relationships. To accomplish this, the product moment correlation coefficient (Pearson Correlation Coefficient - r), was computed using the formula given below.

r = For all significant r values, the regression coefficient, b, was calculated by:

b = which is equivalent to slope. The intercept, a, was worked out by substituting the estimated value of b in the equation: a = y - bx. In order to obtain the regression line, a and b values were rearranged in the equation as y = bx + a. The values of x were selected and the corresponding y – values computed from the straight–line equation.

RESULTS AND DISCUSSIONS

For each of the five tree species sampled, the means () of the canopy–size, tree diameter and tree–height measurements were computed. The standard error for all the sample means are tabulated (Table 1). The data from the measurements of the parameters is given in Table 1 which was used to plot CS/GBH, CS/TH and TH/GBH relationships.

Table 1. Means for canopy width, tree height and tree girth-size

Tree species	CW (m) SE	GBH (m) SE	Tree Height (m) SE
Pinus roxburghii	12.02 (1.36)	1.17 (0.12)	19.54 (1.66)
Ficus auriculata	4.02 (0.44)	0.36 (0.10)	4.38 (0.88)
Jacaranda mimosifolia	4.68 (0.55)	0.49 (0.05)	8.91 (0.50)
Cupressus corneyana	5.74 (0.58)	0.83 (0.18)	14.27 (1.85)
Albizia gamblei	8.71 (0.52)	0.65(0.09)	11.6 (1.23)

Key: GBH = girth at breast height, S.E. = Standard error

Rectilinear relationships were observed for all the plots for means (Table 2). The results of the regression analysis for CS/GBH, CS/TH and GBH/TH relationships between the trees studied and the individual groups are summarized in Tables 2, 3, 4 and 5, respectively.

Table 2. Regression analysis between CW, GBH and TH of trees

	r	b	a	Y	= b x + a
CW Vs. GBH	0.886*	0.82	0.122	- 0.82 x +	0.122
CW Vs. TH	0.851*	1.461	1.465	1.461 x +	1.465
GBH Vs. TH	0.987**	17.784	-0.744	17.78 x +	-0.744

* Significant, r = product moment correlation coefficient, b = regression coefficient/ slope, a = intercept, y = regression line.

A linear relationship was detected between the canopy size and GBH (Table 2 and Fig. 1) for all tree species observed ($r = 0.886$, $P \leq 0.05$), i.e., trees with larger trunks have bigger canopies. This relationship is of adaptive meaning to the trees since canopy size also adds vastly to a tree's total weight. Hence, larger trunks can help trees to support large canopies (Horn, 1976).

Table 3. Regression analysis for canopy width vs. girth

Tree Species	r	b	a	Y	= b x + a
Pinus roxburghii	0.942*	0.081	0.194	0.081 x +	0.194
Ficus auriculata	0.911*	0.213	0.501	0.213 x +	0.501
Jacaranda mimosifolia	0.964**	0.086	0.093	0.086 x +	0.093
Cupressus corneyana	0.645	0.199	0.199	0.199 x +	0.313
Albizia gamblei	-0.294	-0.05	1.078	-0.05 x +	1.078

*Significant, r = product moment corrélation coefficient, b = regression coefficient/ slope, a = intercept, y = regression line

The relationship between the means of canopy–size and tree–height was also linear (Fig. 2) in all the tree species (Table 2), which means taller trees have larger canopies. In addition, there are no significant differences between the slopes of the regression line which implies that photosynthesis is very important in plants and signifies that natural selection favour developmental characters pitched towards utmost light interception.

As tree increases in height, its metabolic and growth requirements would increase too (Arzai & Aliyu, 2010). As the data indicates the increase requirements, it is likely that trees have evolved wide canopies so as to maximize light interception and thus increase their photosynthetic rate (Jahnke & Lawrence, 1965). Furthermore, contest for light is crucial, more importantly for trees in groups. To take on this trouble, trees with larger crowns must have probably developed high positions. So, linear relation between canopy and height ($R^2 = 0.725$) is perhaps an adaptation favoured by natural selection (Fig. 3).

The relationship ($R^2 = 0.975$) between the GBH and tree–height however, appeared more significant than other relations ($r = 0.987$, $p = 0.002$) i.e., shorter tress have smaller trunks while taller trees have larger trunks. A regression analysis confirmed this linearity (Fig. 3) which indicated the calculated r values for all the tree species to be greater than the critical value .878, $p \leq 0.05$,). This relationship is of logical adaptive significance since a tree trunk must be firm enough to resist the wind pressure of Wangdi valley and the tree's own weight, as earlier reported by Fraser (1962). The slope of the regression line shows the relationship between the tree–height, crown width and GBH to be similar regardless of the tree species (Table 2).

However, the group analysis of the tree species studied revealed different relationships (Table 3). A perfect linear relationship was observed between canopy width and GBH of *Pinus roxburghii* ($r = 0.942$, $p = 0.016$), *Ficus auriculata* ($r = 0.911$, $p = 0.031$), and *Jacaranda mimosifolia* ($r = 0.964$, $p = 0.008$) with exception of *Cupressus corneyana* ($r = 0.645$, $p = 0.240$) and *Albizia gamblei* ($r = -0.294$, $p = 0.631$). The observation indicates that the size of the trunk in *Cupressus corneyana* does not depend on the canopy width. Conifers typically have conical crowns and maintain branches deep into the sub-canopy in dense stands (Walker & Kenkel, 2000). Their needles like leaves are photo-synthetically weak because of xeromorphic traits such as thick epidermal-hypodermal layers and sunken stomata (Raven *et al*., 1987) and lack of efficient conductive tissues (Raven *et al*., 1987; Sprugel, 1989). Conical crowns create larger gaps at the top of the canopy (Smith & Brewer, 1994) which is an adaptation to getting more sunlight for better photosynthesis. Therefore,

they grow taller with smaller trunks, giving good reason for *Cupressus corneyana* studied to show non-linearity. In the case of *Albizia gamblei*, multiple forking and the clump growth characteristic would be the reason for showing non-linear relations. All *Albizia gamblei* measured in the campus had single base with lots of forking and expanded crowns.

The relationship between canopy–width and tree–height did not appear linear (Table 4) with only *Ficus auriculata* ($r = 0.872$, $p = 0.054$), and *Jacaranda mimosifolia* ($r = 0.956$, $p = 0.011$) exhibiting very low in *Ficus auriculata*. The other three species, *Pinus roxburghii* ($r = 0.716$, $p = 0.174$), *Cupressus corneyana* ($r = 0.620$, $p = 0.264$) and *Albizia gamblei* ($r = -0.705$, $p = 0.163$) showed no linear relations challenging the theory of taller trees carrying wider canopies. This observation is an indication that the canopy–width and tree–height of conifers (*Cupressus corneyana* and *Pinus roxburghii)* are not correlated. The reason for the canopy–width and height of *Cupressus corneyana* showing non-linear could be to resist the high velocity wind. By reducing the crown width and tapering towards the sky, it can reduce the wind interception. It could also be an adaptation to the campus environment, as the entire specimens observed are planted not many years ago. For *Pinus roxburghii*, the reason could be biotic interference (lopping, debarking, and time and again measurement of them for academic purposes) and cattle grazing, which is rampant in the campus. In the case of *Albizia gamblei*, the reason could be forking of crown, an adaptation to conduction of photosynthesis for adequate supply of nutrients to its numerous parts.

Table 4. Regression analysis for canopy width vs. tree height

Tree Species	r	b	a	y	= b x + a
Pinus roxburghii	0.716	0.871	9.07	0.871 x +	9.07
Ficus auriculata	0.872*	1.737	-2.602	1.737 x -	2.602
Jacaranda mimosifolia	0.956*	0.871	4.833	0.871 x -	4.833
Cupressus corneyana	0.62	1.969	2.966	1.969 x +	2.969
Albizia gamblei	-0.705	-1.662	26.077	-1.662 x +	26.077

* Significant, r = product moment correlation coefficient, b = regression coefficient/ slope, a = intercept, y = regression line

With the exception of *Cupressus corneyana* ($r = -0.177$, $p = 0.776$), the relationship between girth at breast height and tree–height appeared to be a linear in *Pinus roxburghii* (p = 0.05), *Ficus auriculata* (p = 0.01), *Jacaranda mimosifolia* (p = 0.01) and *Albizia gamblei* (p = 0.05) in all other four tree species studied (Table 5). The reason for *Cupressus corneyana* deviating away from this trend could be attributed

to the fact that its tapering trunk is known to, in addition to giving support, serve the dual functions of water storage and resistance to desiccation. Hence, *Cupressus corneyana*'s trunk size may not necessarily be proportional to its height.

Table 5. Regression analysis for girth vs tree height

Tree Species	r	b	a	y	= b x + a
Pinus roxburghii	0.998*	16.692	0.128	16.692 x +	0.12
Ficus auriculata	0.994**	8.454	1.37	8.454 x +	1.37
Jacaranda mimosifolia	0.987**	10.129	3.904	10.129 x +	3.904
Cupressus corneyana	-0.177	-1.818	15.777	-1.818 x +	15.777
Albizia gamblei	0.885*	12.38	3.603	12.38 x +	3.603

* Significant, r = product moment correlation coefficient, b = regression coefficient/ slope, a = intercept, y = regression line

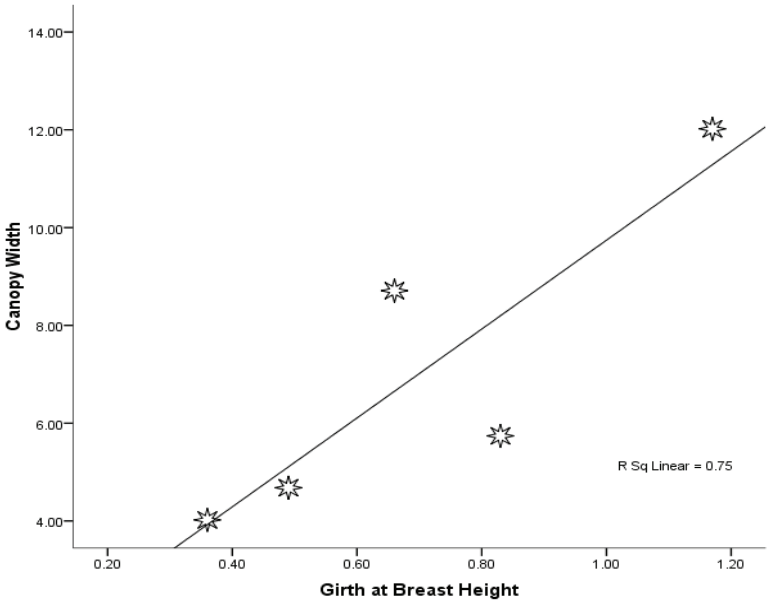

Fig. 1: Regression of all species' CW vs GBH

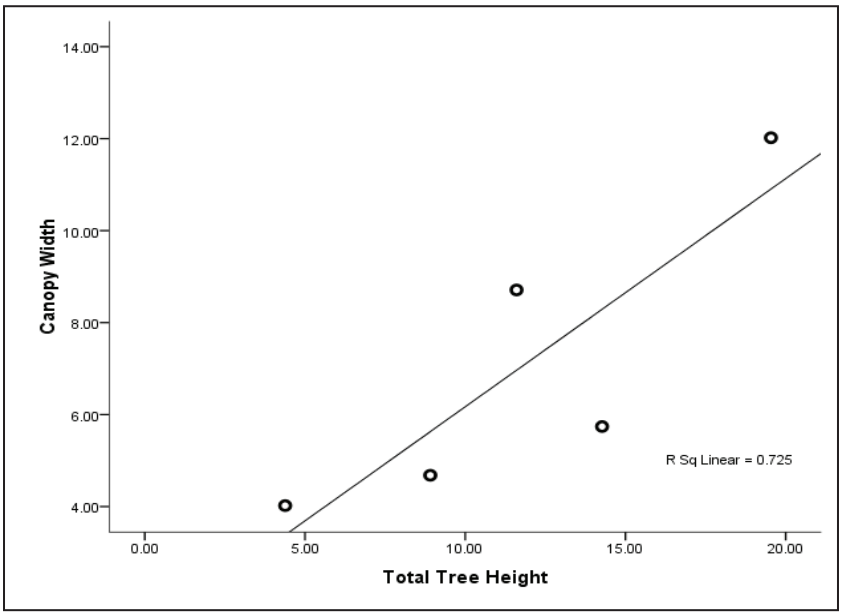

Fig. 2: Regression of all species' CW vs TH

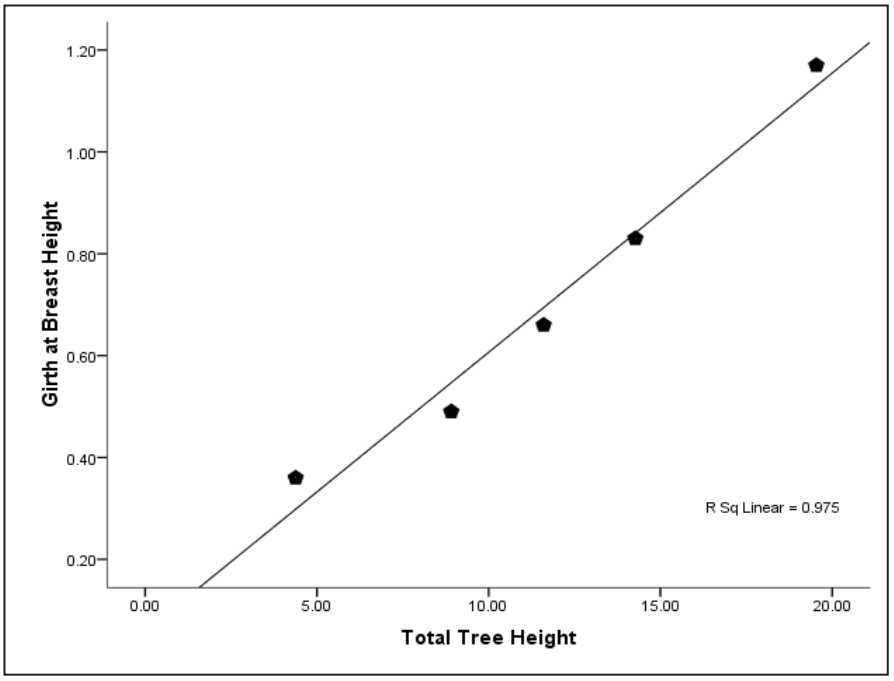

Fig. 3: Regression of all species' GBH vs TH

CONCLUSIONS

The relationships between the species and the group analysis of CW/GBH, CW/TH and GBH/TH in the five tree species were linear due to the adaptive capacity of the species. However, specific group analysis revealed few exceptions, which may be due to small sample size to the linearity and adaptability with *Cupressus corneyana* and *Albizia gamblei*, showing non-linearity because of the negative correlations between the parameters. While *Cupressus corneyana* and *Albizia gamblei* would take some time to adapt to the College campus, other species have become part of the habitat.

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Growth release of retained fir (*Abiesdensa)* trees in the group opening and single tree selection logging

Dorji Dukpa, Yeshay Khandu, Andras Darabant, Edward Roger Cook,

ABSTRACT

*Comparing growth release of retained fir (*Abiesdensa*) trees in differentsilvicultural systems was studied. A total of one hundred and five (105)core samples each from group opening and single tree selections ofDechenKingaChoeling Community Forest, Shingkhar, Bumthang to observe growth increment before and after (i) group selection and (ii) single tree selection. Retained trees under group selection loggingof 1997 showed exponential increase of radial growth for five years, which then leveled off at a level more than four times as high as initial growth rates prior to 1997. The cumulative radial growth from 1997 to 2010 in group openings was 36 mm, while single tree selection had only 14 mm. This shows group openingfacilitates better growth increment than single tree selection and can be applied for commercial logging. To generalize the finding of this study, a detail study on other parameters may be necessary.*

Key words: *Fir (*Abiesdensa*), Group opening selection, Single-tree selection, Community Forest (CF), Growth increment, Commercial harvesting.*

INTRODUCTION

The Forest Management Code of Bhutan (2003) prescribes different silvicultural systems for different forest stands but adherence in field implementation is varied from places. Forestsresources are under pressure from unlimited demand from the growing human population, which frequently leads to the conversion or degradation of forests into unsustainable forms of land use (Forest Resources of Bhutan, 2000).

Currently applied silvicultural practices in the conifer zone of Bhutan are single-tree selection and group selection logging. Commercial loggingin group opening has been prescribed over three decades and has not resulted in sufficient natural regeneration (Gratzer*et al*. 1999). Forester uses single-tree selection to mark trees for fellingfor every demand. As such single tree selection is not always recommended for all forest types because inter-specific differences in response of trees to different light levels have been shown to be important factors in driving tree population dynamics (Kobe *et al*. 1995).

1 RNRRC, Jakar; dendro1972@gmail.com

There are no studies conducted to clarify the growth response of retained trees after logging, in group opening and single-tree selections in Bhutan..To compare the growth response of retained trees after two treatments, DechenKingaChoeling Community Forest (CF), Shingkhar,Bumthang was selected. The dominant tree was fir (*Abiesdensa)* in the study area. The fir stand was logged under single-tree selection by the Divisional forest office and group opening by the Integrated Forest Management Project (IFMP) in 1997.

The presentstudy aimed at investigatingthe retained fir tree's growth response from 1997 harvesting systems (group opening & single tree selection).

MATERIALS AND METHODS

This study was conducted in Dechen Kinga Choeling Community Forest. The forest is dominated by fir stand (*Abiesdensa*) and a few stands of spruce (*Piceaspinolusa*). It is located in Ura, Bumthang. Twenty one (21) group openings ranging from 0.1 to 0.35 hectare was selected after repeated reconnaissance survey of four-cable lines loggedin 1997.

The criteria for choosing openings along the cable lines were (i) presence of remaining saplings and pole stage fir trees that already existed before the creation of opening, and (ii) presence of single tree felling adjacent to the group openings. From the centre of every group opening, the closest five trees(> 14 years old) were cored using increment borer to get two radii and 105 core samples. Aftercoring, samples were stored in plastic tubes and labeled. In singletree selection plots, 50 meters horizontal distance from the centre of opening towards single tree felled area was located and 105 core samples were collected.

Core samples were mounted on a wood by applying *fevicol* glue, banded with *modi* thread and dried for a day. Afterdrying, core samples were polished to half their size usingbelt sandermachine. This process revealed tree ring sequences to be clearly visible. The polished samples were selected using stereo-microscope based on the samples having regular ring patterns to avoid missing rings or absent rings. These selected core samples were used to helpto cross-date the remaining core samples. Once all core samples were cross-dated and a calendar year has been assigned to each ring, the measurement of each annual ring starts.

Tree ring measurement was carried out using the *PJK* measuring program. Tree-ring sequences were measured under a stereo-microscope to an accuracy of 0.001mm using a computer based traveling stage. Once all samples were measured, raw data was processed using the COFECHA program (Holmes, 1983). To determine the relative effects of tree harvesting on retained trees in single-tree selection and group selection, the ARSTAN program (Cook, 1985) was used.

RESULTS AND DISCUSSIONS

Growth release of retained fir trees before and after group openings and single-tree selection

Growth release of retained fir trees in the group openings was high, as compared to the retained fir trees in single-tree selection (Figyre1).

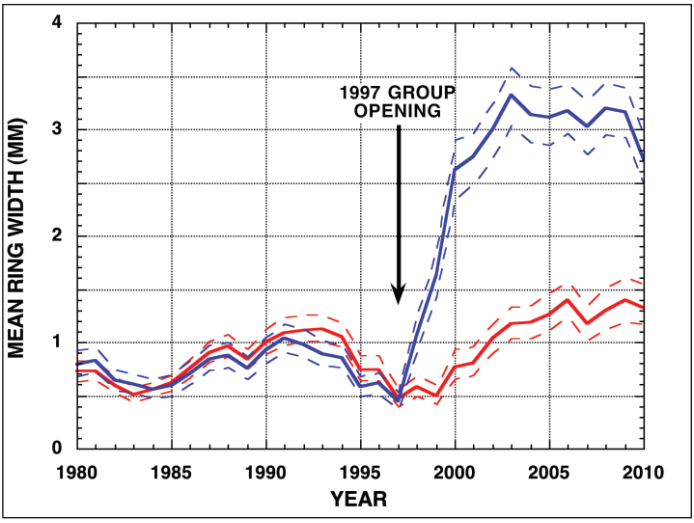

Fig.1: Growth release before and after group opening and single tree selection

Mean annual ring widths did not differ between trees subjected to different silvicultural treatments before the application of these treatments indicating unbiased sampling technique. However, after harvesting treatments in 1997, **bootstrap confidence** intervals did not overlap between ring width measurements of the two-sivilcultural systems and therefore difference in growth rates was considered to be statistically significant at 95% CL. From 1997 onwards, Annual growth increment increased rapidly with group selection harvest for five years after harvesting in 1997 and then leveled off at a level more than four times as high compared to theinitial growth increment before harvesting/logging. Annual growth increment of retained trees in the group selection treatment remained at constantly high until 2009 when it started to decline rapidly. The strong release of mean annual increment from 1997 to 2003 can be attributed to increased availability of sunlight and a fewer competing trees at the over-story. Forest gaps are found tobe sites of establishment of new plant species, increased growth and establishment of plants, or specialized habitats for animals (Hibbs 1982; Philips &Shure 1990; Vitt*et al*. 1998). Denslow & Spies (1990) suggest that canopy openings are important to the population dynamics of forest trees and to forest composition, structure, and heterogeneity.

Falling or standing death of canopy trees results in increased total incident light levels at the ground and sometimes increased nutrients and moisture availability. Gap microclimates may enhance seed germination and increase sapling growth rates in comparison to rates in the forest understory (ibid). The relationship between seedling recruitment and gap size however is not linear (Coates 2002). A recent study conducted in mixed conifer in western Bhutan Dorji2004) on the influence of opening sizes on conifer tree regeneration revealed that smaller group opening sizes favored natural regeneration. Similarly, other *Abies*spp. shows a clear preference for small-sized gaps or for closed canopy as compared to large gaps (Hughes Bechtel 1997; Kneeshaw Bergeron 1998; Kubota 2000; Coates 2002). Underlying factors include greater competition for resources and increased environmental extremes, as well as greater incidence of browsingin larger gaps. The decline of ring widths after 2009 may result from canopy closure of group openings by adjacent tree crowns, as well as from increased competition among trees in the group. The number of years showing strong decline is likely not enough to predict, whetherthe decline is a constant trend, or whether it may be the result of climatic variations between years. A possible factor contributing to declining growth rates could be nutrient deficiency as a result of nutrient export through cattle grazingRoder*et al*. (2002). However, such a rapid decline is likely not the result of nutrient export through grazing. Since age determination of single tree harvesting was carried out by ocular assessment of stump conditions, variation of a decade in accuracy is likely. Therefore, a number of samples included in the single tree selection may have been harvested in the years before 1997, showing non-significantly greater mean annual increment in the seven years prior to application of the group selection harvest.

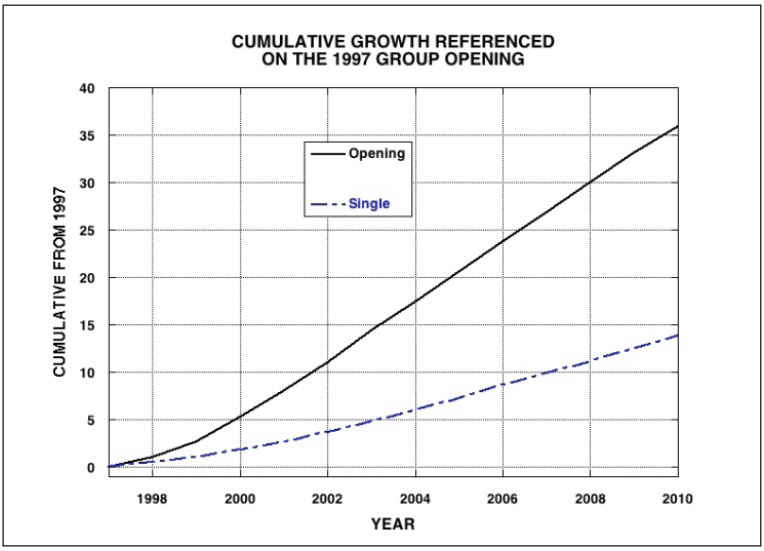

Fig.2: Showing cumulative growth of group opening and single tree selection

To provide absolute comparisons of growth performance, cumulated increments were plotted against each other for the two treatments (Fig.2). Thecumulated growth increment in groupopening harvest was 36 mm from 1997 to 2010, while trees in the single tree selection treatment was foundonly 14 mm during the same period. Therefore, there was a difference of 22 mm mean gross increment between the two silvicultural treatments.

Differences in growth rates between group opening size classes

Group openings were classified into two size categories (Fig.3). One class interval ranged from 0.1 to 0.14 hectare (ha) and other from 0.15 ha to 0.35 hectare. Annual increment of fir trees was significantly higher for a period of six years (2002-2008) in larger openings (0.15 ha to 0.35 ha), as compared to smaller openings (0.1 ha to 0.14 ha). Gratzer*et al*. (1997) showed that the light environment created by the group selection felling in fir forest of Ura valley is suitable for the establishment and early growth of fir. It was however unclear, how trees in different sized openings respond to canopy openings created by group selection harvest along cable crane corridors.

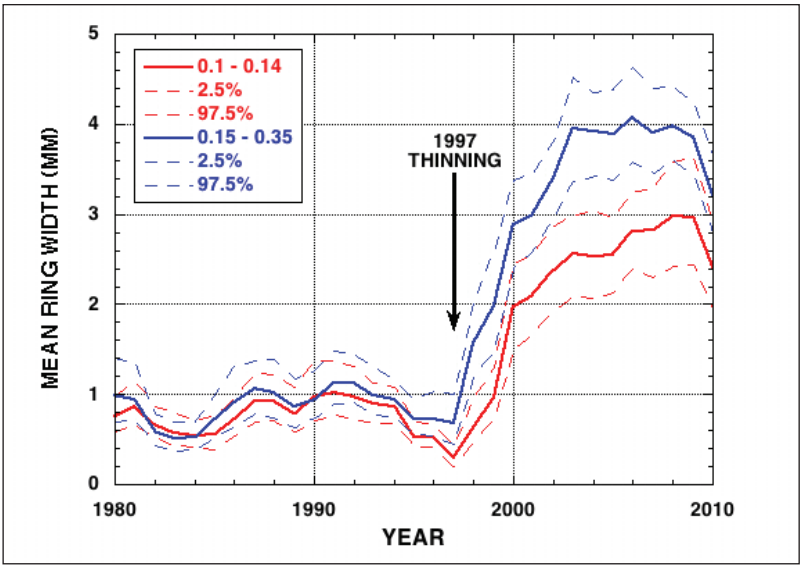

Fig.3: Mean annual increment between retained trees in different opening size classes

Comparison of growth release in different cable lines

In order to see, if site had an effect on growth release, annual increment data was separated based on cable lines (Fig.4). The result shows that even though trees in lines 4 and 3 tended to have higher annual increment as compared to lines 1 and 2, these differences were not significant. Site differences may have been confounded

by measurements grouped by cable lines, encompassing differences several hundred meters in distance and altitude.

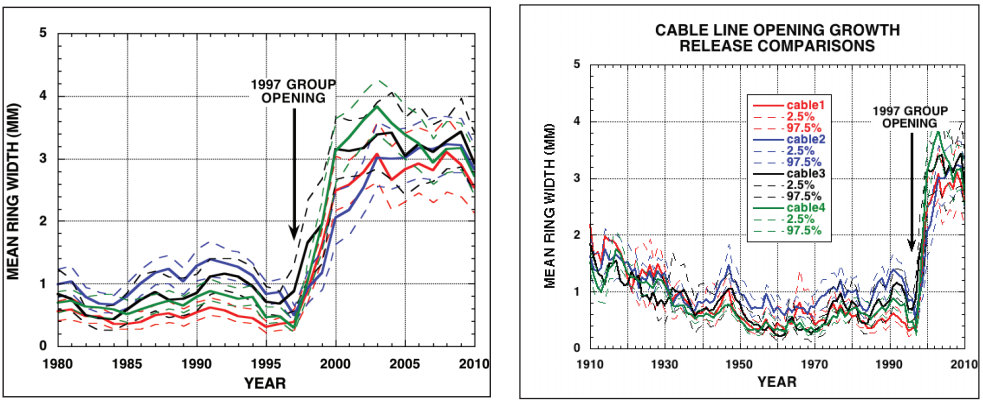

Fig.4: Growth comparisons between cable lines

CONCLUSIONS

Harvesting from group opening promoted growth of retained trees of the post harvest fir forest. These trees grow faster in small group openings (0.1 ha. to 0.35 ha), as compared to trees growing in single tree gaps created by selective felling. This clearly shows group opening facilitates better growth increment than single tree selection and may select group opening for commercial harvesting. To generalize the finding of this study, a detail study on other parameters may be necessary.

ACKNOWLEDGEMENT

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Tenure and income implication for decentralized forest management: Lessons from private forestsurvey in west central Bhutan

Mani Ram Moktan[1], Yog Raj Chhetri[2], Rinzin Dorji[2]

ABSTRACT

With the enactment of Forest and Nature Conservation Act 1995 and consequently rules 2006 legalizing private forest, a number of farmers solicited their interest owning private forest. Although the community forestry scheme has significantly advanced, however, private forestry lags behind. In order to better understand, an appraisal study was conducted to; identify farmers' perception, species desired, policy implementation barriers and outlook on private forest in the west central region. Findings revealed that interest and willingness to own private forest is in direct response to forest resource security due to rapid socio-economic and policy changes. The secured land and tree tenure conferred by private forest has immense potential to take on board and demonstrate forest management closer to people than community forestry and Government Reserved Forest does. Private forest comprised of multi-species, multi-storied forest perpetuating diverse uses ranging from subsistence to commercial ensuring social, ecological and economic sustenance contributing to food security and climate change.

Keywords: Tenure; income generation; private forest; west central Bhutan

INTRODUCTION

With the enactment of Forest and Nature Conservation Act 1995 (MoA, 1995) and consequently rules (DoF, 2006) legalizing private forest, a number of farmers solicited private forest applications. Although the community forestry has significantly advanced with 200 user groups managing 24,997 hectares of forests as of 2009 (DoF&PS, 2010), however, private forestry implementation lags behind. The Forest and Nature Conservation Act 1995 decentralizes community and private forest management to local communities with the aim to foster peoples' participation in the sustainable management of forest resources. In order to strengthen the public-community-private partnership and buttress good governance in forestry, the act promulgates enactment of the Forest and Nature Conservation Rules 2006, which guides the implementation of community and private forestry programmes nation-wide. In the west central Dzongkhag of Dagana and Tsirang,

1 Council for RNR Research of Bhutan manirammoktan@yahoo.com

about 66 and 25 households, respectively solicited applications. However, reasons behind their interest to owning private forest are virtually unknown. This could be hypothesized to rapid socio-economic changes resulting in the shortage of forest products, accelerated environmental change and enabling policy environment. In reality, there could be multitude of factors ranging from social, economic, and regulatory changes that drive farmers' interest. So how do farmers see private forestry programme in the context of rapidly changing environment? Decentralized forestry schemes in many developing countries are emerging success models of public-community-private partnerships. Similarly, community and private forestry programme are cornerstones of the Department of Forest and Park Services geared towards reducing rural poverty and building people-forest friendly image in the mindsets of rural communities. In order to illuminate decision-makers and policy actors, a rapid appraisal study was conducted to identify farmers' interest, tree species desired for household use, policy implementation barriers and outlook on private forestry.

MATERIALS AND METHODS

Study area

Tsirang and Dagana Dzongkhag in the west central region were selected as 91 farmers solicited applications owning private forest in their private land. The checklist of households, who applied for private forest registration under villages and Dzongkhag, respectively was used as sampling frame with household as unit. The number of farmers to be interviewed depended on trade-offs between accuracy, coverage, and cost. A total of 50 private forest applicants comprising of 12 from Tsirang and 38 from Dagana Dzongkhag, respectively were interviewed. The survey questionnaires were administered to 55% of the total private forest applicants from both the Dzongkhags.

Household survey

Farmers' perception on private forestry was solicited using a semi-structured questionnaire. The informants were heads of households who make decisions on behalf of their families. In consultation with Gewog Forest Officer(s), heads of household were invited at the geog centre or nearby a convenient place for interview. Questionnaires were designed to collect information on household demography, land and livestock holdings, farmers' interest, tree species desired, policy implementation barriers and outlook on private forestry. Interviewees constitute 70% male and 30% female aged from 18-81 years and 16-95 years, respectively.

RESULTS AND DISCUSSIONS

Land and tree tenure

The land and tree tenure conferred by private forestry are guaranteed in relation to community forestry and government reserved forest (Fig.1). Land tenure is privatized and access to and control of forest resources are secured by individuals. Unlike in community forestry by-law, individual govern use of forest resources. The secured land and tree tenure provide a desired incentive for forest management by meeting critical (timber, firewood, fodder) and strategic (conservation) needs for generations to come. Sirait (2011) reports tenure issues should be considered first than forest management issues in decentralizing forest management. Since private forests are individually owned and managed, conflicts over forest resource ownership and inequity in the distribution of products and benefits sharing do not arise. Private forest owners rationalize tree-cutting depending on their need and time and protect their forests from cattle and human disturbances.

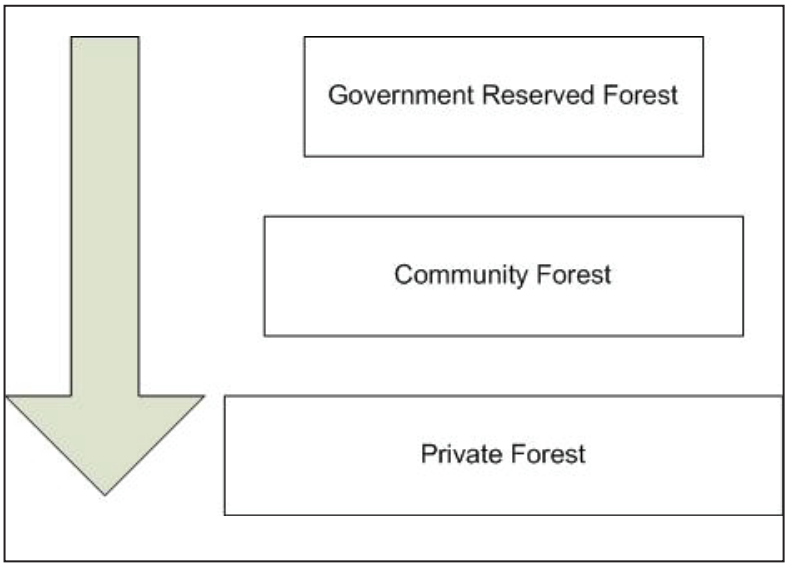

Fig. 1: Schematic representation of degree of access to and control of forest resources by ownership

Figure 2 illustrates the farmers' forest resources constraints and security offered by private forest. Of the total, 68% of respondents stated owing private forest to address critical forest resources need while 22% has little or no idea and, 10% as conserving soil and water in their farms. The driving force behind their interests in upholding private forest attributes to guaranteed land and tree tenure conferred by private forest rules 2006 as stated by 58% of the respondents (Figure 2)

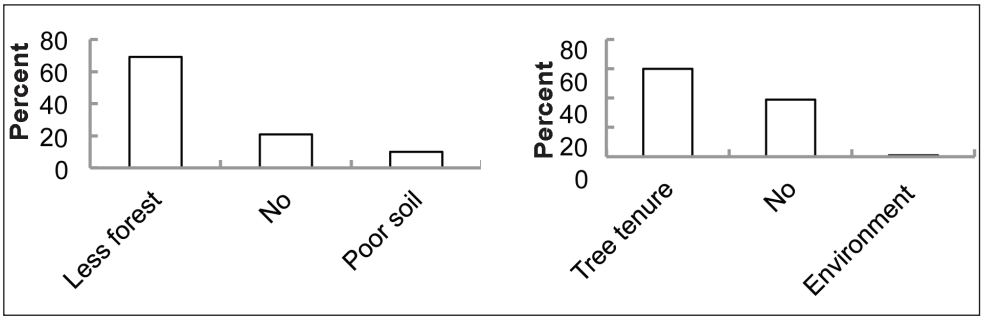

Fig. 2: Forest resources constraints and security offered by private forestry

Ecological sustenance

Private forests are home to diversity of plants which households depend for their critical and strategic needs. Trees planted provide provisioning and regulating services like timber, firewood, fodder, fruits, medicines, control run-off and reduces erosion. Timber trees constitute the over story, firewood and fodder trees as middle and grass fodder (e.g., *Thysanolaena latifolia*) as ground stories. The multi-species and multi-storied forest serves as foundation for conserving farm level species diversity and ecosystem services. Meeting household forest products need from private forest can eventually reduce heavy pressure on the Government reserved forest that are increasingly warranted for regulatory and aesthetic values by the society at large. Yet, private forest owners achieved even more. Their actions helped to "cool" the planet by cutting down green house gases and sequestering carbon in biomass and soils. Carbon storage increases in multi-storied agroforestry systems that have diverse species using ecological "niches" from the high canopy to under story shade tolerant crops (Scherr and Sthapit, 2009). Examples include shade grown cardamom under the canopy of trees sequestering carbon and providing habitats for small animals contributing to carbon storage in agricultural landscapes. Farmers', however, lack adequate knowledge and skills to manage such a complex agriculture-forest interface ecosystem. Silvicultural guidelines for seed collection, germination and nursery techniques including management plan preparation are support needed by private forest owners.

Economical sustenance

Private forest contributes to food security in many ways. Tree species desired ranged from subsistence to commercially important ones, relatively fast growing and varies with locations and socio-economic conditions. Timber species preference include: *Michalea champaca*, *Juglans regia*, *Cupressus corneyana*; *Alnus nepalensis*, *Castanopsis* and, *Quercus griffithii* as firewood; *Ficus roxburghii*, *Ficus cunia*, *Saurauja nepalensis* and, *Thysanolaena latifolia* (broom grass) as fodder. The management of private forest is limited to planting of seedlings and wildlings of

timber, firewood, fodder and fruit trees. Timber and firewood outside household subsistence consumption can be sold for cash income. Integration of multipurpose broom grasses not only provides fodder to cattle during winter but also brooms for commercial prurpose. Broom grass also helps to conserve soil by reducing runoff and erosion and stabilizing sloping agricultural lands. Integration of high value horticultural and medicinal plants that are ecologically compatible beneath the trees can diversify income sources. The high-intensity, carbon-friendly private forest approaches to near natural agroforestry ecosystem providing ecological and economic security.

CONCLUSIONS

Private forestry program need to move forward in response to farmers' interest for maintaining forest resource security. This unfolds a new paradigm for forest management by building public-private partnership in forest conservation, management and carbon sequestration. The advancement of private forest program will mitigate pressure on the Government reserved forests. Integration of non-wood forest products will contribute to food security and income generation. By strengthening the pillars of forest governance, ecological and economic security, private forest approach closer to achieving the goal of sustainability, poverty reduction and climate change mitigation and adaptation.

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Livestock

Characteristics of village chicken production- why indigenous chickens?

Tshering Gyeltshen[1], Henk M.J. Udo[2], Fokje Steenstra[3] and Theo Viets[4]

ABSTRACT

This study was carried out with the objective to find reasons for high indigenous chicken populations and get an in depth understanding of the characteristics of village chicken production. The study was carried out in Yoeseltse and Denchhukha blocks under Samtse District. Thirty-eight households in Denchhukha and 39 households in Yoeseltse were randomly sampled and a semi-structured questionnaire survey was conducted. SPSS 16.0 was used for data analysis. Descriptive statistics, chi square test and ANOVA were used. Indigenous chickens virtually make up the chicken flocks in the villages in both Denchhukha and Yoeseltse. Chickens were reared under scavenging system in both the blocks. Chickens provided households with meat and eggs for consumption, household necessities such as grains through barter and with cash income. In Denchhukha, chickens were reared for dual-purpose. In Yoeseltse, it was mainly for eggs in Buddhist communities and for dual-purpose in Hindu communities. The average flock size in Yoeseltse egg production system was significantly lower (P<0.05) than those in Denchhukha and Yoeseltse dual-purpose production. Forty-three percent of the respondents preferred to continue rearing indigenous chickens while 13% said that they want to try rearing exotic chickens with indigenous chickens. Predation and diseases were the major constraints in rearing the existing flocks. These diseases are usually treated with traditional methods which are quite effective when detected early. Inadequate feed was the most important hindrance to increase their flock size. The reasons for preference of these farmers for indigenous chickens under scavenging system are thus obvious. Any interventions in poultry sector should give due consideration of the constraints faced by the farmers.

KEYWORDS: Village poultry, Production systems, Scavenging system, Constraints, Predation.

1 *College of Natural Resources, Royal University of Bhutan, Lobesa, Punakha. Corresponding author: Phone: +975-2-480509: Mob. +975-17305635. gyeltshen@cnr.edu.bt.*

INTRODUCTION

Poultry rearing is an important activity for many Bhutanese farmers and entrepreneurs. About 66% of rural households are known to rear poultry (NBC, 2011). Apart from food and cash income, poultry in rural Bhutan contribute to social bonding as poultry meat and eggs are used to entertain guests and are given as gifts. The Royal Government of Bhutan implemented many poultry development plans and strategies to improve quality and quantity of poultry products (MoA, 2002). However, according to a review by Nidup et al. (2005), poultry development plans, which focused mainly on distribution of exotic chickens and crossbreeding with native chickens, has not brought about any significant progress in poultry sector. Nidup et al. (2005) and Alders (2001) have cited various reasons for failure of these development programmes such as disease susceptibility and non-preference of exotic chickens by farmers. In accord with their views, Bhutanese farmers continue to rear indigenous chickens in spite of their low egg and meat production. At least 75% of the poultry population in the country consists of indigenous chickens (DoL, 2008). The purpose of this small study was to explore further into the statement made by these authors and to examine in depth the attributes of indigenous chicken rearing.

MATERIALS AND METHODS

This study was carried out in two *geogs* (blocks) - Denchhukha and Yoeseltse- under Samtse *Dzongkhag* (district). Denchhukha is a remote *geog*, about 18 hours walk from the main town of Samtse (road under construction now) while Yoeseltse lies on the road head of Samtse-Sipsu highway. Livestock Statistics 2008 (DoL, 2008) indicates that there were only native chickens in the two *geogs*. Hence these two gogs were selected for the study. Poultry populations in Yoeseltse and Denchhukha for year 2008 were estimated to be 2376 and 2054 respectively.

A semi-structured questionnaire was used for data collection. Thirty-eight households in Denchhukha and 39 households in Yoeseltse were randomly visited for household survey. However, two households did not own chickens at the time of survey. The survey interviews were carried out during the months of September and October in 2010. In addition, details of the village, livelihood means and the general agriculture practice in the villages were collected through informal discussions with key informants such as the Gup, Tshogpas and the livestock extension agents.

SPSS 16 was used for data analysis. Characteristics of the study areas, production systems in the two *geogs* and constraints of chicken rearing were described using descriptive statistics, graphs and charts. Associations among different variables were explored using cross tabulations and chi-square tests. Quantitative variables such as flock size, in different production systems were compared using ANOVA.

RESULTS AND DISCUSSIONS

Household and Farm Characteristics

Households in the two study areas were subsistent farmers and practiced mixed farming. The average on-farm family sizes were 5.7 in Denchhukha and 5.5 in Yoeseltse. Cropping and livestock were the two most important means of livelihood for majority of the respondents (Table 1). Households grew maize, millet, and soya beans for household consumption. Farmers in Denchhukha grew mandarins and cardamom while Yoeseltse farmers grew areca nut and ginger as cash crops. Other means of livelihood for the households were cash income from off-farm activities, non-farming on-farm activities such as tailoring, weaving, carpentry, and businesses and from remittance.

Chickens were the only kind of poultry found in both the areas. All the households interviewed also reared livestock other than chickens. Cattle were the most important livestock to majority (73%) of them and were reared by 94% of the households interviewed. Other livestock were goat/sheep and pigs, which were reared mainly for cash income. About 10% of the total respondents in the two *geogs* considered that chickens are the most important animal. These households owned more number of birds as compared to their neighbours. The average flock size in these households was 18.8 birds as compared to 12.1 birds in other households. Sale of eggs and meat for cash income is the main reason for them to rear chickens.

Table 1. Contribution of various farm enterprises to family income.

Farm characteristics	Most important	% respondents
Sources of income	Cropping	71.4
	Livestock	13.0
Livestock	Cattle	73.3
	Goat/sheep	16.0
	Pigs	1.3
	Poultry	9.4

Poultry Production Systems

Small scavenging flocks of indigenous chickens characterized poultry rearing in the two *geogs*. Chicken production under scavenging system in the two study areas can be categorized as egg purpose production and dual (meat and egg) purpose production. All respondents in Denchhukha reared chickens for dual purpose. In Yoeseltse, Buddhist communities reared chickens for egg purpose and kept fewer birds as compared to Hindus, who reared chickens for dual purposes. Twenty-two respondents in Yoeseltse said that they rear chickens for dual purpose while

17 households reared them for egg purpose only. The average flock sizes were significantly different ($p<0.05$) with 6 birds per household in case of poultry for egg-purpose and 17 birds per household in case of dual purpose production. In Denchhukha, the average flock size was 13.

Management of birds in all three systems was similar. Birds scavenged around the house for food during the day. Household food leftovers and grains such as maize, rice or wheat were fed as supplements two to three times a day. The amount of supplement provided varied from about 0.25 to 3 kg per feeding depending on the number of birds.

Small sheds of approximately 2x1x1 m dimensions, made from locally available materials such as wood and bamboo provided shelter to birds at night (Fig. 1). About 80% of the households in the study areas maintained such sheds for their chickens. But these sheds were poorly maintained and were inadequate to protect birds from predators. In some households, a separate makeshift shelter for brooding hens close to the main house kept the hatching eggs and young chicks warm and dry. Other modes of sheltering chickens at night were keeping them in verandahs, under the caves, or under a bamboo basket (Fig. 2). Provision for a shed depended on the flock size.

Fig. 1: Bamboo basket used to protect chickens

Fig. 2: Chicken shed made from wood.

Time required to carry out poultry work depended on the flock size. Seventy-eight percent of the farmers who had flock size of more than 10 birds said that time required for poultry work is more than one hour per day whereas 81% of the respondents with flock size of less than 10 birds said that time required is less than one hour ($\chi^2=13.75$, $p<0.05$). Works related to chicken rearing are mostly performed by female members in the household. However, there were no specific ownership pattern within the household and poultry is an asset for the family as a whole- for family consumption and cash income.

Chicken Distribution

Number of birds in different age categories differed with the purpose for which they are reared. Table 2 shows the means and the standard deviations of chickens of different categories in Denchhukha, Yoeseltse dual-purpose production, and Yoeseltse egg purpose production. The number of cocks (0.5) in egg-purpose production in Yoeseltse was significantly lower ($p<0.05$) than the averages of 1.5 and 2.1 cocks in Denchhukha and Yoeseltse dual-purpose production respectively. Similarly, the number of chicks was significantly lower in the egg production system. The average flock size of 6.1 birds in Yoeseltse egg production was significantly smaller ($p< 0.05$) than the average flock size of 13.1 in Denchhukha and 17.3 in Yoeseltse dual-purpose production.

Table 2. Means and the standard deviations of different age categories of birds in Denchhukha (n=38), Yoeseltse dual-purpose production (n= 22) and Yoeseltse egg-purpose production (n=15).

Parameters	Denchhukha (Dual purpose)	Yoeseltse	
		Dual-purpose	Egg production
Average flock size	13.1a±6.5	17.3b±5.8	6.1a, b±8.6
Cocks	1.5a±1.1	2.1b±1.7	0.5a, b±0.8
Hens	2.4a±1.1	3.3a±1.5	4.2±3.6
Cockerels	1.3a±1.5	1.7±3.0	0.3a±0.9
Pullets	1.5±1.7	3.0a±3.3	0.7a±1.4
Chicks	6.3a±4.5	7.1b±7.0	0.4a, b±1.5
Means with same superscripts within rows are significantly different at $p<0.05$.			

Nidup et al. (2002) and Wangchuk et al. (2008) found that farmers in Southern Bhutan rear at least 15-20 chickens for meat and egg purpose. The flock size of six birds in the egg production system in Yoeseltse is significantly lower than those in dual purpose production. It can be extrapolated that amongst the households that rear chickens under scavenging system, the average flock size in villages of Western, Central and Eastern part of Bhutan are likely to be similar to the average flock size in the egg production system in Yoeseltse. This is due to the fact that people in this region are mostly Buddhists and rear chickens only for egg production for home consumption.

Egg Production and Hatching

Table 3 gives the average and the range of production parameters of chickens. The average annual egg production was 43 eggs per hen. Farmers estimated that a hen initially laid 10 to 12 eggs in a clutch and the number of eggs increased to about 15

to 18 in her third or fourth clutch after which the number of eggs per clutch declined. Usually a hen laid eggs in three clutches in a year when she broods her young once, but two clutches or four clutches were also observed. Farmers mentioned that hens that do not undergo brooding lay eggs in six to nine clutches a year with an annual egg production of 60 to 90 eggs. A brooding hen remained with her chicks for about two to three months before she starts to lay again.

Table 3. Production parameters of chickens in a year according to farmers' knowledge.

Parameters	Average	Range
Average egg production (per hen)	43	19-80
Number of clutches when hens brood	3	2-4
Number of clutches when hens do not brood	-	6-9
Number of eggs per clutch	-	10-18
Average age at first lay (months)	6	4- 8

Farmers classified chickens into three age groups- chicks (up to the age of 3-4 months), pullets or cockerels (between the ages of 3-7 months) after which they are considered as a hen or a cock. The average age of first laying is 6 months According to Jacobs et al. (1998) chickens are known to start laying between the age of 18 to 22 weeks (5 months). A survey study on village chicken production systems and performance of a dual purpose chicken by Kumaresan et al (2008) at Mizoram (India) showed that the average age of first lay varied from 154 days (5 months) under intensive system to 196 days (6.5 months) under backyard production system. The longer duration of laying in this study may thus be attributed to the birds being maintained under scavenging system.

All farmers allowed a hen to incubate eggs at least once in a year to continue the cycle for meat and egg production. A household set 10 to 18 eggs for hatching per season. Hatchability ranged from 62% to 88%. Hatchability was relatively better during winter months. This, according to the respondents, is because winter months are drier than in summer, and so a broody hen can keep the eggs dry and warm. Therefore, farmers who wish to produce more chickens should preferably allow their chickens to brood in winter. However, this knowledge of the farmers must also be validated with experiments.

Benefits of Chicken Rearing

Chickens provided valuable food in the form of meat and eggs, income and manure for the gardens with minimal input requirement. About half of the respondents in Yoeseltse and 37% in Denchhukha reared chicken for cash income. Farmers

considered chickens as a means to meet immediate cash needs through sale of a bird or two in the neighbourhoods. Cash income from sale of birds and eggs were used for buying household food items, clothes and to meet the expenses of children's education. Studies by Wangmo et al. (2005) at Paro Dopshari and Wangchuk et al. (2008) at Darla *geog* in Chhukha on village chicken farming also reported that earnings from poultry rearing are used to purchase agricultural inputs, clothes, and household needs and pay school fees and rural taxes. Studies in other developing countries by different authors (Clarke, 2004; Copland and Alders, 2005) also are in congruence to these utilities of poultry to the households.

A few farmers in this study also bartered eggs and chicks for grains to meet grain requirements. Others reared them for household uses (socio-cultural uses and household consumption). Asgedom (2007) and Guèye (2000) also reported barter of poultry and poultry products with household necessitites such as grains in Ethiopia and many other African societies where circulation of currency is limited.

Poultry play important socio-cultural roles, as gifts, as objects of offerings to Gods and for consumption during the festivals such as *Dassiah*. Eggs and poultry meat are also important as a means to extend social goodwill by offering guests with a menu of meat. Eggs are carried as gifts during visits to neighbor's house. Nidup et al. (2008) elaborated the cultural importance of indigenous chicken types, such as Frizzle for *Bhim Singh pooja* for *Subbha* group of people and Native White for *Chot pooja* for *Adhibasy* groups. Similar practices of offering poultry as gifts to relatives and visitors, and as sacrificial animals in traditional worships exists in many African societies (Kondombo et al., 2003).

Cash income from a unit of poultry product differed in the two places. In Denchhukha, a cock or a hen fetched between *Nu*. 150 to 300 depending on the size of birds, while an egg fetched Nu. 5/-. In Yoeseltse, a kg of live bird fetched Nu. 120/- while an egg fetched Nu. 7/-. Farmers in Yoeseltse earned more than the farmers in Denchhukha per egg or kilogram of meat. This can be attributed to Yoeseltse being connected with a motorable road, providing more opportunities for sale of farm products as compared to Denchhukha with no access to road. This is in agreement with Alders and Pym (2009) who stressed on the need for market to sale products.

Preferences: Local versus Improved Chickens

Respondents were asked, '*Given the condition that there is enough supply of exotic chickens, which one (exotic or local) would you prefer to rear?'* Forty-three percent of the respondents from the two *geogs* preferred to continue rearing indigenous chickens; another 40% said that they would preferably switch over to rearing exotic chickens, while 13% wanted to try out keeping exotic chicken with the indigenous types. Ease of rearing (easy to rear, less feed requirement and better survivability) was the most important reason for 54% of the respondents who preferred to continue

rearing local chickens. For 27% of the respondents preferring to rear indigenous chickens, annual rituals was the most important reasons to continue with indigenous chickens. Other reasons cited for preference for indigenous chickens were good meat flavour, yellow colour of eggs, their good mothering ability, and disease resistance. Festivals, such as *Dassiah,* are other important reasons to keep indigenous chickens. Respondents who wanted to try rearing exotic chickens reasoned that exotic chickens lay more eggs and are bigger in body size. Fifty-six percent of the respondents who wanted to rear exotic chickens mentioned 'more egg production' as the reason. However, they expressed fear to rear exotic chickens. Respondents were of the opinion that *farm chickens* (exotic chickens), unlike the indigenous backyard chickens, required scientific housing, feeding and management for which they have no knowledge. Given the training and availability of chicks, farmers were willing to rear exotic chickens on a small scale ranging from a few to as many as 50 in numbers.

Constraints of Poultry Rearing

Constraints faced by farmers in rearing their chicken flocks were predation, diseases, inadequate feed and not enough labour. Fig. 3 shows the most important constraints considered by farmers of Denchhukha and Yoeseltse. Predators from the wild stood out as the most important constraint. Predation losses from October 2009 to September 2010 were 5.5 birds per household in Denchhukha and 2.3 birds per household in Yoeseltse. In both the places, raccoons and wild cats were reported to be very common in summer. In winter aerial predators such as eagles and crows were more common which often carry away young chicks. Higher predation in Denchhukha can be associated with more scattered settlement with dense forests harbouring predators such as raccoons and wild cats as compared to more clustered settlement in Yoeseltse. Birds are left out during the day to find their food, exposing them to predators There is a need to improve poultry sheds for night shelter to minimize losses through predation and thefts and diseases.

No prophylactic measures against infectious diseases are being carried out. White diarrhea and red mite (Lhotsham: *Sindurey*) infestation in monsoon were the major disease problems especially in chicks, causing heavy chick losses. These conditions are treated using their traditional knowledge. Garlic and sometimes barks and leaves of *Cinnamomum* (Lhotsham: *Malagiri*) are grounded and mixed with feed to treat white diarrhea. Red mites are treated by applying mustard oil on the wound site. Farmers claimed that these treatment methods are effective if the diseases are detected early. The efficacy of such treatments needs to be confirmed and advocated for use if effective.

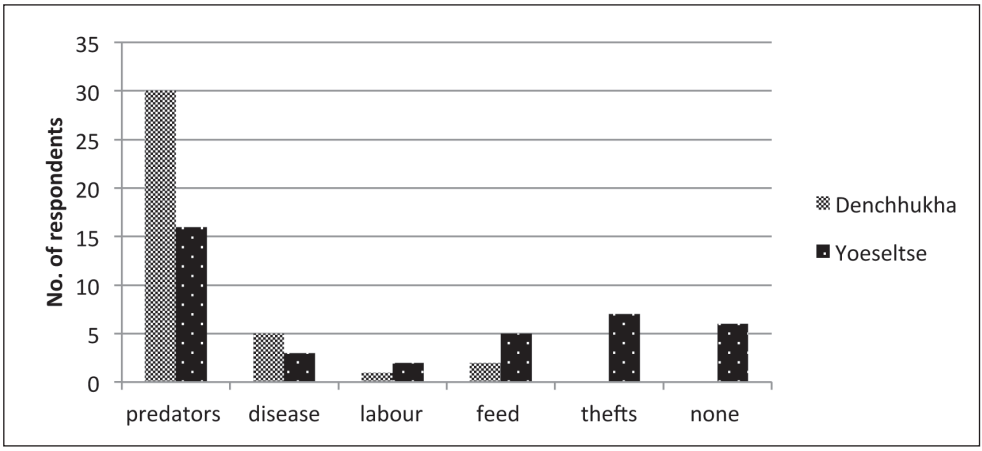

Fig. 3: The most important constraints of rearing chickens as perceived by farmers in Denchhukha and Yoeseltse.

According to Calnek (1998, in Riise et al., 2005), various factors such as genetic constitution, nutrition, environment, management, and diseases affect the efficiency of production. In this study too, low production is attributable to one or more of these causes. Households in this study reared indigenous chickens which laid fewer eggs than the exotic breeds of chicken. Feeding was dependent on birds finding their own food with some grains supplemented two to three times a day. Studies on the nutrient intake of local chickens from scavengeable resources in Kenya by Okitoi *et al*.(2009) found that nutrient intake was below the requirement of free-ranging hens, and hence supplementation was inevitable to increase production. Selective supplementation of nutrients that birds are not able to obtain through scavenging would minimize supplement requirement. However, only interventions that fit into the limited resources of the household (Asgedom, 2007) and socio-cultural realms of the community will be sustainable to increase production. It is therefore, essential that only such development programmes be initiated that are affordable by the farmers and acceptable to the community.

When farmers were enquired about problems they foresee in increasing the number of birds, inadequate grains to feed was the most common answer. 38% percent of the respondents in Denchhukha and 62% in Yoeseltse mentioned inadequate grains as the most important constraints for increasing their flock size. Other problems they foresee were lack of proper housing, predation, and unexpected disease outbreaks. Farmers feel construction of a house for chickens to maintain them under confinement as a costly affair requiring concrete floors, good wall and nice roofing, besides requiring balanced feeding of the birds. De Vries (2000) emphasized that rearing of improved breeds of poultry need not start with confinement of birds in nice sheds. Improved breeds of poultry are also known to thrive well under the

scavenging backyard systems. Therefore, it is necessary to change the perceptions of the farmers as well as the extension agents, who often train farmers, about rearing improved chickens.

Limitations of the study

This study was based on interviews of farmers and accuracy of data relied on farmers recall memory. Therefore, underestimation or overestimation on quantitative parameters such as number of eggs laid, egg offtake and eggs set for hatching, eggs hatched, bird mortality, and bird offtake are possible. In this study, although sample size from both the *geogs* were more or less same, the purpose of rearing differed in different communities at Yoeseltse. Therefore, sample size for different production systems became relatively low, resulting in few sample size under different production systems and high standard deviations. A further study with larger sample size in each of the production systems is warranted.

CONCLUSIONS

The indigenous chickens virtually make up the chicken flocks in rural villages, although villagers have the opportunity to access exotic chickens from the government farms. Predation and diseases were the major constraints in scavenging system while feed is the major constraint that prevents the farmers from increasing their flock size. The reasons for their preference for indigenous chickens are thus obvious. The findings by Nidup et al. (2005) and Alders (2001) that Bhutanese farmers continue to rear indigenous chickens for various reasons hold true. This study also observed some interesting and quite effective traditional method of treatment for certain diseases and pests of chickens which warrant further investigation.

ACKNOWLEDGEMENT

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Effect of socio-economic changes on yak farming in central and western Bhutan

Padam B. Gurung

ABSTRACT

Effect of socio-economic changes on yak farming was assessed in four geogs of Bumthang and one geog of Wangdue Dzongkhag. The study revealed that more than 87.5% of yak herders who specialized in yak rearing in past have gradually switched over to general agricultural farming during last decade. Study indicates that yak herders owning land in the lower valley are more vulnerable to abandoning yak rearing than those who do not have. As per the study, familial labour shortage was the leading factors (58.5%) influencing the change, whereas 21.3% considered inadequacy in basic service facilities, 11.7% government policy and regulations and 7.4% socio-economic that lead to the change. About 66.7% respondents kept their yaks with others, which also declines the households directly engaged in yak rearing. Among the economic factors influencing the change, insufficient income to meet household income (36.2%), market competition (21.2%), declining yak product demand and better income from other sources (16.2%), and processing technology (10.0%) were reported to have greater influence. The current trend needs to be addressed with the help of appropriate policies and support system to sustain the principle livelihood source of highlander.

KEY WORDS: *Socio-economic, Yak rearing, Income, Familial labour, Yak herders*

INTRODUCTION

Yaks (*Bos grunniens*) are mainly reared by the pastoralists of 10 Dzongkhags living at an elevation between 3000 and 5000 masl. A total of 1121 households are still engaged in rearing 38,690 heads of yak in Bhutan (DoL, 2009), which contributes 7% of the total milk production of the country and approximately 3% market shares of meat, butter and cheese (Tamang & Sherpa 2007). Butter, cheese, meat, hair products are the main income generating products derived from yaks and transportation services for eco-tourism. Based on the data, the yak population was reported highest in 2006 (52,911 heads) which declined to 40,374 heads in 2011 (DoL, 2006 & 2011).

Although yak has strong bond with the culture, religion and social life of the yak herders, the socio-economic changes is having irreversible influence on many yak

1 Dzongkhag Administration, Chukha; gurungpb@live.com

herders as they gradually shift to other livelihood sources. Some communities (Macrong, Sombrang, Pangkhar) in central and east central regions have completely given up yak rearing and started with sedentary life style in the lower valleys (Derville & Bonnemaire, 2010; Wangchuk 2011). Apart from these studies, no efforts were made to address the issue of disappearing farming systems in the highland communities. Therefore, this study was designed to document factors influencing yak farming in Bumthang and Wangdue Dzongkhag and to provide potential interventions to curb the declining trend of yak rearing. It is also expected that this study will provide adequate justifications in realigning existing policies and regulations to address the problem.

MATERIALS AND METHODS

The study was carried in five geogs of Bumthang and Wangdue Dzongkhag covering thirty villages. Two types of respondents were adopted in this present study. (1) The yak herders presently continuing rearing yaks (n=94) and (2) those who left for other activities in the past ten years (n=40). Purposive sampling method using Taro Yamane formula was used to cover required numbers of households (HHs) for this study.

$$n = \frac{N}{1 + Ne^2}$$

where:
n = Number of samples, N = Total number of farmers directly involved in different geog and category of yak herders and e = standard error of not more than .05

Fig. 1: Socio-economic interview

Semi-structured questionnaires were used to collect primary data (Figure 1). The additional information on yak farming and yak products were also collected from the key informants through informal discussions. Secondary data was collected from respective Livestock Offices and Department of Livestock.

All the information pertaining to yak farming system was analyzed using excel spreadsheet and SPSS software 16.

RESULTS AND DISCUSSIONS

Results

Familial labour shortage, accessibility to basic service facilities and product marketing, market competition, alternate sources of income, government policies and regulations, and unprofitable farming were some of the key factors influencing the yak farming in the study areas. It is also reported that 72.5% of the erstwhile yak herders left yak farming due to familial labour shortage during last decade (Figure 2). Similarly, others left yak farming due to mortality, pasture deterioration and wild animal depredation.

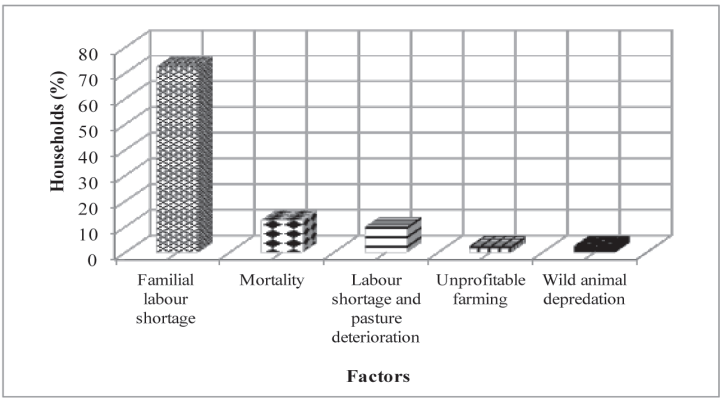

Fig. 2: Reasons for giving up of yak rearing during 2000 – 2010

Although abandoning of yak farming is occurring in all geogs but the study reported that more households from Ura geog (86.6%) has given up yak farming during the period of 2000 – 2010 followed by Tang geog (47.2%) (Figure 3). It was also noted that the yak farming abandoning is going in other geogs of study areas.

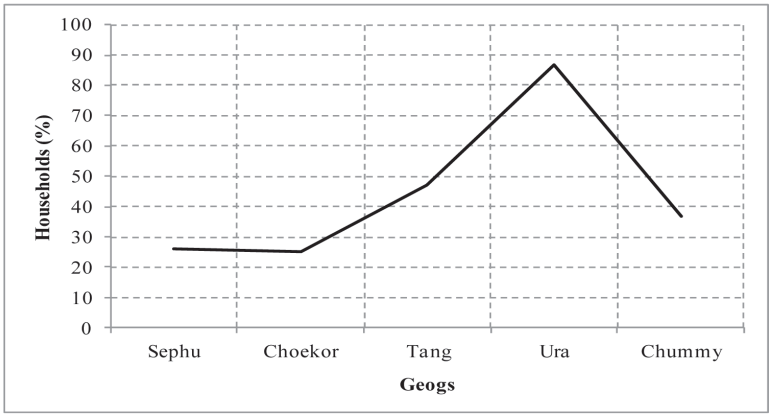

Fig. 3: Percentage of households abandoning yak farming during 2000 - 2010

The study also showed that 87% of the yak abandoning herders switched over to agriculture farming, which could be due to owning of agricultural land in the lower valleys (Figure 4). The study also reported that some yak farmers are switching their herding profession into business venture too.

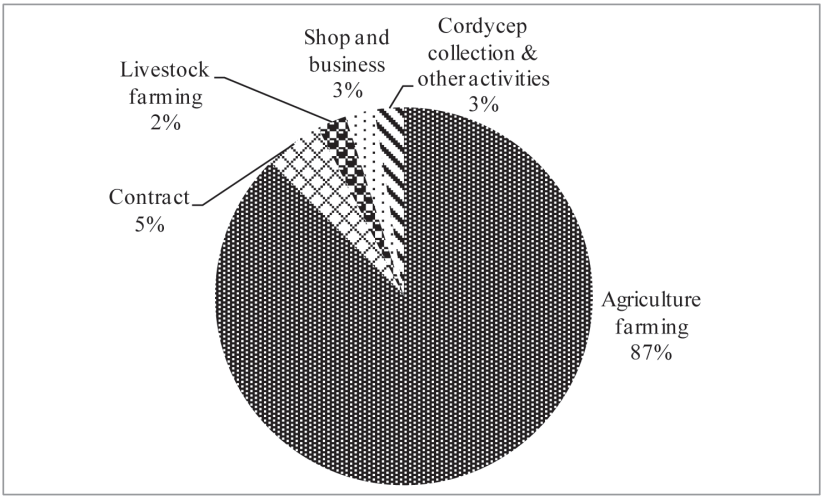

Fig. 4: Main activities taken up after giving up of yak farming

Social Factors

Among all the social factors, familial labour shortage is found as leading factors (58.5%) influencing the yak farming followed by inadequate basic service facilities (21.3%) such as health, school, veterinary, telecommunication, road accessibility. Few respondents (11.7%) also expressed that the yak farming is influenced by the current government policies and regulations and 7.4% by modernization.

The study also revealed that the average family size of yak herders of Bumthang and Wangdue were 8.4 and 6.4 respectively and. The mean family members engaged in yak herding were 2.2 and 1.8 in Bumthang and Wangdue respectively. The familial labour shortage in the study areas mainly happened due to engagement of family members in other activities viz. agriculture farming (21%), enrollment of children in school (19%), civil servant/monks (18%), business/contracts (11%) and children/ oldies (15%) (Figure 5). It also happened due to lack of replacement of aged herders. However, few school dropouts were sighted in the study areas, who returned to continue their traditional yak rearing. Return of such school dropouts could be due to lack of life sustaining resources in the lower valleys, low employment opportunities and presence of lucrative income derived from *cordyceps sinensis* associated with yak farming. Still 87% of the total respondents were optimistic of their return to continue traditional yak herding profession in future.

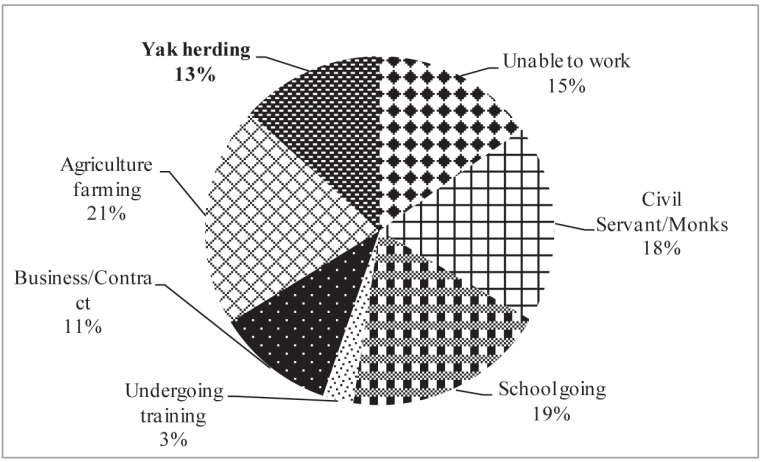

Fig. 5: Distribution of family members in different activities

The study also found that traditional system of rearing yaks by wealthy people and monastic institutes through nomadic people was also declining gradually due to shortage of labours and other socio-economic changes. Currently, only 22.2% of the total herds were owned by such groups. The report also indicates that 67% households keep their yaks with others due to shortage of labour (Figure 6). Further, continuation of traditional yak farming by employing the people may not be possible due to association of high cost and drudgery with yak farming.

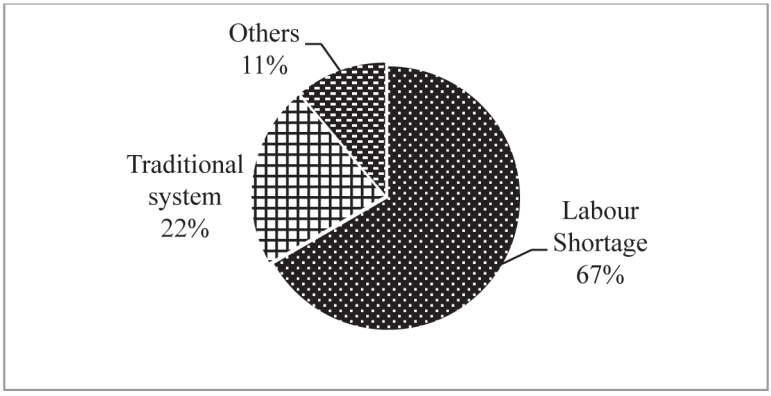

Fig. 6: Reasons for keeping yak with others

The yak herders are mostly leading migratory type of life style; therefore, providing of basic services is not an easy task. The study as per the response of 21.3% respondents found that service facilities like school, health and veterinary are inaccessible to most yak herders. Lack of road has made difficulties in transporting their basic amenities and marketing of their products.

For instance, delivery of veterinary services to yak herders is vital to provide prophylactic and curative treatment to yaks. However, 41.6% of the total respondents reported that the veterinary service delivery is inadequate due to which 494 numbers of yaks were lost to various diseases during 2010 (Figure 7).

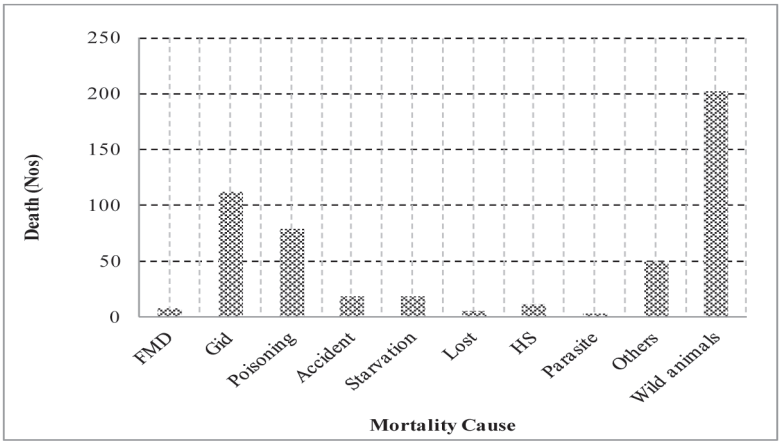

Fig. 7: Causes of yak mortality in 2010

Not all government policies and regulations were found compatible to yak herders. About 41.5% of the respondents reported that the restriction on managing grazing land in traditional method as per Forests and Nature Conservation Rules of Bhutan 2006 has limited the adequate production of fodder for yaks in the study areas. It was also reported in the earlier study (Dorji *et al*., 2003). Currently, most of the grazing lands are found dominated by unpalatable shrubs due to restrictions of slashing and burning these species (Figure 8).

Fig 8. : Left: Grazing land dominated by unpalatable shrubs and bushes; Right: Control of such unpalatable shrubs by control burning to prevent from further propagation

Similarly, traditional system of keeping grazing rights with absentee members also affects the yak rearing in the study areas. In 2010, 57.1% of the total respondents were grazing their herds in leased *Tsamdro*, which are either owned by Dratshang or wealthy absentee members. Existing of such practices has affected both the nomadic yak herders and sustainable use of existing grazing land (Wangchuk, 2003). The revised Land Act 2007 also could not address this problem explicitly till now (NLC, 2007). This type of registering the grazing land in the name of wealthy absentee members was also reported in some parts of India (Nivsarkar *et al*., 1998).

During 2010, 202 numbers (40% of total mortality) of yaks were lost to wild predators, which made serious implication in the economy of yak herders. One farmer of Ura had to give up yak farming due to this reason only. Wild life depredation was reported highest in Sephu and Choekor geogs. Only the yaks depredated by tiger and snow leopard are compensated while yaks depredated by other wild animals are not compensated.

Influence on yak farming by rapid modernization was reported by 24.5% of the total respondents. It was mainly observed with the herders of Sephu and Chokor geogs due to remoteness and isolated life style. However, it did not have much effect to the herders of Tang, Ura and Chummy geogs which could be due to keeping of their herds near the villages. It was also observed that the dreams of migrating to urban areas by most young nomads are not materialized due to inadequate life sustaining resources like land and lack of capital.

Economic Factors

Among five economic factors influencing yak farming, insufficient income to meet household income was found leading factors (36.2%). However, other factors viz. market competition from other sources (21.2%), declining yak products demands (16.2%), better income from other sources (16.2%) and lack of modern processing technology (10%), were other factors influencing the yak farming in the study areas (Table 1).

Table 1. Main economic factors affecting the yak farming

Geog	Insufficient income to meet HH income	Market competition with other sources	Better income from other sources	Declining yak product demand	Processing technology
Sephu	71.4%	11.4%	11.4%	5.7%	-
Choekor	8.1%	35.1%	13.5%	29.7%	13.5%
Tang	-	-	100.0%	-	-
Ura	50.0%	-	-	-	50.0%
Chummy	-	-	60.0%	-	40.0%
Total	36.2%	21.2%	16.2%	16.2%	10.0%

The study found that mean household income from yak farming (Nu 49996.19 ± SE 3906.00) was comparatively lower than the mean household expenditure (Nu 85040.43 ± 5308.87 (Table 2). However, looking at the average total HH income of household including other sources (Nu. 137893.03 ± 12631.87), the yak herders are comfortably meeting their household expenditure in the study areas. Similar study made by Wangchuk (2011) also reported that the yak herding may sustain only if it is blended with other income generating activities. Similar type of finding was also reported in India (Nivsarkar *et al*., 1998).

Table 2. Average HH income generated from yak farming, other sources and expenditures

	Total HH expenditure 2010	Income generated from Yak farming 2010	Income generated from other sources 2010	Total HH income of yak herders 2010
No	94	80	93	94
Mean (Nu)	85040.43	49996.19	95952.15	137893.03
Std. Error of Mean	5308.877	3906.004	12424.581	12631.872

In olden days, yak consumable products were considered as delicacy and were mainly served to the high profile guests or during religious occasion (Derville *et al*., 2010). The dairy products were scarcely available and people used to reserve yak products for such special guests or occasion. With the availability of similar products in the market at cheaper price with better shelf life, the demand of yak dairy products has been declining. It was also reported that the production of *Chugo* (hard cheese) from other dairy breeds and import of such products from Tibet have

also affected the marketing of yak products in the study areas. This was mainly reported by the respondents of Choekor geogs (29.7%) and Sephu geog (5.7%). Similarly, the social stigma and religious sentiments has adversely affected the production of yak meat in the market though it has high demand in the market. However, yak products are in high demand in other yak rearing areas like in Nepal (RAOnline 2011). In China, yak down hairs are used to produce high quality textiles (Wiener *et al*.,2003).

With the rapid socio-economic changes and emerging of many income generating activities in the country, the yak rearing is not found profitable and graceful in the study areas. This could be the reason that some respondents (16.2%) reported that the yak farming is also influenced by better income from other sources. For instance, *Cordyceps* collection has became the money spining activity for most pastorlists. The nomadics have started to invest their surplus income (received from *Cordyceps* collection) in other activities rather than strengthening their herd size. Earlier study also mentioned that this type of trend is posing threat for yak farming in longer run (Derville and Bonnemaire 2010). Similarly, Tshering (2011) also reported that access to better income generating activities from other sources has influenced the traditional yak farming in the country.

Inadequate dairy processing facilities, improper dairy processing technology and transportation have also influenced the yak farming in the study areas, which was reported by 8% of total respondents.

Discussion

Results suggest that there are many driving factors involved in influencing the traditional yak farming in the country. Increased enrollment of children in school and attractive life style in the urban areas, many youngsters preferred to settle in urban areas and lower valleys. People from other places may not be interested to work in yak farming due to association of high drudgery and migratory life style. This is in agreement with Wangchuk (2011) who mentioned that labour shortage was the overarching problems of the yak herders at Sephu and Merak-Sakten geogs. Similar study in India also mentioned that large numbers of yak herders are shifting to daily wage working system to have easier living conditions and stable earnings (Pal 2003). However, looking at the current scenario of low employment opportunities in the government institutions, corporate and private sectors and lucrative income from the *cordyceps sinensis* associated with yak farming, few youngsters may join their parents after leaving the school. Few such young school leavers were already sighted during the data collection.

Inaccessibility to basic services facilities like health, school, veterinary, transportation and communication services was another contributing factor influencing the yak

farming. The herders' children are not receiving good primary health care and school facilities. Their lives are usually isolated in between mountains and hills, confined in tents and temporary sheds, and have to keep on moving as per the season and availability of fodder.

The social life style of yak herders was also not given due consideration while adopting some government policies and regulations. Maintaining of grazing land in traditional method has been banned by government, which leads to deterioration of grazing land by presence of many unpalatable species. Similarly Dorji *et al*., (2003) also reported that the permanent grassland has limited potential to produce adequate quantity of fodder if the existing grasslands are not managed properly.

Similarly, many yaks are lost to wild animal depredation due to increased wild animals, which happened due to restriction of culling of such wild animal. Annually, many yaks died by various diseases due to inaccessible to prompt and efficient veterinary service. Similar type of problems was also reported at Laya and Lunana (Gyamtsho, 1992) and Merak and Sakten (Joshi & Gurung, 2009). The incidence of these diseases can be reduced to great extent if it is adequately addressed, which was also indicated in previous findings (Dorji *et al*., 2003). It was also reported that yak herders of Merak and Sakten are ready to pay veterinary services if some private firms can start to cater veterinary services (Joshi & Gurung, 2009).

With the escalation on the prices of basic amenities and education of children, meeting of household expenditure was becoming difficult to yak herders. However, with the complementary source of income, the yak herders are earning adequate amount to meet the household expenditure comfortably. The amount derived from alternate sources has benefitted yak herders immensely to improve their livlihood. However, the trend of investing the additional income on other activities rather than strengthening their herd size, was posing threat for yak farming in longer run. The *Cordyceps* has encouraged many herders to rely on this and started to forget the primary traditional farming, which was not true in the study areas, The abandoning of yak farming was found high in Ura, Tang and Chummy, where the herders are inaccessible to *Cordyceps* collection . It was also found that some farmers invested these additional income in buying of yaks in the past few years. Most yak herders have the opinions that the income from *Cordyceps* is not certain and the farmers have to rely on yak for their survival in future. Similar study made by Wangchuk (2011) also reported that the yak herding may survive only if it is blended with other income generating activities.

The possible reasons behind declining demand of yak product could be due to escalated price of the yak products and market competition from readily available imported dairy products in the market and importing of similar products from

Tibet. Similar type of study in Paro also reported that the demand of yak products especially butter was dwindling due to presence of high producing hybrid cattle in the valley (Wangchuk 2004). The changing of food habits in the Bhutanese society and present method of processing yak product could be other contributing factors for declining the yak product demand. It is known fact that the demand of yak meat is very high in the market because of its taste, flavor and medicinal value. Unfortunately, the yak herders of Sephu have to give up yak slaughtering due to strong influence of religious group of people, which has not only affected on the economy of yak herders' but also yak meat consumers.

Diversifying the yak products into various forms such as hard cheese, milk cheese, milk skin, toffee, milk wine, smoked meat can also find niche market both within the country and outside. It was also understood that improvising of milk processing equipments is needed to improve the yak products and marketing, which was also indicated in earlier study (Wangchuk, 2011). Exploration of suitable labour saving equipments for the yak herders is required to save time, which was also mentioned in earlier study (Derville, 2010).

CONCLUSIONS

With the rapid socio-economic development and emerging of many income generating activities in urban areas, there are some threats for continuation of yak farming in future. Similarly, earning additional income from complimentary sources especially from *Cordyceps* might distract the nomadic lifestyle into urban or sedentary life.

Keeping alive of yak farming is found important not merely to keep alive of traditional yak farming but also for conservation and preservation of the nomadic culture and tradition. The traditional culture and values of the nomadic yak herders should not be compromised with the conservation of natural resources. Presence of yak herders in the border areas is also found imperative to monitor the illegal entry of undesired intruders in the country.

Shifting of yak herding profession into other activities is inevitable but with the improvement of basic service facilities and blending of income generation with other activities, might help in slowing down the current pace of shifting to other professions. Blending the yak farming with other income generating activities and providing of marketing support are also foreseen to encourage the yak herders in continuing the yak farming in future. Considering on the social life style of yak herders, review of some government policies and regulations is felt necessary in future. However, to validate this findings and results, further study in other areas is also warranted.

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Effects of Ajwain (*Trachyspermum ammi)* seed as feed additive on milk production in dairy cows

Yamnath Acharya[1]

ABSTRACT

Milk produced by dairy farmers group of Dargaythang was not sufficient to cater to the demand of Sarpang town. The gap in demand is fulfilled by import from neighboring Indian villages. The existing milk demand provides ample opportunity to increase milk production in the village. To explore the means of increasing milk production, 30 Jersey cross cows were grouped into three groups of ten and randomly assigned to two treatments of Ajwain seed as an additive in the regular feed and a control as normal feed. Further, two treatment groups of cows were fed with 50 g and 25 g of Ajwain seed per cow per day respectively. Third group was considered as control, which did not receive any feed additive. Feed additive resulted in significant (P < 0.05) increase of milk yield in Treatment I and Treatment II where as there was no significant difference of milk yield in control. However, more feeding trial replications are necessary to confirm the result.

Keywords: Ajwain, Feed additive, Milk yield, Cattle

INTRODUCTION

There are 73,460 milching cows comprising of different breeds in the country producing 24,940 MT of milk (Dukpa, 2010). It can be estimated from the above figures that the average milk production per milking cow is 339.5 kg in Bhutan. Milk production is 815 kg per cow in Asia and 2000 kg per cow in the world (Luethi, 1999). So there is a production difference of 476 kg per cow even at Asian standard. Against this background, the study was conducted in dairy farmers group of Dargaythang that supplies milk to milk collection center at Sarpangtar, Shompangkha geog in Sarpang Dzongkhag. The centre is unable to meet the demand for fresh milk supplied by the dairy farmers group and imports the deficit from Indian villages. There are 5,177 milking cows in Shompangkha geog (Dukpa, 2010) and can easily fulfill the demand of milk if they produce even at Asian production level. This indicates that there is a need to increase milk production level of cows in the area.

To increase the production level of cows in the area, some changes in the aspects of management especially in feeding is necessary as other management aspects like housing is found good. One of the possibilities can be to feed some synthetic galactogogues, but farmers prefer to use easily available and herbal galactogogues in the form of Ajwain seed. Therefore, in an effort to find efficacy of herbal

1 RLDC, Wangduephodrang, Bhutan. acharyayam@gmail.com

galactogogue to increase the milk yield of dairy cows in the existing system of management, the use of Ajwain seed was tried in this study to determine its effect on milk production.

MATERIALS AND METHOD

The study was conducted in Dargaythang, Shompangkha, Sarpang All households in the study area own cattle and farmers were dependent on milk products.

The Randomized Complete Block Design (RCBD) was used for the present study. Thirty jersey cross cows were identified and selected randomly. The animals were grouped as per experimental design, Treatment I (T_1), Treatment II (T_2) and Control(C). Milk produced per milking in the morning and evening was recorded. Ajwain seed was not fed to all the thirty experimental cows for first five consecutive days to record the production of milk before treatment.

From the sixth day onwards, Ajwain seed (50 g) was boiled and added to the morning feed of $T_1$and (25 g) was boiled and added to the morning feed of T_2. The milk yield recording was done for the whole experimental period of 15 days. All the other conditions like feed, feeding time, milking time remained same pre and post treatment.

Collected data was analyzed descriptively and inferentially using SPSS 16.0 version. Microsoft excel was used to produce graphs.

RESULTS AND DISCUSSIONS

Result

Increase in the mean milk yield was noticed in Treatment I followed by Treatment II compared to Control. The mean milk yield per day recorded pre and post treatments are shown in Figure 1. The result is supported by the Paired sample *t* test of Treatments (Table 1) indicating that feeding Ajwain as feed additive in dairy cattle can help improve milk yield

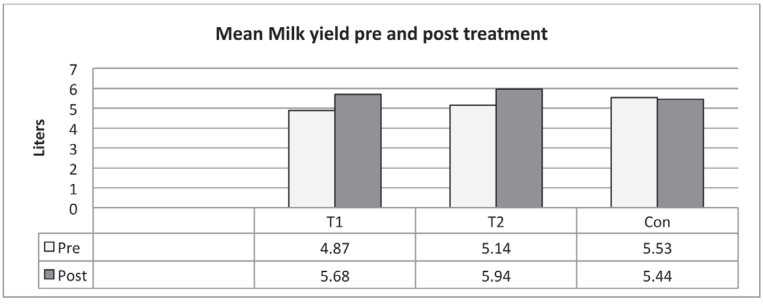

Fig. 1: Mean milk yield pre and post treatment

Table. 1 Paired Samples *t* Test for milk yield in T_1, T_2 and Control
Paired Differences between pre and post treatment

Treatment	Mean	Std. deviation	*t*	df	Sig(2 tailed)
T_1	0.81	0.48	11.82	49	0.00
T_2	0.79	0.72	7.73	49	0.00
Con	0.09	0.82	0.81	49	0.41

Discussion

An attempt was made in this study to find whether Ajwain seed can also be used to increase milk yield of dairy cows in Dargaythang by feeding Ajwain seed as feed additive during hot season. And there was high mean increase in milk yield in treatment I followed by treatment II while no difference was noticed in control. Ajwain might have improved the rumen environment of the cows and enhanced feed efficiency leading to increased milk yield without affecting the milk composition.

It was challenging to set the experiment because of the involvement of milking cows as the farmers were reluctant to accept the conditions required for the experiment. After promising some incentive only, the farmers could be convinced.

Additives are sometimes felt very necessary for the lactating cows to make them produce to their full potential. Roche et al (2010) reported that cows that graze on high quality pasture can consume sufficient nutrients for maintenance and production; supplementation is necessary for more milk solids only, but the genetically good jersey cross cows of Dargaythang produce less despite good feeding and management. There are many instances of successful use of additives for increasing the milk yield without any interference in milk composition like addition of live yeast (*Saccharomyces cerevisiae*) to the feed of dairy cows increased milk yield, improved the dry matter intake and showed no significant differences in milk fat and protein percentages during the hot season by improving rumen environment (Moallen et al., 2009).

Thymol has the antimicrobial properties which can be helpful to keep the animal healthy (Pathak et al., 2010). Some constituents of Essential oils (EO) are favorable for rumen fermentation and production as they can inhibit the Hyper Ammonia Producing (HAP) bacteria involved in amino acid deamination, methanogens and undesirable bacteria and modulate rumen fermentation favorably by increasing the Volatile Fatty Acids (VFA) concentration in the rumen, inhibiting methane, decreasing concentrations of ammonia and increasing linoliec acid production (Patra,2011). Thymol, the EO inhibits deamination and also reduces methane production (Calsamiglia et al., 2007) and energy used for methane production

diverted for milk production which supported the findings of the current study.

Calsamiglia et al., (2007) also reported that thymol increased the acetate to propionate ratio in 60:40(alfalfa hay: concentrate) diets and a reduction in acetate to propionate ratio with 10: 90(straw: concentrate ratio) indicating that thymol acts differently in different conditions and with different feed combination. So in the current study, the daily feed consisted of roughage (green grass and banana stems) and karma feed mostly where the quantity of concentrate might be higher than the quantity of roughage on DM basis, thymol have effected positively on increasing the propionate part of VFA which is responsible for milk yield increase. Some essential oils are natural alternatives to modify rumen microbial fermentation (Castillejos et al., 2007) and increase the total VFA concentration from 35.3 to 54.3% and decreased ammonia N concentration (Castillejos et al., 2007) leading to increase in production which supported the findings of this study.

Plant derivatives with antibiotic properties can be of help to reduce methane production (Penn State, 2010). Penn State, (2010) has also reported that some portion of energy is lost during methane production and the reduction of methane production can increase milk yield as energy utilized for methane production can be used by the cows to produce milk. Likewise, Ajwain seed which contains thymol (Pathak et al., 2010) has the property to save the energy lost for methane production (Evans, 2000) as it has antimicrobial property and make use of saved energy for milk production; hence supporting the result of current study.

Ajwain seed are traditionally used as galactogogue, stomachic, carminative, expectorant, antiseptic, antimicrobial, parasiticide and used also to treat colic (Pathak et al., 2010). In the current study also, its galactogogue action is noticed. Dai et al (2011) demonstrated that addition of vegetable oil like rapeseed oil, sunflower oil and peanut oil to dairy feed enhanced milk production. Ajwain seed which also contains oil might have helped to increase milk yield in dairy cows in this experiment. There was no drop in milk production after termination of the treatment for five more days where the experiment ended which indicates that Ajwain need not be fed continuously for more milk production for the full same lactation. From this study it is found that Ajwain seed as feed additive is beneficial for the well managed low producing jersey cross cows.

There was no drop in milk production till five days after termination of the treatment where the experiment ended which indicated that Ajwain need not be fed continuously for more milk production. Since this preparation is non-hormonal and has no combination of any other material, this can be considered as safe, cost effective and environment friendly without side effects. Therefore, the inclusion of this herbal seed in dairy cow's diet should be encouraged to improve the efficiency

of feed utilization to alleviate adverse effects of environmental stress and to enhance the overall animal performance and health. Further researches on this subject would be beneficial to authenticate the use of Ajwain seed in the dairy industries to boost milk yield.

CONCLUSIONS

There was significant increase in milk yield in two treatment groups of cows compared to control. Treatment I showed the highest increase in milk yield followed by Treatment II and there was no increase in milk yield in the Control. The sample (cows) included for this study were within 90 days of lactation, hence, it is not known whether milk yield will improve in the milking cows of lactation stage later than 90 days. It is felt that Latin square design method with more replications would be more appropriate to validate the use of Ajwain seed as feed additive to improve milk production in dairy cows.

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Fish diversity assessment in Punatsangchu

Ugyen Tshering[1]

ABSTRACT

Fish diversity in Punatsangchu was studied from below the confluence of Punakha Dzong to Chachey in Tsirang Dzongkhag that included 12 tributaries and three sites along Punatsangchu. The catch and release method was used for the assessment. The study found 14 different species including newly recorded species. The new species recorded were Garra arupi, Glyptothorax telchitta,Barilius vagra and Garra sp. (species not identified yet) for Bhutan and Crossochelius latius, Pseudecheneis sulcata, and Psilorhynchus balitora for Punatsangchu. Schizothorax richardsonii was recorded highest and almost throughout all the sample sites. The study showed species diversity slightly uneven in all sample sites (E<1). The highest species diversity was five species in the sample sites. The studied recommends a need for developing methods to find out ecological changes in fish communities, life cycle and habitat requirement of rare and endangered fish species of rivers in Bhutan (This should be slightly mentioned in conclusion too).

Keywords: Diversity, Punatsangchu, Fish, Habitat, Life cycle,

INTRODUCTION

Environmental degradations resulting from development activities are one of the major factors that contribute to decline in fish diversity (Strayer and Dudgeon, 2010). The rapid expansion of hydropower projects (HPP) in Bhutan is expected to have impact on freshwater fish diversity in Bhutan. Although the concerned has been raised by different stakeholders, any objective assessment is constrained by lack of baseline on the fishery resources in the country. The past studies done on fish diversity in *Wangchu* river confirmed existence of Brown trout (*Salmo truta*) and Snow trout (*Schizothorax progastus*). Subsequently study of rivers in the southern foothills by Tenzin (2005) documented 41 fish species. In case of Punatsangchu where a major HPP is being constructed, no inventory on fish has been carried out. However the database may need to be revisited.The study showed that indigenous species like Katle (*Neolissocheilus hexagonolepis*) is known to occur up to an altitude of 1,200 m, whereas Masheer (*T. tor* and *T. putitora*), Chepti (*Cyprinion semiplotum*), *Labeo dyocheilus* and other varieties of fish like Buduna (*Garra gotyla*), and Hill trout (*Barilius* spp.) are abundant in the rivers of the foothills (DPR II, 2009).

1 Dzongkhag Forest Officer, Dzongkhag Forestry Sector, Thimphu . Ugyen_00@yahoo.com

Since introduction of Brown trout in 1930 and establishment of hatcheries in Haa and Wangchutaba, it has now established in Ha Chu, Wang Chu, Pa Chu and in some tributaries of Sunkosh and Manas Rivers (Dubey, 1974). However, (Petr, 1999) argues that there is a need for baseline data on distribution, abundance, and migratory patterns for fish species as apart from these few studies, there is no comprehensive database on the distribution of fish species in the rivers and lakes of Bhutan. This study will therefore, provide the fish diversity and develop a database for individual fish species in Punatsangchu river basin.

MATERIALS AND METHODS

The study was conducted between the confluence of Phochu/ Mochu (Punakha) and Chacheychu (Tsirang) along Punatsangchu river basin. The study area covered approximately a distance of 85km. Catch and release method was used wherein different methods to catch live fish was used and released after the data collection. The local cast net (2.5 x 2.5 cm) and angling equipments were used in the main river course while sieves (0.5 mm and 2 - 5 mm) and the river diversion were used in the tributaries of the Punatsangchu. The sample caught was measured in detail, the rays and scales counted, photographed, identified and released back into the river; one voucher specimens of all sampled species were preserved for future studies by euthanizing with clove oil and kept in 10% formaldehyde solution for one week after which samples were preserved in 70% alcohol. GPS coordinates were taken for all the sites using Garmin GPS map60Sx and its readings used for locating the survey sites on the Arcmap (Figure 1. Table 2). The other study materials used were pictorial guide, latex gloves, specimen jars and digital camera. For measuring fish diversity, Shannon diversity index (Equation 1) was used to determine the number of species and relative abundance of species present in different habitat as Shannon diversity index. For calculation of species evenness, equation 2 was used.

Equation 1: Shannon Biodiversity Index (H')

$$H' = \sum_{i=1}^{S} PiLnPi$$

Equation 2: Evenness (E)

$$E = \frac{H'}{Ln(S)}$$

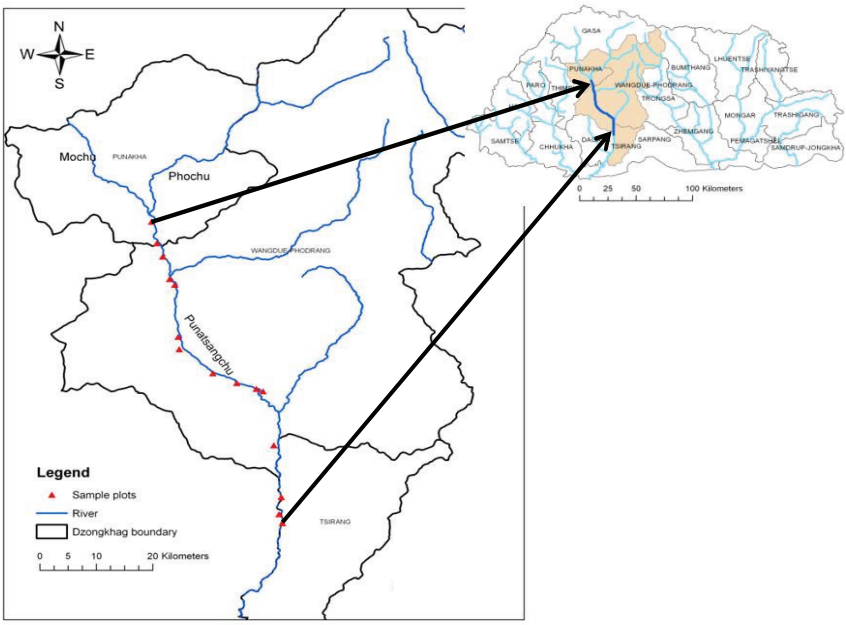

Fig. 1: Study area

RESULTS AND DISCUSSIONS

All the caught fish were, identified, counted and analyzed for their species evenness and diversity along different habitats of Punatsangchu (Table 1).

Table 1. Fish species found in different location of Punatsangchu

Scientific name	Common name	Location
Schizothorax richardsonii	Asala, Snow trout	Punatsangchu, Toebrongchu, Limbuteychu, Dangchu, Nahirongchu, Basochu, Rurichu, Kamerongchu, Dikchu, Takshachu, Burichu, Harachu
Garra gotyla	Buduna	Rurichu, Harachu
Garra arupi	Buduna	Dikchu, Kamerongchu, Punatsangchu
Pseudecheneis sulcata	Kabre, sucker throat catfish	Basochu, Rurichu, Teobrongchu, Burichu, Kabjisa (Punakha), Takshachu,
Psilorhynchus balitora		Rurichu, Teobrongchu, Serichu

Scientific name	Common name	Location
Salmo truta	Brown trout	Punatsangchu, Toebrongchu, Limbuteychu, Dangchu
Neolissochilus hexagonolepis	Katle, Copper Mahseer	Punatsangchu, Kamerongchu, Dikchu, Harachu, Takshachu, Burichu
Glyptothorax telchitta		Punatsangchu
Labeo pangusia	Gerdhe	Punatsangchu
Barilius vagra		Rurichu, Burichu
Crossochelius latius	Lori	Punatsangchu
Tor putitora	Sahar,Golden Mahseer	Dikchu, Punatsangchu
Garra sp.	Bobinang, Buduna	Punatsangchu above Kamechu
Schizothorax progastus	Chuche Asala	Serichu (Salamji)
Barilius bendelisis	Fageta	Burichu

Table 2. Overall composition of fish species diversity

Species	St1	St2	St3	St4	St5	St6	St7	St8	St9	St10	St11	St12	St13	St14	St15
Schizothorax richardsonii	3	25	11	7	39	10	3	-	-	17	20	4	-	-	-
Garra gotyla	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Garra arupi	-	-	-	-	-	-	-	-	-	7	15	-	-	-	-
Pseudecheneis sulcata	-	1	-	-	-	1	1	-	-	-	-	-	-	-	-
Psilorhynchus balitora	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Salmo trutta	-	7	6	1	1	-	-	-	-	-	-	-	-	-	-
Neolissochilus hexagnolepis	-	-	-	-	-	-	-	-	-	6	16	3	2	-	3
Glyptothorax telchitta	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-
Labeo pangusia	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
Barilius vagra	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-
Crossocheilus latius	-	-	-	-	-	-	-	-	1	2	-	-	-	-	-
Tor putitora	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
Garra sp.	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
TOTAL	3	33	17	8	40	16	4	0	4	34	51	7	2	3	3

**St1=near Punakha Veterinary Hospital, St2=Teobrongchu, St3=Limbuteychu, St4=Dangchu, St5= Nahirongchu, St6=Basochu, St7=Rurichu, St8=Baychu, St9=Above Kamechu, St10=Kamerongchu, St11=Dikchu, St12=Takshachu, St13=Burichu, St14=Above Chachey, St15=Chacheychu.*

A total of 14 freshwater fish species belonging to 3 genera under 4 families were identified in the sample sites (Table 1). Based on the analysis it was found that one species as Endangered (EN), 9 were Least Concern (LC), 2 were Near Threatened (NT), 1 was Vulnerable (VU) and 1 was Highly Vulnerable (HV) (Vishwanath, *et. al*, 2010). It was found that all the caught fish were native except Brown trout, introduced in 1930. *Schizothorax richardsonii* was found the most common species in the study area (Table 2). A *Garra* sp. was found in the main Punatsangchu which needs to be identified. The highest species richness was recorded at Dikchu and Kamerongchu and no species have been recorded at Baychu (Table 2; Figure 3). The strict vigilance of the area by the forest officials and low human activities within the sites lead to high species richness.

It was found that the sites with gravel or rocky substrates had higher species richness than those with a muddy substrate. *Salmo truta* was found only in the upstream areas (above Hesothangkha Bridge) whereas *Schizothorax richardsonii* was found throughout. This is mainly due to lesser number of *S. truta* (brown trout) which predates on *S. richardsonii*. However, the individual numbers of *S. richardsonii* seems lesser along the Punatsangchu in comparison to its tributaries. This could be due to the fact that they tend to stay in small streams for spawning and enters big rivers only when they are matured. The number of catches seems to be more above the project construction area than within or below the area. The reason could be due to high conductivity in water below and within project area which contains high minerals brought about by the developmental activities and biotic interference. DPR II (2009) reported the presence of Common Carp, Grass Carp and Silver Carp in Punatsangchu. However, the present study did not find any such species. Similarly, Petr (1999) reported these species were found only in the southern foot hills and mainly in the fish farm. Interestingly, several new records for Bhutan were observed such as *Glyptothorax telchitta, Garra arupi* and *Garra* sp. in the study area. Three species (*Crossochelius latius*, *Pseudecheneis sulcata, & Psilorhynchus balitora*) were recorded new for Punatsangchu (Table 2).

Diversity analysis revealed that sites 6 and 10 had the maximum with 5 species; sites 2 and 11 showed 3 species, followed by sites 3, 4, 5, 7, 9 and 12 with 2 species each while sites 1, 13 and 15 showed only 1 species. No fish was recorded in site 8 (Fig 2) mainly due to human interventions.

The diversity comparison between habitat using Shannon Weiner Diversity index

revealed that the species distribution is slightly uneven in all the plots as evenness (E<1 in all the sample areas (Fig 3) with plot number 5 showing the maximum (E=-0.06). There seems to be not much difference in evenness among the sample sites. The sample plots 6 and 10 with the H value of 1.24 and 1.33 respectively were the most diverse sample areas of my selected study sites. This clearly shows that the species distribution and diversity are better in plots 6 and 10 than other plots. While comparing individual species evenness among the sample sites, the results showed differences in evenness.

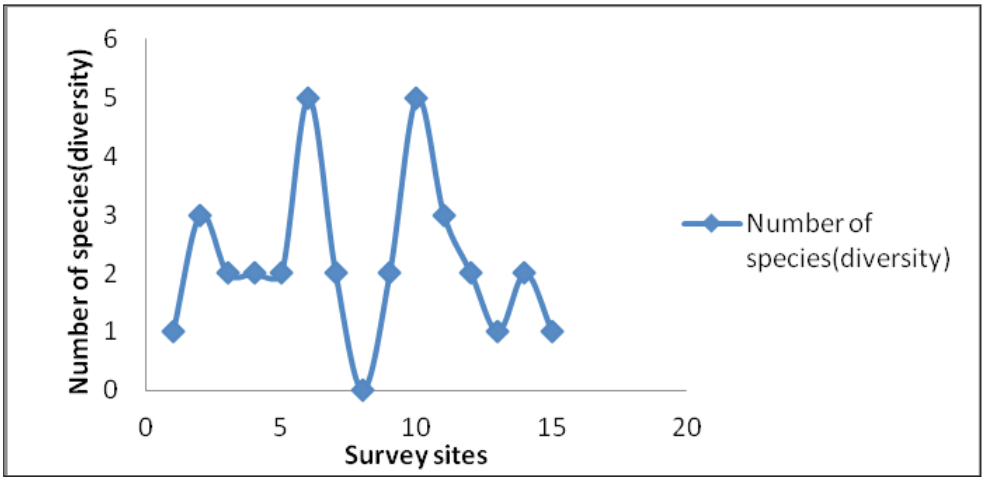

Fig. 2: Individual species count at different survey sites

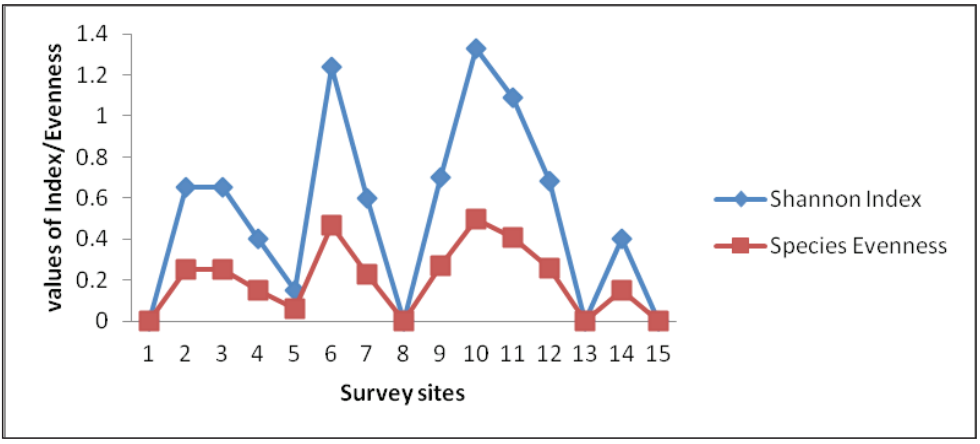

Fig. 3: Diversity and evenness comparison between sample sites (Shannon Biodiversity Index)

CONCLUSIONS

Assessment of biodiversity of Punatsangchu and its tributaries from Punakha, Phochu- Mochu confluence till Chacheychu in Tsirang showed 14 species. Out of which, the new species recorded were for Bhutan and Punatsangchu. *S. richardsonii* was found almost throughout all sample sites and some of those species found in the main Punatsangchu was not found in the tributaries and vice versa.

The earlier survey done by DPR II, (2009) for Punatsangchu hydropower project revealed the presence of Silver Carp, Grass Carp and Common Carp but during our survey, the above mentioned species were not found. The reason could be due to the fact that these species are never found in fast flowing rivers. Indeed they are said to be found in lakes and ponds in southern foothills and also in fish farms. DPR II reported *S. progastus* in Punatsangchu above Kamechu but our survey revealed not a single catch of *S. progastus* till Walkleytar bridge. It was *S. richardsonii* that was found above Kamechu area whereas S. *progastus (*Chuche Asala) is found only below Wakleytar bridge and Salamji area (survey, 2011). This could be due to misidentification of the species.

The introducing of Rainbow trout, Brown trout and Snow trout in the Punatsangchu (DPR, 2009) needs to be looked into as the impact by R. trout on B. trout and native Asala is seen in countries where they have been introduced. Bhutan, proposing to develop 220MW incremental generation capacity per annum over the next twenty years through hydropower projects means more damming of our riverine system.

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Market chain analysis of dairy products in eastern Bhutan

Naina Singh Tamang[1]

ABSTRACT

With the expansion of dairy development program in Bhutan, the availability of dairy products both for household consumption and market has expanded by manifolds. To document the existing dairy marketing chain in Eastern Bhutan, this study covered 43 dairy group members as producers, 10 selected dairy groups' as retailers and 51 individual consumers from five selected Dzongkhag.

The dairy products like milk, butter and cheese are important products marketed in the area through group's retailing counter.. The study found that the retailer's market margins are at Nu 4.23±0.32 for milk, 4.57±10.65 for butter and 13.5±11.45 for cheese, which shows that the producers and consumers are comfortable in terms of production cost and consumers' price in the market chain. The groups' retailing counter daily sold 69.76% of product and acted as the main intermediary in the dairy market chain. The other forms of retailing such as supply to general retail shops (16.27%) and direct supply to consumers (13.95%), served as informal market channels. Although consumers' preferred domestic products only 31% of the demand are fulfilled from the domestic production and the deficit is being fulfilled through import. The study suggests that production enhancement, market information, efficient dairy value chain, capacity building of extension and market actors in marketing of dairy product are crucial areas of interventions to improve the existing dairy market chain.

Key words: Dairy groups, Dairy product, Market chain, Market channel, Market actors,

INTRODUCTION

Milk and dairy products are biochemically unstable, as they deteriorate very quickly (Tessema and Tibba, 2001). The perishable nature of milk and milk product demands good market chain right from the producer to consumers.

Bhutan after embarking on planned development in 1961, has achieved all round development. The health conscious citizen demands safe, high-quality and longer shelf-life dairy product as their main component of daily diet. The vibrant and strong network of marketing chain lies in product value addition with adequate product hygiene and branding.

1 *ADLO, Trashiyangtse Dzongkhag; tamang_nsing@yahoo.com*

An efficient, integrated and responsive market mechanism marked with good performance is crucial for optimal allocation of resources in dairy production to encourage producers to increase the production. In absence of market about 90% of the milk produced was processed into butter and cheese by rural household (Wangchuk, 2006). The study on the dairy maket chain by (Dervile and Tenzin, 2006) found that dairy chain directly benefits 28 percent of the Bhutanese population. The inclusion of dairy farming as one of the One Gewog Three Products (OGTP) program in the 10th FY plan, the production and health services have received greater emphasis leading to transformation of dairy farmers from subsistence to semi-commercial level. The GDP contribution from dairy production in terms of value in ngultrum is also steadily increasing (NSB, 2010). The study focuses on analyzing existing dairy market chain, the involvement and benefits of different market actors and consumers' product preferences.

MATERIALS AND METHODS

The study was carried out in five eastern Dzongkhags of Trashiyangtse, Trashigang, Monggar, Pemagatshel and Samdrupjongkhar. The survey for retailers was selected from 10 dairy retail shops of five Dzongkhags. Further 43 dairy household head as producers and the consumers' survey of 51 individual were conducted in the three Dzongkhags of Trashiyangtse, Trashigang and Monggar.

Both primary and secondary data were collected and used for data analyses. The primary data were collected by structured and semi-structured survey questionnaire as 'Producer' (dairy farmers/group members) 'Retailers' (sale of milk, butter and cheese by dairy groups' sale counter) and 'Consumers' (availability of products, demand and supply in the market). Data analyses and result interpretation were done by using the descriptive and inferential statistics of SPSS-16 software.

RESULTS AND DISCUSSIONS

The general characteristic of dairy farmers (Producers)

The producers were the first link in the marketing chain of dairy products and their brief characteristic were shown in Table 1. Producers are important actor in the production and supply chain. Most of them produce raw milk and most of their products were supplied to Groups' Retailing Counter.

Table 1. General demographic and socio-economic characteristic of dairy households

Characteristics	M±SD
Age of dairy household head	45.65±11.65
Total family members in household	8.33±4.30
Farm labours available in household	2.37±1.00
Walking distance to market in hours	.79±.80
Jersey cross cattle	4.95±1.65
Milk yield per day in liter	9.47±4.55

Age of the household head

A significant difference was observed between the age of the dairy groups of household heads of SGNT, CGTT, PMGGNT and NGGCPT (Table 2).

Table 2. ANOVA analysis of Age of dairy farmers between dairy groups

Sources	df	MS	F	p
Between dairy Groups	3	514.653	4.841	.006
Within dairy Groups	40	106.303		
Total	43			

This indicates that dairy farmers in the study area have experiences with different age groups. The result also depicts that age of the household head as expected had a positive and significant impact on dairy production decision. This is an indication of positive future dairy farming of the country by attracting more educated younger generation with introduction of improved dairy farming, processing and marketing technology.

Although, the aged households heads were believed to be wise in resource uses and it is expected to have a positive effect on market participation and produced marketable surplus. However, Tshiunza et al. (2001) reported in cooking banana planted for market; found that age significantly affected its market output. He also found that younger farmers tended to produce and sale more than the older farmers.

Walking distance of dairy farmers to market in hours

There was significance of difference in walking distance to market between the Dzongkhag in (Table 3)

Table 3. ANOVA analysis of walking distance to market point in hours

Distance to market	Sources	df	MS	F	P
Walking distance to market in hours	Between Groups	2	4.693	11.463	.000
	Within Groups	41	.409		
	Total	43			

Thus, performance of dairy household mostly depends on access to market and other infrastructure facilities. Dairy products being perishable commodities, good access to market is of paramount importance for dairy farmers to produce more marketable surplus. The information on average distance to dairy products market centers was analyzed as an indicator of access to market and market information. As per the statistics' above PMGGNT of Trashigang Dzongkhag have least distances to walk to the nearest market point comparing with other three dairy groups of Trashiyangtse and Monggar.

Similarly, study conducted by Holloway et.al. (2002) & Gizachew (2005) found that there was negative relationship indicating that, the farther was the household from the market, the more difficult and costly it would be to get involved in the probability of participation in dairy products marketing.

Producers' preferred market destination

The result indicates that most of the group members about 69.76% sold their milk, butter and cheese to groups' retail counter, 13.95% sold directly to individual costumers and 16.27% to other retail shops (Figure 1). The survey also found out that group members felt convenient, secure and satisfied when products were sold to groups' retail counter.

According to Zia (2007) marketing chain might also be linked to both formal and informal market agents. Thus, the significant proportion of dairy product produced in rural areas were consumed at source within the villages, either through individual farm household or in some cases direct sale to the individual consumers.

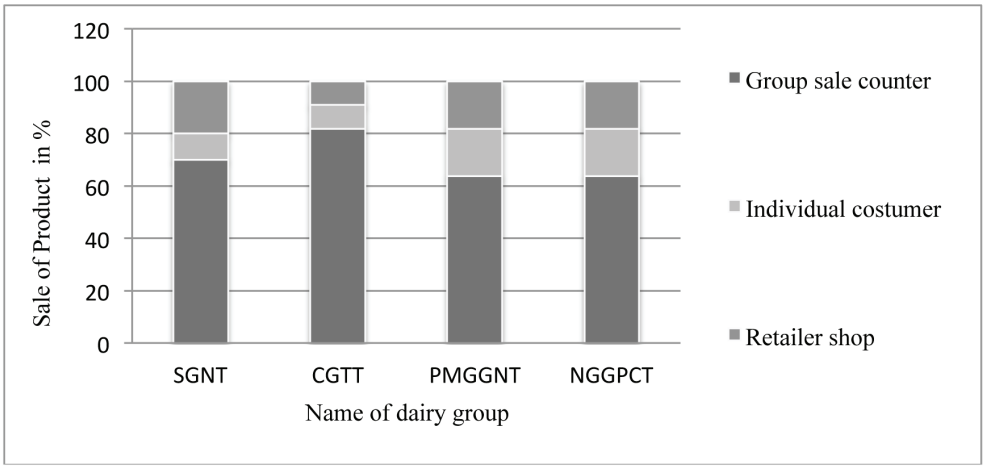

Fig.1: Local dairy products' main market

(Note: SGNT= Sonam Gonor Nyamrub Tshogpa, CGTT=Chirphen Gonor Tshongdrel Tshogpa, PMGGNT=Pam Meday Gonor Gongphel Nyamlet Tshogdey, NGGPCT= Ngatshang Gonor Gongphel Phinshum Chitheun Tshogpa)

Retailers and their roles in dairy market chain

These were the middlemen/women acting between the dairy producers and the final product consumers. These include group members' representative as salesmen/women, hired salesmen/women or any general shopkeeper selling the dairy products to consumers in smaller units. This market chain was the last link between the producers and consumers functioning in between production and supply chain.

Study revealed dairy groups' retailing counters retailed the major chunk of retailing activity as there were about two other active market actors involved in the market chain. They play the vital role liking between the producer and consumer, and earn some profit with comfortable market margin (Table 4 and Table 5). These market actors include farmers, wholesalers, dairy cooperatives, importers, exporters and retailers (Zia, 2007).

Table4. Farm gate price of dairy products of ten retail counter

Price of dairy products for producer by groups' retail counter	M	SD
Price paid to producers per liter of milk	20.17	4.07
Price paid to producers per kilograms of butter	181.00	12.45
Price paid to producers per kilograms of cheese	94.00	21.90

There exist no big price gaps between the retailers and producers. This indicates the

producers, retailers and consumers are in comfortable stand in terms of production cost and market margin. The general consumers were also need not to pay higher prices while consuming local dairy products. Otherwise, if there was wide gap between producers and retailers, it indicates low price to producers and higher prices to consumers. As presented in Table 5 and Figure 2, the milk market has the least market margin comparing the market margin for butter and cheese.

'A marketing margin is the percentage of the final weighted average selling price taken by each stage of the market chain. The total marketing margin is the difference between what the consumer pays and what the producer/farmer receives for his product. A wide margin means usually high prices to consumers and low prices to producers' (Woldu, A. 2004).

Table 5. Sale price to consumers by dairy groups 'retail counter

Sale of dairy products by Retailers/Groups' sale counter	M	SD
Price charged to consumers per liter of milk	24.40	4.39
Price charged to consumers per kilograms of butter	195.50	23.10
Price charged to consumers per kilograms of cheese	107.50	33.35

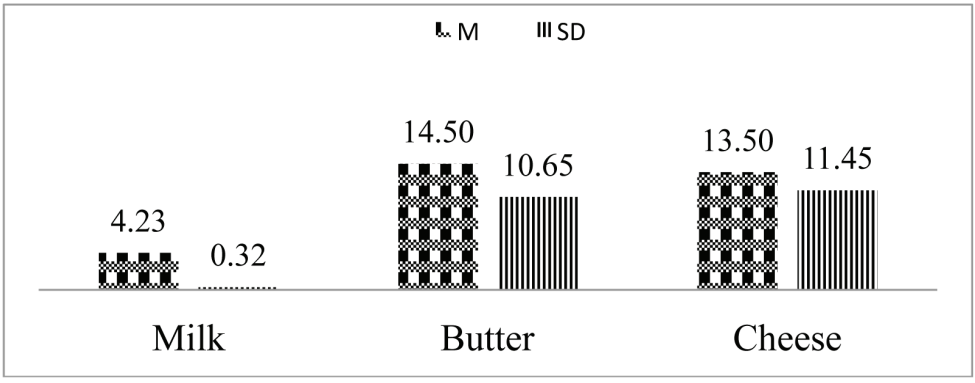

Fig. 2: Mean of market margin for dairy groups' retailers (Figures in Nu.

Consumers' preferences on Local and Imported dairy products

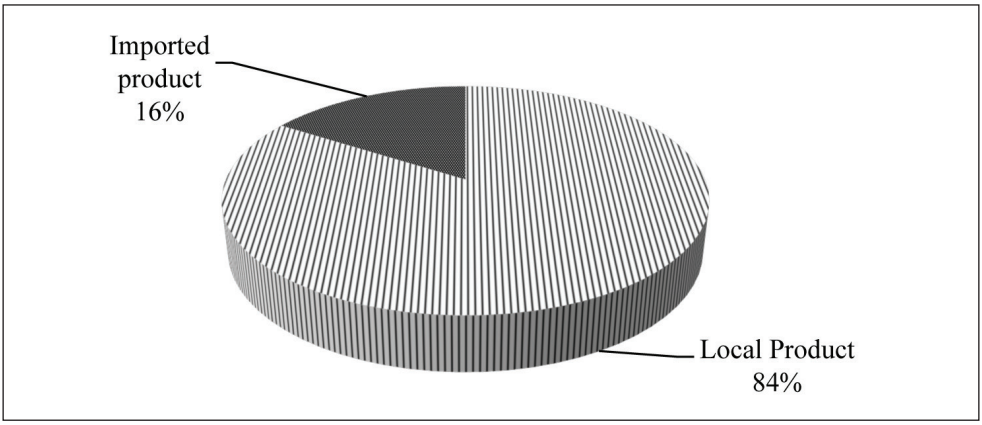

Fig.3: Consumers' products preferences on Local and Imported

The result indicates, though bigger market share was occupied by variety of dairy products from India, but 84% of consumers still have preference for local product in Figure 3.

The reason quoted by most consumers were, that local product are, organic, no chemicals or preservatives, fresh and tasty. If our local products are available all the time in right quantity and in right place consumers are satisfied with local product. On the other hand, about 16 % preferred imported products. The reason they stated were: these products are available all round the season, easy to get, easy handling and long shelf life with flavour. As per the survey imported products were also available in diversified form, good packaging and hygienic.

To upgrade our existing market the government involvement in formulating enabling physical environment like bigger market shed construction and improvement in transportation system for dairy enterprise are very essential. The market rules and regulation in place for efficient functioning of market chain. On top of the existing market structure, the physical, social, legal environment and the internal organization of the dairy enterprise influence the market conduct (Woldu, A. 2004

Status of local dairy products to fulfil consumers' demand

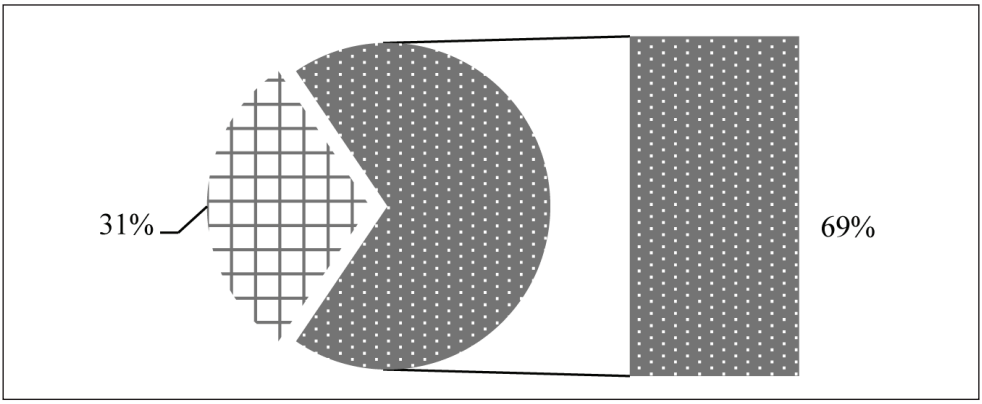

Fig. 4: Fulfillment of Consumers' demand by local dairy product

This indicates there is wide gap to fulfill the consumers demand. Thus, vigorous improvement in dairy farming should be encouraged by enhancing improved marketing technologies in place. The study found out about 31% as this study was done on dairy groups where dairy production was little higher compared to non group area. Also in their case, the study was done about five years back focusing on whole country. As per the study made by Dervile and Tenzin (2006) they have reported that dairy chain directly benefits 28% of the Bhutanese population.

Existing dairy market channel in the study area

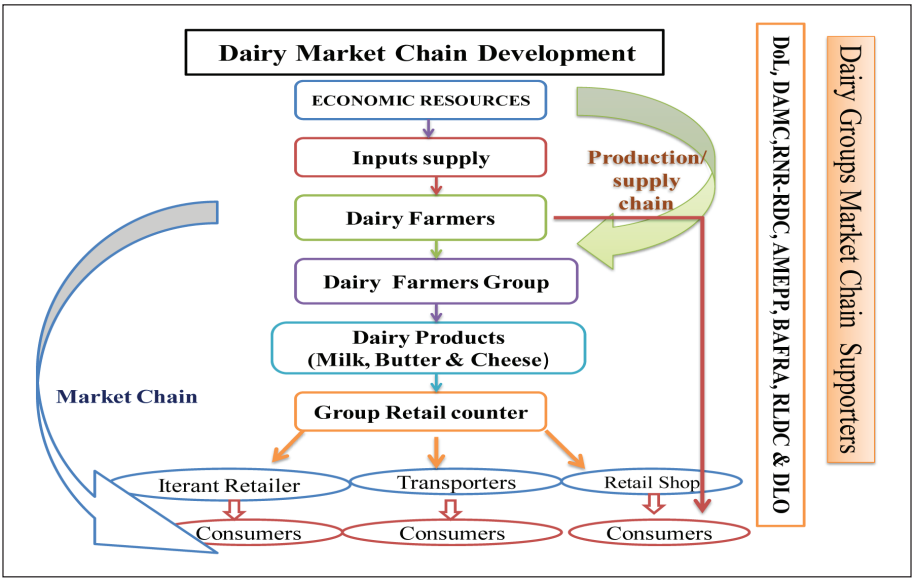

Fig.5: Dairy market chain development in the area

The number of market actors involved in the (Figure 5) above shows that net work of marketing channel will have prominent effect on both producer and consumer on price structure of dairy products. More market actors present in the given market chain, shorter the market channel and more likely the consumer prices became low and the producer will get a higher returns area (Koler, et.al, 2003).

The survey result identified four types of dairy products market channel in the area. Contrary to this, the study area has very basic market channel which was initiated by dairy group marketing formed about 5 years back. This market chain or market channel may be short or long depending on the kind, quality and quantity of the product marketed, available marketing services, market information and prevailing social and physical environment of given milk shed (Islam et al., 2001).

The major dairy products market channel

Producer Consumer: These channels accounts for about 13.95%. This was the shortest of all market channels identified during the survey in the milk sheds. The existing dairy group's norms treated this market channel as informal.

Producer Groups' retail counter Consumer:
This channel was identified to be operational in all the milk sheds. No whole sale activities were carried out in this chain. The group retail counter directly linked the producers and consumers in the market chain. This market actor channeled about 69.76% of the products the area. This market channel was found to be the most reliable and best alternative market chain for both producer and consumers. The producers get their returns on monthly basis without any hassles and consumers get their share of products on time.

Producer Group' Retailing Counter Itinerant traders Retailers Consumer
About 16.27% of the butter and cheese were traded by itinerate trader to the retailing shop and from retailing shop to the consumers. These portions of products were mainly accessible to road worker, businessman and other travelers**.**

Producer Group' Retailing Counter Transporter Consumer:
About 50% the dairy products were taken by the Trashigang -Thimphu national high way bus driver/taxis and other travelers to the western parts of the country especially to urban (Thimphu) consumers. Although same price were offered to the group retailers by the transporters the selling price for Thimphu consumers were not studied. These market chains were functional mainly in NGPCT, ZSNT and CGGNT of Monggar Dzongkhag.

CONCLUSIONS

Study indicates improvement in dairy production and marketing after the initiation of group marketing in eastern Bhutan. The group marketing approach motivated our subsistence dairy farmers to produce surplus dairy products (milk, butter and cheese) with improved farming practices. The impact of AMEPP project in the east on dairy development is vibrant. The rural income enhanced and livelihood uplifted and the nutritional status in rural villages improved. Rural employment rate have increased as younger generation too involved in dairy marketing activities. Study revealed that dairy farming further needs to develop through high-tech approach in production, processing and marketing to attract younger educated generations.

At present the producers and consumers are in comfortable in terms of production cost and consumers price in the market chain. The market margin of retailers from sale of fresh milk is least comparing to butter and cheese. The groups/cooperative management body must be aware of business oriented market tricks and principles to avoid dependency syndrome among the producers. The government actions need to create the enabling and supporting environment by reducing bureaucratic obstacles for effective formation and management of dairy groups in self-help motives with support on market information flows and financial management.

In general, the survey found that, dairy marketing system in the study needs improvement especially in packaging, storage and transportation. The upcoming dairy groups must be scrutinized against its cost and success must be evaluated annually. In the consumer front, although 84% consumers' preferred domestic products only 31% were fulfilled and huge market share of 69% was occupied by the imported dairy products. Thus, government actions are also required to inspect and monitored the quality of local dairy product to attract markets.

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Performance of pure breed pigs in Gelephu Farm

Lokey Thapa[1]

ABSTRACT

The success of the government pig breeding farms is directly related to the performance of pigs in the field where pure breed pigs are reared. The study was carried out to obtain baseline information on the performance of different pure breed like Saddleback, Large Black and Duroc pigs at Gelephu farm. The data were collected for the period of five years starting July 2006 and were analyzed using descriptive statistics, analysis of variance in different performance parameters. The study revealed that the mean litter size at birth and at weaning for Gelephu farm was 7.87 and 7.53 pigs resulting pre-weaning mortality of 4.32%. Similarly, Litter weight at birth and at weaning was 9.63 and 64.63 kg respectively with average weaning age of 48.84 days. The mean litter weight at birth in Gelephu farm was 9.65 ± 2.74 kg, with highest for Saddleback (10.28 ± 2.83) kg and lowest for Duroc (8.87 ± 3.07) kg. There was a *significant difference in litter weight at birth amongst pure breeds of pig reared at Gelephu farm. This could be attributed due the differences in birth weight among different breeds of pig.*

In general, the findings revealed that the overall performance of these pig breeds was lower compared to other countries like Philippines. There is a need to improve the production performance of various pig breeds maintained at Government pig farms through sound breeding and better management practice in place.

Key words: Pig, Litter size, Litter weight, Pure breed, Cross breed

INTRODUCTION

Livestock farming is an integral part of the agriculture system in Bhutan. Indigenous pigs constitute more than 60% (DoL, 2010) of the total pig population in the country. Crossbreeding of indigenous with exotic pigs to increase meat production was initiated by Department of Livestock since early 1960s (Nidup, et al., 2011). Pig rearing is an important source of income for the farmers besides increasing the dietary intake of protein in their menu. In the rural household level, pig rearing and sale of pork by the farmers is one of the measures to alleviate poverty.

The National Pig Breeding Centre (NPBC) in Gelephu is a nucleus farm which started in 2003 with an initial herd size of 82 pigs imported from United Kingdom.

1 *NCAH Serbithang, DoL, MOAF, Bhutan; lokeythapa@yahoo.com*

Three imported pure breeds reared at the farm are Saddleback, Large Black and Duroc. The farm was mainly established to breed pure bred piglets, supply to the multiplier farms in Serbithang and Lingmethang and also to the farmers of five Dzongkhags of East central and western region for cross breeding with indigenous breeds.

In the current study, some of the important reproduction and production parameters like age at first service, number of service per conception, weight at farrowing, litter size at birth, litter weight at weaning, pre-weaning mortality and weaning to estrus interval were compared for analyzing.

The findings from this study may be useful to the Department of Livestock for proper planning and decision making, to introduce other exotic pig breeds in Government pig farms in Bhutan. It would also serve as a baseline data for further studies and to bring necessary improvement on management tools for enhancement of farm production efficiency. Thus, the objective of this study was to assess the current production efficiency of these breeds reared at Gelephu farm

MATERIALS AND METHODS

The study was carried out in National Pig Breeding Centre (NPBC), Gelephu in which the data from pure breeds of pigs like Large Black, Saddleback and Duroc was considered. In total, 106 sows between 5th to 8th Parity were selected for the study. The selected sows were segregated based on breed information on sows. Age at first service, number of service per conception, pre-weaning mortality, weight at farrowing and weight at weaning, age at weaning, weaning to service interval were collected. The information was analyzed from 62 number of Duroc, 170 numbers of Large Black and 197 Saddleback pig breeds numbers of farrowing data. The data for analysis of performance parameters were extracted from Eliteherd database maintained in the farm. The annual temperature maintained by the farm was used as a basis to analyze the effect of environment on production. For analysis of information, the data from the Eliteherd was exported to excel sheet for coding. Then, the coded data was analyzed further by descriptive statistics and Analysis of variance using SPSS 16.

RESULTS AND DISCUSSIONS

Age at first service

The mean age at first service (n = 77) was 460 ± 123 days. The mean age at service was recorded highest from Large Black (501 ±99) and lowest from Duroc (389 ±139) days (Table 1).There was a significant difference in the age at first service between the different breeds (p = .022) and difference was noted between Duroc and Large Black (p =.026).

The age at first service ranged from 8 months to 36 months and this could be due to high temperature which suppress sexual maturation and delay onset of puberty (Phiri L. M., 2005).

The delayed age at first service could also be due to non detection of heat by the farm management as the duration of heat period is short in gilts compared to multiparous sows.

Table 1. Different parameters with its performance

Parameters	Duroc	Large Black	Saddleback	Sig
Age at Service in days	389 ± 139	501 ± 99	449 ± 147	p< 0.05(ab)
Number of Service per conception	1.15 ± 0.47	1.16 ± 0.40	1.23 ± 0.57	NS
Litter size at birth (number)	7.34 ± 2.64	7.49 ± 1.70	8.38 ± 2.17	p< 0.01 (ac) p< 0.05(bc)
Litter weight at birth (kg)	8.87 ± 3.07	9.21 ± 2.32	10.28 ± 2.83	p< 0.05(ac) p< 0.05(bc)
Pre weaning mortality (mean)	1.76 ± 0.82	1.83 ± 1.42	1.78 ± 1.13	p< 0.05(ab)
Weaning Age (days)	48.76 ± 6.81	49.09 ± 6.56	48.6 ± 6.4	NS
Litter weight at weaning (Kg)	8.17 ±	8.69	8.63	NS
Litter size at weaning (Number)	6.77 ± 2.68	7.13 ± 1.81	8.10 ± 2.20	p< 0.05 (ab) p< 0.05 (ac)
Weaning to Service interval (days)	34.36 ± 50.4	29.19 ± 56.6	30.8 ± 61.3	NS
Farrowing interval	196.68 ± 50.8	192.37 ± 57.4	195.2 ± 61.8	NS

a = Duroc; b = Large Black, c = Saddleback & NS = Non significant

Number of services per conception

The finding indicated that the mean number of services per conception for pure bred pigs was *1.19* ± 0.49 per conception (n = 410). There was no significant difference in the conception rate between different breeds. The study found out that with the increase in parity, the number of service per conception and litter size increased and is in agreement with (Roongsitthichai *et al*., 2010).

Litter size at birth

The mean litter size at birth was 7.87 ± 1.98 pigs. The mean litter size at birth was highest from Saddleback (8.38 ± 2.17) and lowest from Duroc (7.34 ± 2.64) pigs (Table 1 & Fig. 1). There was a significant difference in litter size between different pig breeds reared (p=.000) and were between Duroc and Saddleback (p =.002) and Large Black and Saddleback pure breeds (p =.000)

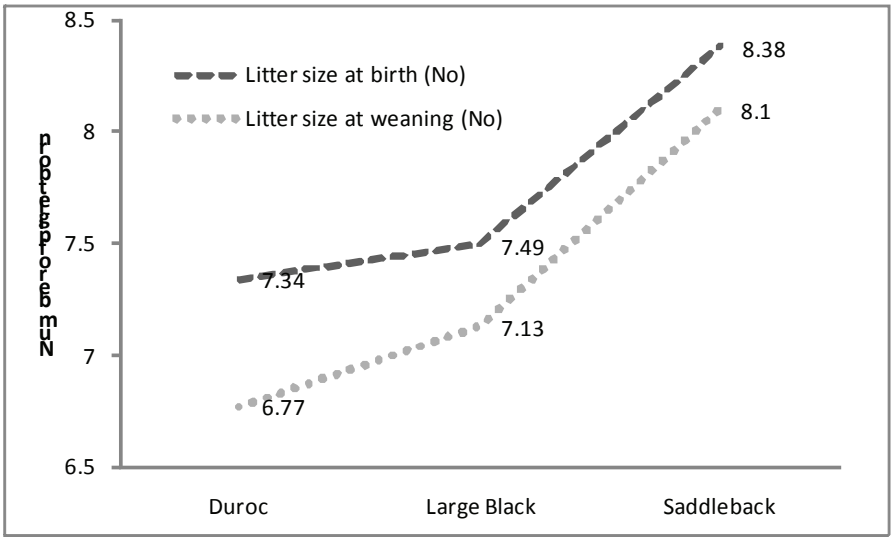

Fig. 1: Litter size at birth and litter size at weaning different pig breeds

The gradual decline in litter size at birth was noted from 7th parity onwards which could have been contributed by age at first service, body weight, ovulation rate, implantation rate. Rearing of unproductive sows could the other possible reasons for lower litter size at birth. The unproductive sows were reared at the farm because of difficulty in meeting the replacement stock. The study indicated that litter size at birth showed a progressive increase with increased in parity number, until 7th parity and then a declining trend. These findings are in agreement with other studies (Roongsitthichai *et al*., 2010). The small litter size at birth in the farm could be due to failure in fertilization and losses during parturition as still birth and foetus born death.

Litter weight at birth

The mean litter weight at birth was 9.65 ± 2.74 kg. The mean litter weight at birth was highest from Saddleback (10.28 ± 2.83) kg and lowest from Duroc (8.87 ± 3.07) kg (Table 1). There was a significant difference in litter weight at birth between different pig breeds (p =.000) and the difference was evident between Duroc and Saddleback (p = .001) and Large Black and Saddleback pure breed (p =.001). The highest litter weight at birth was observed from pig breeds between 3rd to 7th parity and this finding is in general agreement with (Roongsitthichai *et al*., 2010). The average litter size in the farm on average was above 1 kg and could be due to less number of weight per farrowing. This finding was in agreement with (Jourdine *et.al*., 2006) who reported that litter weight were heavier in hot places and also when the litter size was small. Low birth weight in piglet could be the result of inadequate nutrition during last two week of pregnancy.

Pre weaning mortality

The mean pre weaning mortality in pig farm was 5.37 percent. The mean pre weaning mortality was highest from Large Black (1.83 ± 1.42) and lowest from Duroc (1.67 ± 0.82) (Table 1). There was a significant difference (p=.007) on pre weaning mortality of different pig breeds and the difference was observed between Large Black and Duroc pure breeds (p =.010).

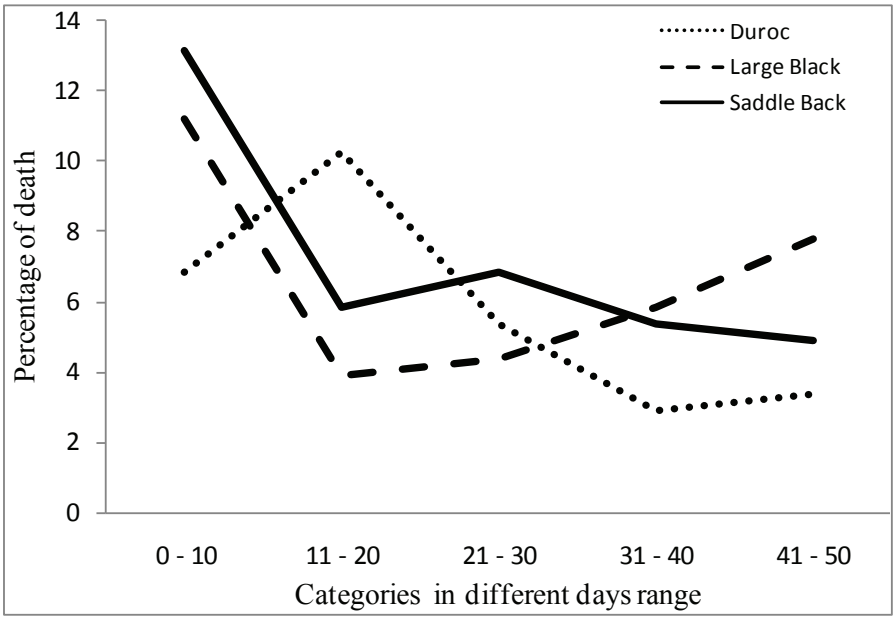

Fig. 2: Pre weaning mortality in piglet from different pig breeds

Thirty one percent of the pre weaning mortality was between 0 to 10 days and this is the most critical period where high mortality occurs due to less colostrums intake and low litter weight (Fix, 2010) (Fig. 1) . The mortality from Large Black pig was higher between the 40 to 50 days and could be due to the breed more acclimatized to temperate climatic condition and presently reared at sub tropical area. The farm overall mortality of 5.37 percent was in line with the bench mark set by Department of Livestock.

Forty percent of pre weaning mortality was due to the death of runt piglet and this finding is in contrast with Shankar *et. al.* (2009) who reported that 53% of their death was due to crushed by sow (Fig. 2). Runt is the last piglet born in that particular litter and is usually under weight and dies due to starvation. Seventeen percent mortality was due to digestive problem such as Diarrhoea and piglet scours. Born dead and mummified foetus was also recorded high in the farm which may need further investigation.

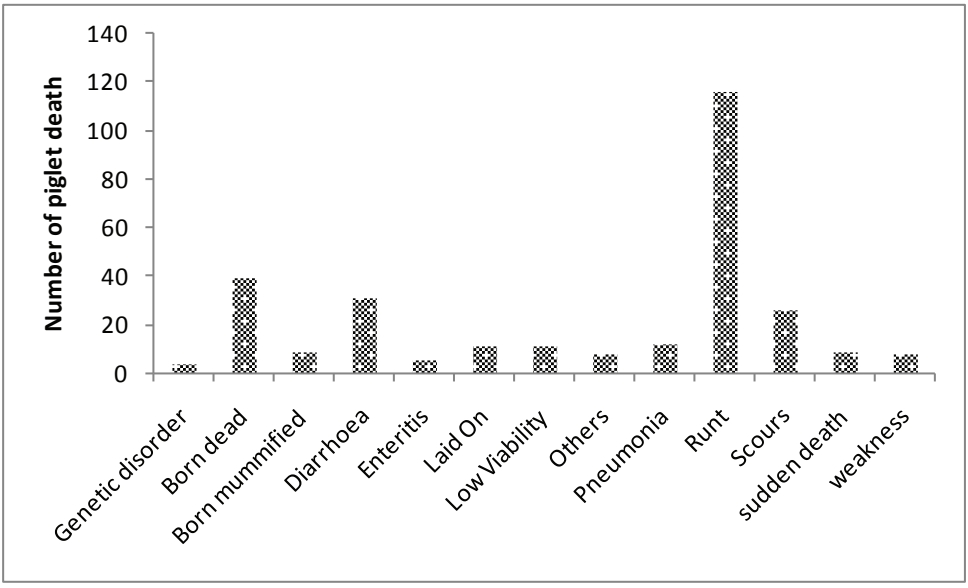

Fig. 3: Different causes of pre weaning mortality in piglets

Mean pre weaning mortality percentage was highest in January with 14 percent, followed by June, September and December with approximately 10 percent. Higher mortality in the above months could be due to change of seasons where the temperature reached 14^0C and is very low for piglets to survive. Similar trend of mortality in different months were also reported (Andersen *et. al.*, 2005). Improving the piglet management during the first 10 days after farrowing may improve pre weaning mortality in this critical period.

From the study, it is evident that pure Duroc breed can survive better in hot places compared to other breeds. Higher survival rate in the farms could be the result of the small litter size, heavier individual birth weight. This finding is in agreement (Milligan *et. al*., 2002) which also indicated effect of small litter size on pre weaning mortality.

Weaning Age

The mean weaning ages was 48.78 ± 6.50 days. The mean weaning age was highest from Large Black (49.09 ± 6.56) and lowest from Saddleback (48.59 ± 6.32) (Table 1). The mean weaning age range from 30 to 69 days and this long range could be due to piglet not reaching minimum weight at weaning. Weaning age in all the breeds was high and this finding is in agreement with (Young *et.al*., 1976) who reported slightly higher weaning age in pure breed.

Piglet weight at Weaning

The mean piglet weight at weaning was 8.50 kg. The mean litter size at weaning at this farm was 7.53 ± 2.19 numbers. The piglet weight at weaning was highest from Saddleback (8.10 ± 2.20) and lowest from Duroc (6.77 ± 2.68) (Fig.4) There was a significant difference on weaning weight in different pure breeds of pigs and the difference was also observed between Duroc and Saddleback (p =.05) and Duroc and Large Black (p =.05) (Table 1).

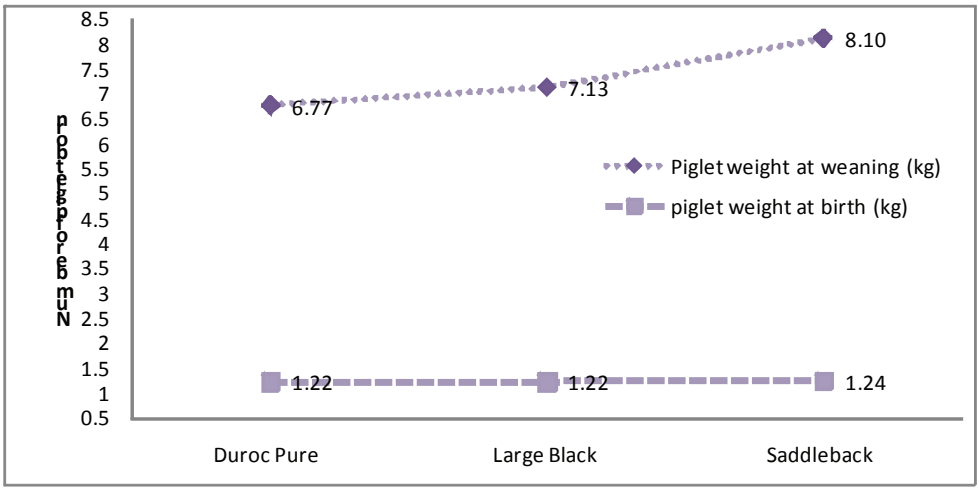

Fig. 4: Piglet weight at birth and at weaning from different pig breeds

There was significant difference on weaning weight in different pure breeds of pigs ($F_{(2)}$=16.21, p =.000) and the difference was also noted between Duroc and Saddleback (p =.05) and Large Black and Saddleback (p =.05) (Table 1).

Piglets that were born with heavier birth weight tend to be heavier at weaning and thereafter. The weaning weight was heavier when the litter size was small. The weaning weight of piglet from Saddleback pig was comparatively higher than other breeds**.** Saddleback is considered to be a good sow mother and an excellent milker besides having heavier litter weight. (Organic Vet. UK). The Saddleback breed has better mothering abilities as indicated by number of piglets weaned than other breeds.

Weaning to service interval

Mean Weaning to service interval (WSI) in different pig breed was 30.63 ± 57.99 days (Table 1). The mean weaning to service interval age was highest from Duroc (34.36 ± 50.45) and lowest from Saddleback (30.75 ± 61.31.

About 82 percent of the services were done within 10 days from weaning. However, the farrowing rate was 65 percents and farrowing index of 1.51 farrowing per year. This performance was found to be low for economic viability of the farm in a long run. Seventy percent of breeding occurred within 6 days of post weaning and is in general agreement (Wilson & Dewey., 1993). There was long weaning to service interval because of which the estrus period was short and is in agreement (Belstra, 2003). Long WSI was observed in the sows and this could be due to loss in body weight during lactation by more than 15 percent (Kunavongkrit & Heard, 2000).

Farrowing interval

The mean farrowing interval was 194.32 ± 58.66 days. Farrowing interval was highest from Duroc (196.68 ± 50.78) days and lowest from Large Black (192.37 ± 57.37) days. This finding is consistent with (Kumari and Rao, 2010) which proved that the farrowing interval was similar in small scale pig farming.

CONCLUSIONS

Litter size and litter weight at weaning from any pure pig breed are considered to be the most important parameters to judge the prolificacy of any farm. Study has revealed that from total of ten performance parameters used in this study, six of them showed a significance differences. The study found that the overall performance was better in Saddleback when compared to other pig breeds. Duroc breed reach the age at first service earlier then other pig breeds. The weaning weight of piglets from Large Black was found to be higher although the pig took longer time to reach the age at service. Higher pre weaning mortality in piglet was observed from Large Black although there was no significant difference between different pig breeds. The finding from the study was confirmed to one nucleus farm only. There is a need to conduct a similar study in other two Government multiplier pig farms and contract pig production pocket with more sample size to validate and substantiate the present findings.

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Rice straw as winter fodder for cattle in western Bhutan

Leela Maya Dahal[1]

ABSTRACT

In areas where rice-based cropping is popular, rice straw serves as the major fodder for cattle. Study was conducted in three geogs of western Bhutan covering 30% of total households owning improved cattle breed in each geog to assess quantity and quality of rice straw fed to cattle. In addition adoption rate of urea treatment of rice straw by farmers was also studied. Rice straw sample collection to analyze nutrient composition was done at the time of harvest. Study found that rice straw contributed the highest percent (40%) to the overall feed and fodder resources for cattle during winter. There was no significant difference in dry matter (p = .072), crude protein (p = .135), phosphorus (p =.081) and calcium (p = .059) content of rice straw of the three geogs. None of the respondents practiced urea treatment of rice straw due to lack of technical knowledge. Rice straw plays an important role as fodder resource for feeding cattle during winter in elevations ranging from 400 – 2340 masl. Therefore, emphasis should be provided on promoting and training farmers on enrichment techniques of this low nutrition fodder resource in Bhutan.

Key words: *Crude protein, Calcium, Dry matter, Phosphorus, Urea treatment*

INTRODUCTION

The scarcity of fodder in winter is a major concern for dairy development in Bhutan (Gyamtsho, 1996, Singh 2006). In rice- based cropping areas of Bhutan rice straw serves as the major fodder for cattle during winter. In Bhutan 19,357 hectares of rice is cultivated producing 77,316 metric ton (MT) grain (Policy and Planning Division, Ministry of Agriculture and Forests, 2009). This is equivalent to about 154,633 MT of rice straw estimated at 1:2 grain-straw ratio which is a huge fodder resource. The fodder shortage is more pronounced from December to February and availability of rice straw is also high at this time of the year. Therefore, rice straw remains important cattle feed during winter. However, rice straw has low digestibility, low crude protein (CP) content and poor palatability. According to Drake *et al*. (2002) nutrient content of rice straw varied tremendously with crude protein (CP%) ranging from 2 to 7% and Acid Detergent Fiber (ADF) from 41 to 56%. To improve the nutrient content of rice straw urea treated by ensiling was promoted during Sixth (1987 – 1992) and Seventh (1992 – 1997) Five Year Plan.

1 NLBP, Yusipang, DoL, MoAF. leelamaya@yahoo.com

But the technology was not adopted by farmers. As rice straw continues to remain as principal winter fodder in western Dzongkhags, a detail study on the volume fed to cattle, its nutritive value and problems in implementing enrichment technologies is expected to help in improving the feeding management of cattle.

MATERIALS AND METHODS

The study was conducted in three altitudes zones (low in Sipsu, medium in Darla, and high in Wangchang) where rice was identified as One Geog Three Products (OGTP) commodity in the 10th plan. Further these sites were identified based on improved breed the cattle population. The altitude of study area ranged from 400 to 2340 masl. The study used structured and semi- structured questionnaire to interview 182 households (Sipsu-40, Darla-82, and Wangchangn-60) which constituted 30% of the household who reared improved cattle in the selected geogs. Information on quantity of rice straw produced per household in a year, quantity feed to cattle and feeding system, main reasons for not adopting urea treatment of rice straw for feeding cattle were collected from the questionnaire survey. For nutrient content analysis, samples were collected from 18 households (6 each from each geog) using 0.25m x 0.25m quadrants from the field of each farmer. Nitrogen, calcium and phosphorus content in sample were analysed by Soil and Plant Analytical Laboratory in Simtokha. The data collected were punched in Microsoft Excel. The analysis was carried out using Statistical Package for Social Science (SPSS 14.0).

RESULTS AND DISCUSSIONS

Land holding and land use pattern

The results showed that all sampled households (100%) in Sipsu, Darla and Wangchang practiced mixed crop-livestock farming. The average land holding in acres is presented in Table 1. Rice is the major crop grown in wetland. After harvesting rice farmers of Wangchang and Darla grow either wheat or oat in but Sipsu respondents left fallow due to irrigation problem.

Table 1. Average land holding (acres) in the three geogs

Geog	Wetland	Dryland	Orchard	Improved pasture
Sipsu	1.2	1.1	0.37	0.32
Darla	0.89	1.4	0.1	0.83
Wangchang	1.4	0.3	0.2	0.15

Only 75%, 89% and 21% owned improved pasture in Sipsu, Darla and Wangchang respectively. The average improved pasture land in acres was low 0.32 in Sipsu, 0.83 in Darla and 0.15 in Wangchang. Similarly, Roder (2002) reported that introduction

of improved pasture has still not made much impact in terms of area coverage in Bhutan.

Breeds and herd composition of cattle

The breeds and class of cattle holding differed in different geogs. The respondents of these geogs owned only Jersey, local breeds and buffaloes. Sipsu and Darla geog respondents had 10 and 20 numbers of pure Jersey cows respectively. Rest was only Jersey cross and local. The herd composition of cattle indicated that Wangchang geog has the highest number of improved breed milking cows (2.10 ± 0.83) which was encouraged by the high price of milk. Farm gate price of fresh milk per litre in Ngultrum (Nu.) was 30, 22, 17 in Wangchang, Darla and Sipsu respectively. The highest number of improved breed milking cows in Wangchang geog was followed by Darla (1.71 ± 0.38) and lowest was Sipsu (0.85 ± 0.58). However, the local cattle per household was highest in Sipsu (0.85 ± 0.58), Darla (0.32 ± 0.16) and lowest in Wangchang (0.4 ± 0.12). Buffaloes were also reared by Sipsu respondents.

Feed and fodder resources

The main feed/fodder resources for feeding cattle during winter found from this study were forest grazing, rice straw, grazing crop land/fallow land, improved pasture, native pasture, hay, fodder crops, fodder trees and concentrates (Figure 1).

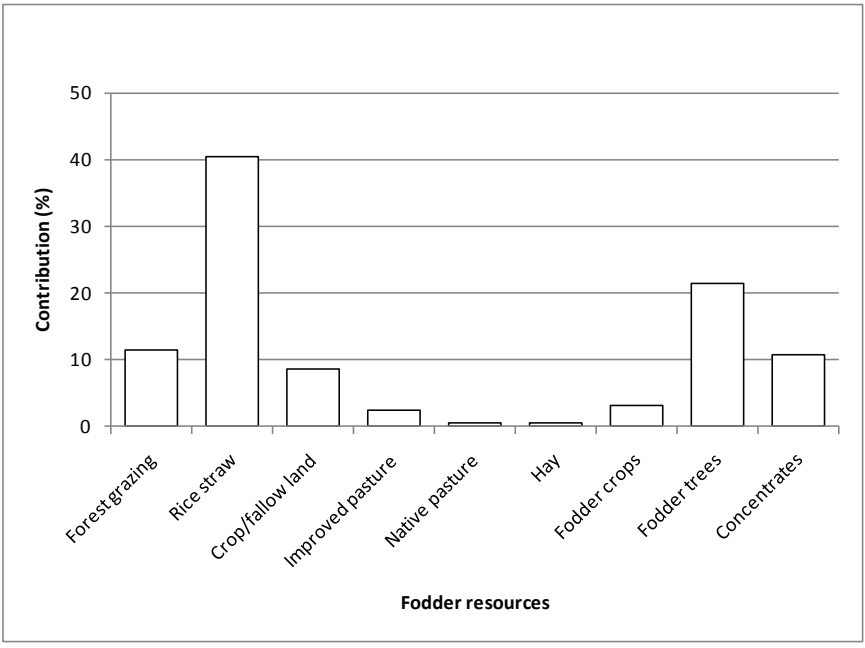

Fig.1: Respondent's perception on percentage contribution by different fodder resources during winter in the three geogs

The cattle feeding mainly included grazing combined with stall feeding. This system was practiced by 95.5% in Darla, followed by 93.5% in Wangchang and least 90 % in Sipsu of sampled household. The study found that rice straw contributed the highest (40%) followed by fodder trees (21%) to the fodder available to cattle during winter. Not much previous studies was done focusing on winter fodder resources but Roder *et al*. (2001) indicated that forest grazing and natural grassland contribute about 23% and 30% respectively to the fodder requirement in Bhutan. He reported grazing fields after harvest as the most important source of winter fodder.

Rice straw production and utilization

Average rice straw yield (MT/ha) recorded from this study was 6.3, 3.85, and 12.69 in Sipsu, Darla and Wangchang respectively. Average rice straw produced (MT) per household was (4.76 ± 3.04) in Sipsu, (1.44 ± 0.99) in Darla and (4.85 ± 1.38) in Wangchang per year. The total quantity (100%) of rice straw produced was fed to cattle. The difference between three sites in rice straw production was highly significantly ($F_{(2, 167)} = 80.731$, $p = .000$).

Dry matter and nutrient content of rice straw of the three geogs

Majority of respondents cultivated local varieties, *Musli* in Sipsu, *Bhangeray* in Darla and *Dumja* in Wangchang. Straw from these varieties were collected and analyzed for dry matter and nutrient composition (Table 3).

Table 3. Mean dry matter and nutrient content of rice straw of three geogs

Geog	Dry matter (DM%)	Crude Protein (CP%)	Phosphorus (P%)	Calcium (Ca%)
Sipsu	76.50	4.62	.08	1.82
Darla	72.81	3.93	.08	1.14
Wanchang	86.62	3.21	.13	.94

One – way ANOVA did not show significant difference in dry matter ($p = .072$), crude protein ($p = .135$), phosphorus ($p = .081$) and calcium ($p = .059$) content of rice straw of the three geogs. The results of CP and DM were similar to that recorded by FAO (2002) at 3.7 and 83.3, Ibrahim *et. al* (2008) at 3.84 and 92.5 respectively. However, P and Ca content recorded were much higher than previous records by FAO (2000) at 0.05 and 0.11 , Ibrahim *et. al* (2008) 0.1 and 0.2.

Adoption rate of urea treatment of rice straw

All respondents informed that they are aware that rice straw can be treated with urea for feeding ruminants but not a single respondent practiced it at present. In Sipsu, 5% of the respondents have prepared twice and 10 % once in late eighties. In Darla, 9% have done twice and 15% once but the respondents of Wangchang have never

treated. All the respondents who had treated twice stated that feeding urea treated rice straw increased milk yield but they discontinued because of intensive labor requirement. The respondents who treated only once cited reduced intake by the animals for not continuing the activity. The following were the main reasons put forward for not adopting the technology (Table 4).

Table 4. Reasons for not adopting urea treatment of rice straw (%)

Reasons	Sipsu	Darla	Wangchang
No technical knowledge	38.4	35.6	60.8
Labor intensive	15	16.8	28.4
Less voluntary intake	12.3	9.6	
Not many improved breed animals	21	12.1	2.6
Not much fodder deficit	2	18.8	4.4
Payment for urea	11.1	7.1	3.8

The interview found technical know-how was the main reason for not adopting the technology as reported by 38.4 % respondents in Sipsu, 35.6% in Darla and 60.8% in Wangchang.

Training on urea treatment of rice straw

There were no records about number of farmers trainings conducted in urea treatment of rice straw. Respondents of all three geogs informed that training was conducted when most of them were either students or too young to attend it. Roder (2002) stated that more than 50% of the rice cultivating households were given training in urea treatment of rice straw. In Sipsu, 6 (15%) respondents had attended training, 24 (29.26%) in Darla and 3 (0.05%) in Wangchang (Table 5)

Table 5. Contingency table on status of training attended on urea treatment of rice straw

	Training on urea treatment of rice straw	
Geog	**Yes**	**No**
Sipsu	6	34
Darla	24	58
Wangchang	3	57
Total	33	149

According to Asian Development Bank (1999) report of Highland Livestock

Development Project (HLDP) where Darla and Sipsu geog under Western Bhutan was also covered with an aim to prevent environment degradation through better resources management many farmers were trained on urea treatment of rice straw. Guo and Yang (2006) stated that the technology was a success in China but failure in Bangladesh because in China there was intensive training provided to the farmers whereas minimum trainings were given to farmers of Bangladesh. According to Roy and Rangnekar (2006) the farmers will only adopt a new technology if they notice benefits from that particular technology. The author further reported that there should be sustained support from the organization, particularly in the initial stages of introducing the technology.

Support from government in feed and fodder

Despite of having scarcity of fodder as the main constraints in rearing cattle, it is known from the study that the respondents felt there was good support from government in the field of feed and fodder production (Table 5).

Table 5. Respondents rating on support from government in feed and fodder (%)

Scale	Sipsu	Darla	Wangchang
Strongly agree	40	21.95	21.68
Agree	45.6	70.48	71.67
Undecided	10.4	7.57	6.66
Disagree	4	-	-
Strongly disagree	-	-	-

About 71.67% respondents in Wangchang, 70.48 in Darla and 45.6 in Sipsu strongly agreed that there was adequate support from the Government in the field of feed and fodder. As per the respondents, future support is needed for improving winter fodder shortage in Sipsu, establishing feed plant in Darla and providing land for improved pasture development in Wangchang.

CONCLUSIONS

The study showed that rice straw was the main fodder resource contributing 40 % of the total winter fodder available to cattle in Western Bhutan. Dry matter, crude protein, calcium and phosphorus composition of rice straw between study sites were not different but the overall calcium and phosphorus content were higher than the previous records. Adoption rate of urea treatment of rice straw for feeding cattle was zero and the reason for non-adoption of the technology was attributed to lack of technical know-how amongst the farmers. Although, the trainings had been provided to the farmers in the past, these trainings were not sufficient for the farmers

to carry on the activity by themselves. It is therefore suggested that the trainings are provided until the farmers are well-equipped to take over the activity on their own.

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Extension & Cooperative

Factors affecting motivation and job-satisfaction levels of g*eog* extension staff in Bhutan

Samdrup Rigyal[1] and Chaicharn Wongsamun[2]

ABSTRACT

The extension agents are expected to work harder and perform better and so it is vital that they are kept motivated and satisfied with their jobs. This study was conducted to find out the motivating and job satisfaction levels of the extension agents in Bhutan based in the geogs. A total of nine out of the 20 dzongkhags comprising of 60 geogs from four regions of the country were selected for the purpose of the study. A structured questionnaire-based survey was administered. Overall, it was found that the extension agents were fairly motivated and satisfied with their jobs. The senior group of extension agents appeared more motivated and satisfied than the juniors. The mobility facility and opportunity for in-service training were the least motivating factors. The reward for performance and recognition of service were also rated low while it was felt that extension centres in the geogs were poorly equipped. It is recommended to create attractive mileage system to facilitate alternative means of transport and increase the frequency of in-service training to up-grade the knowledge and skills. There is also the need to create a more enabling environment to work by properly equipping extension centres with basic minimum facilities.

KEYWORDS: Motivation; Satisfaction; Extension agents; Mobility; Training; Recognition; Facilities

INTRODUCTION

According to Qamar (2005) extension is an essential pillar for research and development. However, unfortunately, a poor perception of extension prevails in many developing countries, caused by a weak extension lobby, faulty initial organizational set-up, an inherent lack of trust in extension by most of the research organizations, and traditionally poor career development conditions in the profession of extension. The extension system in Bhutan operates within this purview; more so the extension framework functions within the conventional system of technology transfer, wherein the EAs were believed to be involved in merely passing on the recommendations released by the research system to farmers.

The Ministry of Agriculture and Forests (MoAF) in Bhutan also believes that

1 Royal University of Bhutan; r_samdrup@hotmail.com

the effective delivery of public extension services is the key to success of rural and agricultural development programmes to improve the livelihoods of farmers. The delivery of extension programmes, however, remained a challenge. Within the decentralised plan of action and delivery of services, the implementation of most of the development programmes including agricultural extension services are delegated to the *dzongkhags* and *geogs*. However, the field level extension agents (EAs) are often subjected to critical review over issues of technical competency and effectiveness.

The Resolution 19 of the RNR Conference (2007) implied that *geog*-level EAs are technically incompetent and lack effective delivery of services. There were also issues about EAs being underutilised or improperly engaged in the field works. These statements have a number of implications on the job performances of EAs. They raised questions about standard of training provided in training institutions, professional up-gradation opportunities offered once employed and environments conducive for continued learning and knowledge management created for further enhancement of their knowledge and skills. However, all these statements and claims required to be further corroborated and substantiated with proper evidences.

Some of the problems are attributed to the "weak monitoring and evaluation (M&E) system across all levels of the Renewable Natural Resources (RNR) sector and at the national level as one of the main drawbacks adversely affecting the success of most plans and programmes," (MoAF, 2007). The 9th RNR conference even "endorsed to set up a mobile monitoring unit at the Centre that could visit the *dzongkhags* / districts with a proactive and consultative responsibility."

These problems are also viewed in the context of raising issues on how the M&E system, besides undertaking its routine function of identifying weaknesses and failures, could also act as instruments for motivation, learning and leverage for improved performances of extension agents. The M&E system should also monitor the factors involved in the job satisfaction and motivation of EAs in terms of work challenges, financial incentives, promotion and training opportunities, recognition, staff welfare, office and mobility facilities, controlling officer - subordinate relationships, clear job descriptions, etc.

THEORITICAL FRAMEWORK

Maslow (1954) suggested a hierarchy of needs where once individuals have satisfied one need in the hierarchy, it ceases to motivate their behaviour and they are motivated by the need at the next level up the hierarchy. The theory suggests that employees will always tend to want more from their employers. When they have satisfied their subsistence needs, they strive to fulfil security needs. When

jobs are secure they will seek ways of satisfying social needs and if successful will seek the means to the ultimate end of self – actualization. Although this theory was not intended as an explanation of motivation in the workplace, many managerial theorists have enthusiastically adopted it.

According to Beder (1990), Cohen (1990) and Watanabe (1991), employees work harder and perform better if motivated and satisfied with their jobs. Therefore, extension managers need to know what motivates their staff to be able to manage them more effectively, minimise employees' frustration and boost their working morale (Mwangi and McCasline, 1994 cited in Fabsoro, Awotunde, Sodiya & Alarima, 2008, p. 141)

Within an agricultural setting, particularly an agricultural extension outfit, motivation of staff is important in achieving the desired agricultural development plan. Agricultural extension aims at improving the practice of agriculture in the developing world through extension of knowledge to farm families on improved agricultural practices and technologies (Fabusoro, E. Awotunde, Sodiya, & Alarima, 2008).

Hackman and Oldham (1975) suggested that jobs differ in the extent to which they involve five core dimensions including: skill variety, task identity, task significance, autonomy and task feedback. They suggest that if jobs are designed in a way that increases the presence of these core characteristics, then the employees could experience meaningfulness of work, responsibility for work outcomes and knowledge of results of work activities. When these critical psychological states are experienced, work motivation and job satisfaction will be high.

The Hertzberg motivation theory summarises that "if you want people to do a good job, give them a good job to do." MoAF (2007) noted that, "job status of extension staff" in Bhutan was reportedly low and that there is an urgent need to "explore other ways and means of motivating the extension staff". This indicates that the motivating factors with field extension workers within the MoAF are low which is further compounded with attributes of performance ineffectiveness and incompetency.

The draft new extension policy of Bhutan recognises that motivation of staff is important to deliver the expected goods and services to the farmers. "The extension system is only as good and effective as the extension agents are. Therefore, how to keep the extension agents highly motivated, dedicated and committed towards their work is a major challenge" (MoAF, 2009).

The same draft policy document emphasises the need to create an enabling working

environment by putting in place, "a clear national extension policy, clear plan of activities, proper supervision mechanism in place, good extension leadership at all levels, discretionary funds to undertake self initiated and self-directed extension projects in their particular geog."

MoAF (2007) also observed that there is total absence of a workable monitoring system which acts as major obstacle in the current system. It is therefore, important to study the effectiveness in the implementation of the M&E guidelines and evaluation on the adoption and impact of the M&E tools used at various delivery points. This could also encompass identifying performance motivating factors and job satisfaction of extension agents.

MATERIALS AND METHODS

A total of nine *dzongkhags* selected out of the total 20 *dzongkhags* as study samples based on cluster sampling. The cluster sampling was employed by subdividing the *dzongkhags* distributed in the four regions covered by the RNR Research and Development Centres (RNR R&DC) of the MoAF. The R&DCs in Bhutan are distributed to cover the whole of the country through the four regions of East, East-Central, West and West-Central. The national mandates of R&DCs are horticulture research for east with six *dzongkhags*, cereal crops research for west with five *dzongkhags*, forestry research for west-central with six *dzongkhags*, and livestock research for east-central with three *dzongkhags*. Table 1 illustrates the distribution of the four geographical regions.

Table 1. Four geographical regions along with the research & development centres with their national research mandates and sample districts from each region

Region	Research Centers (RC) & mandates	Total No. of *dzongkhags*	Names of Sample *dzongkhags*	No. of respondents
West	Yusipang: *Forest research*	5	2 *dzongkhags*: *Haa and Paro*	31
West-central	RC, Bajo: (*Field crop research*)	6	3 *dzongkhags*: *W/ Phodrang, Tsirang and Punakha*	69
East	RC, Wengkhar: (*Horticulture Research*)	6	2 *dzongkhags*: *Mongar and Trashigang*	30

East-Central	RC, Jakar: (*Livestock research*)	3	2 *dzongkhags*: *Bumthang and Trongsa*	20
Total		20	9	150

Having stratified the *dzongkhags* in the four regions, two sample *dzongkhags* each were selected from all the regions through simple random sampling. One additional sample was selected from the west-central region, as its mandate extended to one of the largest research areas, thereby making a total of nine *dzongkhag* samples. As the total number of *dzongkhags* in Bhutan is 20, the nine sample *dzongkhags* were equivalent to 45% of the total size.

There are three extension agents representing AG, AH, and FO in each extension centre in every *geog*. As indicated in the introduction, there are a total of 205 *geogs* in the various *dzongkhags*. Since there are three EAs in each extension centre in every geog, a blanket count of a total of 615 EAs was taken. From this total number of EAs, 29.27% of the EAs totalling to 180 EAs was taken as samples for the study. These many EAs covered 60 *geogs* in the sample *dzongkhags*. These 60 *geogs* were apportioned to the nine sample *dzongkhags* based on the sizes of the samples (29.27% EAs) and size of the *dzongkhags* in terms of the number of *geogs*.

A structured questionnaire was designed and mostly self-administered questionnaire survey was executed. The survey was preceded by the pretesting of questionnaires with 45 respondents in two *dzongkhags*. Prior to distributing the questionnaires, a training-workshop was conducted with all the respondents in respective *dzongkhag* headquarters. Data format from EAs were collected through postal and personal hand delivery from October - November 2009.

Out of the nine sampled *dzongkhags* with 180 EAs, 153 EAs responded out of which three data formats were screened and a sample size of 150 retained. The data analysis was carried out using Statistical Package for the Social Sciences (SPSS).

To obtain a quantitative measure of respondents' perceptions on motivation and job satisfaction levels, the Likert-type rating scales used in the questionnaire included: very low = 1; low = 2; average = 3; high = 4 and; very high = 5 (for satisfaction level only). These rating scales were used as the basis for deriving the percentages and calculating the mean scores (M) and standard deviation (SD) of the level of motivation for job performance of the EAs. The overall motivational levels were derived by calculating the interval mean mid-scores based on the total number of interval levels of the Likert-type scales.

RESULTS AND DISCUSSIONS

Personal characteristics

The personal characteristics of the EAs showed that there were 127 male and 23 female respondents with ages ranging from 21 to 53 years. The average age was 32.9 years out of which 138 of them were married with some of the spouses who also worked as EAs. The EAs have joined services from 1971 to 2009 with the range of 38 years. There were 53 respondents from AG, 56 from AH and 41 from FO sub-sectors. About 92% of the EAs have diploma-level education and training skills with the rest possessing post-graduate diploma or mere certificates. As many as 24 EAs reported having to stay overnight to reach their extension centres in the respective *Geogs* while 126 of them said they could reach their centres within a day or less.

Level of motivation

Table 2 shows the scores of motivating factors identified with respect to order of importance and status of motivation. The descending order was derived based on the mean score with the highest mean score considered to be highly motivating and vice versa. The overall motivating level is also indicated.

The order of importance and status of motivation based on the mean scores indicated that the four most important motivating factors that encouraged EAs for high performance were: in finding the improved quality of life of farmers (M=3.17); work challenges (M=3.13); increased income of farmers (M=3.06); and boss-subordinate interactions (M=3.06). The least motivating factors which can be assumed to discourage EAs' performance are: mobility / transport of staff (M=2.42); in-service training (M=2.50); reward for performance (M=2.51); and communication system / facilities available at the block extension centres (M=2.58).

With standard deviations of both the levels in almost all categories ≤ 1, there is less variations in the perceptions of the respondents.

The overall motivational level derived by calculating the interval mean mid-scores, however, indicated that by and large all the motivating factors measured were rated as motivating by the EAs except the motivating factor on mobility of staff (transport) which was rated as only slightly motivating. The overall rating did not indicate highly motivating and not motivating ratings.

Table 2. Scores of motivating factors of EAs in order of importance (n=150)

R	Motivating factors in order of importance by mean score	HM (%)	MT (%)	Sl.M (%)	NM (%)	Mean	SD	OM-level
1	Improved quality of life of farmers	30.7	58.7	7.3	3.3	3.17	0.699	MT
2	Work challenges	25.3	62.7	11.3	0.7	3.13	0.616	MT
3	Increased income of farmers	23.3	60.7	14.7	1.3	3.06	0.658	MT
4	Boss-subordinate interaction	25.3	58.7	12.7	3.3	3.06	0.716	MT
5	Remuneration and salary	14.0	70.7	14.0	1.3	2.97	0.579	MT
6	Financial incentives (TA/DA)	19.3	56.7	21.3	2.7	2.93	0.715	MT
7	Opportunities for promotion and growth	20.7	54.7	18.0	6.7	2.89	0.804	MT
8	Job prestige (as EA)	17.3	56.0	18.0	8.7	2.82	0.820	MT
9	Clear job descriptions	17.3	51.3	24.7	6.7	2.79	0.805	MT
10	Adequate technical information	14.0	51.3	30.0	4.7	2.75	0.753	MT
11	Recognition of achievement	24.0	34.7	30.0	11.3	2.71	0.958	MT
12	Staff welfare	14.7	42.7	29.3	13.3	2.59	0.899	MT
13	Communication system facilities	18.7	39.3	23.3	18.7	2.58	0.998	MT
14	Reward for performance	20.7	30.0	29.3	20.0	2.51	1.035	MT
15	In-service training	20.0	28.0	34.0	18.0	2.50	1.008	MT
16	Mobility of staff (transport)	18.7	29.3	27.3	24.7	2.42	1.057	Sl.M

Note. R = rank; SD = standard deviation; OM-level = overall motivation Level;
Mean scores: 3.26 – 4.00 = highly motivating (HM); 2.51 – 3.25 = motivating (M); 1.76 – 2.50 = slightly motivating Sl.M); 1.00 – 1.75 = not motivating (NM)

Comparison on motivating factors

Table 3 shows the differences of groups on the motivating factors of EAs. The differences in the perceptions between those who have joined service from, 2001 and before, and 2002 and later, on the motivating factors are presented. Apparently, the comparisons made were between those senior groups of EAs with the junior EAs. The senior group have fairly longer experiences of having worked in the extension field, financially more secure, but technically assumed to be more traditional workers. The junior group have less field experiences but fairly more up-to-date with technical knowledge and skills. Therefore, comparison of opinions of these two groups of EAs, on the motivating factors, was considered important.

Results showed that there was only one significant difference (P.05) in the mean scores of the two categories of respondents for the statement, mobility / transport of staff (t=2.109). It also observed that the standard deviation from the mean for all the statements were ≤ 1 which indicated that both the groups' individual scores as regards to their perceptions on motivating factors did not differ much from the mean score. The mean score of the senior group of EAs (M=2.60) was slightly higher than the junior group (M=2.24) indicating that the senior group was better motivated than the junior group in terms of the mobility. This may be possible because the senior group of EAs, because of their position, are by that time able to enjoy higher mileage claims for organising alternative transport system.

There were no significant differences between the perceptions of the two groups in the remaining 15 statements as presented in Table 3.

Table 3. Comparison of motivating factors of EAs by period of joining service (n=150)

Sl. No.	Items	Periods of joining service				t-value
		2001 and Before (n=75)		2002 and Later (n=75)		
		Mean	S.D	Mean	SD	
1.	Improved quality of life of farmers	3.17	0.685	3.16	0.717	0.116
2.	Work challenges	3.15	0.562	3.11	0.669	0.396
3.	Increased income of farmers	3.05	0.676	3.07	0.644	0.124
4.	Boss-subordinate interaction	3.08	0.749	3.04	0.687	0.341
5.	Remuneration and salary	3.05	0.567	2.89	0.583	1.704

Sl. No.	Items	Periods of joining service				t-value
		2001 and Before (n=75)		2002 and Later (n=75)		
		Mean	S.D	Mean	SD	
6.	Financial incentives (TA/DA)	2.95	0.695	2.95	0.738	0.342
7.	Opportunities for promotion and growth	2.87	0.811	2.92	0.801	0.405
8.	Job prestige (as EA)	2.85	0.833	2.79	0.810	0.497
9.	Clear job descriptions	2.88	0.788	2.71	0.818	1.322
10.	Adequate technical information	2.75	0.737	2.75	0.773	0.000
11.	Recognition of achievement	2.77	0.938	2.65	0.979	0.766
12.	Staff welfare	2.63	0.897	2.55	0.905	0.511
13.	Communication system (phone/fax/media/ internet)	2.68	0.975	2.48	1.018	1.229
14.	Reward for performance	2.51	1.083	2.52	0.991	0.079
15.	In-service training	2.57	1.055	2.43	0.961	0.890
16.	Mobility of staff (transport)	2.60	1.000	2.24	1.089	2.109*

Note: *Significant at 0.05 level

It is also interesting to note that, the motivating factor, mobility of staff (transport), found the least motivating in the order of importance and status of motivation, also indicated significant difference in the comparison between the two groups of senior and junior EAs. Along with mobility of staff, the mean scores for reward for performance and in-service training were found the lowest indicating these two items are also the least motivating factors perceived by EAs. Overall, however, the above findings on the motivating factors of EAs indicated that the EAs are motivated to deliver their extension services.

Job satisfaction level

Table 4 shows the score of the job satisfaction variables and levels. Based on the mean scores of the motivation variables on the job satisfaction of EAs, it was found that, statements like, I love my job, found the highest mean score (M=4.38), followed by, I am highly motivated as an extension agent (M=4.24), and the hours I spend

on the job are the ones I enjoy most (M=4.13). The least satisfaction they derived from their jobs according to the mean score were on the statement, in the extension service I have many opportunities for personal growth (M=3.52) followed by, while on vacation, I often wish I were back to work, and if I were to choose a career once more, I would again choose to be an extension agent, with mean scores of 3.82 each.

Table 4. EAs' job satisfaction variables and levels (n=150)

Sl. No.	Variable level	SA (%)	A (%)	Sl.A (%)	D (%)	S.D (%)	Mean	SD	OA-level
1	I am highly motivated as an extension agent	32.7	58.7	8.7	0.0	0.0	4.24	0.598	SA
2	I love my job	46.7	46.0	6.0	1.3	0.0	4.38	0.662	SA
3	Working as an extension agent is in itself rewarding	23.3	50.0	21.3	2.7	2.7	3.89	0.886	A
4	The hours I spend on the job are the ones I enjoy most	30.0	54.0	14.7	1.3	0.0	4.13	0.698	A
5	If I were to choose a career once more, I would again choose to be an extension agent	22.0	46.0	24.0	8.0	0.0	3.82	0.868	A
6	While on vacation, I often wish I were back to work	18.7	51.3	24.0	5.3	0.7	3.82	0.820	A
7	In the extension service, I have many opportunities for personal growth	18.0	42.0	20.0	14.0	6.0	3.52	1.122	A

Note: SD = standard deviation; OA-level – overall agreement level;
Mean scores: 4.21 – 5.00 = strongly agree (SA); 3.41 – 4.20 = agree (A); 2.61 – 3.40 = slightly agree (Sl.A); 1.81 – 2.60 = disagree (D); 1.00 – 1.80 = strongly disagree (S.D)

The overall job-satisfaction level derived by calculating the interval mean mid-scores, however, indicated variable levels, I am highly motivated as an extension agent (M=4.24), and I love my job (M=4.38), scored "strongly agree" overall agreement levels. The rest of the five variables scored "agree" levels.

Comparison on job satisfaction level

Table 5 shows the group comparison on job satisfaction in seven items made between the senior and junior EAs to find out how satisfied the senior group who have served longer and have greater experiences in extension service were as compared to junior group who have less experiences and shorter period of service. The group comparison of perceptions showed statistically significant differences in three items: the hours I spend on the job are the ones I enjoy most (t=2.253); if I were to choose a career once more, I would again choose to be an extension agent (t=1.996); and while on vacation, I often wish I were back to work (t=2.535). The means of these three items for the senior group were all higher than the means of the junior group showing that the senior groups are more satisfied with their job on these items as compared with the junior group. It may be assumed that as they get used to working as EAs, they derive more satisfaction when they discover they are able to deliver useful outputs for the benefit of the farmers.

Table 5. Comparison on job satisfaction of EAs by year of joining service (n=150)

	Items	Period of service				t-value
		2001 and Before (n=75)		2002 and Later (n=75)		
		Mean	S.D	Mean	S.D	
1.	I am highly motivated as an extension agent	4.27	0.622	4.21	0.576	0.544
2.	I love my job	4.39	0.655	4.37	0.673	0.123
3.	Working as an extension agent is in itself rewarding	3.99	0.951	3.79	0.810	1.386
4.	The hours I spend on the job are the ones I enjoy most	4.25	0.617	4.00	0.753	2.253*
5.	If I were to choose a career once more, I would again choose to be an extension agent	3.96	0.796	3.68	0.918	1.996*
6.	While on vacation, I often wish I were back to work	3.99	0.762	3.65	0.846	2.535*
7.	In the extension service, I have many opportunities for personal growth	3.59	1.164	3.45	1.082	0.727

Note: *Significant at 0.05 level

Apantaku and Apantaku (2008 cited in Fabsoro, Awotunde, Sodiya & Alarima, 2008) were quoted as saying that motivating factors accounted for 56% of the variance in job satisfaction of agricultural extension workers. The factors that contributed to this variance are money (wages), job status, job security, working conditions, and interpersonal relationships. The results of the study on motivating factors (Table 2) also showed that motivating factors such as work challenges, boss-subordinate interactions, salary and financial incentives were listed in the top five motivating levels indicating there is high level of satisfaction in the jobs.

CONCLUSIONS

To enable EAs to provide prompt services, it is vital for them to remain freely mobile. The mobility of extension staff is one of the key determining factors for motivation but found to be the least motivating while measuring the various motivating factors of EAs. Therefore, the transport facilities should be made more accessible and attractive incentives like mileage system improved to facilitate alternative means of transport.

The test on motivating factors also showed statistically significant differences of perceptions between the senior and junior groups of EAs on this same item. The higher mean differences indicated that the senior EAs remained better motivated than the junior EAs on mobility facility. Therefore, it can be recommended that more attention may be paid, to arrange this facility, particularly to those EAs who were newly recruited.

The communication system / facilities available at the block extension centres were the fourth least motivating factors for EAs from a total of 16 items measured. An enabling working environment should be created for EAs by properly equipping all the block level extension centres with basic minimum facilities and extension toolkits for effective implementation of programmes.

In terms of the mean score rating on motivating factors, the reward for performance and recognition of achievement, were rated the last third and last sixth rankings respectively from a total of 16 items. A study also showed that only 24.7% of the EAs felt they are rewarded for their good performance (Rigyal 2011). Therefore, incentives and rewards for outstanding performances and merit-based opportunities should be encouraged at all levels to enhance motivation of field staff. According to the EAs, the most desirable reward for good performance, in order of importance are, opportunities for further study, short-term training, promotions and good posting (Rigyal 2011).

The in-service training opportunity was also rated as one of the least motivating factors. In-service training is vital for up-gradation of extension knowledge and skills

particularly for senior EAs who have been in the field for a long time. Therefore, the MoAF should pay attention in increasing the frequency of providing in-service training to EAs in future.

The test on job-satisfaction of EAs showed statistically significant differences of perceptions between the senior and junior EAs on the items, repeatedly choosing the career of an extension worker and on missing the extension work while on vacation. The mean differences on the items measured showed that senior EAs were more satisfied than their junior colleagues. Therefore, it would be important, that at the time of appointing the EAs in their jobs, proper orientation of the working environment are provided and awareness created on the many possibilities of deriving job-satisfactions while in service. One of the possibilities could be the fact that they would be serving the farmers where seeing farmers benefit from their service itself could provide some form of job-satisfaction.

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Factors affecting sustainability of dairy farmers' group and co-operative in western Bhutan

Deki Choden[1]

ABSTRACT

Since the establishment of first dairy farmers' group in 1993 there has been rapid expansion of such groups throughout the country. However, many groups have failed once the government support was phased out. This study was conducted to identify factors affecting the sustainability of Dairy Farmers' Group & Co-operative (DFG&C) in Western region of Bhutan. Primary data was obtained through a questionnaire survey and secondary data obtained from official documents. Set of indicators were used to determine the factors. There was significant difference in meeting attendance by the members amongst DFG&C, $F_{(2,108)} = 14.11$, $p = <.001$. *Decision is made jointly by the members and office bearers. There was difference in continuity of membership in the past. However existing ones wanted to continue membership (96.49%). Among the groups under study, Shari Lothun Omgi Tshogpa was leading in milk supply. Instances of conflict were reported in all DFG&C arising from lapses in management of the DFG&C in terms of record keeping, transparency and monitoring. The study recommended for a need to enhance competency of the office bearers and monitoring of group performance.*

Keywords: Sustainability, Government support, Social, Indicators, Office bearers, Commitment,

INTRODUCTION

Considering the benefits associated with group formation, Department of Livestock (DoL) under Ministry of Agriculture and Forests (MoAF) initiated Dairy Farmers' Group (DFG &C). DFG&Cs received joint financial assistance from MoAF and different donor agencies based in different regions. Recently some promising dairy groups were upgraded to cooperative. Currently there are 4 dairy cooperatives and 112 DFGs (NLBP, 2011) in Bhutan. DFG&C differ in their functions, while some only collect and do the marketing of fresh milk, while others collect, process and market butter, white cheese (locally known as *Datshi*) and *Gouda* cheese. Norbu (2008) reported Government support has been instrumental in the formation and functioning of these groups as there was a general lack of capacity among the communities to initiate and organize the groups. Many groups have failed once

1 National Livestock Breeding Programme, Yusipang, Thimphu, Bhutan cdeki11@yahoo.com

the government support is withdrawn and sustainability of DFG&C becomes questionable if continued support by the Government is not provided to them (Subedi, 2009).

Most of the sustainability assessment encompasses on three components environment, economics, and social responsibility called Three P's (people, planet, and profit). However like Bellows (1994) said due to variation in biophysical and socio-economic conditions, indicators used in one country are not necessarily applicable to other countries and is of great subjectivity. Like other farmers' group, DFG&C are enterprises owned, operated and managed by the group members' themselves (Sonam, 1998). Subedi (2009) reported that lack of necessary dynamism and capacity within the members lead to failure of DFG&C. Similarly (Norbu, 2008) enumerated many factors contributing to failure of farmers' groups. Therefore study was conducted to determine the managerial factors affecting the sustainability of DFGs and cooperative in Western region of the country.

MATERIALS AND METHODS

Dairy Farmers' Group & Co-operative (DFG&C) chosen for this study were: 1) Yangthang Om Gongphel Tshogpa (YOGT) in Haa, Shari Lothuen Omgi Tshogpa (SLOT) in Paro and Thimphu Om Thuenken Namley Tshogdey (TOTNT) in Thimphu Dzongkhag (Figure.1).

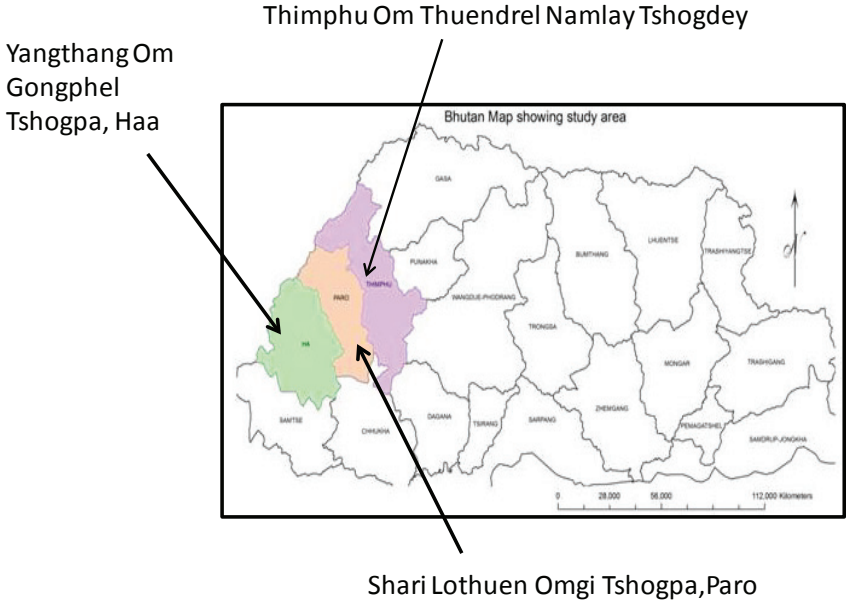

Fig. 1: study area

Some studies on farmers' groups were conducted in other parts of the country but not a single one in Western region. A purposive sampling was used to get DFG&C which are at least three years old from each of the western Dzongkhags.

Sample size (n=114) was calculated by Taro Yamane formula. Prior to sample size calculation, list of the members were collected from the concerned Dzongkhag Livestock Officers (DLO) of the study area.

Primary data were obtained through a questionnaire survey using a structured questionnaire containing close ended questions. Same set of questionnaires were applied to all the target groups in the study area.

Focused group and key informants discussions were conducted using checklists with the DFG&C office bearers, extension officials, and local Government members and selected group members.
Data collected was analyzed using Microsoft Excel and Statistical Package for Social Science software version 16.0 (SPSS 16.0). Opinion on different variables were gathered using five point Likert's scale (1=strongly disagree to 5 = strongly agree).

RESULTS AND DISCUSSIONS

General information of DFG&C of study area

YOGT was established in Bji Geog during September 2009 with 34 members. SLOT was established in Dopshari Geog in 2004 with 43 members. TOTNT was earlier known as Peri Urban Development Project, established in 2004 with 77 members composed of four subgroups such as Bjemina, Khasadrapchu, Namseling and Rama covering Chang and Maedwang Geogs. In 2009 four more groups joined namely Tshaluna from Maedwang Geog and Begana, Hangkawog and Dazhi from Kawang Geog. It was upgraded to co-operative in 2009 and then named as Thimphu Om Thuendrel NamleyTshogdey.

Gender of respondents

Respondents consist of 41.2% male and 58.8% female indicating both sex participate actively in the dairy farming and DFG&C activities (Figure 2).

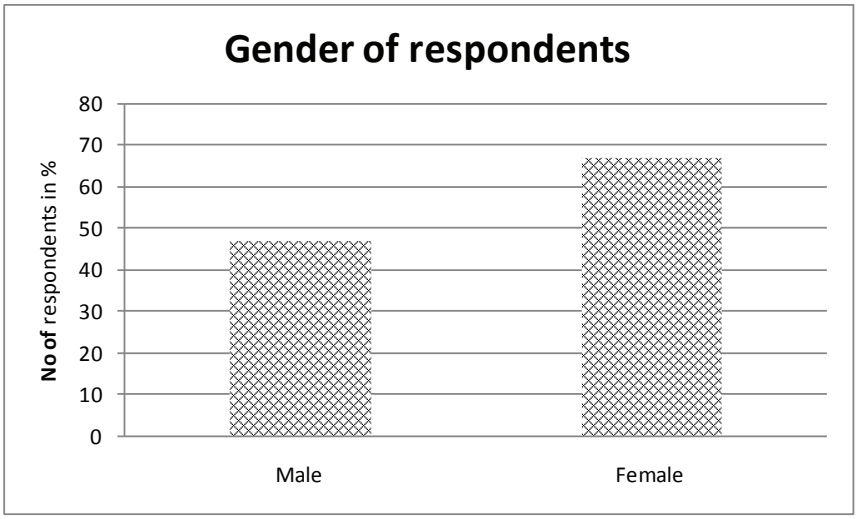

Fig. 2: Gender of respondents

Occupation of the respondents

Majority of respondents were farmers followed by skilled labour and off farm activities (Table 1). Occupation of members plays a significant role towards sustainability of the DFG&C.

Table 1. Respondent's occupation in (%)

	YOGT, Haa	SLOT, Paro	TOTNT, Thimphu	Total
Farmer	20.18	21.93	55.26	97.37
Skilled labour	0.88	0.88	0	1.75
Off farm	0	0	0.88	0.88
Total	21.05	22.81	56.14	100

Indicators of sustainability of the DFG&C

Sustainability of DFG&C is depended on participation and commitment from members and management efficiency of office bearers. To determine participation and commitment from members, indicators such as commitment in attending meeting of DFG&C, support in supply of milk, number of milking cow holding and volume of milk production and continuation of membership were discussed. To determine commitment and effectiveness of office bearers, indicators such as financial management, transparency and monitoring, conflict resolution ability and literacy of office bearers were discussed.

Commitment in attending meeting

All the DFG&C conducted meeting regularly and were aware of the importance of maintaining minutes of meeting (Table 2). However there was significant difference in meeting attendance by members ($F_{(2,108)} = 14.11$, p=.000). Tukey *Post hoc* comparison indicated significant difference in meeting attendance between YOGT and SLOT, p=.000 and also between TOTNT p=.000. However, no significant difference was observed between YOGT and TOTNT , p=.060.

Generally the groups meet regularly to discuss and take consensus based decisions for proper functioning of DFG&C (Voluntary Action Lewisham, 2011). In line with the guidelines, decisions in the meeting were taken jointly by members and office bearers in all DFG&C. However, some influential members of the SLOT made decisions (Table 3) which may incline away from the general interest of the group.

Table 2 Mean of meeting attendance by members of various DFG&C

Variables	YOGT	SLOT	TOTNT	*P*
Meeting attendance	1.39 ± 0.499	2.16 ± 0.624	1.65 ± 0.481	0.000

Table 3. Regularity of meeting conduction, importance of maintaining minutes of meeting and major role in decision making (%)

Variables		YOGT	SLOT	TOTNT	Total
Regularity of meeting conduction	Yes	20.4	22.1	54.9	97.3
	No	0.9	0.9	0.9	2.7
	Total	21.2	23	55.8	100
Importance of maintaining minutes of meeting	Yes	8.8	8	31	47.8
	No	0	0.9	8	8.8
	Don't know	12.4	14.2	16.8	43.4
	Total	21.2	23	55.8	100
Management committee		3.6	2.7	25.9	32.1
Members		0.9	4.5	-	5.4

Variables	YOGT	SLOT	TOTNT	Total
Both members and management committee	16.1	8	30.4	54.5
Influential members	-	8	-	8
Total	20.5	23.2	56.2	100

Number of milking cow holding

Most predominant breed of milking cow was Jersey cross followed by local and Mithun cross. There was no significant difference in breed number of milking cow holding, local $F_{(2, 19)} = 0.178$, $p = 0.838$; Jersey cross $F_{(2, 92)} = 1.69$, $p = 0.19$ and Mithun cross $F_{(2, 2)} = 1.4$, $p = .417$ (Table 4) which means members in the study area owned similar number of milking cows (1-2 heads).

The dominance of Jersey crossbred was attributed to the breed improvement policy of DoL. Owing to characteristics of Bhutanese farming system, indequacy of land, labour and fodder farmers cannot hold more milking cows. Similar findings have been observed by Devendra (nd).

Table 4. Mean breed wise number of milking cows (n=114)

Breed wise number of cows	YOGT	SLOT	TOTNT	*P*
Local	1.75±1.5	1.75±0.96	1.5±0.76	0.838
Jersey cross	1.79±0.71	2.48±1.26	2.11±1.33	0.19
Mithun cross	2±0	1±0	1.5±0.71	0.417

Volume of daily milk production

Daily milk production differed significantly among DFG&C $F_{(2, 111)} = 12.576$, p=0.000 (Table 5). Tukey *post hoc* comparisons indicated difference was between YOGT (M= 4.58, SD= 3.04) and SLOT (M=10.08, SD=4.01) p=0.000 and also between TOTNT (M= 6.55, SD= 4.26) p=0.001. YOGT (M= 4.58, SD= 3.04) and TOTNT (M= 6.55, SD= 4.26) comparisons were not significant, p= 0.117.

Results indicated SLOT (M=10.08, SD=4.01) was leading followed by TOTNT (M= 6.55, SD=4.26) and YOGT (M=4.58, SD=3.04) was lowest in daily milk production. Volume of daily milk production of study area was found slightly higher than Doban Geog which is 5.35 litres (RNRDC Bjakar, 2004).

Although there was no significant difference in milking cow holding but there was significant variation in the milk production indicating strong correlation to management practices. Observations from the field visit and results of focused group discussion found that most of SLOT members practiced better management practices. Harsh environmental condition and shortage of green fodder during the winter months lead too low milk production in YOGT.

Table 5. Daily milk yield (in litres) of various dairy breeds among DFG&C (n=114)

Breeds	YOGT	SLOT	TOTNT	Total	*P*
Local	2±0.71	5±3.45	2.67±1.23	2.89±1.815	0.065
Jersey cross	5.21±2.64	10.82±3.61	7.12±3.74	7.6±3.98	0.000
Mithun cross	3±0	4.5±0.71	5±4.24	4.4±2.302	0.873
Total daily milk yield	4.58±3.04	10.08±4.01	6.55±4.26	6.94±4.37	0.000

Daily milk supplied to DFG&C in summer (May-July) differed significantly among DFG&C, $F_{(2, 102)} = 7.876$, $p = .001$(Table 7). Tukey *post hoc* comparisons indicated that daily milk supplied in summer differed significantly between YOGT (M=6.95, SD=5.09) and SLOT (M=14.92, SD=7.17) $p= .001$; and also between TOTNT (M=9.32, SD=7.75) $p= .004$. YOGT and TOTNT comparison was not significant, $p = .410$.

Daily milk supply in winter (November - December) also differed significantly across the DFG&C, $F_{(2, 100)} = 4.921$, $p = .009$(Table 9). Tukey *post hoc* comparisons indicated daily milk supplied in winter was significantly different between YOGT (M=4.42, SD=3.01) and SLOT (M=8.84, SD=5.96), $p= .011$; and also between TOTNT (M=5.78, SD= 5.11), $p= .033$. YOGT, Haa and TOTNT, Thimphu comparison was not significant, $p = .550$.

Daily supply of milk in summer and winter were analyzed and found that in both seasons SLOT is leading the amount of milk supplied followed by TOTNT and YOGT was lowest.

It can be deduced that milk supply to DFG&C is directly proportional to volume of milk produced which is indicting members were adhering to the Bylaw which is a good indication towards sustainability of DFG&C.

Table 6. Mean of daily milk supply in summer and winter (in litres) by members

Variables	YOGT	SLOT	TOTNT	Total	*P*
Milk supply in summer	6.95±5.09	14.92±7.17	9.32±7.75	10.2±7.65	0.001
Milk supply in winter	4.42±3.07	8.84±5.96	5.78±5.11	6.26±5.21	0.009

Continuity of membership

The members were defined as 1) Members during establishment (Numbers of members during DFG&C establishment); 2) Members now (number of members existing during study period) and 3) Active members (only those members supplying milk to DFG&C during study period) YOGT had maintained consistent number of members since establishment. There was negligible percentage decline in SLOT whereas TOTNT membership declined by 26.03% (Table 8). However this study revealed existing members wanted to continue membership.

This finding is in contrast in view of fact that members are main patrons of DFG&C, their continuity and ability to patronize were deemed important for its effective operation and profitability or else DFG&C will cease to exist (Sonam, 1998).

It was learned from focused group discussion that YOGT wanted to stick to this member size as it was agreed upon from the beginning of group formation in contrary to their By-law which states membership is open and any one at any time can join the group. The main reason behind maintaining the same number of members was to avoid confusion in group dividend sharing which otherwise could be done by adopting some simple strategies. Restricting growth of its membership can significantly impact its profitability and thus sustainability. Urbanization effect was main reason for withdrawal of membership in TOTNT since many members reside in periphery of the capital city, Thimphu.

Table 7. Continuation of membership in (%)

	YOGT	SLOT	TOTNT	Total
Yes	21.05	20.18	55.26	96.49
No	0	2.63	0.88	3.51
Total	21.05	22.81	56.14	100

Table 8. Membership status

DFG&C	Members during establishment	Members now	Active members	Percentage decline in membership
SLOT	43	40	36	1.29
YOGT	34	34	34	-
TOTNT	169	152	90	26.03

Management and coordination ability

There was significant difference in opinion on good management and coordination by the office bearers $F_{(2,111)} = 43.728$, p=.000 (Table 10). Tukey *post hoc* comparisons indicated opinion was significantly different between YOGT and SLOT, p=.000; and also between TOTNT, p= .000. YOGT and TOTNT comparison was not significant, p = .999. The result indicated that there was proper management and coordination in YOGT and TOTNT but SLOT group is suffering from lack of management and coordination within the group.

Similar findings by Subedi (2009) and Norbu (2008) reported that management and coordination within the group were the main factors that affected success or failure of some farmers' groups in Eastern Bhutan.

Degree of management level regulates the performance of DFG&C towards achievement of its goals and objectives. Managers are organization builders and more so when it belongs to small and marginal farmers (Benson, 2000). Therefore good management and coordination by management committee is required for development and sustenance of DFG&C.

Table 9. Mean of opinion on good management and coordination in group/co-operative

Variable	YOGT		SLOT		TOTNT		
Good management and coordination	M	SD	M	SD	M	SD	*P*
	4.33	0.917	2.31	1.32	4.34	0.821	0.001

Financial management by office bearers

The significant difference was observed on the opinion of maintaining financial record $F_{(2, 63)} = 73.388$, p=.001; Transparency ($F_{(2, 65)} = 65.652$, p=.000) and monitoring system ($F_{(2, 64)} = 56.66$, p=.003) respectively (Table 10). The result indicated financial record maintenance, transparency and monitoring were good in TOTNT and YOGT but weak in SLOT. According to Sonam (1998) the performance

of cooperative is commonly evaluated by examining its financial status. In order to examine its financial status, a good record of financial transactions is necessary. Maintaining careful financial records and controls gives a clear picture of income and expenses. Similarly a report by Voluntary Action Lewisham (2011) stated where there is good financial management; organizations are likely to show good levels of trust and communication among trustees and between staff and management. Therefore good as well as transparent financial management is crucial for the long term sustainability of DFG&C but SLOT group was lacking transparency which can pose threat to its long term viability if not remedied.

Monitoring system was very weak in all the DFG&C although some form of monitoring was initiated in TOTNT co-operative. Whether system of auditing DFG&C by Royal Audit Authority existed or not was not clear to all the D FG&C management body as well as members since they have not experienced so far. Now with Co-operative Regulation 2010 in place and actors responsible for monitoring of the DFG&C well defined, henceforth monitoring will be convenient and hopefully implemented.

Table 10. Mean of members' opinion on financial management in DFG&C

Variables	YOGT		SLOT		TOTNT		
	M	SD	M	SD	M	SD	*P*
Maintenance of financial record	4.29	0.61	1.93	1.03	4.57	0.60	0.001
Transparency	4.50	0.52	2.13	1.02	4.53	0.65	0.000
Monitoring and Auditing in group/ co-operative	4.07	0.83	1.40	1.06	4.37	0.91	0.030

Conflict resolution ability of the office bearers

There had been conflict in all DFG&C with varying degree. SLOT had highest followed by TOTNT while YOGT had lowest conflict as reflected in Table 11.
In conflict resolution, intervention of Dzongkhag and Geog livestock sector staff was high followed by local Government intervention.

In terms of conflict resolution, the result is indicative of office bearers of SLOT not strong enough to handle their problem and relying more on external actors, Dzongkhag and Gewog Livestock sector staff and Local Government personals. This shows there is weakness in management of the DFG&C by the office bearers especially in SLOT group.

Table 11 Presence of conflict in DFG&C in percentage

	YOGT, Haa	SLOT, Paro	TOTNT, Thimphu
Yes	3	25	9
No	21	1	55
Total	24	26	64

Table 12. Conflict resolution method in percentage

	YOGT, Haa	SLOT, Paro	TOTNT, Thimphu	Total
Office bearers not able to resolve the conflict	-	2.78	13.89	16.67
By Intervention of Dzongkhag and Geog livestock sector staff	8.33	30.56	5.56	44.44
By Intervention of Local Govt.	-	16.67	2.78	19.44
Conflict not resolved	-	19.44	-	19.44
Total	8.33	69.44	22.22	100

Literacy level of the office bearers

In this study all office bearers/management committee of the DFG&C were found educated in varying level. Majority (50%) of office bearers have studied minimum of class ten (Table 11).

According to Sinha *et al*., (2006) more literate ones are more likely to keep good financial record and accountable than less literate or illiterate ones. Though majority of office bearers in all DFG&C have attended high school yet their record keeping in all DFG&C were found weak indicating need for basic book keeping training.

Table 13. Literacy level of the office bearers of various DFG&C in (%)

Literacy level	YOGT	SLOT	TOTNT	Total
Primary	6.25	-	6.25	12.5
Junior	-	-	18.75	18.75
High	12.5	6.25	31.25	50
Secondary	-	-	12.5	12.5
Monastic education	-	6.25	-	6.25
Total	18.75	12.5	68.75	100

CONCLUSIONS

Assessment of indicators indicated varying situation within groups and between groups and co-operative. Variations were found in terms of management efficiency of office bearers and level of commitment from members and office bearers. The number of milking cow holding has no significant effect on the amount of milk supply to DFG&C. Where there was weakness in management efficiency but in contrary to that, commitment from members in terms of meeting attendance, continuity of membership and milk supply were high. This is directly attributed to income the members generate from DFG&C. If managerial competency of the office bearers is strengthened and the performance of the DFG&C is monitored, degree of participation and commitment from members will be increased thereby by enhancing the sustainability of the DFG&C.

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