

Dedicated

to

The Coronation of the Fifth King of Bhutan, His Majesty  
Druk Gyalpo Jigme Khesar Namgyel Wangchuck and 100  
years of the Wangchuck Dynasty

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ROYAL GOVERNMENT OF BHUTAN  
Ministry of Agriculture  
Thimphu : Bhutan



FOREWORD

From the Minister

I am pleased that the Ministry of Agriculture is able to bring out this issue of the Journal of Renewable Natural Resources of Bhutan at a time when we are celebrating the achievements of several milestones in our country's history. This year, 2008 will be remembered as the year in which we marked 100 years of glorious reign by the Wangchuk dynasty, during which our country enjoyed unprecedented socio-economic development, peace and happiness; the Coronation of our Fifth King, His Majesty Jigme Khesar Namgyel Wangchuk; and the introduction of parliamentary democracy under a new Constitution. It is a year for us to reflect on our past achievements and to look ahead with renewed enthusiasm and faith towards an even brighter future under the leadership of our young and dynamic Monarch.

The Renewable Natural Resources (RNR) sector, being one that has always remained at the core of Bhutanese culture, economy and identity, has to be prepared to take on even greater responsibilities to contribute to the nation's pursuit and achievement of Gross National Happiness (GNH).

RNR research, I believe, would be the catalyst to stimulate agricultural production and productivity. It is imperative that the RNR research system continues to evolve to address these and other issues that would challenge our agricultural developmental goals. It is my belief, that a strong research system is fundamental to solving any developmental issues. Therefore, it is befitting to dedicate this journal to the three most important occasions in the recent history of our country as a testimony of our efforts to contribute to nation building and rededicate ourselves to the service of Tsa-Wa-Sum.

In my capacity as the Minister of this important sector, I would like to assure all my colleagues my full support and urge you to give your very best at all times even if you feel at times that we are not there to acknowledge your good work. I strongly believe that good work will never go unrewarded and will eventually get the deserved recognition. In our daily endeavour, we shall draw **inspiration** from our enlightened kings and the **motivation** from serving our people with the belief that everyone of us **can** and **will** make a difference.

I would also like to take this opportunity to express my gratitude to our development partners, NGOs, private sector, and concerned citizens, without whose support and cooperation, it would have been impossible to reach the milestones that we have reached thus far. We shall always look forward to working as equal partners with renewed vigour and vision.

Last but not the least, I would like to congratulate my colleagues in the RNR Research System and others involved in bringing out this Journal on this momentous occasion. I feel very proud to be part of this dedicated and professional team.

TASHI DELEK

Pema Gyamtsho  
Minister for Agriculture



# *Forestry*



## **Comparative study on conversion of chams (beams) through traditional hand chopping versus sawmilling**

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### **ABSTRACT**

*The comparative study of cham conversion in Blue pine (Pinus wallichiana) was conducted to compare the timber wastage with hand chopping and sawmilling in Bumthang. The sizes of trees used for the study were in DBH class of 30 to 40 cm. Chams were cut at 15 feet (4.57 m) and 9 feet (2.78 m) lengths. Three different sizes of chams (8"x8", 8"x7" and 7"x6") were made as per local people's information on their use.*

*No conclusions can be drawn from the recovery of logs from standing tree volume. We suggest based on results of the present study and another independent study that presently applied volume functions are inappropriate as they underestimate standing tree volume.*

*Mean sawn timber recovery from logs with traditional methods was 41% as opposed to 59% in the sawmill. Wastage increased with log diameter and this increase was stronger with hand chopping. Cham output did not differ between hand chopping and sawmilling. The increased output with sawmilling was a result of utilizing timber wasted with hand chopping into smaller assortments such as buttons and bits.*

*Unit costs for sawn wood were lower with sawmilling due to higher timber recovery in spite of much higher total costs.*

*It is recommended that sawmilling of chams should be considered for rural use in order to reduce pressure on forest resources as a result of higher recovery.*

### **KEYWORDS**

*chams (beams), hand chopping, sawmilling, Blue pine (Pinus wallichiana), Felling, cross-cutting and transportation, Tree selection and measurements Volume calculations, Timber recovery.*

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## **INTRODUCTION**

Bhutanese people have traditionally used timber for house construction for centuries. The cutting of trees for chams (beams) goes on throughout the year, but preferably between the 1<sup>st</sup> and the 19<sup>th</sup> of every lunar month. If trees are cut within this period, it is believed that chams will last longer. Most trees are felled from February to April but cutting continues until November or December depending on weather conditions.

Villagers go long distances in order to find trees of optimal size with straight bole and weak taper and few branches suitable for chams (Giesch, 2000).

In Bumthang region chams are commonly made from Blue pine (*Pinus wallichiana*), because the wood is easy to work with and does not warp while drying. The cham is processed with axe and dawoe by removing excess wood from the round stem. Chams are processed immediately after the felling of trees, as fresh wood is easy to work with. Villagers make two types of beams locally known as chams and khows. Chams are beams of approximately between 6 to 7 meters in length and 20x20 cm in width. Khows are beams of smaller dimension approximately 10x10 cm to 15x15 cm (Giesch, 2000).

Ideal trees with straight boles, without branches and with low taper can yield two chams and one khow, but most trees can only yield one to two chams and one khow. The khows are the by-products of chams production; trees are never felled for khows.

After forming, the chams and khows are left in the forest to dry. After drying, for transportation, men carry it to the construction site or to the road point. Only chams and khows are extracted, while remaining logging residue is left in the forest.

The remaining logs and logging slash are conceived to be bad from the forest sanitation point, as they hamper natural regeneration and can also serve as breeding ground for bark beetles.

The present traditional practice of timber extraction for rural house construction has extremely high wastage of timber as compared to sawmilling. Even though obvious, there is no data available until now to quantify wastage of timber with traditional cham conversion versus sawmilling. Therefore, the present comparative study of construction timber recovery with manual processing of chams versus mechanized

sawing will provide data to the ongoing discussion on whether to allow sawmilling of subsidized rural construction timber.

The study has been endorsed during 7<sup>th</sup> National Research Co-ordination Workshop in Lobesa in 2004.

### **Objectives**

- ❖ To assess the wastage of timber while preparing beams through hand chopping with axe versus sawmilling
- ❖ To analyze economic implications of manual chopping and mechanized sawing

## **MATERIALS AND METHODS**

### **Tree selection and measurements**

The study was conducted in Karshong FMU, Chumey, Bumthang, above Hurchi village. The study location was in the vicinity of a logging road and terrain was only slightly inclined.

A total of 40 trees within the DBH range of 30-40 cm were selected for the study. Selected trees grew under mesic site conditions and were free of severe competition or damage. DBH measurements were taken at 1.30 m height with calipers and measurements were rounded to 1 cm accuracy. Subsequently 0.5 cm was added to the measurements as required with caliper measurements. No height measurements were taken within this study as we made use of the local volume tables for Bumthang based on DBH only (Bürgi, 1992).

Trees were felled after marking and cross cut into logs of 15 or 9 feet length. The measurement of logs was taken in feet at mid girth of the log using measuring tape and subsequently converted into metric units. The over bark girth measurement was converted to under bark girth measurement by deducting 1 inch per 1 foot.

20 trees were randomly assigned for manual conversion of chams using traditional methods with axe and dowe (arched axe used for preparation of chams) for shaping the size of chams. The remaining 20 trees were taken to sawmill and sawn into beams of desired cham size. The remaining timber was sawn into smaller beams, planks, buttons, buckles and bits. Transportation costs are based on transporting both logs for sawing and chams to the sawmill.

### **Felling, cross-cutting and transportation**

The transportation of logs from the forest in log form was done by hired tractor. No other mode of transport was possible due to bad condition of the forest road.

The hauling of logs to the forest road head was done manually by involvement of local people from Hurchi village. Chams were also transported to the road head through dragging and carrying by men. Loading and unloading of logs and chams was also done manually.

### **Volume calculations**

Two volume functions based on DBH only were used to calculate standing tree volume.

The PIS (Pre-Investment Survey, 1974-1981) local volume function for central-eastern Bhutan for Blue Pine under bark is:

$$V_{ub} [m^3] = 0.185555 - 3.040264 * DBH [m] + 16.183975 * (DBH [m])^2$$

The local volume function for Bumthang developed by IFDP Lame Gompa (Bürgi, 1991) for Blue Pine over bark is:

$$V_{ob} [m^3] = 0.0001521 * (DBH [cm])^{2.520318}$$

We calculated log volumes using Huber's log volume formula:

$$V_l [m^3] = (d_m [m])^2 * \pi / 4 * l [m]$$

With

$V_{ub}$ ....standing tree volume under bark

$V_{ob}$ ....standing tree volume over bark

$V_l$ .....log volume

$d_m$ .....log mid diameter

## **RESULTS**

### **Comparison of tree size parameters between treatments**

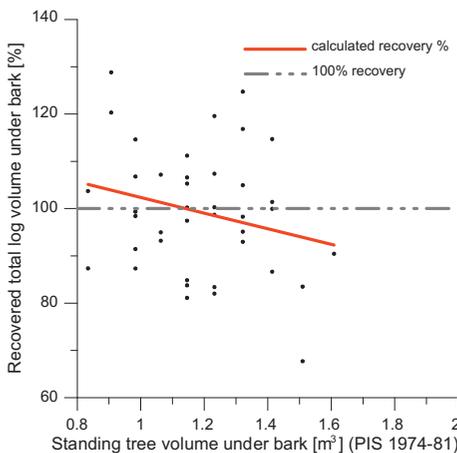
We compared DHB, standing tree volume calculated with two different volume functions, total log volume per tree, mean log volume and sawn timber output for randomly assigned trees for hand chopping and sawmilling. DBH, standing tree volume and mean log volumes did not differ (ANOVA,  $p > 0.05$ ), while tree-wise total log volumes were significantly higher in the sawmill group (ANOVA,  $p \leq 0.01$ ; Table 1).

**Table 1:** Mean and standard error of size and volume parameters for hand chopped and sawn trees and logs (letters indicate statistically significant differences)

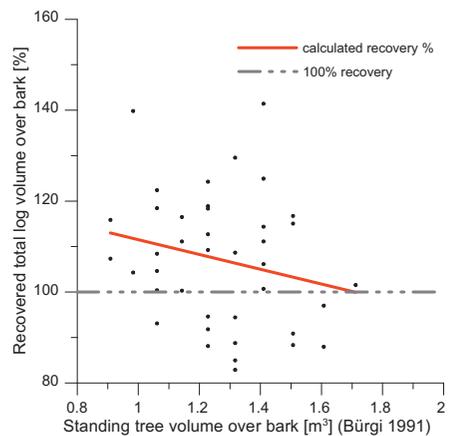
Measured parameter	Trees assigned for hand chopping	Trees assigned for sawmilling
Mean DBH ± SE [cm]	35.4 <sup>a</sup> ± 0.51	36.3 <sup>a</sup> ± 0.48
Mean tree volume over bark ± SE [m <sup>3</sup> ] (Bürgi 1991)	1.23 <sup>a</sup> ± 0.05	1.31 <sup>a</sup> ± 0.04
Mean tree volume under bark ± SE [m <sup>3</sup> ] (PIS 1974-81)	1.15 <sup>a</sup> ± 0.04	1.22 <sup>a</sup> ± 0.04
Mean log volume per tree over bark ± SE [m <sup>3</sup> ]	1.21 <sup>a</sup> ± 0.05	1.40 <sup>b</sup> ± 0.04*
Mean log volume per tree under bark ± SE [m <sup>3</sup> ]	1.06 <sup>a</sup> ± 0.04	1.20 <sup>b</sup> ± 0.05*
Mean total log volume over bark ± SE [m <sup>3</sup> ]	0.31 <sup>a</sup> ± 0.01	0.32 <sup>a</sup> ± 0.01
Mean total log volume under bark ± SE [m <sup>3</sup> ]	0.26 <sup>a</sup> ± 0.01	0.28 <sup>a</sup> ± 0.01
Mean sawn output per log ± SE [m <sup>3</sup> ]	0.13 <sup>a</sup> ± 0.00	0.19 <sup>b</sup> ± 0.01**
Mean beam output (any size under 2" excluded) ± SE [m <sup>3</sup> ]	0.13 <sup>a</sup> ± 0.00	0.12 <sup>a</sup> ± 0.01

### Timber recovery from standing tree volume to sawlogs

Stem-wise summed-up log volumes exceeded standing tree volumes calculated through local volume functions (PIS, 1974-1981; Bürgi, 1991) in several cases, especially with smaller trees. Even though the sum of log volumes was closely correlated with the stem volume, spread of individual trees was considerable (Figure 1, Figure 2). Recovery percentages utilizing the local volume functions for Bumthang (Bürgi, 1991), more strongly underestimated volume than did the PIS volume function (PIS, 1974-81).



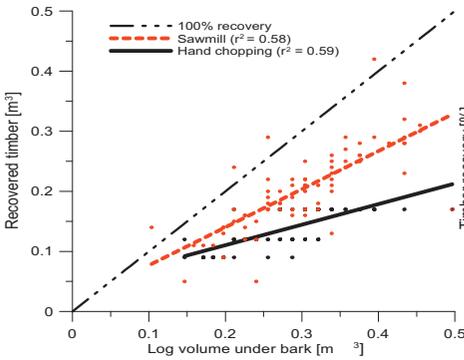
**Figure 1:** Recovery percentage from standing tree to logs under bark (PIS, 1974-81)



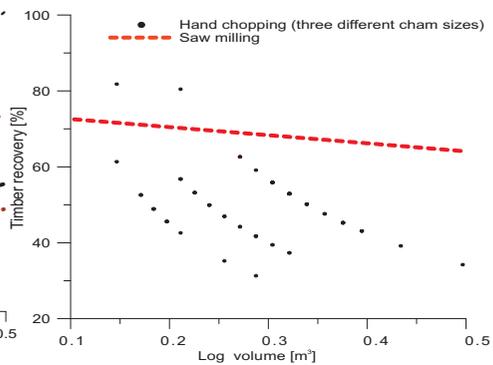
**Figure 2:** Recovery percentage from standing tree to logs over (Bürgi, 1991)

## Timber recovery from sawlogs to sawn assortments with hand chopping vs. sawmilling

As expected, timber recovery was much higher with sawn assortments as compared to hand-chopped ones (ANOVA  $p \leq 0.01$ ; Table 1). While differences were not very large with smaller logs, timber recovery with bigger logs was about 40% higher with sawmilling as compared to hand chopping (Figure 3).



**Figure 3:** Log volume versus recovered timber (beams, planks, etc.) with sawmilling and hand chopping of 15 feet long logs



**Figure 4:** Timber recovery three different cham sizes (8" x 7", 7" x 6", 6" x 5") and sawmilling

Recovery percentage slightly declined from above 70% with smaller logs to about 65% with larger logs, when sawn in the mill. In case of hand chopped beams, there was a pronounced decline of timber recovery to about 35% with larger logs, while recovery with smaller logs was in many cases comparable to the sawmill (Figure 4).

We did not detect any statistically significant differences between hand chopping and sawmilling considering larger assortments, such as beams and planks only and not considering output in terms of smaller assortments (any size smaller than 2") (; ANOVA,  $p > 0.05$ ).

## Timber wastage calculation

The wastage calculation is all based on mean recovered sawn/chopped timber volumes. Larger diameter logs have higher wastage than smaller logs (Figure 4).

**Table 1:** Recovery percentage and unit costs of recovered timber with hand chopping and sawmilling

	Log volume o.b. [cft]	Timber output [cft]	Loss [%]	Recovery [%]
Hand chopping	859.36	350.54	59.21	<b>40.79</b>
Sawmilling	985.87	586.51	40.51	<b>59.49</b>

Timber recovery with hand chopping was as low as 40.79%. With sawmilling 59.49% of the log volume could be converted into sawn timber (Table 1). Accordingly, recovery with sawmilling was 46% higher than with hand chopping.

### Cost analysis

**Table 2:** Detailed expenses for hand chopping of chams (20 trees)

Particulars	Unit of payment	Rate per unit [Nu]	Number of units	Total Cost[Nu]
Permit	number of trees	30	20	600
Felling and cross cutting	log volume o.b. [cft]	2	859.36	1,719
Siding	number of <i>chams</i>	40	78	3,120
Sizing of <i>chams</i>	number of <i>chams</i>	75	78	5,850
Transportation	<i>cham</i> volume [cft]	7	350.54	2,454
Loading and unloading	<i>cham</i> volume [cft]	3	350.54	1,052
<b>Total cost</b>				<b>14,795</b>
<b>Unit cost for <i>chams</i> [Nu/cft]</b>				<b>42.2</b>

**Table 3:** Detailed expenses for sawing of beams in the sawmill (20 trees)

Particulars	Unit of payment	Rate per unit [Nu]	Number of units	Total Cost[Nu]
Permit	number of trees	30	20	600
Felling and cross cutting	log volume o.b. [cft]	2	985.87	1,972
Siding	log volume o.b. [cft]	4	985.87	3,943
Transportation	log volume o.b. [cft]	7	985.87	6,901
Loading and unloading	log volume o.b. [cft]	3	985.87	2,958
Sawing charge	log volume u.b. [cft]	17	861.13	14,639
Debarking	log volume u.b. [cft]	1	861.13	861
<b>Total cost</b>				<b>31,874</b>
<b>Unit cost for sawn timber [Nu/cft]</b>				<b>37.0</b>

Costs of the felling permit and costs for felling and cross cutting of trees was the same for sawn and hand chopped trees. Siding costs were based on number of chams in case of hand chopping and on log volume in case of sawmilling. In spite of a different basis for calculation, the costs were comparable, with higher costs for sawmilling. With transportation, loading and unloading, cost in case of sawmilling were a multiple of the costs with hand chopping, since the calculation basis in case of sawmilling was log volume, whereas in case of chams only their own volume, as the remaining wood was left behind and residue in the forest. The cutting charge was more than double as high with sawmilling compared to hand chopping. The unit cost for hand-chopping of chams is 14% higher as compared to sawmilling (Table).

## **DISCUSSION**

### **Timber recovery from standing trees to logs**

Mean standing tree volumes did not differ for trees assigned for hand chopping from those assigned for sawmilling, indicating that the assignment of trees was random and thus statistically correct. However, comparing the summed up values resulting from section-wise measurement of logs revealed significantly higher volumes sent for sawmilling as compared to hand chopping (Table 1).

With smaller DBH-classes, the stem-wise total log volumes resulting from section-wise measurements tended to yield higher values than standing timber volumes calculated with functions by Bürgi (1991) and PIS (1974-81) (, ). As PIS and Bürgi volume functions showed a correlation of 1 with highest significance, the only difference being the difference in methods of measuring over or under bark, it is assumed that the slightly larger stem-wise log volumes are a result of the bad fit of the volume function in the DBH range between 30 and 40 cm.

One possible explanation would be that the cutoff diameter limit for the formation of logs was set at a higher diameter and therefore lower height on the tree with larger diameter classes as compared to smaller diameter classes. As a result, the summed-up volume of logs of larger diameter trees ended up having comparatively smaller volumes than for trees with smaller diameters.

In an unrelated study carried out Dhur, the same results have been obtained, where summed up log volumes were higher than standing tree volume calculated using existing volume functions (RNR-RC unpubl.). We suggest

that the use of volume functions based on DBH only is inappropriate, as they do not reflect site-specific differences in tree shaft form. Trees on sites with higher site index have larger diameters as compared to trees of the same height growing on lower site index class. Accordingly trees with the same DBH can have different heights and thus volumes between different sites.

We suggest the development of volume functions based on DBH and height as dependent variables.

### **Sawn timber recovery from logs**

The highly significant difference in terms of sawn timber output between hand chopped and sawn logs () can be attributed to the increased output of small sized sawn timber with sawmilling. This was confirmed by the lack of difference between the two treatments in terms of sawn timber output of beam size only (). For this purpose, beams were defined having a minimum width and breadth of 2 inches. Accordingly, hand chopping and sawmilling result in the same amount of beams. In addition to this, with sawmilling we obtained smaller size planks, bits and buttons amounting to about 50% of the beam output volume, whereas this volume was left behind in the forest with hand chopping ().

The more pronounced decline of recovery with hand chopping with increasing log volume () is attributed to the higher amounts of wasted timber with larger logs. With sawmilling, this higher loss with larger logs is compensated by sawing them into smaller planks, bits and buttons.

### **Economic comparison**

The costs were considerably lower than for several other areas, due to the fact that the study site was in the vicinity of a logging road and that the sawmill was not very far from the study sites, thereby reducing siding and transportation costs.

The considerably higher costs of timber sawn in the mill resulted mainly increased charges for sawing and transportation and to a lesser extent for loading and unloading. In spite of the much higher total costs, the unit costs per cft for the conversion of 20 trees into sawn timber were lower for sawmilling due to increased output (, ). Therefore, sawmilling of logs for beams is cheaper, considering the 50% higher sawn timber output in terms of small sawn assortments as by-products of beams.

## **CONCLUSION**

In areas without road access, hand chopping of chams remains the only feasible method. In places with road access and nearby location of a sawmill comparable to the present study location, sawmilling of trees for rural household and other uses should be considered due to slightly lower unit costs and considerably higher timber output. The higher timber output would somewhat reduce pressure on timber resources, even though it has to be noted that this increased output is only in form of small assortments.

## **ACKNOWLEDGEMENT**

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## **Regeneration of Brown Oak (*Quercus semecarpifolia* Sm.) in an Old Growth Oak Forest**

Sonam Tashi<sup>1</sup> and Cheten Thinley<sup>1</sup>

### **ABSTRACT**

*Quercus semecarpifolia* or Brown oak is the most preferred species used for home heating during the cold winter months in Bhutan. However, concerns on the depletion of the oak forest and the lack of regeneration of the species have been raised (Annual Report 2002-2003). Therefore this study was undertaken to unravel some of the regeneration requirements of the species and to contribute to developing silvicultural recommendation of Oak forest in Bhutan.

From this study the height growth and the number of leaves on the *Quercus semecarpifolia* seedling was positively correlated with canopy openness. However, *Q. semecarpifolia* seedling survival showed a negative correlation with canopy openness. The presence of *Q. semecarpifolia* seedlings had no correlation with canopy openness at all.

This study also found that *Yushania microphylla* cover was positively correlated with the presence, survival and height of *Q. semecarpifolia* seedling. *Berberis* and *Daphne* frequencies were positively correlated with the height increment and with the presence of *Q. semecarpifolia* seedling. The regeneration of *Q. semecarpifolia* seedling though not statistically significant responded optimally to a soil pH of about 6, and it is favoured on gentle slopes rather than on steep slope.

From these findings, the Shelterwood system is the most appropriate system to regenerate the oak forest, as *Q. semecarpifolia* is susceptible to strong light during the early seedling stage, but nonetheless requires increasing light with growth and development of the seedling

### **KEYWORDS:**

Oaks, *Quercus semecarpifolia*, Regeneration, Forest Ecology

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## INTRODUCTION

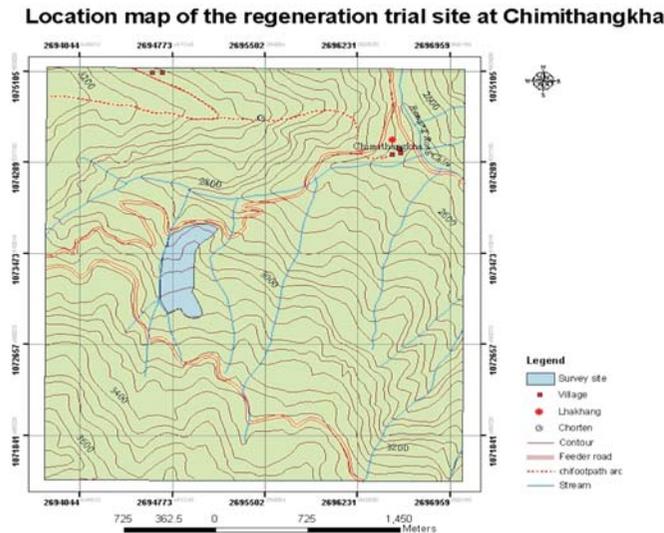
The absence of natural regeneration of Brown oak (*Quercus Semecarpifolia*) in Bhutan has been attributed to grazing by cattle and the microenvironment hindering the development of oak in old growth Oak forest (World Bank, 1995; Sangay, 1997). Studies elsewhere by Riley (2002) also support the fact that herbivory of broadleaved seedlings is high, especially in Pinus dominated systems.

For a sustainable management of old growth Oak Forest in Bhutan, a thorough understanding of the environmental factors for the species is very important. Despite the fact that there are areas of old growth Oak forest, there seems to be a general trend in the lack of natural regeneration in the forests as supported by inventory carried out in Chimithanka and studies done by Saxena et al; 1984; Singh and Singh, 1987; Vetaas, 2000. This can lead to the degradation of the species from the forest of Bhutan, which is not desirable as they are extremely important to the local people. Thus to begin to understand the regeneration requirements of the species, this study was initiated.

## MATERIALS AND METHODS

### Study Area:

An area of 9-hectare forest was allotted by the Department of forest, to study the natural regeneration of *Q semecarpifolia* in 1999, at Chimithanka, Gidakom Forest Management Unit under Thimphu Dzongkha.



**Fig. 1:** Location map of regeneration trail site at Chimithanka

The forest has a north-westerly aspect with slopes ranging from 20% to 70%. The soils are acidic, well drained, very deep, dark greyish brown to yellowish brown, silty clay loam to sandy clay loam texture with no mottles. (BSS/NSSC, 2003).

The forest has been traditionally used for grazing by transhumant cattle population during summer months and by yak during the winter months. As common practice, firewood is extracted for local consumption.

The forest can be described as mixed broadleaved temperate mature forest with multi-layered structure, but with a clear delimitation between the 3 or so layers, that composes it. *Q. semecarpifolia* make up the majority of the dominant species, with some *Picea spinulosa* and *Tsuga dumosa* also dotted about as a component of the canopy species. *Betula* sp., *Acer* sp. *Rhododendron arboreum*, *Gambelia ciliata*, *Enkianthus deflexus* and *Ilex dipyrena* are some of the species that make up the middle tree layer. *Yushania microphylla*, *Pieris formosa* and *Daphne bholua* comprise the main species in the understory (Stierlin, 1999).

## Experimental Design

In the 9-hectare study area, a total of 114 nos of 2m<sup>2</sup> plots were laid out in the year 2000. The plots were systematically spaced at 25m x 25m apart in the accessible portion of the entire 9 hectare plot.

In each plot, the slope gradient percentage and aspect were recorded. *Yushania microphylla* cover was estimated by subdividing the plots into smaller units and then estimating the total coverage in the plot (%). Every *Q. semecarpifolia* seedling found in the plot were tagged in the year 2000, the actual height were measured since then. For canopy opening, hemispherical photographs were taken for each of the plots in the year 2003. For each of the plot, the depth of the litter layer was measured by gently pushing a garden shovel into the soil. The depth of the litter layer was then measured with a ruler in cm. The pH of the soil was also measured with a Kelway soil pH meter for ever plot.

To understand the vegetation composition and status of the recruitment of the different species, and especially the recruitment of *Q. semecarpifolia*, a general inventory was carried out in the vicinity of the study area so as not to disturb the regeneration in the study area. Sites with northwest to northeast facing slopes, with altitude ranging from 2850 to 3100m and *Q.*

*semecarpifolia* dominating at the canopy was selected. Eight plots of 50m X 50m were set up at relatively gentle slopes ranging from 20 to 35 % slope gradient, and eight other plots were set up at, relatively steep slopes ranging from 40 to 65 % slope gradient.

For *Q. semecarpifolia* all the trees above 1.3 m height were measured. For other species Diameter at Breast Height (DBH) greater than 10cm were recorded.

## Data Analysis

To get an overview of the vegetation diameter distribution and basal area of the forest on steep and on relatively gentle slope, the diameter distribution of the forest on two categories of slope was calculated. ANOVA was performed to test the effect of slope on the density and basal area of trees and the basal area and density of *Quercus semecarpifolia*.

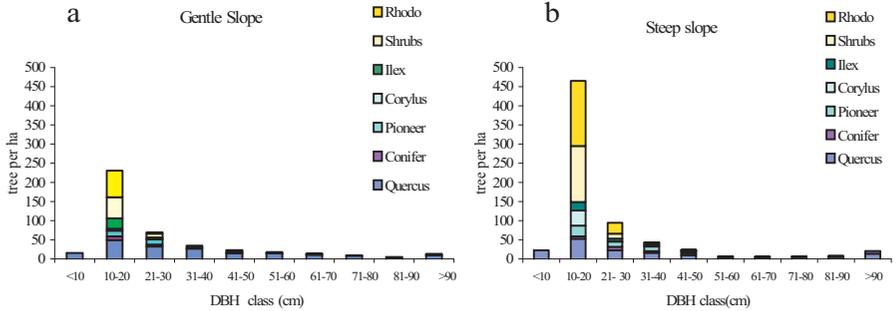
A logistic regression was done to test the presence of *Q. semecarpifolia* with plot variables, such as canopy openness, slope, soil pH, litter depth, frequency of *Daphne* and *Berberis* and *Yushania microphylla* cover.

The plots with the presence of *Q. semecarpifolia* for the year 2003 with the attributes of the plots like canopy openness, *Yushania microphylla* cover, *Daphne bholua* and *Berberis* frequency was analysed for effect on shoot growth, number of leaves and height of *Q. semecarpifolia* seedling. First a collinear check was performed to see that the independent variables taken were not highly correlated with each other. Then a General Linear Model (GLM) multivariate analysis was performed to test the significance of each of the variables on the log transformed growth parameters. Log transformation improved the normality distribution for the growth parameters.

To test the survival of the *Q. semecarpifolia* seedling, only the seedling tagged in the year 2000 were considered. If the seedling was again recorded during the measurement in 2003, it was considered as surviving. A logistic regression was carried out to test the effect of different factors, such as canopy openness, *Yushania microphylla* cover and height of *Q. semecarpifolia* seedling, on the survival after a collinearity check for the factors was done

## RESULTS AND DISCUSSION

From the DBH distribution graph of the inventory plots (Fig. 2), it is evident that the regeneration of *Q. semecarpifolia*, which is the dominating overstorey species in the area, is definitely lacking in the 1cm to 10cm diameter class.

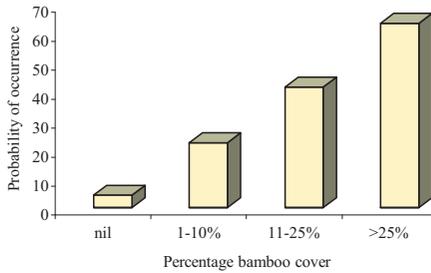


**Fig.2:** Species and DBH distribution on, a) gentle slope, b) Steep slope (Data for <10cm DBH collected only for *Q. semecarpifolia*)

The density of *Q. semecarpifolia* is not significantly different between the two slopes. However, it can be seen that the density is higher for relatively flat slope. Johnson et al. (2002) also report that on a given aspect, oak reproduction density is greatest on gentle slope and decreases with increasing slope gradient. The competitive success of *Rhododendron* on the steep slope as seen from Fig 2. could also be an influencing factor in the number of *Q. semecarpifolia* being greater in gentle slope, as species richness and regeneration layer decreases with increase of *Rhododendron* thickets (Baker and Van Lear, 1998).

### Effect of environmental factors on regeneration of *Q. semecarpifolia*

A logistic regression for the presence of *Q. semecarpifolia* seedling in the systematic plots, with respect to the environmental and vegetation variables such as percentage canopy openness, soil pH, litter depth or the other vegetation frequency showed a significant difference only for *Yushania microphylla* cover class  $P < 0.001$ . The percentage canopy openness, soil pH and litter depth or the other vegetation frequency did not show any significant difference on the number of seedling found in the systematic plots laid out. The *Q. semecarpifolia* seedlings however seemed to prefer a soil pH of around 6, though not statistically significant.



**Fig.3:** Probability occurrence of *Q. semecarpifolia* seedling with respect to *Y. microphylla* cover

$$\text{Log}(p/(1-p)) = -8.588 + 1.259 * (Y. microphylla \text{ class})$$

Predicted probability of the occurrence of *Q. semecarpifolia* with respect to cover class of *Yushania microphylla*

The results show that with increasing *Yushania microphylla* cover, the probability of finding a *Q. semecarpifolia* seedling is higher.

From our study, the combination of the understory vegetation of *Yushania microphylla*, *Berberis* and *D. bholua* has a positive effect and act as facilitators for *Q. semecarpifolia* seedlings. The largest oak seedling recorded during the present study was found surrounded by the thorny *Berberis* species. This accentuates the fact that natural interplay of herbivore and plant defences may still be at work, and that associational resistance is an important mechanism for the regeneration of palatable trees in grazed systems (Bakker et al., 2003).

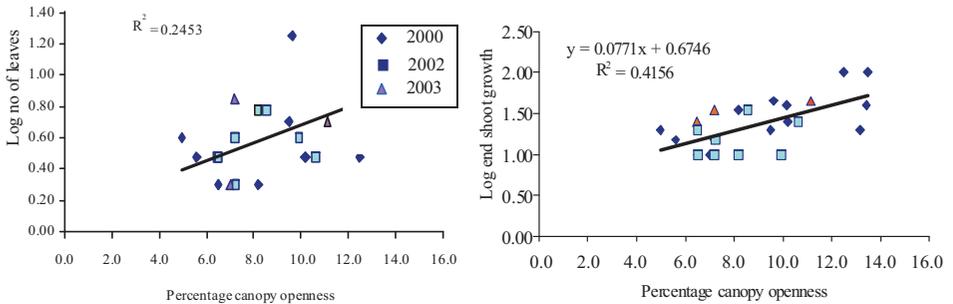
### **Effect of canopy openness and *Y. microphylla* cover on *Q. semecarpifolia* seedling growth**

A GLM multivariate analysis showed that the canopy openness had a significant positive effect on shoot growth ( $R^2=0.41$ ,  $P<0.01$ ) and number of leaves on the *Q. semecarpifolia* seedling ( $R^2=0.24$ ;  $P<0.05$ ). The cover of *Yushania microphylla* showed a significant positive effect on height of the seedling ( $P<0.05$ ). The density of *Berberis* and *D. bholua* also showed a positive correlation for the shoot growth with  $P< 0.05$  for both variables (Table 1).

**Table 1:** GLM Multivariate analysis for *Q. semecarpifolia* growth variables

Independent variables	Shoot growth	No. of leaves	Ht of seedling
<i>Canopy openness</i>	P = 0.002	P = 0.039	P = 0.798
<i>Y. microphylla</i> cover	P = 0.136	P = 0.075	P = 0.048
<i>Berberis</i> density	P = 0.015	P = 0.296	P = 0.405
<i>Daphne</i> density	P = 0.018	P = 0.079	P = 0.124

**Fig.4:** a). Log number of leaves. b) log end shoot growth of seedling with respect to percentage canopy openness in 2000/2/3



**Table 2:** Spearman's rho Correlations for the Growth parameters with plot variables

	Log height	Log leaves	Log ht growth	Yushnia	Daphna	Berberia	Canopy open
Log height	1.00						
Log leaves	0.22	1.00					
Log ht growth	0.59**		1.000				
Yushnia	0.07	0.45*	0.140	1.000			
Daphne	-0.23	-0.24	-0.020	0.043	1.000		
Berberis	0.27	0.18	0.117	-0.045	0.173	1.000	
Canopy open	0.50*	0.50*	0.692**	0.006	-0.255*	0.017	1.000

\*\* Correlation is significant at the 0.01 level (2 tailed)

\* Correlation is significant at the 0.05 level (2-tailed)

The presence of *Q. semecarpifolia* seedlings is not significantly effected by canopy openness, however height increment of the seedling and number of leaves on the seedling is significantly and positively correlated with canopy openness. That is, as canopy openness increased, the number of leaves and the height increment were higher. Studies done by Suh and Lee (1998) also report that the heights of oak seedlings in larger clear cuts were greater than those under canopies or in small gaps (Li and Ma, 2003).

The significant increase in number of leaves with increase in canopy openness from this study is also supported by study by Welander & Ottosson (1998). They state that the light intensity during winter bud initiation in the previous year greatly determines the number of leaves developed in the first flush for *Q. robur* seedlings the following year, and that the number of leaves that flush increases with light intensity.

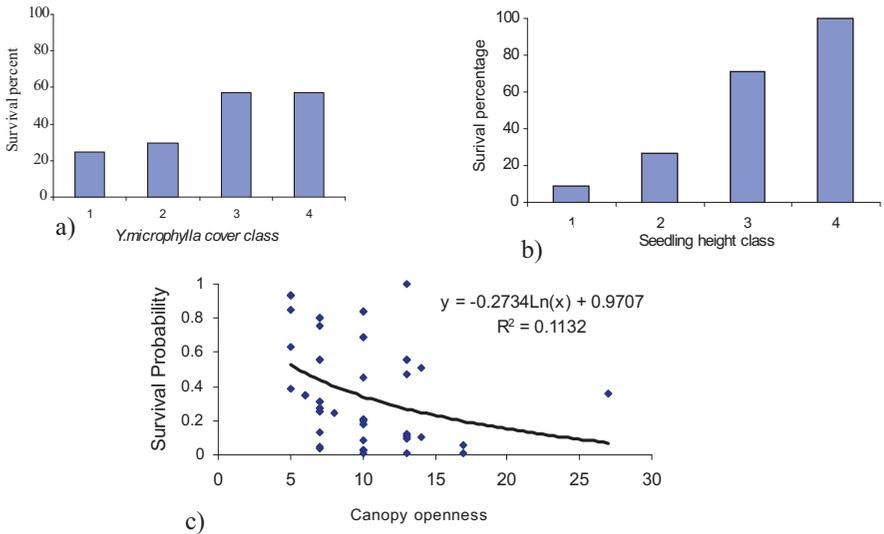
**Effect of canopy openness, *Y. microphylla* and height of *Q. semecarpifolia* seedling on the survival of the *Q. semecarpifolia* seedling**

A logistic regression was carried out to test the effect of different factors on the survival of *Q. semecarpifolia* seedling. The logistic regression showed that cover of *Yushania microphylla* had a significant effect on the survival of the *Q. semecarpifolia* seedlings. With seedling height and canopy openness incorporated in the model, survival was also influenced positively by seedling height and negatively by canopy openness.

**Table 3:** Result of logistic regression for the survival of *Q. semecarpifolia* seedling

Factors	Coefficient ± S.E	t- stat	Sig.
<i>Y. microphylla</i>	1.012 ± 0.498	4.130	0.042
Canopy openness	-0.195 ± 0.097	4.022	0.045
Seedling height	2.175 ± 0.685	10.080	0.001
Constant	-4.871 ± 1.749	7.758	0.005
Model chi square (df)	21.695 (3)		
% correct Prediction	76.9%		

Fig.5: Percentage survival of *Q. semecarpifolia* seedling with respect to a) *Y. microphylla* cover b) seedling height and c) with canopy openness



The percentage canopy openness alone does not seem to satisfactorily explain the survival trend of *Q. semecarpifolia* seedlings. A study by Riley (2003) also did not find a significant difference between the clearcut and the understory seedling survival for two-year-old *Q. alba* seedlings. However the biomass growth and leaf area was much higher in the open sites as was reported by Riley (2003).

The results of the logistic regression for survival of *Q. semecarpifolia* seedling showed a positive influence with the percentage of *Yushania microphylla* cover and a negative influence with increasing canopy openness. The results are consistent with studies by Li and Ma (2003) who report that seedling survival and recruitment in the shade were significantly better than those in the open sites. Similarly, Callaway and D'Antonio (1991) reported that shrubs could have strong facilitative effects on the survival of *Q. agrifolia* seedling.

The height of seedlings had the strongest influence on survival of the seedling. This is consistent with finding of Collins and Battaglia (2002), who reported that plant size, principally measured by maximum leaf length and stem height, was most strongly related to seedling survival through one or two seasons. This just confirms the well established fact that survivorship rates increase as seedlings get larger (Turner, 2001).

## **CONCLUSION**

The north-facing, moister slopes favour the regeneration of oak but also the establishment and growth of competing species. Successful regeneration of oaks partly depends on the species that oaks must compete with. Thus, to develop a strategy to regenerate *Q. semecarpifolia*, conditions of the site and competing vegetation must be understood as the physiographic and climatic conditions of a particular site strongly influence the species present. Firstly, the germination and survival of the seedlings for a few years are favoured by the presence of a canopy cover, and other facilitative shrubs like *Berberis* and *Y. microphylla* as shown by the present study and also from report by Vetaas (2000). For further growth of the seedling, the report by Crow (1992) states that oak seedling requires multiple stem flushes and the frequency of multiple flushing is closely and positively correlated with light intensity. This is consistent with findings from the present study where height growth and the number of leaves on the seedling were seen to be positively dependent upon the amount of canopy openness.

From these findings, the Shelterwood system would appear to be the most appropriate system to regenerate the oak forest, as *Q. semecarpifolia* seems to be susceptible to strong light during the early seedling stage, but nonetheless requires increasing light with growth and development of the seedling. To facilitate the regeneration of *Q. semecarpifolia*, it is imperative that there is plenty of advance regeneration (Thadani and Ashton, 1995) and that the forest is excluded from grazing for a period of time till the oak seedlings outgrow from being grazed by cattle.

After a good seed crop, and plenty of advance regeneration in the forest, the canopy should be partially removed to facilitate the growth of the oak seedlings. A cautious amount of canopy removal about 30-40% openness is recommended as the *Q. semecarpifolia* seedlings are susceptible to strong light as shown by this study. As it is almost definite that the canopy openness will also facilitate the growth of other shrubby vegetation, mechanical weeding should be practiced at least once a year. This would give the oak seedling a better chance of survival from the competing weeds and also rodents that take shelter in the thickets and gnaw the oak seedling. During weeding the facilitative benefit of some of the shrubs as shown from this study for the survival of the oaks must be recognized, especially if exclusion of grazing cannot be guaranteed.

The oak seedlings in association with the facilitative shrubs can escape certain amount of grazing pressure. Therefore the key for the successful

regeneration of the Oak Forest is the proper timing and amount of canopy opening, and to have controlled grazing to provide the right window of opportunity for oak seedling to establish into the next stage.

The second cut should be planned when the seedlings have grown relatively tall, about 50cm high or when there is less likelihood of facing competition for light from other shrubby species, but are still flexible enough to resist breakage during harvesting. At least 15 to 20 % of the original stand should be left standing for further seed production, seedling protection and for biodiversity conservation in general. Once the oaks have reached the pole stage the remaining trees can either be harvested or left standing for aesthetic reasons or as snag trees for wildlife habitat.

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# *Field Crops*



## The importance of South American crops for mountain farmers in Bhutan

Walter Roder<sup>1</sup>, Tshering Dochen<sup>1</sup> and Karma Nidup<sup>1</sup>

### ABSTRACT

*Crops originating from South America have become very important for Bhutanese mountain farmers improving their diet and income, especially, scarlet bean (*Phaseolous coccineus*), potato (*Solanum tuberosum*), slipper gourd slipper gourd (*Cyclanthera pedata*) and chilli (*Capsicum annum*). Research was conducted to document introduction, extend of cultivation, producer preferences, importance in the diet and economic importance. Based on circumstantial evidence these species became popular in Bhutan within 100-200 years after their introduction to Europe and India. For the households above 2300 m the frequency of cultivation was 94, 92, 92, 83, 74, 67, 59, 52, 51, 44, 36% for potato, turnip (*Brassica rapa*), radish (*Raphanus sativa*), mustard green (*Brassica campestris* ssp. *pekinensis*), pea (*Pisum sativum*), scarlet bean, garlic (*Allium sativum*), onion (*Allium cepa*), cabbage (*Brassica oleracea capitata*), bean (*P. vulgaris*), slipper gourd, and chilli, respectively. The preferred vegetables for rural and urban households consistently included potato, radish, chilli, mustard green and bean. Recently, potato has become on of the most important cash crop, fueling the transformation from subsistence to market oriented agriculture.*

### KEYWORDS

South America, potato (*Solanum tuberosum*), surveys, species, adoption, ethnobotanic, producer, consumer, diet.

### INTRODUCTION

The most common traditional Bhutanese vegetables are radish (*Raphanus sativa*), turnip (*Brassica rapa*) and mustard greens (*Brassica campestris* ssp. *pekinensis*). All three species are adapted to a wide range of environments and can thrive under cold and harsh conditions. The British emissary, Turner who visited the country in 1776 described the Bhutanese turnips to be the best in the world (Turner 1800). The three aforementioned species have remained important vegetables even today, especially for households at elevations above 2500 m.

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Conditions for Bhutanese mountain farmers who live at elevations above 2500m are similar to those in the Andes. Several of the most important crop species used today originated from Central or South America. Three vegetable species, scarlet bean (*Phaseolous coccineus*), potato (*Solanum tuberosum*) and slipper gourd (*Cyclanthera pedata*) are especially important. Furthermore, the country is known for its affinity to chilli (*Capsicum annum*) and most Bhutanese can not believe that the diet of their ancestors may not have included chilli. Based on documented records potato was first introduced to the country in 1776 (Markham, 1876) but no records are available on the introduction of chilli, slipper gourd and scarlet bean. Similarly, limited information is available on their importance and use by the Bhutanese rural and urban population.

Investigations were carried out with the objectives to document experiences with scarlet bean, slipper gourd and chilli in temperate and alpine regions of Bhutan, especially: 1) introduction and ethno-botanic information 2) extend of cultivation and preferences by producers and consumers, and 3) trends in consumption.

## **MATERIALS AND METHODS**

### **Review of literature**

Published and unpublished references from Bhutan were reviewed for information on vegetables in general and chilli, potato, scarlet bean and slipper gourd in particular.

### **Surveys**

During 2005, surveys were carried out in regions selected to represent most of the rural population living at elevations above 2000 m in West, Central and East Bhutan (Table 1). Two regions at elevation below 2000 m were also included for comparison. A consumer survey was conducted in the markets of Thimphu (2400m) and Phuntsholing (300m). These two towns are the largest urban centres in the country and represent about 80% of the urban population. Formal structured questionnaires were used for all the surveys. The surveys were carried out by different teams of surveyors. This was necessary because of the wide area covered and the different languages spoken. Using different teams may have, however, affected the consistency in data collection.

### **House hold survey for producers**

Geogs (sub-unit of districts with 200-500 households) were selected in West Bhutan (Chhukha and Paro), Central Bhutan (Punakha, Wangduephodrang

and Bumthang) and East Bhutan (Trashigang) with altitudes ranging from 2200-4400 m (Table 1). For comparison the same information was collected from 3 geogs in Punakha district (Guma, Kabisa, Dzomi, all below 1500m). In each geog 14-26 households were visited. Information collected from each respondent included: vegetables produced, vegetables sold, preferred vegetables (list in descending order of preference), rating of importance (list in descending order of importance based on annual consumption) and potato consumption. In addition, questions were asked about local names and information relating to the introduction of potato, scarlet bean, chilli, and slipper gourd. The information for three geogs in Punakha district was combined. For all other geogs data is shown separately.

### **Consumer survey Thimphu and Phunsholing**

The respondents were randomly selected from consumers while returning from the weekly vegetable markets. The number of respondents was 50 for Thimphu (20 in October 2004 and 30 in March 2005) and 30 for Phunsholing (21 in October 2004 and 9 in March 2005). Information recorded included quantities and prices of vegetables purchased on the day of the survey, ranking of vegetables (importance and preference) and vegetable cultivation.

## **RESULTS**

### **Species introduction and Early adoption**

Extensive search in the available literature did not bring any clue as to when and how scarlet bean and slipper gourd were introduced to Bhutan. Neither of them are mentioned in the list of agriculture products made by the Portuguese priests, Fathers Estevao Cacella and Joao Carbral traveling to Bhutan in 1627 (Baille, 1999). They mention the availability of pea (*Pisum sativum*) and a very good quality turnip and they also noted that vendors in the Paro market “never had anything to sell except walnuts (*Juglans regia*), pears (*Pyrus pyrifolia*) and radishes”. Similarly, British visitors during the 18<sup>th</sup> and 19<sup>th</sup> century (Griffith, 1839; Markham, 1876; Turner, 1800) did not provide any information on vegetable introduction except for the records on potato introduction by Bogle (Markham, 1876).

Observations made by Bogle (Markham, 1876), while travelling through Bhutan in 1776 provide some hints on chilli, potato and maize introduction. Bogle noted that during the meal he had with the Shabdrung (ruler of Bhutan), a dish, gegaw, was “well seasoned with red peppers” and he also noticed the presence of “Indian corn” planted in patches with wheat and barley. From his report we can speculate that the introduction of maize and chilli may have preceded potato.

According to his records, Bogle planted a few potato tubers at each halting place during a voyage to Bhutan and Tibet in 1774/75 (Markham, 1876). While this is the earliest record on potato introduction to Bhutan, it is quite possible that potato may have reached parts of Bhutan before that date. Freyer (quoted in Laufer, 1938) travelling in India during 1672 to 1681 mentions potato twice. Other sources claim that good crops of potato were seen in Northern India as early as 1617 (Nayar et al. 1987). Hooker (1885) observed that in Sikkim “the potato thrives extremely well as a summer crop at 7000feet” and a description of agriculture practices in Hooghly (West Bengal) for the period 1850-1910 notes a high demand for potato and widespread cultivation in Hooghly and Burdwan districts (Kelly, 1981). Yet, Griffith (1839) travelling through Bhutan in 1837/38 noted that “they are unaware of the value of potato”, an indication that potato may not have spread widely by that time.

Records of another Englishman, Turner (1800), who passed through Bhutan nine years later listed the vegetables cucumbers (*Cucumis sativus*), chilli, potato, cabbage (*Brassica oleracea capitata*), lettuce, (*Lactuca sativa*), melons (*Citrullus lanatus*), gourds (*Momordica charantia*, *Lagenaria siceraria*) and eggplants (*Solanum melongena*), but again, he did not mention any of the bean species. The presence of bean was, however, recorded by Griffith in 1839.

None of the respondents to the survey had any idea on the introduction of scarlet bean, chilli, and olochato, except statements such as “we do not remember”, “the species was introduced long ago”, and “must have been introduced more than a generation ago”. While no records on the introduction of Andean species are available, it is obvious that the Bhutanese farmers have chosen them over other species such as carrot, cabbage and lettuce. For example carrot, originating from Asia (World, carrot museum, 2006) and cabbage originating from Europe (Baldwin, 1995) could have been available to Bhutanese farmers centuries before chilli or beans. The fast diffusion of Andean species such as chilli and beans to every house hold in Bhutan could be the cause of envy among today's extension programs. Taste preferences for chilli, bean and slipper gourd, and also adaptation to the mountain environment were probably the main factors leading to their fast adoption. Till today, Bhutanese farmers and consumers do not prefer to eat carrot because of its sweet taste which does not go with chilli and cheese. Beside culinary preferences and cooking method the susceptibility to insect problems may have been another reason for not adopting cabbage, cauliflower (*B. olearcea botrytis*) and broccoli (*B. olearcea italica*).

### Species cultivated in the temperate and alpine areas

Today, based on the frequency of cultivation, potato, turnip and radish are clearly the most important species (Table 1). For the households above 2300 m the frequency of cultivation was 94, 92, 92, 83, 74, 67, 59, 52, 51, 44, 36% for potato, turnip, radish, mustard green, pea, scarlet bean, garlic (*Allium sativum*), onion (*A. cepa*), cabbage bean (*P. vulgaris*) slipper gourd, and chilli, respectively (Figure 1). Interestingly turnip is less important in Khaling.

**Table 1:** Locations and frequencies of the most important vegetables cultivated and sold

District	Chhukha	Paro	Wangdu	Punakha	Bumthang	T.gang		
Geog	Chapcha	Lango	Naja	Phojikha	3 gewogs	Chumey	Ura	Khaling
Elevation range	2341-2570	4000-4400	2402-2798	2849-3039	1000-1200	2788-2969	3130-3413	2200-2300
Sample number	16	26	15	14	74	14	15	15
Vegetables cultivated (% house holds)								
Potato	100	62	100	100	54	100	100	100
Turnip	88	65	100	100	66	100	100	-
Radish	100	65	100	100	81	86	100	73
Mustard green	100	69	100	29	48	100	100	93
Pea	100	0	100	86	13	86	73	66
Scarlet bean	100	0	40	71	35	100	93	n.s. <sup>1</sup>
Garlic	93	0	53	36	66	100	73	100
Onion	93	0	93	86	82	71	7	100
Cabbage	43	27	100	0	16	50	93	73
Bean ( <i>P. vulgaris</i> )	93	0	87	0	41	100	26	93
Slipper gourd	93	0	73	0	43	79	20	40
Chilli	100	0	100	0	98	14	0	100
Vegetables sold (% house holds)								
Selling potato	93	0	100	100		100	100	100
Selling cabbage	7	0	100	0		0	13	67
Selling other vegetables <sup>2</sup>	100	0	100	0	Not included	7	7	93

<sup>1</sup>No separate records for *P. coccineus* and *P. vulgaris*

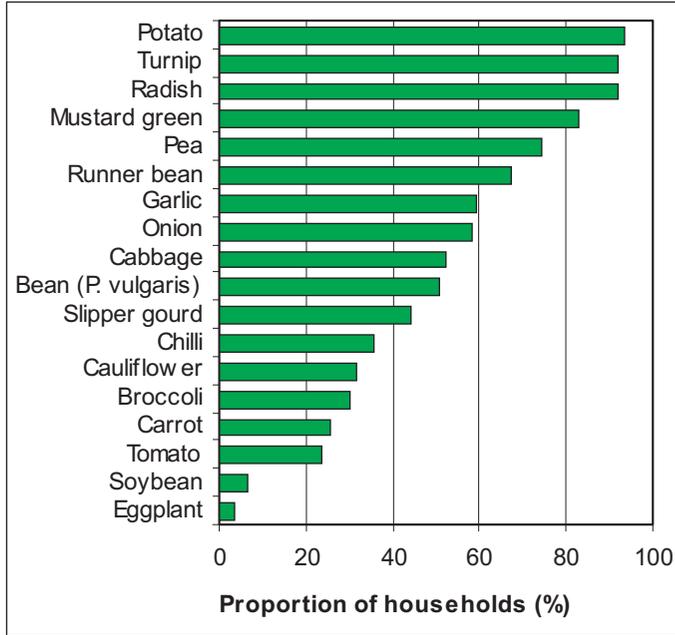
<sup>2</sup>Other vegetables in order of importance were: pea, chilli, bean, radish, mustard green, carrots, garlic, tomato, onion

The frequencies for potato, radish, and turnip tend to be lower for regions with lower elevations (<2000 m) in Punakha. This may partly be due to increased options for planting other species such as tomato (*Lycopersicon esculentum*), eggplant and vigna species (*Vigna unguiculata*, *V. radiata*) for both, home consumption and market. For Lango gewog the frequencies were lower because of less importance given to vegetable production by migratory families and due to poor growing conditions. In an earlier survey in Laya, Lingshi area (Gasa and Thimphu district, elevation range 3800-4000m), Koenig et al. (1986) reported frequencies of cultivation of 100, 100, 100, 41, and <20% for potato, radish, turnip, mustard green and pea, respectively. The upper attitude limits depending on local climate are approximately 4500 m for potato, mustard green, radish and turnip, 4200 m for pea and cabbage, 3100 m for scarlet bean, 2900 for chilli and slipper gourd. Slipper gourd is less important for the cold regions than expected, as it is not suitable for elevations above 2900 m. Yet, based on the frequency of cultivation it was ranked number 11 for elevations above 2500m (Figure 1), with much higher frequencies than chilli, cauliflower, broccoli, carrot, tomato, soybean and eggplant. In a market survey carried out in 1989 slipper gourd was listed as an important locally produced vegetable (Roder and Gurung, 1990).

With the gradual change from subsistence agriculture to a market oriented production system the frequency of vegetables cultivated today not only reflect the preferences of producers for certain species, but also the emerging market opportunities. This has certainly had an impact on the extent of cultivation for potato, chilli and cabbage.

Thirty six percent of the respondents to the consumer survey in the Thimphu had their own vegetable garden. The vegetables planted with the highest frequency were chilli, followed by potato, bean and mustard green as listed by 26, 18, 16 and 14% of the respondents, respectively.

The ubiquitous importance of scarlet bean, slipper gourd and turnip is unique to Bhutan. At the global and regional level (India), these two species have hardly received any attention as reflected by the number of publications (Table 2).



**Figure 1:** Frequency of vegetable species cultivated by rural house holds above 2300m (indicates preference as vegetable for consumption and for income generation)

**Table 2:** References with CAB abstracts

	Global	Bhutan	India
<i>Cyclanthera pedata</i> or korila	12	0	2
<i>Phaseolus coccineus</i> or <i>P. multiflorus</i> or scarlet bean	523	1	4
<i>Solanum tuberosum</i> or potato	59605	23	3951
<i>Capsicum annum</i> or chili or chilli	2635	2	1076
<i>Brassica rapa</i> subsp. <i>Rapa</i> or turnip	3384	3	153

### Ethnobotanic observations

A range of different names are used for the four species, mostly based on the different language groups (Table 3). The regions surveyed would have included at least 5 different language groups, yet the variety in names used is lower than expected. Two generic names for bean (also used for other *phaseolus* species) were also included in the table. The names used do not provide any information as to when and how plants were introduced except

perhaps the name “*Bangala*” used for chilli in some parts may indicate that it came through Bengal. Over the centuries chilli has been adapted to local conditions and evolved into many different landraces. These Bhutanese varieties are differentiated based on physical attributes (shape, fleshiness) pungency and suitability for specific conditions. Almost all chilli planted today are Bhutanese varieties. The situation is very different for potato where all old varieties have been replaced by modern varieties. Although both, slipper gourd and scarlet bean are grown from locally maintained populations, no specific varieties are known.

**Table 3:** Names used for scarlet bean and olochoto

Name	Meaning	Chapcha	Naja	Phobjikha	Chumey	Ura	Khaling
Scarlet bean							
Sheven <sup>1</sup>	Bean				X	X	
Semchum <sup>1</sup>	Bean	X	X	X			
Craptang	Hard to touch					X	
Pata sem	Sword bean		X	X			
Sowsemchou	X						
Ap zow	Looks like a sickle			X			
Upa rim	Climbs high	X					
Slipper gourd							
Slipper gourd	Crows beak	X	X	X	X		
Kichipoktho	Crows beak						
Ajangkairu						X	X
Carabanthu							X

<sup>1</sup>Generic names for bean (*P. vulgaris*, *P. coccineus* and sometimes even for *Dolichos* bean)

### Producer and consumer preferences

The ranking of favourite and important vegetable species (Table 4) follows similar patterns as the frequencies of vegetables planted (Table 1, Figure 1). Potato, chilli, mustard green, radish and bean are consistently mentioned as the favourite and most important species by both, rural and urban respondents. In the ranking of favourite vegetables all *Phaseolus* species were collectively included under bean (no differentiation between *P. vulgaris* and *P. coccineus*). The results show a high preference of urban households for potato (Table 4). Urban households also listed tomato and onion as important vegetables but did not consider them as favourite species. Interestingly cabbage comes up as an important and favourite “new” species in urban and rural households. In most areas cabbage became popular only 20-30 years ago and it does not have a Bhutanese name. Apparently cabbage appeals more to the Bhutanese taste and is more suitable for cooking with

chilli and cheese recipes than other species such as tomato, carrots and cauliflower.

**Table 4:** Ranking of favourite and important vegetables

Block/town (altitude, m)	Potato	Chilli	MG <sup>1</sup>	Radish	Bean	Others
<i>Rural house holds (rank)</i>						
Chapcha (2400-2700)	2	1	4		3	Pea (5) <sup>2</sup>
Naja (2500-2800)	2	1		5	3	Cabbage (4)
Lango (3500-4000)	1	5	3	2		Turnip (4)
Phobjikha (2900-3100)	3	1		4	2	Eggplant (5)
Chhume (2800-3000)	1	4	5		3	Cabbage (2)
Ura (2900-3200)	4		1	2	3	Cabbage (5)
Khaling (1900-2100)	1	4	2	3		Cabbage (5)
<i>Urban house holds (rank)</i>						
Thimphu (2400)	2	4	1		3	Cabbage (5)
Phuntsholing (300)	1	3	2		4	Cabbage (5)

<sup>1</sup>Mustard green; <sup>2</sup>Rank

The preferences expressed by the urban households are also reflected in the frequency of households buying a particular vegetable species and the weekly quantities purchased (Table 5). During October, potato, chilli, bean, radish, cabbage and mustard green would almost exclusively originate from Bhutanese producers, while in March a large proportion would originate from India.

**Table 5.** Vegetables purchased in Thimphu and Phuntsholing markets based on frequency (% of households) and quantity (kg/household) purchased

Species	Thimphu				Phunsholing			
	Frequency (%)		Quantity (kg/hh)		Frequency (%)		Quantity(kg/hh)	
	March	Oct	March	Oct	March	Oct	March	Oct
Potato	90	85	3.2	2.6	78	100	1.9	3.2
Green Chilli	97	100	1.0	2.3	78	100	1.2	1.5
Onion	93	95	1.2	1.4	67	71	0.7	0.6
Tomato	90	100	1.2	1.5	78	91	1.2	1.0
Cabbage	73	100	1.0	1.4	56	86	0.8	1.2
Mustard green	83	75	1.8	0.9	33	62	0.4	1.4
Beans	53	80	0.6	1.2	11	48	0.1	0.5
Radish	37	75	0.4	0.9	22	43	0.2	0.5
Dry chilli	23	65	0.1	0.6	11	24	0.1	0.2
Eggplant	27	30	0.3	0.4	22	10	0.22	0.12
Cauliflower	47	20	0.8	0.18	22	5	0.67	0.05
Pea	0	70	0	0.7	0	19	0	0.21
Bitter gourd	30	20	0.2	0.25	0	5	0	0.05
Carrot	27	20	0.3	0.25	22	14	0.28	0.14

### Importance in the diet

Potato, radish, turnip and mustard green are regularly eaten throughout the year. Leaves and roots of radish and turnip are used in wide variety of ways, raw, cooked, fermented and dried. Dried turnip leaves (*Lomm*) is the major winter vegetable for the rural population living at higher elevation. A dish of radish and pork is highly esteemed and prestigious in west and east Bhutan. Scarlet bean is an important source of protein in the elevation range of 2500-3500m. Bean is eaten in many different ways either as pods or as mature seed.

Potato consumption has increased rapidly over the last 40 years (Tables 6 and 7). Recent survey data and estimates from surveys carried out in 1982 (Scott 1983) indicate that the quantities consumed by urban households are as high (or higher) as those for households in major potato producing areas. Non-producing rural households are generally consuming lower quantities (Table 6 and 7). The average national consumption for 2006 was estimated to be 40 kg/person, one of the highest for Asian countries. Examples of consumption levels in other countries for the same year are 128 kg for Poland, 54 kg for the USA, 51 kg for Nepal, 40 kg for China, 24 kg for Bangladesh, and 16 kg for India (FAO, 2007).

Over 50% of the respondents reported that they eat more potato today than 10 years ago (Table 8). Preference for potato by children is reported as an important reason for increased potato consumption. It can therefore be expected that the level of consumption may further increase. Potato is versatile and can be used in the Bhutanese cuisine many different ways with meat and cheese and is very compatible with chilli. Furthermore, potato can be easily stored. Potato is more important for the higher elevation where it is the only fresh vegetable available in the winter months beside radish and turnip.

Considering the social and cultural barriers, the changes in potato consumption are remarkable. It is also interesting to note that unlike in other Asian societies today, the increase in consumption was solely based on increased availability and rapid urbanization which took place under a total absence of any fast food industry.

**Table 6:** Trends in consumption level

Population group	1970 <sup>1</sup>	1985 <sup>1</sup>	2005 <sup>2</sup>
Average consumption (kg/person/year)			
Urban population	10	35	60
Rural population	5	20	35
National average	5	22	43

<sup>1</sup>Source: Scott, 1983; <sup>2</sup>Consumer and producer surveys 2005

**Table 7:** Potato consumption

Categories	Consumption (kg/person/year)	
	Average	Range
Producers (rural house holds)		
Producing for market	10	0-27
Self consumption only	57	17-167
Net consumer in towns (urban house hold)		
Thimphu	56	10-316
Phuntsholing	82	13-217

**Table 8:** Trends in potato consumption reported

Parameter	Survey respondents (%)	
	Urban <sup>1</sup>	Rural <sup>2</sup>
<i>Trend in consumption (compared to 10 years ago)</i>		
Increased	59	56
No change	29	32
Decreased	10	11
<i>Reasons for increased consumption</i>		
More person in family	43	13
Children like potato	25	46
Higher production		38
Potato availability <sup>3</sup>	19	0
Cheap	7	0
More ways of preparing		7
We like potato	6	0
Easy to store	1	0

<sup>1</sup>Net consumers; <sup>2</sup>Net producers; <sup>3</sup>Respondents stated “potato are easily available” or “potato are always available”

## CONCLUSION

Crops originating from South America have become very important for Bhutanese farmers. Chilli and bean species have made a tremendous important contribution towards enriching the diet of the Bhutanese population over centuries and evolved into a unique Bhutanese cuisine. Suited for cold environment, potato and runner bean were especially important for house holds located above 3000m. Although not supported by records, we can assume that chilli and bean were adopted at very fast rates and widely used in Bhutan over the last few centuries.

With a gradual shift from subsistence agriculture to market oriented agriculture some of the species; especially chilli and potato have become important cash crops. For many regions, especially those above 2500 m, potato is presently the only economic cash crop available. For these communities potato was the main force driving the change from a subsistence to market oriented agriculture (BPDP, 2008). For households at elevations above 2900 m (Ura, Phobji and Gangte) the value of potato typically represents over 80% of the agriculture production and accounts for almost 100% of the agriculture products sold.

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## **Yield Response of Rice under System of Rice Intensification (SRI) Management at Kanglung, Bhutan**

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### **ABSTRACT**

*Of late, the System of Rice Intensification (SRI) has emerged as a promising and an innovative method of growing rice organically under irrigated and even rain-fed conditions. Studies in a number of countries have shown significant increases in rice yield compared to conventional methods; with seed, water, and cost savings. However, yield response of SRI in Bhutan has not been reported. This has prompted the study reported in this paper. Three location-specific trials, both on-farm and on-station, were carried out at elevations of 1600-2000 masl to assess the respective responses to SRI practices of different rice varieties (cultivars) popularly grown at Kanglung. The trials assessed SRI methods that could be most easily introduced in Bhutan.*

*The yield results of these SRI trials in Bhutan and an analysis of the yield-contributing parameters showed a positive effect using SRI methods, similar to what has been observed in many other countries. Higher mean yields of 6.0 ton/ha using Khangma maap in the study site I and 4.2 ton/ha with Paropa and Verna varieties at other two sites, compared to the average yield of 3.6 ton/ha with prevailing methods, were recorded. Among the treatments, best result was obtained with 30 x 30 cm spacing, 3 - leaf stage seedling in all the sites. It was observed that 80% of the SRI plots had a large number of secondary tillers (more than in the control plots of conventional methods) with filled but immature grains, so some further adjustment of agronomic practices might contribute to further improvements in yield.*

### **KEYWORDS:**

Bhutan, System of Rice Intensification, trials, yield contributing parameters, yield

### **INTRODUCTION**

The System of Rice Intensification (SRI) is a new and promising resource-conserving method of growing rice under irrigated and even rain-fed

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conditions (Laulanié, 1993; Stoop et al., 2002). Since its first trial outside of Madagascar in 1999 - 2000, it has been gaining acceptance and popularity in the farming community in view of the associated benefits viz., saving seed, water, cost, increased soil health and grain yields vis-à-vis traditional method of rice cultivation (Lhendup, 2007). SRI has been successfully tested in more than 30 rice-growing countries such as China, India, Indonesia, Philippines, Cambodia, Myanmar, Sri Lanka, Bangladesh, and Nepal (Uphoff, 2005). The bumper rice harvest obtained by farmers in Nepal (BBC, 2006) is a testimony of SRI success next door to our country, Bhutan, making the controversy about SRI raised inter alia by McDonald et al. (2006) moot. Besides increasing rice crop productivity, other benefits of SRI that have been experienced by farmers include earlier crop maturity, higher grain and straw yields, and reduced cost of production as less inputs of seeds, water, manure, fertilizers and pesticides are required (Uphoff, 2005).

It is worth mentioning that SRI techniques of rice cultivation are not entirely different from conventional methods. They involve changing certain management practices for rice plants, soil, water and nutrients, so as to produce better growing conditions, particularly in the root zone, for rice plants than those prevailing for plants that are grown under traditional practices (Uphoff, 2001). Early transplanting at 8 - 12 days or 2 - 3 leaf stage, planting single seedlings at wider spacing, careful transplanting, moist but un-flooded soil conditions during the vegetative growth phase, early and timely weeding with rotary weeder, and application of organic manure are the recommended practices of SRI. Many claim that these practices assert synergistic effects resulting in higher yield than the conventional rice production methods (Uphoff, 2001; Vallois, 1996).

Farmers in Bhutan grow different varieties of rice, both local and introduced, in a wide range of elevation from subtropical lowlands (150 m) in the south up to elevations as high as 2600 masl in the north (Chettri et al., 2000). Several innovations have been in place to increase the rice productivity in the country. However, the present average productivity of rice is less than 3 ton/ha (MOA, 2004), which reflects low performance of the current practices used for cultivation. Further, the productivity is constrained by a lack of farmer education on rice planting and rice ecosystems in the country.

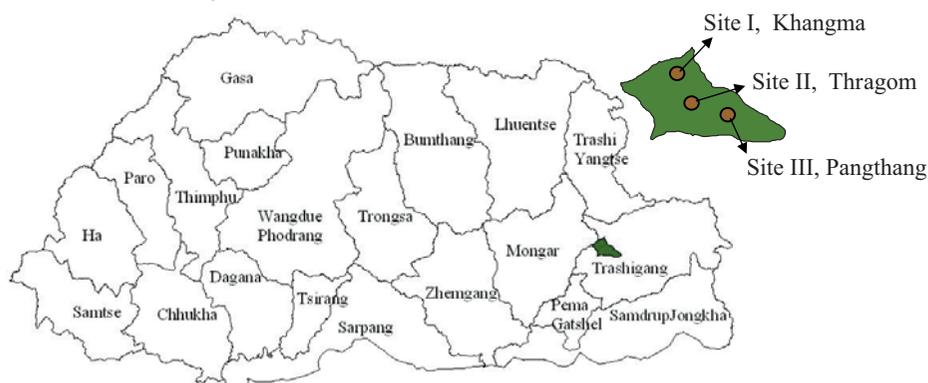
Given the above context, a study was undertaken to assess the performance or response of three rice varieties, namely Khangma maap, Paropa and Verna, cultivated at Kanglung, in relation to seedling spacing and age of SRI practice. This practice include careful transplanting of younger seedling (2 - 3 leaf stage usually), wider spacing (above 20 x 20 cm), water management

(alternate wetting and drying during vegetative stage followed by continuous water supply in reproductive stage), and early weeding and active soil aeration using rotary weeder in our conditions.

## **MATERIALS AND METHODS**

### **Site Profile**

The evaluation trials were carried out at three sites at Kanglung geog (1800 masl) during the rice-growing season in 2006 (Figure 1). Kanglung is one of the 16 geogs of Trashigang district with a total of 588.5 acres under paddy cultivation. The total rice production is recorded at 408.3 tons (equal to 3.6 ton/ha), which is higher than the average yield of 2.9 ton/ha in the country (MOA, 2004). Kanglung falls within the mid and high altitude rice-growing zones with a mean temperature of 17.2 °C and 850 - 1200 mm of rainfall in a year. Table 1 presents additional information on soil texture and pH, and altitude of the study sites.



**Figure 1:** Location of study sites

**Table 1:** Soil types, pH and altitude of study sites

<b>Site</b>	<b>Altitude (masl)</b>	<b>Soil texture</b>	<b>pH</b>
I (Khangma)	2000	Loam	4.40
II (Thragom)	1850	Loamy to sandy clay	4.47
III (Pangthang)	1600	Sandy loam to sandy clay loam	5.99

### **Experimental Design**

The experimental design was a simple randomized block design (RBD) with three replications and five treatments at each site. Plot size was 5 x 4 m<sup>2</sup>, and there were a total of 15 plots in each site. The treatments are:

1. 20 x 20 cm spacing, 3 - leaf stage seedling
2. 20 x 20 cm spacing, 4 - leaf stage seedling

3. 30 x 30 cm spacing, 3 - leaf stage seedling
4. 30 x 30 cm spacing, 4 - leaf stage seedling
5. Control (farmers' normal practice, > 7 leaf stage)

For control, farmers' normal practices of rice cultivation was followed such as transplanting of older seedlings having three to four tillers at close spacing of less than 15 cm in a bunch of two to three seedlings; application of pre-emergence selective herbicide (Butachlor) at three days after transplanting at the rate of 40 gm per plot; maintaining about 7 cm water level from transplantation to two weeks before harvest; and weeding for two to three times.

### ***Rice Variety and Seedling Transplanting***

Each site was planted with a different variety of rice: Paropa and Verna (two local varieties) at Sites II and III respectively, while a released variety Khangma maap was used at Site I. Selection of variety for this study was based on popular cultivar grown by farmers at each site.

Seeds were pre-soaked in water for 24 hours before sowing in the solarized nursery bed (Culman et al., 2006). Seedlings were transplanted at three and four leaf stage, following a square pattern of 30 x 30 cm and 20 x 20 cm spacing, attainable at about 22 – 25 days at the given altitude. For control plots, 50 - 60 day-old seedlings or greater than 7 leaf stages were transplanted. The total numbers of seedlings transplanted per plot were 222, 500 and 900 for 30 x 30 cm and 20 x 20 cm spacing, and control plot respectively.

### ***Water Management and Weeding***

After the transplantation of seedlings at shallow depth (2 - 3 cm) slightly in a slanting position in well-puddled soil, moist soil condition was maintained for about two weeks in all the experimental plots except the control, which was flooded. Then, a cycle of alternate wetting (up to 2 cm water level) and drying (about to crack) was executed during the vegetative phase. Initially, the duration of wetting was kept about two to three days more than that of drying, due to high summer heat. About 5 - 7 cm water levels were maintained during the entire reproductive phase and the water was removed about 15 - 20 days before the harvest.

A total of three weeding were done by hand, aided by small tools. The first weeding was carried out at about two weeks after transplantation, and the subsequent weedings at an interval of two weeks. There was no active soil aeration with hoe, and rotary weeder is usually recommended with SRI.

### **Application of Fertilizer**

A small quantity of urea (46:0:0) at the rate of 173.8 gm per plot, equivalent to 40 kg/ha, was applied at 55 days after transplantation in all the plots due to yellowing of the tips of leaves. Normally, SRI practice involves provision of organic manure.

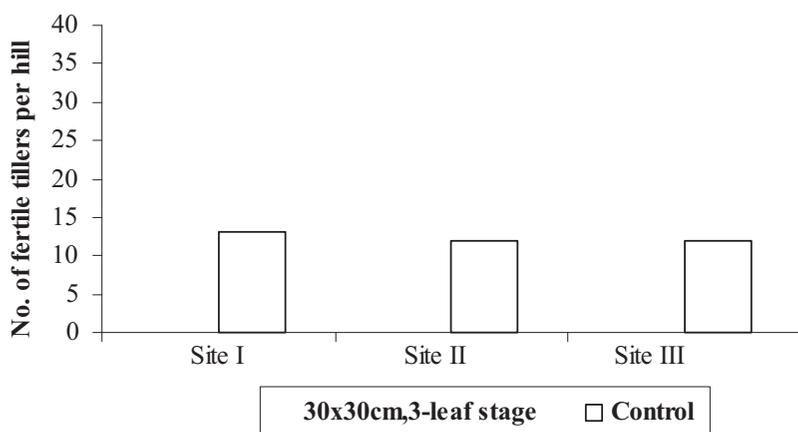
## ***RESULTS AND DISCUSSION***

The main results of the evaluation trials on SRI are summarized in Table 2. The 3 - leaf stage seedlings spaced at 30 x 30 cm gave the best results for yield contributing parameters and yield measurement, which were consistent with SRI theory and expectations. The prevalence of diseases was negligible, which showed the effect of soil solarization on nursery bed. However, a few insect pests (stem borers) were observed in all plots.

### **Yield-contributing Parameters**

The yield contributing parameters such as total numbers of productive or fertile tillers (panicles) per hill, length of panicle, and number of filled grains per panicle were found more in SRI plots than the conventional plots (Table 2). The highest numbers of productive tillers, 34, 32 and 30 were found in plots with wider spacing (30 x 30 cm) in three sites as compared to 16, 15 and 14 of control plots (Figure 2). The difference in fertile tillers is 53% at site I and II, and 50% at site III, as compared to percent of fertile tillers in conventional plots. Similarly, the difference in average number of filled grains per panicle is 22% at site I, 37% at site II and 29% at site III for plots with wider spacing (30 x 30 cm) in all the sites as compared to control plots. Both of these parameters appear important factors in determining the rice yield presented in Table 2.

However, the percentage of difference in fertile tillers and filled grains is slightly less by about 10% of fertile tillers and 3% of filled grains compared to the difference seen in individual 30 x 30 cm spacing plot, when all the SRI plots with different spacing and leaf stage of seedlings combined at each site. This indicates that maintaining wider spacing, one plant per hill, and transplanting younger seedling induces more robust root growth, profuse tillering, longer panicles and consequently more grains per panicle than closer spacing and transplanting older seedlings.



**Figure 2:** Number of fertile tillers in 30 x 30 cm spacing (3 - leaf stage seedling) and control plot in three sites.

### Yield

In all the three sites, on average, SRI plots showed better yield performance compared to plots with conventional methods (Table 2). This finding is in line with the evaluation conducted by Anthofer (2004) that SRI method had better yield performance than conventional methods in Cambodia. Among these sites, better yield performance was observed at Site I as compared to Site II and III for both SRI as well as control plots. This may be attributed to the type of variety planted (Wang et al., 2002), or to the soil types and differences in nutrient status (Amiri, 2006; BIND, 2003) found among study sites.

**Table 2:** Yield and yield-contributing parameters of trials at three different sites

Sl.No	Parameters	Site I (Khangma)	Site II (Thragom)	Site III (Pangthang)
<b>1</b>	<b>Rice variety</b>	<b>Khangma maap</b>	<b>Paropa</b>	<b>Verna</b>
2	Average fertile tiller/hill			
2.1	20 x 20 cm, 3 - leaf stage	25	27	21
2.2	20 x 20 cm, 4 - leaf stage	21	22	18
2.3	30 x 30 cm, 3 - leaf stage	34	32	30
2.4	30 x 30 cm, 4 - leaf stage	29	27	26
2.5	Control	16	15	14
3	Plant height (cm)			
3.1	20 x 20 cm, 3 - leaf stage	142	134	142
3.2	20 x 20 cm, 4 - leaf stage	141	138	141
3.3	30 x 30 cm, 3 - leaf stage	144	146	144
3.4	30 x 30 cm, 4 - leaf stage	143	135	143
3.5	Control	136	121	133

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4	Average filled grains/panicle			
4.1	20 x 20 cm, 3 - leaf stage	163	160	163
4.2	20 x 20 cm, 4 - leaf stage	170	170	170
4.3	30 x 30 cm, 3 - leaf stage	174	176	174
4.4	30 x 30 cm, 4 - leaf stage	155	165	155
4.5	Control	135	111	124
5	Yield ton/ha*			
5.1	20 x 20 cm, 3 - leaf stage	5.7	3.9	3.8
5.2	20 x 20 cm, 4 - leaf stage	5.2	3.8	3.3
5.3	30 x 30 cm, 3 - leaf stage	6.0	4.2	4.2
5.4	30 x 30 cm, 4 - leaf stage	5.3	3.8	3.6
5.5	Control	5.2	3.6	3.6

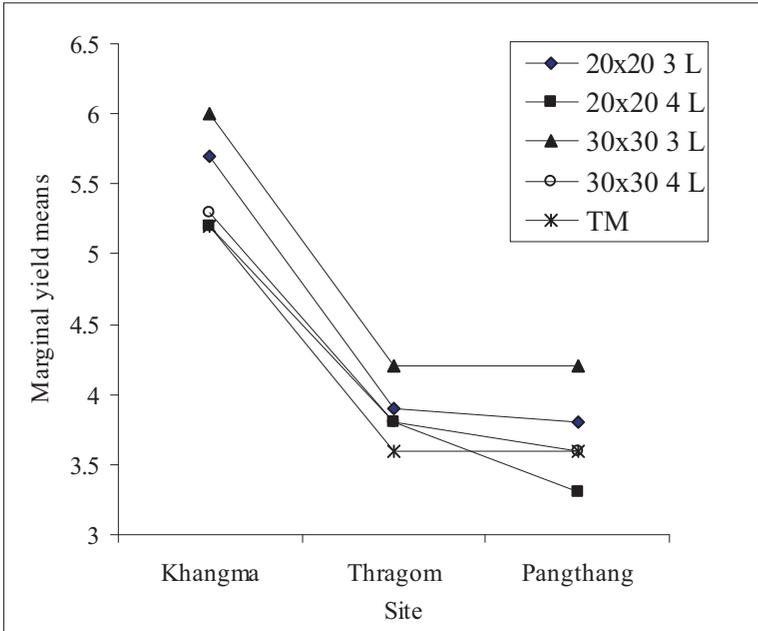
\* Mean yield from 66, 150, and above 200 seedlings for 30 x 30 cm spacing, 20 x 20 cm spacing, and control plot respectively, in 6 m<sup>2</sup> crop-cut area at 14 % moisture content.

As seen in Table 2, among the treatments, SRI plot with 30 x 30 cm spacing (3 - leaf stage seedling) obtained higher mean yield of 6.0 ton/ha at site I and 4.2 ton/ha at site II and III, followed closely by 20 x 20 cm spacing (3 - leaf stage seedling) with 5.7 ton/ha, 3.9 ton/ha and 3.8 ton/ha respectively in three sites. The mean yield for the control plots are 5.2 ton/ha at site I and 3.6 ton/ha at site II and III. For SRI plot with 30 x 30 cm spacing (3 - leaf stage seedling) against control plots, the mean yield achieved is higher by 13% at site I and 14% at site II and III. Considering the smaller number of seedlings used with 30 x 30 cm spacing (66) compared with control plots (Table 4), the difference in mean yield obtained seems considerably higher for SRI plots. So, in this study, lesser the number of seedlings used with wider spacing, higher is the yield obtained. With SRI methods, there is a potential to save seed use by about 78% (considering average use of 22.5 kg seeds per acre for conventional methods against maximum 5 kg seeds for SRI methods).

**Table 4:** Number of seedlings or hills in 6 m<sup>2</sup> crop-cut area.

Sl. No	Treatment	Seedling or hill in 6 m <sup>2</sup> crop-cut area
1	20 x 20 cm spacing, 3 - leaf stage	150
2	20 x 20 cm spacing, 4 - leaf stage	150
3	30 x 30 cm spacing, 3 - leaf stage	66
4	30 x 30 cm spacing, 4 - leaf stage	66
5	Control plot	> 200

Further, the estimated marginal means of yield with specific variety used in all the sites is highest for 30 x 30 cm spacing plot (Figure 3). This corresponds to the findings reported elsewhere which have shown that with SRI, optimally wider spacing gives better yield.



**Figure 3:** Estimated marginal means of yield in all the three sites.

The pair wise comparison between mean yields of the control and four treatments showed that there is a significance difference ( $p < 0.01$ ) in yield between 30 x 30 cm spacing (3 – leaf stage seedling) and control plot; 30 x 30 cm spacing (3 – leaf stage) and 20 x 20 cm spacing (3 - leaf stage) ( $p < 0.05$ ); 30 x 30 cm spacing (3 - leaf stage) and 20 x 20 cm spacing (4 - leaf stage) ( $p < 0.01$ ); 30 x 30 cm spacing (3 - leaf stage) and 30 x 30 cm spacing (4 - leaf stage) ( $p < 0.01$ ) at site I using Khangma map variety. Similar results were observed for other sites using specific variety.

Additionally, almost all the SRI plots had a large number of secondary tillers (more than in the control plots) with filled but some immature grains, which could have matured had the growth period been longer, which was not possible under the prevailing climatic conditions at this location. Further trials should be performed to assess the possibilities for proper growth of secondary tillers up to maturity using same variety at different locations with different management practices such as early sowing and transplanting, organic fertilization, and nursery beds.

## **CONCLUSION**

The results of SRI study at Kanglung on yield and the yield contributing parameters showed a positive effect of SRI methods assessed in this study, as has been observed in many other countries. Higher mean yield of 6.0 ton/ha, above the nation's average yield of 2.9 ton/ha, was observed for Khangma maap variety at site I and 4.2 ton/ha with Paropa and Verna varieties at sites II and III respectively. Additionally, about 78% of seed use was saved compared to the conventional methods. From the SRI combination tested using seedling age and spacing, 30 x 30 cm spacing, 3 - leaf stage seedling provided better result. These SRI practices, diverging slightly from conventional practices, had a very clear impact on rice plant productivity and seed saving. There is a potential for subsistence farmers to eventually capitalize on higher yield with this SRI technique once skills are improved and recommended by research and extensions through further standard experimentation. These trials have already sparked some interest among farmers and researchers.

As reported in the June-December 2006 issue of the Himalayan Permaculture Group's *Newsletter and Progress Report*, a farmer working with the Group in the Humla region of Nepal was successful in using SRI methods at an elevation of 2500 masl. This further supports the proposition that SRI methods can be applied across a wide range of agro-climatic conditions. Further trials and demonstrations involving farmers and extension agents are required at various locations to demonstrate and consolidate the benefits of SRI technique, using recommended practices, under varied agro-ecological conditions comparing yields of SRI technique and conventional practices, thereby helping to build trust and confidence among farmers to adopt this methodology.

## **ACKNOWLEDGEMENT**

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# *Horticulture*



## **Citrus Cultivars: Potential for Increasing the Citrus Cultivation Range**

Kinlay Tshering<sup>1</sup>, Khampa<sup>1</sup>, Yuichi Tomiyasu<sup>2</sup> & Kinley Tshering<sup>2</sup>

### **ABSTRACT**

*Local mandarins show very good horticultural fruit characteristics between the altitude range of 900 – 1300m asl. Above the upper limit, fruit quality is compromised. Therefore, a varietal evaluation on citrus was conducted at Wengkhar (1660 m asl) with the objective to identify a cold tolerant varieties with good horticultural characteristics that can be cultivated above the usual citrus growing zone (900 – 1300m asl).*

*The cultivars evaluated were AREP 2, Teishu Ponkan, Ohta Ponkan, AREP 1, Ohtsu and Local Mandarin. There was significant difference among the cultivars. The horticultural characteristics of Local Mandarin were much inferior to the other cultivars. Among them, Ohta Ponkan and Teisho Ponkan possess the best horticultural characteristics and were found to be early cultivars. By mid November, there was good skin colouration, the brix% was higher and they gave better citric acid percentage (1.3-1.6).*

*It may be concluded that Ohta Ponkan and Teisho Ponkan are very good cultivars for mid-altitude areas (1300 to 1700 m asl) offering the opportunity for expansion of citrus cultivation zone by 400 m above the usual citrus cultivation zone.*

### **KEYWORDS:**

Citrus, Mandarin, Cultivars, Pulp, Brix, Citric Acid

### **INTRODUCTION**

In Bhutan, the cultivation of citrus is mainly dominated by mandarin orange although some amount of lime, lemons, pummelos and citron do exist. Plantations are found mainly in humid sub-tropical areas in the foothills at altitudes between 300 and 1500m (RNRRC-E, 2006). Among the fruit crops, citrus is a major crop holding the maximum area and is grown on a commercial scale followed by apples and arecanut (DoA, 2004). In total there are around 1,831,312 citrus trees, of which 983,407 are fruit bearing

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trees. Over 70% of the crop is grown in the five Dzongkhags of Samdrup Jongkhar, Chukha, Sarpang, Tsirang and Samtse (in decreasing order), while the Dzongkhags of Punakha, Wangdue, Trongsa, Mongar, Trashiyangtse and Trashigang grow on a much smaller scale (DoA, 2004).

The quality of local mandarin fruits which are cultivated in higher altitude areas are very poor and the yield of mandarin orange in Bhutan is very low (32 kg per tree) compared to other developed countries (DoA, 2004). There was also a decrease in production level by 14% between 2002 and 2004 and decrease in the total number of trees and bearing trees by 11% and 16% between 2002 and 2004 respectively (RNRRC-E, 2006). It could be due to poor management (no proper fertilization, grown under rain-fed conditions, negligible pest and disease control, no fruit thinning, etc) and citrus decline due to HLB disease. In addition, we do not have any released variety of improved citrus beside our local mandarin.

Therefore, a varietal evaluation on citrus was conducted in a location which lies above the normal citrus cultivation zone with the objective to identify a cold tolerant variety with good horticultural characteristics that can be cultivated above the usual citrus growing zone.

## **MATERIALS AND METHODS**

### **Site Selection**

The experiment was established at Wengkhar UNDER Mongar Dzongkhag at an elevation of 1660 m asl on a north-west facing slope in March 2002.

### **Cultivars for evaluation**

The exotic mandarin cultivars were obtained from Japan through AREP-JICA Project. The Local Mandarin cultivar was obtained from Dorokha under Samtse Dzongkhag and it was used as a check cultivar. This local check is called Dorokha Local. The cultivars evaluated were AREP 2, Teishu Ponkan, Ohta Ponkan, AREP 1, Ohtsu and Local check. The cultivars were grafted onto USDA Trifoliolate rootstock (Shigeto *et al.*, 2004) in March 2001. The one-year old grafted plants were established in March 2002 and there are three trees per cultivars. All the cultivars came into fruiting from 2005 and fruit quality analysis was carried out in 2006. All the cultivars were managed similarly in terms of fertilization, irrigation, weed control, fruit thinning, tree training, pest and disease management.

### **Evaluation date and evaluation parameters**

The cultivar assessment in terms of fruit quality was carried out in 2006. The cultivars were evaluated over a time period starting from 30<sup>th</sup> September till 15<sup>th</sup> December at an interval of 15 days. Three matured fruits randomly selected per variety per analysis date were analysed and in total 6 analysis were carried out. The following parameters of the fruits were analyzed; fruit weight in grams, fruit length & width in cm, skin colour using the citrus maturity scale, skin thickness in mm using vernier callipers, number of seeds, pulp weight in grams, juice weight in grams, brix % using refractometer and citric acid content using titration scale. Finally a cumulative variety ranking was carried out to assess overall merit. A highest score of 6 were given to the cultivar with best quality parameter and a lowest score of 1 was given to the cultivar with least preferable quality parameter.

### **Data Analysis**

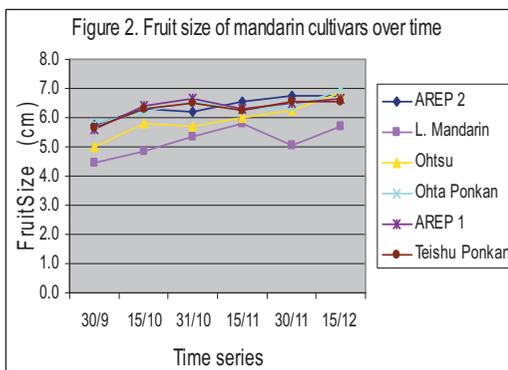
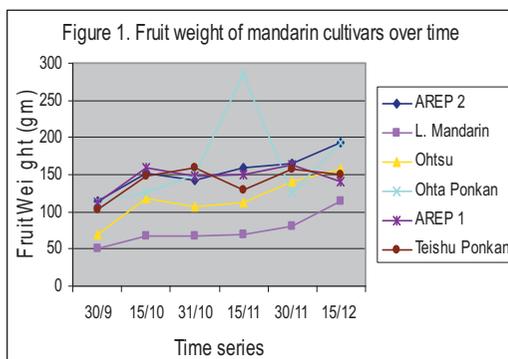
MS Excel was used in compiling the data and then exported to GENSTAT for Windows, Version 3.2, Lawes Agricultural Trust, Rothamsted for fruit quality analysis with the analysis of variance (ANOVA).

## **RESULT AND DISCUSSION**

### **1. Fruit Weight and Fruit Size**

Fruit weight and fruit size varied considerably among the mandarin cultivars (Figure 1 and Figure 2). There was a significant differences in fruit weight ( $P < 0.001$ ). The fruit weight of Ohta Ponkan was the highest followed by AREP 2 and Teisho Ponkan. Among all, Local Mandarin gave the smallest fruit weight.

There was a significant difference in fruit size among the 6 mandarin cultivars. The check cultivar Local Mandarin gave the smallest fruit. Among the exotic mandarin cultivars, Ohta Ponkan, AREP 2 and AREP 1 gave bigger fruits than Teisho Ponkan and Ohtsu.



The fruit size of different mandarin cultivars ranged between 5.2 and 6.4 cm.

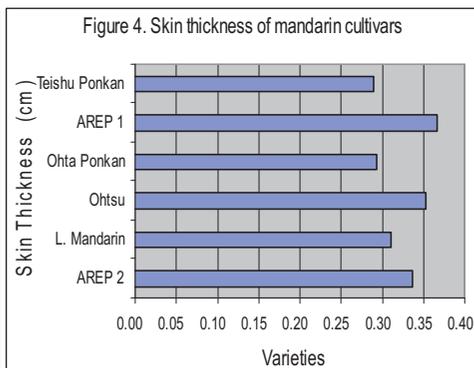
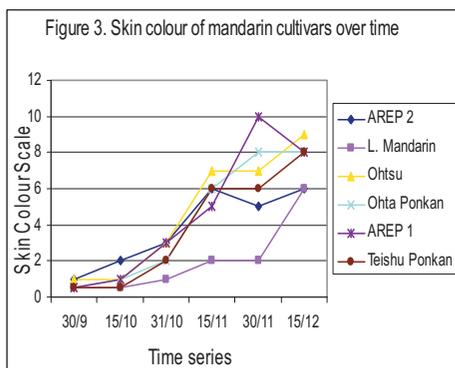
Significant differences were also observed in fruit height ( $P < 0.001$ ) and fruit width ( $P < 0.001$ ) among the cultivars and over the time frame. The height of Ohta Ponkan and Teisho Ponkan were significantly bigger than the height of AREP 2 and AREP 1. Dorokha Local was the smallest in fruit height. The width of AREP 2 and AREP 1 were significantly wider than the width of Ohta Ponkan, Teisho Ponkan and Ohtsu. Dorokha local got the smallest fruit width. Thus, it was clearly shown that Dorokha Local was the smallest fruit among the evaluated cultivars.

Based on the fruit weight and fruit size, the superiority of exotic mandarin cultivars over our local Mandarin cultivar was clearly demonstrated.

## 2. Skin Colour and Skin Thickness

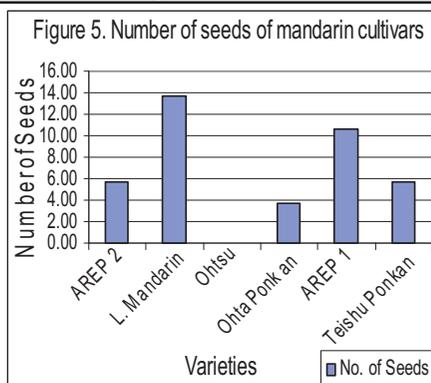
The colour of skin is also an important indicator of mandarin maturity. There was a significant difference in the skin colouration and skin thickness of the mandarin cultivars (Figure 3 & Figure 4). By mid November, Ohtsu, AREP 1, Teishu Ponkan and Ohta Ponkan attained good skin colouration whereas Local Mandarin and AREP 2's skin colouration were not very good. The skin colouration indicated the earliness of Ohtsu, AREP 1, Teishu Ponkan and Ohta Ponkan in comparison to Local Mandarin and AREP 2.

Skin thickness is also an important quality parameter and there is more demand in the international market for mandarins with thinner skin therefore most of the newly bred mandarin cultivars will have very thin skin. Significant differences were observed in skin thickness of the mandarin cultivars ( $P < 0.001$ ). Ohta Ponkan had the thinnest skin followed by Teishu Ponkan whereas AREP 1 had the thickest skin followed by Ohtsu. Skin thickness result showed the superiority of Ohta Ponkan and Teisho Ponkan.



### 3. Seediness

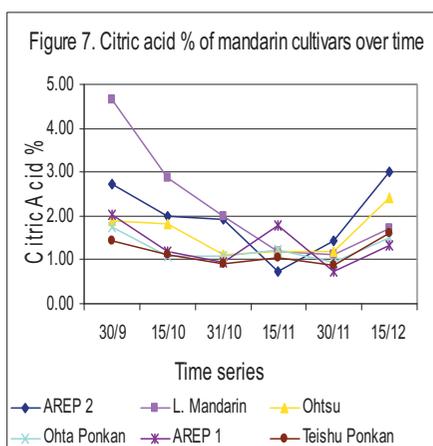
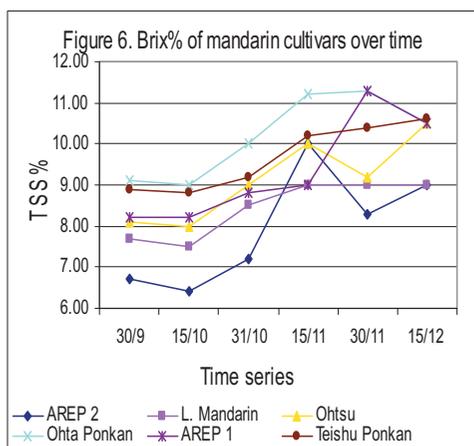
There was a statistically significant difference in the number of seeds among the 6 mandarin cultivars ( $P < 0.001$ ). Local mandarin had the highest number of seeds followed by AREP 1 and AREP 2 which also had significantly higher number of seeds ( $> 10$  seeds) than Teisho Ponkan and Ohta Ponkan (4-6 seeds). Among them, Ohtsu is almost a seedless variety (Figure 5). The higher the seediness of a mandarin cultivar, the lesser will be the market opportunities.



The citrus breeders are working towards bringing out seedless citrus cultivars.

### 4. Brix percentage and citric acid content

In all the harvest dates, the sugar content (brix percentage) of Ohta Ponkan and Teishu Ponkan was higher than the sugar content of other cultivars (Figure 6). By mid November, Ohta Ponkan and Teishu Ponkan gave more than 10% which indicates that they are early cultivars and can be harvested by mid-November. By mid December, two more cultivars, i.e. Ohtsu and AREP 1 gave good brix % which indicates that they are mid varieties. AREP 2 and Local Mandarin may be considered as late cultivars and they may be harvested only in January when the sugar content is expected to rise with time.



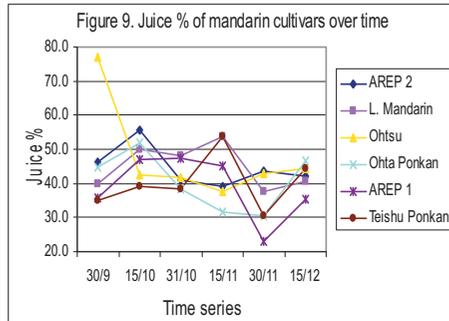
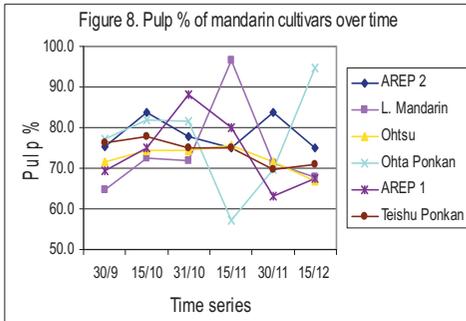
The optimal range of citric acid content should be in between 0.7 to 1.2 %. However, all the evaluated mandarin cultivars had slightly higher citric acid content than the optimal range. Among them, AREP 1, Ohta Ponkan and

Teishu Ponkan gave better citric acid percentage (1.3-1.6) than the other three cultivars (Figure 7). The reason could be due to low temperature during the last few months of crop maturity.

Brix-acid ratio of Ohta Ponkan and Teisho Ponkan tended to be low in comparison to other varieties, therefore, the taste of Ohta Ponkan and Teisho Ponkan are better than other cultivars.

### 5. Pulp percentage and Juice percentage

There was a significant difference in the pulp percentage between the cultivars ( $P<0.01$ ) and between the different harvest dates ( $P<0.001$ ). All the



cultivars had their pulp percentage more than 70% (Figure 8). The pulp percentage of AREP 2 was the highest followed by Ohta Ponkan and Teisho Ponkan. The pulp percentage of Ohtsu was the lowest.

There was also a significant difference in juice percentage between the cultivars ( $P<0.001$ ) and between the harvest dates ( $P<0.001$ ). Ohtsu had the highest juice percentage and Ohta Ponkan had the lowest juice percentage. Although there was a significant difference in juice percentage, all the cultivars had more than 39% juice which is very good (Figure 9). The minimum requirement of juice percentage for a mandarin fruit is 30%.

**Table 1:** Cumulative Variety Ranking Matrix

Mandarin Cultivars	Fruit Wt.	Skin Color	Fruit Ht.	Fruit Wtd.	Skin Thick	Seed No.	Brix %	Citric %	Juice %	Pulp %	Total
AREP 2	5	3	4	6	3	3	1	2	4	6	37
L. Mandarin	1	1	1	1	4	1	2	1	5	3	20
Ohtsu	2	6	2	2	2	6	3	3	6	1	33
O. Ponkan	6	5	6	4	6	5	6	5	1	5	49
AREP 1	3	4	3	5	1	2	4	4	2	4	32
T. Ponkan	4	2	5	3	5	4	5	6	3	2	39

Table 1 shows the cumulative variety ranking exercise. It considers all the fruit quality parameters. It was found that the best cultivar among the evaluated mandarin cultivars was Ohta Ponkan followed by Teisho Ponkan. Ohta Ponkan and Teisho Ponkan suggest themselves to have the most promising fruit quality.

## **CONCLUSIONS**

It may be concluded that by using the 5 exotic varieties evaluated here, citrus cultivation can be further expanded by 400 metres above the existing optimum citrus growing area without compromising on the quality of fruits. All the exotic cultivars were successfully harvested, with variation in harvesting time.

Although all the exotic cultivars were better than the Local Mandarin, Ohta Ponkan and Teisho Ponkan performed the best. These two cultivars had very good fruit characteristics. Teisho Ponkan and Ohta Ponkan have higher brix % and lower citric acid content which makes the new cultivars sweeter than Local Mandarin. Therefore, these two cultivars may be proposed for release so that Druk Seed Corporation can multiply them and make them easily available for farmers.

With the promotion of Ohta Ponkan and Teisho Ponkan, farmers will be able to fetch premium price for their crop because they can be brought into the market earlier than Local Mandarin and that also with much better taste and size.

## **ACKNOWLEDGEMENT**

Our sincere acknowledgement for this piece of work goes to AREP-JICA for providing us with the germplasm and analyzing equipments and resources.

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## **Pathogenic Variability of *Colletotrichum capsici* Isolates on Chili (*Capsicum annuum* L. and *Capsicum chinense*)**

Kinlay Tshering<sup>1</sup>

### **ABSTRACTS**

*With the past efforts in breeding for resistance to anthracnose in chili, resistance to three species of Colletotrichum, i.e. C. acutatum, C. gloeosporioides and C. capsici has been observed in two accessions of Capsicum chinense viz. CO4554 and PBC932. However, very few isolates of Colletotrichum capsici have been tested on these accessions. The present study was conducted to examine the resistance of PBC932 to different isolates of C. capsici from a range of locations and hosts. Two methods of inoculation (drop and wound/drop) were used. A significant difference in the pathogenicity of the C. capsici isolates was observed. All the 8 isolates from Thailand were pathogenic on the susceptible line Bangchang (C. annuum), and four of the eight C. capsici isolates from Thailand were also pathogenic on the resistant line PBC 932. Three isolates out of five from Queensland infected the susceptible line but not the resistant line. From this study, it could be suggested that PBC 932 may have to be screened further before releasing an anthracnose resistant chili pepper variety using PBC 932 as a parent line.*

### **KEYWORDS:**

Anthracnose, *Colletotrichum*, Chili, *Capsicum*, Resistance, Pathogenicity

### **INTRODUCTION**

*Capsicum annuum* L. is the major species of commercial chili grown throughout the world, while *C. chinense* is grown for its high capsaicin content and disease resistance. The production of chili is greatly constrained by anthracnose disease caused by fungal pathogen, *Colletotrichum* species viz. *C. capsici*, *C. gloeosporioides*, *C. acutatum*, *C. coccodes* and *C. dematium*. Among them, *C. capsici* and *C. gloeosporioides* are noted as the most significant pathogens of chili pepper fruit (Roy *et al.* 1997, Manandhar *et al.* 1995, Hadden and Black 1989, Kim *et al.* 1999).

Breeding for resistance is a very important component of the integrated management techniques for control of anthracnose because of the ease of use

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of resistant varieties and the lack of potential negative effects on the environment (AVRDC 2002, Kim *et al.* 1999). However, breeding for resistance to anthracnose is complicated by the ability of most *Colletotrichum* species to form quiescent infections. Recently, resistance to three species of *Colletotrichum*, i.e. *C. acutatum*, *C. gloeosporioides* and *C. capsici* has been observed in two accessions of *C. chinense* (CO4554, PBC932) and three accessions of *C. baccatum* (PBC 880, PBC 81, PBC 133) (AVRDC 2002). Since genetic exchange is possible between *Capsicum chinense* (PBC932) and *C. annuum*, several studies have attempted to develop resistant cultivars of *C. annuum* through interspecific hybridization with PBC932 (Pakdeeveraporn *et al.* 2005, AVRDC 2002). BC<sub>3</sub>F<sub>4</sub> lines are now being used as the resistant parent in a breeding program to develop advanced anthracnose resistant *C. annuum* cultivars (AVRDC 2003).

Although PBC932 has been found to be resistant to *C. capsici*, very few isolates of the fungus have been tested. In addition, it was reported by Tshering (2008) that there was a huge variability within the *Colletotrichum capsici* species at both morphological and molecular level because of geographical isolation. Moreover, Pring *et al.* (1995) reported that *C. capsici* is not a host specific pathogen. Therefore, it is important to test resistance of PBC932 to different isolates of *C. capsici* from a range of locations and hosts.

This study on the pathogenic variability of *Colletotrichum capsici* was conducted with the objectives to: i) Examine the pathogenicity of *C. capsici* isolates collected from different locations and different hosts, ii) Determine the resistance level of *C. chinense* genotype (PBC 932) to isolates of *C. capsici*, and iii) Assess the effect of inoculation method on the severity of fruit infection.

## **MATERIALS AND METHODS**

### **Preparation of chili pepper fruits**

*C. chinense* PBC 932, a resistant line and *Capsicum annuum* cv. Bangchang, a susceptible line were grown in a glasshouse between February and October 2005 at the Parkville campus, University of Melbourne, Victoria. For inoculation experiments, six fruits each were collected from both the resistant and susceptible lines. The detached fruits were washed under running tap water for 60 seconds followed by surface sterilization by immersing the fruit in 70% ethanol for 3 minutes, followed by 1% sodium hypochlorite solution for 5 minutes and then washing three times in sterile distilled water for 2 minutes each time and drying with sterile paper towels.

**Isolates used**

Thirteen isolates of *Colletotrichum capsici* and one isolate of *Colletotrichum gloeosporioides* was used for this experiment.

**Table 1:** *C. capsici* and *C. gloeosporioides* isolates used for pathogenicity trial

Pathogen	Isolate	Origin of isolate	Pathogen	Isolate	Origin of isolate
<i>C. capsici</i> (Chili)	DoAC 1511	Thailand	<i>C. capsici</i> (Sugar Apple)	BRIP 25478	Australia
<i>C. capsici</i> (Chili)	F1-2E	Thailand	<i>C. capsici</i> (Manettia)	BRIP 25584	Australia
<i>C. capsici</i> (Chili)	F2-1E	Thailand	<i>C. capsici</i> (Chili)	BRIP 26974	Australia
<i>C. capsici</i> (Chili)	F3-1A	Thailand	<i>C. capsici</i> (Chili)	BRIP 28371	Australia
<i>C. capsici</i> (Chili)	F4-2C	Thailand	<i>C. capsici</i> (Soybeans)	BRIP 4739	Australia
<i>C. capsici</i> (Chili)	F5-5A	Thailand			
<i>C. capsici</i> (Chili)	F6-5A	Thailand			
<i>C. capsici</i> (Chili)	F8-3B	Thailand			
<i>C. gloeosporioides</i> (Chili)	DoAC 1508	Thailand			

**Preparation of fungal inoculum**

Mono-conidial cultures of the thirteen *C. capsici* isolates and one *C. gloeosporioides* isolate (DoAC 1508) (Table 1) were grown on potato dextrose agar (PDA; Difco Laboratories, USA) for 14 days at 28°C under 12 hour light/dark cycle. The spores were harvested in wet condition. Ten ml of sterile distilled water was added to the surface of the cultures, gently scraped and agitated using a bent glass rod to get spore suspension. The spore suspension was filtered through four-folds of cheesecloth to remove mycelium and other debris. The inoculum density was adjusted to  $1 \times 10^6$  spore/ml using a haemocytometer. Same spore concentration was used as standard inoculum concentration for carrying out all experiments.

**Inoculation method**

The surface sterilized fruits were placed on a polystyrene tray that was then placed in a plastic box (25x16x6cm) that contained 500 ml of sterile distilled water to maintain 100% relative humidity. Two laboratory inoculation methods i.e drop (AVRDC, 2002) and wound/drop were adopted for inoculation. For each inoculation method, 6 fruits of the resistant accession and 6 fruits of the susceptible accession were used. The drop method was executed by placing 6 µl of conidia suspension in the middle portion of each

chili pepper fruit. The control fruits received 6 µl of sterile distilled water. The wound/drop method was accomplished by pin-pricking the chili pepper fruit wall to a 1 mm depth with a sterile needle in the middle portion of each chili pepper fruit and then placing 6 µl of conidia suspension onto the pin-pricked wound. Control fruits had the same pin-pricking but received 6 µl of sterile distilled water. Containers were then covered with black cloth with darkness for 24 hours at 25°C after which they were incubated at 25°C at 12 hour light/dark cycle of 7 additional days until evaluation.

### **Evaluation of anthracnose symptom development**

The parameters used for measuring disease severity and development were lesion length, lesion appearance, conidia characteristics and the severity of infection. The severity of infection of *Colletotrichum capsici* and *C. gloeosporioides* on *Capsicum chinense* and *C. annuum* was assessed by making a direct visual estimation of the percentage of diseased area of each fruit. Disease symptoms were scored from 7 to 14 days after inoculation (DAI) using a 0-5 point scale, where, 0 = no infection; 1 = 1-2% fruit area infected; 2 = 3-5% fruit area infected; 3 = 6-10% fruit area infected; 4 = 11-25% fruit area infected; 5 = > 25% fruit area infected. Isolates that induced reaction types 0, 1 and 2 were graded as non-pathogenic, while isolates that induced reaction types 3, 4 and 5 were rated as pathogenic. To assess the conidia characteristics, 5 mm<sup>2</sup> pieces of fruit tissue were cut from lesions and placed in 1 ml of sterile water. After vortexing for 1 min, the conidia were observed using a compound microscope using 100x magnifications.

### **Statistical analysis**

For all experiments a complete randomised design was used and a factorial analysis of result was used, considering three factors as follows: Factor 1 = Isolate; Factor 2 = chili pepper species; and Factor 3 = Chili fruit maturity stage. Analysis of variance (ANOVA) and correlation analysis were performed using Minitab Version 14 for Windows.

## **RESULTS AND DISCUSSION**

### **RESULTS:**

#### ***Development of anthracnose on susceptible and resistant lines***

A highly significant difference in the pathogenicity of the *C. capsici* isolates was observed. All the isolates from Thailand were pathogenic on the susceptible line Bangchang (*C. annuum*), and four of the eight *C. capsici* isolates from Thailand were also pathogenic on the resistant line PBC 932

(*C. chinense*) (Table 2). Three isolates out of five from Queensland infected the susceptible line but none of them infected the resistant line. The out group *C. gloeosporioides* was also pathogenic on the susceptible genotype as well as on the resistant genotype.

### ***Rate of symptom development***

There was a significant difference in the rate of symptom development by the *C. capsici* isolates. All the isolates from Thailand infected the chili pepper fruits at a relatively faster rate when compared to isolates from Queensland (Table 2). Visual anthracnose symptoms for all Thai isolates appeared on the susceptible 'Bangchang' fruits as early as 3-4 DAI (days after inoculation). On the resistant line 'PBC 932' the visual anthracnose symptoms induced by four Thai isolates (F2-1E, F6-5A, F8-3B and DoAC 1511) appeared 4 DAI. In comparison, the first visual symptoms on 'Bangchang' induced by three Queensland isolates (BRIP 28371, BRIP 26974 and BRIP 25584) appeared 6 DAI and the remaining two isolates (BRIP 4739 and BRIP 25478) failed to cause infection even 7 DAI and did not infect any chili peppers.

### **Visual anthracnose symptoms**

F1-2E and F3-1A induced a black sunken water soaked lesion covered with wet, gelatinous salmon coloured conidia exuding from ample acervuli containing numerous black setae scattered within the lesion areas. F4-2C induced dark brown sunken water soaked lesions covered with wet, gelatinous buff coloured conidia and there was mycelial growth on the infected area. However, no acervuli and setae were formed at 7 DAI. F5-5A, BRIP 28371, BRIP 25584 and BRIP 26974 produced translucent lesions with no visible spore pustules, acervuli and setae. F6-5A, F8-3B, DoAC 1511, F2-1E had dark sunken water soaked lesions with lots of acervuli containing numerous setae scattered within the lesion area.

Based on the disease severity, rate of symptom development and evaluation of anthracnose symptoms induced by the 13 *C. capsici* isolates on the resistant and susceptible genotypes using the wound/drop fruit inoculation method, the isolates could be grouped into five pathotypes, as outlined in Table 3.

**Table 2:** Disease severity ranking based on lesion length (cm) caused by *Colletotrichum capsici* isolates and *C. gloeosporoides* isolate on chili peppers 'Bangchang' and 'PBC 932' using wound/drop and drop inoculation method

Isolate	Wound/drop Inoculation		Drop Inoculation		Disease Severity Ranking
	Bangchang	PBC932	Bangchang	PBC932	
BRIP 25478	0.0	0.0	0.0	0.0	0
BRIP 25584	1.9	0.0	0.0	0.0	3
BRIP 26974	1.1	0.0	0.7	0.0	3
BRIP 28371	2.0	0.0	0.0	0.0	3
BRIP 4739	0.0	0.0	0.0	0.0	0
DoAC 1508	2.3	0.0	0.0	0.0	4
DoAC 1511	4.1	0.8	0.6	0.0	5
F1-2E	2.0	0.0	0.8	0.0	3
F2-1E	3.1	0.9	0.7	0.0	5
F3-1A	1.1	0.0	0.7	0.0	3
F4-2C	2.8	0.0	0.0	0.0	4
F5-5A	1.6	0.0	0.0	0.0	3
F6-5A	4.2	0.8	1.2	0.0	5
F8-3B	3.0	0.5	1.7	0.0	5
p-Value	<0.05	<0.05	<0.05	<0.05	

**Table 3:** Proposed pathotype groupings of the *Colletotrichum capsici* isolates based on their pathogenicity, rate of symptom development and lesion appearance on a resistant and susceptible accession.

Pathotype group	Isolates	Bangchang	PBC932	Characteristics
CCP-I	F1-2E, F3-1A, F5-5A	Y	N	Pathogenic only on susceptible genotype. Black sunken water soaked lesion covered with wet, gelatinous salmon coloured conidia.
CCP-II	F2-1E, F6-5A, F8-3B, 1511	Y	Y	Highly pathogenic on susceptible and resistant genotype with high rate of infection. Lots of acervuli and setae were present.
CCP-III	BRIP 28371, BRIP 25584, BRIP 26974	Y	N	Infect susceptible genotype but at a slow rate of infection. Translucent lesions after 6-8 days with rotting after 12-14 days.
CCP-IV	F4-2C	Y	N	Highly pathogenic on susceptible genotype. Lesion symptoms are different to CCP-I. Dark brown sunken water soaked lesions covered with wet, gelatinous buff coloured conidia.
CCP-V	BRIP 4739 BRIP 25478	N	N	Not pathogenic on both susceptible and resistant genotype. No sporulation

CCP = *Colletotrichum capsici* pathotype, Y = Yes infection and N = No infection

From the information in Table 2, the isolates can be divided into 4 groups. However, when the rate of symptom development and lesion appearances were taken into consideration, the isolates had to be further broken down into 5 pathotype groups (Table 3).

### **Development of anthracnose symptom using different inoculation methods**

The two inoculation methods caused different severity levels of anthracnose on chili pepper fruits. The wound/drop inoculation method resulted in infection with the virulent pathogen as early as 3 DAI. In contrast, the drop method did not result in anthracnose symptoms on the resistant line and on the susceptible genotype, symptoms did not appear until 7 DAI. At 9 DAI, only four isolates which were very pathogenic with the wound/drop inoculation method had infected the susceptible line with the drop inoculation method and at 11 DAI, an additional three isolates had infected the susceptible genotype. The rest of the isolates failed to cause infection on the fruits with the drop inoculation method until 14 DAI after which the experiment was terminated because the fruit started to senescence. The lesions that formed using the drop method were significantly smaller than lesions that were formed using the wound/drop inoculation method.

## **DISCUSSION**

This study revealed considerable pathogenic variation in *Colletotrichum capsici* from chili growing areas. *C. chinense* accession PBC 932 was resistant to the majority of the *C. capsici* isolates, which supports the reports of resistance by AVRDC (2003) and Pakdeevaporn *et al.* (2005). However, four of the Thai *C. capsici* isolates infected PBC 932 (Table 3). In comparison, the susceptible *C. annuum* line Bangchang was susceptible to all the Thai isolates as well as some of Queensland isolates. The identification of *C. capsici* isolates capable of infecting the resistant chili genotype is a major concern for the on-going anthracnose resistant chili pepper breeding programs by AVRDC (2003) and Pakdeevaporn *et al.* (2005) where resistance has been shown to be controlled by a single recessive gene of PBC 932 (Pakdeevaporn *et al.* 2005).

The rate of symptom development by Thai isolates was faster than that of the pathogenic isolates from Queensland. The variability in pathogenesis of the isolates and rate of symptom development between isolates of *C. capsici* suggests that pathotypes may exist, like in *C. lindemuthianum* (Drijfhout and Davis 1989) and that geographic location may be a factor in pathogenic variability. Therefore, there is a need to further understand the resistance

mechanism and the pathogenesis factors involved in specific pathotype infection.

Wounding increased the pathogenicity of all the isolates and symptom expression was more significant on the susceptible line. The lack of infection by 11 DAI using the drop method may have been due to the physical barrier of the cuticular wax layers on chili fruit which prevented or delayed the direct infection by the pathogen. The importance of the cuticular layers of the pepper fruits to preventing fungal infection was reported by Manandhar *et al.*, (1995) who observed that cuticle thickness is negatively correlated with anthracnose lesion expansion.

Although testing the pathogenicity of *C. capsici* collected from different hosts on chili pepper was desirable, the sample size was very small due to the lack of availability of a large-scale collection of *C. capsici* isolates. Only three isolates from different hosts were included in the study and of these only the isolate from Manettia caused infection on chili peppers. The other two isolates; BRIP 25478 from Sugar Apple and BRIP 4739 from Soybeans may be host-specific pathogens. These isolates were found to be quite different from the rest using molecular analysis (BRIP 4739) and morphological observations (BRIP 25478). Therefore, any statement based on host specificity was difficult and further pathogenicity testing of the *C. capsici* isolates that did not infect chili fruit and molecular analysis such as gene-sequencing work is needed before recommendation on speciation and host range can be made.

## CONCLUSION

The pathogenicity of *Colletotrichum capsici* isolates was found to be variable with some isolates being highly pathogenic while others were not very pathogenic. *Capsicum chinense* accession PBC 932 was resistant to the majority of the *C. capsici* isolates, but there are few isolates of *Colletotrichum capsici* which can infect PBC 932. Further pathogenicity testing of a larger collection of *C. capsici* isolates and isolates of other pepper infecting *Colletotrichum* species on chili pepper fruit, especially the resistant genotype PBC 932, are urgently required before releasing a resistant variety using PBC 932 as a parent line. There is also a need to further understand the resistance mechanism and the pathogenesis factors involved in specific pathotype infection.

Since chilli anthracnose caused by *Colletotrichum* species is prevalent in Bhutan especially in the low altitude areas, future research will need to work

on the identification of major species of *Colletotrichum* infecting chilli and also will need to consider the variable pathogenicity of *Colletotrichum* isolates on the local chili landraces and resistant lines before promoting any variety as an anthracnose resistant line.

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## Evaluation of Local Pears as Rootstocks

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### ABSTRACT

*Bhutan's rich and diverse agro-ecological zone harbours a vast number of pear species like *Pyrus pashia* D.Don, *Pyrus communis* L and *Pyrus serotina*. Although their production and export potentials are limited, their use as rootstock holds great potential. Therefore, this study was conducted to look into the possibility of utilizing them as rootstock for propagating improved pear cultivars and at the same time find an alternative use of local pears which will bring economic benefits to the rural poor.*

*Two types of locally available pear viz. small fruited pear and large fruited pear were evaluated as rootstock cultivars and two promising improved cultivars of Asian pear viz. Kosui and Chojuro were used as scion cultivars. The grafted plants were evaluated for their fruit quality and scion-rootstock compatibility. From the evaluation, it was found that the performance of local pears as rootstock were comparable to the exotic rootstock varieties when Kosui and Chojuro were used as scions. Therefore, from this study it could be surmised that local pears evaluated could be an alternative source of rootstock for the scion varieties tested.*

### KEYWORDS:

Locally available rootstock, compatibility, scion, quality parameters, precocity, trunk growth, Nashi pear (*Pyrus serotina*), abiotic and biotic stress, Total soluble solids (TSS)

### INTRODUCTION

Pear fruits are believed to have originated in temperate Europe and West Asia regions (IHC, 1994). Broadly speaking two types of pears are grown: European pear (*Pyrus communis*), which is usually pyriform in shape and has a fleshy pedicel and Asian or Japanese pear (*Pyrus serotina*), which is round in shape and has a non-fleshy pedicel. In Bhutan pears have been grown for ages although most of the cultivars are found to be of poor in fruit quality thereby rendering un-marketable.

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As per the RNR Statistics 2000, there were 12,580 numbers of pear trees. The year 2004 saw an increase in the number of trees by about 1000 plants (DoA, 2004). As of today there is no record of pear being exported. According to RNR Statistics 2000, only 23.1% of the total production was sold in the local markets. Lately, with the development of agriculture and horticulture in the country, improved varieties have been introduced. RC Wengkhar is working on many types of Asian pears. It is expected to contribute towards the income generation of our farmers besides improving their nutritional status.

Pear trees are found in almost every parts of the country ranging from 955 to 2700m above the mean sea level although not on a commercial level. Some of the pear species found in Bhutan are *P. pashia*, *P. communis* and *P. serotina*. The rootstocks used for the investigation purposes were two cultivars of local pear PL and PS.

In order to promote improved pear cultivars, a good rootstock variety and a grafting technique is essential (ICAR, 1997, Hartmann *et al.*, 1990). The success and failure of fruit cultivation is determined to a large extent by the choice and use of rootstocks. Rootstocks play a vital role as they influence the vigour of the plant, fruit yield, fruit size and quality, precocity and resistance and/or tolerance to the abiotic and biotic stresses. In other countries, the pear rootstocks are raised either from the seeds of a commercial variety or from those of wild pear (*Pyrus pashia*) (ICAR, 1997). On the contrary, farmers in Bhutan propagated and cultivated fruit crops through seeds leading to long gestation period, poor crops, unmanageable tree size and low productivity. To date, there are no suitable pear rootstocks identified and documented for pear cultivation in Bhutan. Therefore, identifying suitable rootstocks from locally available germplasm is essential for future development of pear cultivation.

As there are many local pear types with non-marketable fruit qualities, it is necessary to look into the possibility of utilizing them as a rootstock for propagating improved pear cultivars, which, if found successful, will bring economic benefits to the farming community. Therefore, the pear rootstock research was designed and carried out to assess local pear cultivars as rootstock for improved cultivars.

## **MATERIALS AND METHODS**

For evaluation purposes, two different types of locally available pears: one that bears small fruits (PS) and the other that bears large fruits (PL) were evaluated as rootstocks; and two promising improved cultivars of Asian pear: a) Kosui and b) Chojuro were used as scions. The seeds of two rootstocks types were stratified for 90 days in the refrigerator at about 4°C and the nursery was raised in January 2001. After a year, the two rootstock seedlings were grafted with the scions, Kosui and Chojuro, using top-veneer grafting technique in February 2002. Then the trial was established with one-year old grafted plants in 2003 at RNRRC-East, Wengkhar. The trial design used for the experiment was CRD with three replications. The six different treatment combinations used for the trial were:

1. Chujuro on PS
2. Chujuro on PL
3. Chojuro on exotic rootstock
4. Kosui on PS
5. Kosui on PL
6. Kosui on exotic rootstock

All the grafted plants in all the treatments and replications were managed in the same way as per the recommendations (Production technology for Asian Pears). In order to assess the quality of fruits, representative sample fruits were collected from different plants and analyzed for their quality parameters like fruit weight, fruit diameter, fruit height and firmness of the fruit, and total soluble solids in the laboratory using weighing balance, vernier caliper, refractometer and penetrometer respectively.

Trunk growth of the grafted seedling and successful graft union formation were assessed to look at the rootstock-scion wood compatibility. The data were statistically analyzed on one way ANOVA using Genstat for Windows Version 3.2, Lawes Agricultural Trust, Rothamsted.

The control rootstocks were raised after stratifying for 90 days at 4°C. When the seedlings attained graftable size (that is after one year) they were grafted with improved varieties of Kosui and Chojuro. Then one year later, they were established in the field along with those grafted on other two rootstocks of PS and PL and they were given uniform treatments as per the recommendations. Once the trees have come into fruiting (in the second year), representative fruit samples were collected and analyzed for fruit quality parameters and statistically analyzed.

In a similar fashion, the trunk growths of the plants were also taken note of after second year onwards to analyze for rootstock-scion wood compatibility.

## RESULTS AND DISCUSSION

### Fruit quality

#### Kosui fruit on PS and PL rootstocks

Table 1 shows fruit quality of Kosui and Chojuro when grafted on to two pear rootstocks PS and PL. Our findings indicate that Kosui when grafted onto PS and PL rootstocks there was no significant difference in fruit quality parameters like size, total soluble solids (taste) and firmness (Table 1). Hence, it suggests that PS and PL are equally good as rootstocks for Kosui variety.

#### Chojuro fruit on PS and PL rootstocks

Chojuro grafted onto PS and PL rootstocks showed similar results in terms of fruit quality. There was no significant difference observed with respect to fruit size, total soluble solids and firmness (Table 1) indicating that either of the two, Pl or PS, can be used as rootstocks for Chojuro variety.

#### Scion-rootstock compatibility

We also measured the trunk growth of the experimental plants over a period of 3 years to determine scion wood-rootstock compatibility (Figure 1). A steady growth of trunk was noted in all the combinations although it was marginally better in Kosui on PS rootstock.

**Table1:** Fruit quality evaluation on different rootstocks

Sl No.	Trial	Av. fruit diameter (cm)	Av. Fruit height (cm)	Av. TSS (%)	Av. firmness (kg/cm <sup>2</sup> )
1.	Kosui on exotic rootstock (control)	7.86b	6.70	11.21	0.72b
2.	Kosui on small rootstock	7.79b	6.67	11.26	1.02b
3.	Kosui on large rootstock	7.76b	6.92	12.00	1.07b
1.	Chojuro on exotic rootstock (control)	8.85a	7.20	12.60	1.60a
2.	Chojuro on small rootstock	9.41a	7.41	12.40	1.70a
3.	Chojuro on large rootstock	9.36a	7.76	12.57	1.92a
	p-Value	<0.001	ns (0.550)	ns (0.096)	<0.001
	Lsd	0.526	1.656	1.602	0.364

Chojuro on PS indicated a slower growth after 3<sup>rd</sup> year though Chojuro on PL indicated improvement even though it was bit slower to start with.

However, no significant difference was observed with respect to trunk growth among these combinations.

In the final analysis, the results indicated that there were no incompatibility observed between the improved varieties (Kosui and Chojuro) and locally available rootstocks (PS and PL).

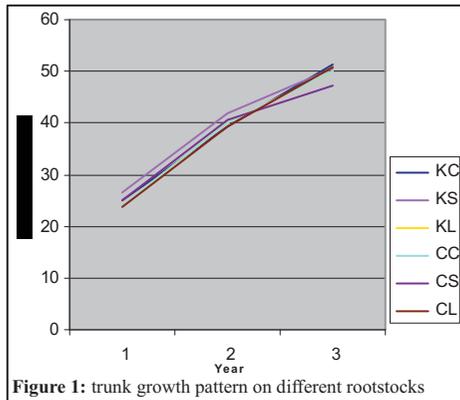


Figure 1: trunk growth pattern on different rootstocks

KC: Kosui on exotic rootstock (control); KS: Kosui on small rootstock; KL: Kosui on large rootstock  
CC: Chojuro on exotic rootstock (control); CS: Chojuro on small rootstock; CL: Chojuro on large rootstock

## CONCLUSION

Our research clearly indicates that there is no significant difference between the two local rootstocks, PS and PL, and the exotic rootstocks on the performance of the scion varieties, Kosui and Chojuro, used for the parameters tested. The fruit quality and the trunk growth rate were comparable between the local pear rootstocks and exotic rootstocks used for the scion varieties. Therefore, from the study it could be said that the local pears could be utilized profitably and productively as rootstocks. Local pears can also be top worked with improved varieties. Hence, local pears (both small and large fruited ones) can be utilized effectively.

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## **Assessment of Improved Method of Persimmon Processing, Packaging, and Marketing; and Economics of Improved Method**

Gyambo Tshering<sup>1</sup>

### **ABSTRACTS**

*In Punakha-Wangdue valley, Nobgang village is known for persimmon production and marketing of fresh and dehydrated fruits products. Of late, Farmers from Nobgang reported problems of persimmon marketing since domestic market for fresh fruit is sensitive to over supply and fruit cannot be stored once harvested. Therefore, a study on persimmon processing, packaging and marketing of dehydrated persimmon products was conducted with two farmers from Nobgang. Different dehydrated persimmon products were developed and the trial marketing of these products was conducted in local market in the country. From the trial marketing, it was observed that the dehydrated products developed locally were comparable in quality to the imported dehydrated fruits products from India and Thailand as the products were found readily acceptable with consumers.*

*From the cost-benefit analysis of farmers' and improved dehydrated persimmon products it was found that the whole fruit dehydrated product gave the highest return, followed by fruit splits and least by the fruit slices. It was also found that farmer practice of fruit dehydration, packaging and marketing runs into loss or in other words there was no value addition. The study also revealed that the performance of improved NPHC dryer was better than imported electrical dryer (Ezi dryer) and natural sun drying for persimmon dehydration.*

*Therefore, the from this study it may be concluded that the Ministry of Agriculture must promote the improvised persimmon drying methods, the NPHC dryer and sale of the dehydrated persimmon products to enhance cash income of small farmers.*

### **KEYWORDS:**

Persimmon; astringent; non-astringent; processing; dehydration; packaging; marketing; prices; profit; loss; farmers; researcher; extension.

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## **INTRODUCTION**

Farmers in Punakha-Wangdue Valley grow mostly astringent type of persimmon cultivars viz. *Aundeybom*, *Pemchen* & *Lamchu* in their homestead (annual report 2002-03, RNRRC-Bajo). Farmer in Nobgang village under Punakha Dzongkha is known for its persimmon production and marketing of fresh fruit and dehydrated fruit products. On an average farmers at Nobgang grew about 4-40 persimmon trees. Increasing number of farmers are planting persimmon as it does very well in the area and is one of the important source of cash income for them.

In the recent past, farmers of Nobgang raised concern of persimmon marketing as increasing numbers of farmers are growing persimmon and marketing has increasingly become difficult as price fetched and amount sold are very low. The Renewable Natural Resource Research Centre (RNRRC)-Bajo and Punakha Dzongkha Agriculture staff held a consultative meeting with Nobgang persimmon growers for addressing the issue of persimmon production and marketing. The most pertinent issue that came out of the meeting was the need to address the improvement of production, packaging and marketing of persimmon.

Persimmon cultivars grown by the farmers were processing type (astringent type), meaning they are best sold as processed (dehydrated) products. However, dehydrated products fetched very low prices (Nu. 40-50/kg) due to poor quality. Fresh fruit for market can be picked only at ripened stage with very short shelf life. As a result, if fruits are not sold immediately, they are not fit for either consumption or processing. With increasing production, farmers are faced with the challenge of marketing both fresh fruit and dehydrated product.

Fresh fruits are picked at ripened stage and immediately taken to the local market or to the weekend market in Thimphu. Farmers also market dehydrated products. The dehydrated fruit slices are made by slicing the fruits with skin intact, and then sun drying them to achieve a certain consistency. These dehydrated fruit slices are packed in gunny bags for market in Thimphu during the weekends. The bulk of dehydrated persimmon products are sold during the first month of Bhutanese Lunar calendar as it is bought for religious purposes. Due to this inferior quality of packaging, often times causing mold growth, the quality of product is low and fetches very low price (Nu. 40-50/kg of dehydrated product).

In the light of the above limitations leading to low market prices, a study on

improved persimmon processing, packaging and marketing was conducted with two farmers in Nobgang village with the following objectives:

- To carry out participatory development of different grades of dehydrated persimmon products; and
- To assess economic benefits of improved persimmon processing, packaging and marketing in comparison to local practices.

## **MATERIALS AND METHODS**

The study was conducted with two farmers in Nobgang village who produces persimmon and have problem of marketing their produce. The astringent persimmon fruits are harvested when fully matured but still firm because all local persimmon cultivars (*Aundeybom*, *Pemchen* and *Lamchu*) become soft when ripened and are not suitable for processing as fruit burst on peeling and slicing.

Four grades of dehydrated fruit products were made, viz. whole fruit, fruit plits, fruit slices with skin and without skin intact. The dehydrated whole fruits were prepared by harvesting fruits with a bit of the branch attached to the stem so as to form cross bar of 'T'. Fruits were washed in running water to remove any adhering materials; fruits peeled using simple kitchen knife and tied together with a loop of strings around the base of the 'T' and knotted along the long trenched of rope for natural sun drying.

The fruits splits are prepared by peeling, washing and splitting the fruits into four or more depending on the fruit size. The fruit slices or rings prepared by slicing fruit into thin round slices with and without skin intact.

The different persimmon products (whole fruit, fruit splits and fruit slices) are either sun dried or dehydrated using improved electrical dryers. Two types of electrical dryers were used, viz. improved NHPC electrical dryer and imported one (Ezi dryer). The fruit splits and slices/rings were laid either on improved simple dehydrator trays prepared from locally available bamboo for electrical dehydration or on bamboo mats spread in open space for natural solar dehydration. The trays and mats containing persimmon products were covered with nylon net for natural sun drying. To protect from rain, wooden frames were made that were laid over the tray/mats with processed products and a tarpaulin was pulled over the frame. The fruits slices and splits had to be gently over turned to promote even drying if products are dried under the sun and this process is not required for improved electrical dehydration.

For electrical drying, once the products are placed inside the dryer trays, temperature was set at 35°C or 45°C as appropriate and heater or electrical dryer was switched on until the product is leathery dry. Once the persimmon products become leathery on twisting, they are packed in bigger capacity plastic bags, stacked and kept in a clean storeroom for curing (sugar crystallizes especially on whole fruit surface) for a couple of weeks. After the curing process the products were ready for market. They are then packed, labeled and sealed in plastic bags of 100g capacity. Then, the trial marketing of different products that were properly packed and labeled was done in Supermarket and few retail shops in Thimphu and Wangdue, respectively.

Data on time taken for peeling of fruits which is only additional works in the improved methods of persimmon processing were noted. The dehydration time required both for natural sun drying and improved electrical dryer was recorded. The products quality of different methods of processing and different product grades was assessed through consumers rating.

The economic assessment of farmers and improved method of persimmon processing were done with help of agriculture economist of this centre. The cost of raw materials (fresh fruit, packaging materials), labour, electricity and equipment (electrical dryer and sealer) depreciation cost were used to calculate the cost of production of different products. The farm gate price (FGP) per unit of the products was fixed based on cost of production, product quality, consumers rating, drying recovery rate and with a profit margin of about 100% for whole fruit and fruit split products and about 60% for fruit slices or rings. The maximum retail price of product was fixed with a profit margin of 20% for the retailer. The existing market price for farmers' product was retained in this calculation. The sensitivity analysis on cost-benefit of different grades of dehydrated products was done at varying level of raw material cost (Nu.10, 15, 20 per kg of fresh fruit) and was being compared with farmer's product.

## **RESULTS AND DISCUSSION**

The time taken for natural sun drying and using improved electrical dryer (NPHC & Ezi dryer) and drying recovery rate of various persimmon products are given in Table 1. The time taken for peeling of fruit prior to dehydration and processing bi-products are documented in Table 2. The different grades of dehydrated products, packaging, pricing, cost of production, net return and consumers rating are given in Table 3.

The whole fruits took longest hours to dry while fruit slices or rings dried up in the shortest time under Nobjang weather condition regardless of the

different drying methods (Table1). Among various dehydrated products, drying recovery percentage is highest for whole fruit, followed by fruit splits and fruit slices. This could be due to varying level of drying on the surface and inner parts of whole fruits and fruit splits products but in case of fruit slices, uniform drying of product is easily achieved. It is observed that the dehydrated products made from improved methods of persimmon processing were clean and hygienic compared to the farmers' practices (natural sun drying).

Imported electrical Ezi dryer is not suitable for drying fruit splits and whole fruits since the space between the crates are small but it can be used for drying of fruit slices. Improved NPHC electrical dryer is preferred at the farm as it is suitable for drying of all grades of persimmon products as well as for drying of other products like meat, fruits and vegetables. It was also found that the local persimmon cultivars like *lamchu* (small) and *Pemchen* (medium size) are suitable for drying into whole fruits while *aundaybom* is too big and takes very long time for drying. Thus, *aundaybom* can be suitably processed into persimmon splits and slices or rings without peel.

**Table 1:** Time taken for dehydration of different persimmon products under different drying methods and the dried fruit recovery rates

Different persimmon products	Time taken for drying (hours)					Drying recovery (%) at about 12% moisture level
	Natural open Sun drying	Under the roof natural drying	Ezi dryer at 45 <sup>0</sup> C	Improved NPHC dryer at 45 <sup>0</sup> C	Improved NPHC dryer 35 <sup>0</sup> C	
Whole fruits	185-190	Not suitable (mould fungus)	Not suitable	Case hardening in 24 hours	120-130	29.2
Fruit splits	120-125	„	24	36	72-80	26.8
Fruits slices with peel removed	80-90	„	10	12	48-50	24.6
Fruit slices with peel intact	80-90	„	10	12	48-50	24.6

**Table 2:** Time taken for peeling of 1 kg of fruits and processing waste percentage (peels & calyx)

Different types of persimmon	No of fruits per kg	Average time taken for peeling (minutes)	Average time taken for slicing (minutes)	Processing waste (%)
Aundaybom	4 to 5	3	2.4	17.4
Pemchen	10 to 11	5	4.5	18.3
Lamchu	15 to 16	10	8.6	19.2

Pricing of different products is based on the product quality as per consumer rating, cost of production, drying recovery rate and profit margin (Table 3). It was also found that consumers' perceptions were congruent with quality standards developed and presented by the researchers. Among the various dried persimmon products, whole fruits is rated “Excellent”; “Very Good” for fruit splits; “Good” for fruit slices with skin peeled off; “Poor” for fruit slices with skin intact (farmers practices); and fruit peel/skin was rejected for human consumption but can be processed as an excellent animal feed.

The economic assessment of different dehydrated products (Table 3 & Fig 1) clearly demonstrated that unit cost of production of whole fruit is significantly lower than all others different dehydrated fruit products, exception being farmer's product. Among the different products, fruit slices recorded highest cost of production. This is mainly due to additional labour cost involved in making fruit slices for this product and low drying recovery percentage. The net return per unit product was obtained highest from whole fruit (> 100% profit), followed by fruit splits and least from fruit slices. The quality products combined with good presentation of products fetched better price (3 times higher return) than the farmer's dehydrated product. Farmers' practices of fruit processing, packaging and marketing runs into loss of Nu.2.79 per 100gm of dehydrated product produced and sold at the existing market price of Nu.40 per kg of dehydrated product or in other words there was no value added by the processing of fruits and marketing as dehydrated product (Table 3).

**Table 3:** Different processed products, production cost, net return, pricing and its consumers rating

<b>Dehydrated products</b>	<b>Net weight (gm)</b>	<b>Cost of prod. (Nu.)</b>	<b>Return (Nu.)</b>	<b>FG price (Nu.)</b>	<b>Retail Price (Nu.)</b>	<b>Consumers rating</b>
1. Whole fruits	100	6.53	8.47	15	20	Excellent
2. Fruit splits	100	7.05	7.95	15	20	Very Good
3 Fruits slices with peel removed	100	9.11	5.89	15	20	Good
4. Fruit slices (farmers)	100	6.79	-2.79	4	4	Poor

Further, it was found that the different processed products packaged in sealed plastic bags improved shelf life of products drastically compared to farmer's packaging and storing in gunny bags. Improved dehydrated products packaged in plastic bags and sealed can be stored or kept in shop's

shelf for more than a year from time of packaging and remain fit for consumption which is a huge advantage over farmer's product.

The trial marketing indicated that the improved persimmon products are readily acceptable with consumers and was found comparable to imported dehydrated fruits products from India and Thailand. In the local retail shops and market, when the dehydrated persimmon products were sold alongside the imported similar products of persimmon, trial marketing was very successful. This may suggest that the quality of our products and costs were comparable to the imported ones.

The economic assessment or sensitivity analysis of different dehydrated products was carried out in comparison to return per kg of fresh fruit market basis at varying level cost of fresh fruit (Fig 1.). This was mainly done to assess the viability of processing of fresh persimmon into dehydrated products as fresh fruit is the

main raw material and its cost (fresh fruit market price) is the main factor contributing to the cost of production and thereby net return from this enterprise. Fig 1 clearly demonstrates that the net return or profit is highest if the fresh persimmon cost is lowest (Nu.10/kg) and profit decreases with increasing cost of fresh fruit. It also shows that processing fresh persimmon into dehydrated products such as whole fruits and fruit splits is profitable even at the cost of Nu.20 per kg of fresh fruit but fruit slices or rings products result into loss at that cost. Farmers processed product (fruit slices with skin intact) runs into varying degree of loss at different fresh fruit cost (Nu.10, 15 & 20/kg), mainly due to poor quality and low price it fetches in the market.

## CONCLUSION

The study clearly demonstrated that farmers' practices of persimmon processing, packaging and marketing runs into loss but the improved methods of persimmon processing, packaging and marketing was economically viable and added value on fresh fruit market price basis and 3 times higher than farmers' dehydrated product.

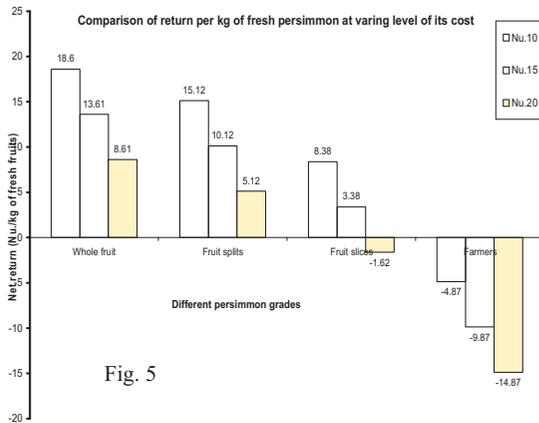


Fig. 5

Among the various dehydrated persimmon products, whole fruit was rated best in quality and also gave highest return, followed by fruit splits and fruit splices or rings. Thus, it may be recommended to process persimmon into dehydrated products such as whole fruit and fruit splits taking technical and economic viability into consideration. The processing of persimmon into fruit splits was recommended though it yielded lesser return than whole fruit, mainly due the fact that existing persimmon cultivar- *Aundreybom* is not technically suitable for processing into whole fruit product as the size is too big for drying with the available dryers. Therefore, *Aundreybom* can be processed into fruit splits and other two existing cultivars-*Lamchu* and *Pemchen* can be processed into dehydrated whole fruit product.

The improved NPHC electrical dryer should be promoted as the best dryer for drying dehydrated persimmon products and encourage farmers for processing of local persimmon into whole fruit and fruit splits dehydrated products to enhance the profit from this enterprise.

## **ACKNOWLEDGEMENT**

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# *Livestock*



## **Effect of pasture type and supplementation level on nutrient intake and milk production of Holstein-Friesian cows in summer**

Chencho Dukpa<sup>1</sup> and Julian Hill<sup>2</sup>

### **ABSTRACT**

*Summers in south-eastern Australia are usually hot and dry during which time the productivity of perennial ryegrass based pastures are at their lowest. This calls for need to look into alternative fodder systems if dairying in the region is to remain viable in the long term.*

*In order to examine effects of pasture type and level of supplementation of whole-crop oat on milk production, 40 Holstein-Friesian cows in late lactation in summer were allocated randomly into a RCBD trial. The typical Australian system, i.e., ryegrass supplemented with concentrate (RC) was compared with 4 other systems, viz. ryegrass + chicory (Ch), ryegrass + chicory + concentrate (ChC), ryegrass + chicory + whole-crop silage (ChS) and ryegrass + chicory + concentrate + whole-crop silage (ChCS).*

*The study suggests that milk production was in the increasing order ChS, Ch, RC, ChC and ChCS ( $P < 0.01$ ). The response was an effect of the substitution of whole-crop silage on pasture intake and overall intake of metabolisable energy.*

### **KEYWORDS:**

ryegrass, chicory, whole-crop cereals, milk production.

### **INTRODUCTION**

Existing production system which is dominated by ryegrass-white clover pasture poses certain problems to dairy farmers in Southern Australia (Nie *et al.*, 2004). Their seasonal growth pattern creates feed deficit in summer and winter. Milk production during mid to late summer is adversely affected by declining rates of pasture production and a consequential decrease in voluntary intake from grazed grass. There is a need to look for alternative strategies to even out the seasonal distribution of forage supply. Whole-crop

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cereal silages offer the potential of a high yielding crop that can be fed as buffer feed during such times. Cereal silages typically have medium to high content of neutral detergent fibre (NDF) depending on the grain to straw ratio as affected by cutting height and harvesting date (Castejon, 1992; Hill, 1992). This feature could be utilised effectively in summer if fed in combination with highly digestible summer crops with low fibre content such as chicory (Barry, 1998).

The aim of this experiment was to study the effect of pasture type (summer active + perennial rye grass vs. perennial rye grass only) and level of supplementation of whole crop silage and concentrate on the performance of late lactation cows in summer.

The specific objectives of the experiment are to (a) quantify the effect of supplementing late lactation cows grazing perennial ryegrass pasture in summer with 4 kg DM/cow/day of concentrate (estimated 13 MJ/kg DM, 172 g CP/kg DM) on total intake and milk production (b) quantify the effect of offering a restricted allocation of chicory (7 kg DM / cow / day) with either 0 or 4 kg DM/cow/day of concentrate on total intake and milk production and (c) assess the effect of offering whole crop (oat) silage (4 kg DM / cow / day) fed under identical regimes to objective 2 on total intake and milk production.

## **MATERIALS AND METHODS**

### **Experimental site**

The experiment was conducted at the North Farm, Glenormiston College, University of Melbourne, near Terang, South West Victoria, during the period 7-24 March 2005. The soil on the site was described as 'grey heavy clay loam' (Skene, 1948). It was slightly alkaline (pH 7.5) with a P (Olsen) status of 32 mg/l.

### **Pastures**

Pasture field divided into perennial ryegrass (PRG) and chicory paddocks was selected as experimental site. The ryegrass pastures (cv. Samson, sown autumn 2002) had received normal management practices before the grazing experiment with heifers and cows grazing the pastures to the desired sward height (approximately 8 cm) in the months immediately preceding the trial. The chicory paddocks, established in 2004, were composed of Choice chicory, Tribute white clover and Sensation red clover, hereafter referred to as 'chicory' pasture. The chicory pastures were allowed to grow through the period November to early March receiving fertilizer (45 kg/ha mono ammonium phosphate) in early November 2004.

### **Silage production**

Whole crop oat silage (cv Echidna) was sown in May 2004 and mown with Laylely Spledin disc mower and harvested at anthesis using a round baler (John Deere 466) on 16<sup>th</sup> October 2004. The oat crop had received single superphosphate (11% S, 8.8 % P) at 125 kg/ha at the time of planting. Prior to harvesting, an additive (Sil-All water soluble powder, Alltech Biotechnology Pty Ltd. Australia) was applied at a rate of 15 g/t of wet crop. Pre harvest samples of the crop were taken (n=5) to estimate yield, botanical composition and chemical composition. The harvested crop was wrapped using a string binding and double wrapped (75% overlap) and stored for 130 days before feeding.

### **Treatment rations**

The treatment rations and pasture allowances are shown in Table 1. Each treatment ration aimed to supply the energy requirements of the cows without limitation of dietary protein for the synthesis of metabolisable protein. At the time of treatment designing, the assumptions regarding the cows were that they produced 15 litres milk/d with 3.7% fat and 3.5% protein, weighing approximately 450 kg, gaining 0.2 kg/d and 150 days pregnant. Based on these assumptions, a figure of approximately 145 MJ/d was calculated (AFRC, 1993). The rations were then designed to supply the same (using approximate feed values (M/D) as: ryegrass 10, grain 13.3, chicory 10.6 and silage 9). The pasture allowances suggested should not have limited voluntary intake of pasture and/or nutrient selection by cows and therefore allowed them to fully express the forage-forage or forage-concentrate interactions. Each treatment was replicated twice with a total of 40 cows used in the experiment. Thus, a group of 4 cows formed the experimental unit.

### **Animals**

Forty multiparous Holstein Friesian cows were selected from the Glenormiston autumn-calving herd. The cows were calved down the previous winter (mean calving date 6 July 2004; range 20 June to 20 July 2004) and were in late lactation at the start of the experiment. The cows selected were average 236 days (range 223 to 252 days) into lactation at the start of the experiment. The allocation of cows into 10 four-cow groups was based on parity (mean parity  $4.6 \pm 1.57$ ; range 3 to 7), milk yield in kg/day ( $18.1 \pm 2.35$ ), body weight in kg ( $455 \pm 53.4$ ), condition score according to Earle (1976) ( $4.7 \pm 0.6$ ), days pregnant (151 days pregnant; range 137 to 171), fat plus protein yields in kg/day (F+Y  $1.40 \pm 0.09$ ; range 1.04 to 1.75). The allocation was achieved by stratified randomisation based on body weight, milk yield, body condition, milk fat and milk protein yields, in descending order of importance.

**Table 1:** Treatment rations and pasture allowances.

Sl No.	Treatment Code	Treatment ration (kg DM/cow/day)				Pasture allowance**	
		Silage	Grain	Chicory	Estimated DMI of ryegrass*	Chicory	Ryegrass
1	RC	-	4	-	9.2	-	18.5
2	Ch	-	-	5	9.4	7.1	19
3	ChS	4	-	5	5.4	7.1	11
4	ChC	-	4	5	2.5	7.1	10
5	ChCS	4	4	5	0	7.1	10

\* Assuming intake of the other components were 100%, these had to be the intake from ryegrass to fulfil the daily energy requirement of 145 MJ.

\*\* For perennial ryegrass-based cows (RC), pasture was offered at 50% DM utilization of above ground mass. For chicory + ryegrass cows (Treatments 2-5), chicory was offered at 70% utilization and perennial rye grass was offered at rates ranging from 25% to 50% utilization. Treatments 4 and 5 were allocated 10 kg DM pasture allowance – the lowest allowance possible from a practical point of view for grazing. The pasture allowance and utilization principles were drawn from Hodgson (1990).

### Feeding protocol of rations

- Daily cereal silage allowances were offered in one single feeding, immediately after the morning milking. Cows not allocated to cereal silage treatments were kept in a yard after milking and let onto their respective paddocks after the silage cows have finished eating the offered feed.
- The daily allowance of the concentrate (4 kg DM / cow) was fed at a rate of 2 kg DM in the morning and 2 kg DM in the evening.
- The chicory-perennial rye grass base (Treatments 2 – 5) was strip grazed with the daily chicory allowance between the morning and evening milking. The chicory allowance was allocated using a double wire at offer and back to prevent after-math grazing. After evening milking the cows strip grazed the daily allowance of perennial rye grass pasture base again using a double wire system at offer and back.
- Cows offered with perennial ryegrass pasture only strip grazed with the daily allowance allocated after morning milking, using a double wire at offer and back.
- Cows had *ad libitum* access to water in the paddocks.

### **Experimental program**

The experiment comprised three periods - a 5-day uniformity period, a 7-day adaptation period and a 5-day measurement period. During the uniformity period all 40 cows strip grazed perennial ryegrass paddocks as a single herd and were fed a supplement of 5 kg DM/cow/day of ryegrass hay/silage in the paddock. Production data during this period was used to allocate the cows to the various treatments and also to serve as covariate data for subsequent data analysis. The 7-day adaptation period was required to allow the cows to adapt to the experimental rations and routine. Data on voluntary DM intake, diet composition, nutrient intake, and yield and composition of milk were recorded throughout the experimental program, however, analysis was done only on data over the last 5 days, and hence that period was referred to as measurement period.

### **Measurements**

The cows were milked twice daily at 0700 and 1700 h. Milk yields (AM and PM) of individual cows were weighed daily throughout the experiment using a platform scale. Milk meters (automatic representative sampling) were used to sample milk for compositional analysis. Milk sampling occurred on days U1 and M4. Samples of milk were analysed by Warrnambool Herd Improvement for fat, protein and lactose.

Daily voluntary intakes of oat silage and grain concentrates were measured. Any refusals of silage and concentrate were collected and sampled. The samples were stored frozen for subsequent chemical and nutritive analysis. Both the offered and refused samples were pooled separately over the measurement period.

The total intake was estimated from ME requirement employing a procedure similar to that described by Baker (1982). Intake of perennial ryegrass was calculated by subtraction of silage, concentrate or chicory intake (calculated using pre and post grazing assessments) as appropriate from total intake.

Pasture allocation was done by estimating pre-grazing pasture mass using calibration equations derived by cutting 25 quadrats ( $0.1 \text{ m}^2$ ) to ground level and regressing the mass on pasture height measured by a rising plate meter (RPM) as described by Stockdale and King (1983). Herbage mass of the chicory paddocks were determined by cutting five  $1 \text{ m}^2$  quadrats to ground level across the paddock. Additional quadrats were cut from each replicate paddock of ryegrass and chicory every fourth day during the adaptation and measurement periods and the data were pooled to update the initial calibration equation for the crops.

Toe cut samples of the pre and post-grazing pastures were taken to ground level on most days throughout the experiment to determine the botanical composition, chemical and nutritive value of the pasture (Dry Matter (DM), Crude Protein (CP) Neutral Detergent Fibre (NDF), Acid Detergent Fibre (ADF), Neutral Detergent Cellulase Digestibility (NDCD) and Dry Matter Digestibility (DMD)-estimated Metabolisable Energy (ME)). The samples were separately mixed thoroughly and a representative sub-sample containing about 200 pieces were taken and apportioned into sown pasture, clover, weeds and dead portion. Individual components were dried at 100°C for over 24-h to estimate the DM and chemical composition of the pre-grazing pastures and the residues.

The rest of the toe-cut samples were stored in the freezer before being bulked. The samples were dried for 48 hours at 60°C and analysed for DM, CP, NDF, ADF, WSC and DMD (estimated ME).

### **Data analysis**

Data on milk yield and milk constituent contents and yields were analysed by one way ANOVA (Genstat 8). Milk production data (yield and composition) of the measurement period were covariate adjusted for between-cow differences based on data of uniformity period. Simple linear regressions were used to determine relationships between pasture height and mass when calibrating the rising plate meter.

## **RESULTS**

### **Feed quality**

Table 2 shows the botanical composition of the two pasture types. The dead materials were quite substantial, especially in the chicory pasture. Clover and weeds formed substantial proportion of the chicory pasture, hence the paddocks were far from being a pure chicory stand. Table 3 shows the chemical composition and nutritive value of the feedstuffs. The M/D values for all feedstuffs, except the concentrate, came out to be slightly lower than the estimated values on which the energy supply estimations were based when designing the rations. The crude protein content of chicory was high and similar to levels in spring pasture whereas that of the ryegrass was low relative to the 12-14% requirements for late lactation cows (NRC, 1989).

**Table 2:** Botanical composition of perennial ryegrass (PRG) and chicory pastures offered to animals in the experiment. Green/dead ratio calculated from live sward components.

Pasture type	Perennial ryegrass	Clover	Chicory	Weeds	Green	Dead
PRG	0.89	-	-	0.11	0.58	0.42
Chicory		0.18	0.59	0.23	0.23	0.77

**Table 3:** Chemical/nutritive composition of feedstuffs

Feedstuffs	NDF (g/kg)	ADF (g/kg)	CP g/kg)	Ash (g/kg)	DMD (g/kg)	M/D*
PRG pasture	577	342	118	96	643	9.3
Chicory	473	221	267	84	675	10.4**
WCC silage	521	288	89	86	574	8.9**
Concentrate	277	189	127	58	844	13.3***

\*estimated from DMD by NIRS \*\*estimated as NDCD (DMD x 0.0155)

\*\*\*declared value by manufacturer

### Treatment effects on ryegrass pasture

No significant differences between individual calibration equations derived for each perennial rye grass paddock was observed. The data for all paddocks was therefore pooled to provide a single calibration equation for pre grazing:

$$y = 179.53x + 894.56 (R = 0.754; \text{r.s.d.} = 605; \text{CV} = 19.9; n = 98)$$

where y = pasture mass (kg DM/ha), x = rising plate meter reading (cm).

However, there were significant differences among the paddocks for post-grazing equations which did not permit pooling. The respective equations for post-grazing are as follows:

Ch  $y = 0.675x + 27.233 R^2 = 0.0526; \text{rsd} = 698; \text{CV} = 32.4 n = 26$

ChS  $y = 0.289x + 30.254 R^2 = 0.0141; \text{rsd} = 455; \text{CV} = 33.6 n = 22$

ChC  $y = 0.345x + 29.147 R^2 = 0.0645; \text{rsd} = 398; \text{CV} = 29.5 n = 24$

ChCS  $y = 0.555x + 28.134 R^2 = 0.0534; \text{rsd} = 439; \text{CV} = 30.8 n = 31$

Where y is pasture mass t DM/ha and x is rising plate meter reading (cm)

There is considerable variation among the equations suggesting that the treatments imposed had varying levels of grazing pressure. This is evident from pasture height and mass post grazing (Table 4). Furthermore, the lack of relationships between pasture mass and rising plate are typical for summer conditions in south east Australia and therefore support the use of pooled equations.

**Table 4:** Details of pre and post grazing ryegrass paddocks (values in parenthesis are std. dev)

	Pregrazing sward height (cm)	Post grazing sward height (cm)	Pre-grazing pasture cover (kg DM/ha)	Post grazing mass (kg DM/ha)
RC		3.675 (0.61)		2483 (291)
Ch		4.76 (0.85)		2891 (158)
ChC	6.3 (0.59)	4.08 (1.44)	3286 (126)	2407 (240)
ChS		4.19 (1.25)		2652 (304)
ChCS		4.46 (1.22)		2655 (268)

### Dry matter intake of various feedstuffs

Table 5 shows the intake of various feedstuffs among the treatments. The intake of ryegrass pasture for ChC and ChCS were more than estimated.

With respect to pasture type (RC vs. ChC), the addition of chicory component led to a decrease in the intake of ryegrass. The substitution of chicory for ryegrass was 0.41 kg DM ryegrass per kg DM chicory.

The inclusion of the whole-crop silage component showed a consistently substituting effect for other components. If we compare Ch vs. ChS, the inclusion of 4 kg DM silage led to depression of 1.76 kg and 1.48 kg for chicory and ryegrass respectively. The total forage substituted was therefore 0.81 kg/kg DM silage. Similar substituting effect was seen when comparisons were made between ChC vs. ChCS, although the effect was less. Depressions in intake were 0.77 and 1.36 kg/d for chicory and ryegrass respectively, with a total forage substitution rate of 0.53 kg DM/kg silage.

The case is interestingly different with inclusion of concentrate in the diet. Instead of substituting for forage, intakes of the later were enhanced. Comparing Ch vs. ChC, intakes were maintained (not significant increase) with differences between RC, Ch and ChC of only 0.10 and 0.18 kg/d for ryegrass and chicory respectively, giving a total forage intake increase of 0.07 kg forage/kg concentrate. With ChS vs. ChCS, the increases in intakes were 1.17 and 0.22 kg/d for chicory and ryegrass respectively. The total forage intake increase was therefore 1.39 kg/kg concentrate.

**Table 5:** Dry matter intake of various feedstuffs (kg DM/cow/day).

Treatment	Concentrate	Silage	Chicory	PRG pasture	Total VFI
RC	4			6.51	10.51
Ch			5.32	4.16	9.48
ChS		4	3.56	2.68	10.24
ChC	4		5.50	4.26	13.76
ChCS	4	4	4.73	2.90	15.63
s.e.d			1.054	1.210 <sup>p</sup>	1.381

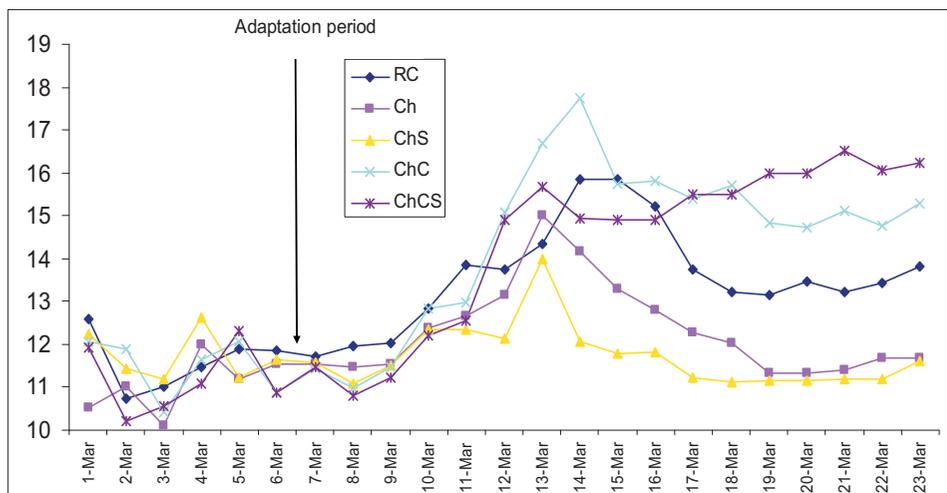
\*\*P<0.01, \*\*\*P<0.001, ns-Non significant, VFI-Voluntary feed intake

### Milk yield, milk fat and protein

If the milk yields during uniformity period are compared to the milk yields of all the treatments in the measurement period, there was an increase except for treatment ChS. The response to treatments can be ranked as ChCS = ChC (highest), RC (intermediate), Ch = ChS (least). This is evident from the

pattern of milk production towards the end of the experiment (Fig. 1). The fat content of the milk was, in general, variable. Fat yield followed more or less the same trend as milk yield/milk solids. The milk protein content was numerically (but not significantly) different with Ch being lower than any other treatment. As with fat yield, protein yield showed a similar trend as milk yield.

When examining more specific aims of the experiment, the effect of types of pasture (RC vs. ChC), was an increase in milk yield by 1.2 kg (not significant) due to inclusion of chicory. However, the effect of incorporation of concentrate and/or silage to chicory-based pasture system was to depress intake of forage with whole-crop silage whereas intake was increased by inclusion of concentrate. If a comparison between Ch vs. ChS is made, milk yield was depressed by 0.2 kg/d due to 4 kg silage inclusion but between ChC vs. ChCS, a depression of 4.8 kg/d due to 4 kg silage was observed. The effect of concentrate inclusion followed a similar pattern as with intake. Increases in milk yield were 3.4 and 1.2 kg/d due to 4 kg/d intake of concentrate for the comparisons Ch vs. ChC and ChCS vs. ChS respectively.



**Fig 1:** Milk yield (kg/cow/d) changes across the experimental period

## DISCUSSION

It is important to note before the discussion of the milk production responses that a few remarks are made concerning the experimental design. The experiment used two replicate paddocks per treatment with 4 cows per replicate. This means that there is limited information on voluntary intake (especially pasture intake) with two pooled means per treatment. Therefore, the lack of true replicates of pasture intake limits the interpretation of results.

Furthermore, as pasture intake was based on a pre-determined calculation of energy requirements, the pasture intake is constrained by energy budget. Recently, Milne (2006) identified the key issues that affect the design and implementation of dairy production trials.

The intake of ryegrass pasture for ChC and ChCS were more than estimated. This clearly suggests that there were no limitations on pasture intake imposed due to varying levels of pasture allowance and that depressions in forage intake observed may be attributed to substitution effects of either whole-crop silage, concentrate or chicory.

As a percentage of body weight, the total voluntary feed intake figures were 2.08, 2.25, 2.31, 3.02 and 3.44 for Ch, ChS, RC, ChC and ChCS respectively. Cows of this body weight and condition producing below 20 litres of milk are estimated to eat 2.8% BW (AFRC, 1993). The intakes of Ch, ChS and RC were therefore low to moderate. For ChC and ChCS, the levels of intake were greater than expected.

The whole-crop silage had in general depressed intakes of the forage component, however, the range (0.53-0.81) of replacement (substitution) was moderate. The literature reports the levels of substitution much higher than these reported. Hargreaves *et al.* (personal communication, 2006) reported substitution for pasture of whole-crop barley silage in the range 0.84 – 1.1 kg pasture DM/kg silage. There was no evidence to suggest that silage intake increased fat content, suggesting that the level of silage used in the trial did not shift rumen fermentation parameters, especially of acetate output greatly.

The effect of concentrate in this experiment contrasted with most situations reported in the literature. In most cases, supplementation with concentrate led to a replacement of pasture (Stockdale, 1999; Walker *et al.*, 2001). The range of substitution reported were 0.02 – 0.31 kg forage/kg concentrate depending on the type of forage base used and level of supplement offered. In certain circumstances when the forage is of a fibrous nature, inclusion of a readily available source of energy helps better digestion of the former by the rumen microbes (McDonald *et al.*, 1995). This seems to have occurred in the case with ChS vs. ChCS. This may explain why the whole-crop silage had a lower effect on other forages when fed with concentrate.

The explanation for the variability in the milk yield of the various treatments can be clearly seen in their varying intake of energy. Energy (especially the supply of fermentable ME) is the major determinant of milk production in

dairy cows (McDonald *et al.*, 1995). Table 6 shows the ME intake for various treatments based on calculations using intake and energy content data (Tables 3 and 5). It can be seen that the rankings for milk yield or milk solids follows the same pattern as for ME intake. Although, ME intake calculations show ChS with a higher ME intake than Ch by about 3 MJ, this was not reflected in concomitant increase in milk yield, rather it was quite the opposite. Diets of low metabolizability (ME/GE ratio, denoted by  $q_m$ ) can adversely affect utilization of ME (McDonald *et al.*, 1995). The whole-crop silage used in the trial was dominated by material other than grain (89% of total dry matter) and bulky, suggesting that it may have low  $q_m$ .

Due to the low intake of ME, the performance of cows in Ch and ChS was poor relative to the other treatments. However, compared to yields reported elsewhere under similar diets, the yields were within expected levels. In a New Zealand study Waugh *et al.* (1998) offered late lactation cows 4 kg/cow.day of Grassland Puna chicory as supplements to ryegrass pasture and observed yields between 10 and 11 litres.

**Table 6:** ME contributions from various feedstuffs and total ME intake (MJ ME/cow/day).

	Ryegrass	Chicory	Silage	Grain	ME intake
Ch	38.69	55.33	-	-	94.02
ChS	24.92	37.02	35.6	-	97.55
RC	60.54	-	-	53.2	113.74
ChC	39.62	57.20	-	53.2	150.02
ChCS	26.97	49.19	35.6	53.2	164.96

## CONCLUSION

In summer when cows are in late lactation, and when ryegrass pasture quality and quantity declines, milk production can be improved in a number of ways. The usual practice of supplementing with concentrate is one such method (treatment RC). Chicory can replace concentrate as the sole supplement (Ch), however, the response was less than that observed with concentrate (RC). When chicory and concentrate are both used as supplement (ChC), response is greater than with concentrate alone (RC), reflecting the additional plus synchronous supply of nutrients. If whole-crop oat silage is considered as a supplement to ryegrass-chicory base pasture (ChS), no improvement in milk yield can be expected contradicting the assumption that whole-crop silage may complement chicory. However, if it is integrated with concentrate, milk yields are improved (ChCS). Concentrate in this situation appears to enhance intake and digestibility of

the various forage feedstuffs. It is suggested that the real benefits of whole-crop silage must be considered in context of farming system where it can have a sparing effect on valuable pasture, extending the feed supply in periods of feed shortage.

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## **Bovine tuberculosis survey in peri-urban dairy farm, Thimphu**

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### **ABSTRACT**

*A tuberculin skin test was used to detect and determine the prevalence of bovine tuberculosis infection in cattle of Thimphu peri urban dairy project areas of Ramma, Khasadrapchu, Namseling and Bjimena during April 2006. A total of 66 dairy cows from the project area participated in the study. The test was carried out using intradermal injection of 0.1ml of bovine tuberculin purified protein derivatives (PPD) into the middle third neck area and subsequent detection of swelling or inflammation at the site of injection 3 days (72±2hours) later. The reactions were interpreted based on the OIE guidelines. Not a single animal tested positive for bovine tuberculosis in this study confirming the absence of infection in the study animals.*

### **KEYWORDS:**

Thimphu peri-urban dairy project, bovine tuberculosis, Intra dermal tuberculin test,

### **INTRODUCTION**

Bovine tuberculosis (TB) is a chronic bacterial disease of animals and humans caused by *Mycobacterium bovis*. In many countries bovine TB is still a major infectious disease both in domestic animals and the wildlife population, and transmission to humans constitutes a public health problem (Menzie & Neill, 2000; Grange, 2001). The global prevalence of human tuberculosis due to *M. bovis* has been estimated at 3.1% of all human tuberculosis cases, accounting for 2.1 and 9.4 percent of pulmonary and extra pulmonary tuberculosis cases respectively (Cosivi et al., 1998). In addition, the presence of the disease in animals is a major economic problem for agricultural trade and industry in the world (Pollock and Neill, 2002).

Surveillance of bovine tuberculosis in cattle is an essential component of disease control program. And for this, the tuberculin skin test is generally accepted for diagnosing bovine tuberculosis in cattle and used as a tool for active surveillance and control of the disease (OIE, 2004). The test is

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considered to be highly specific (>99%) (Monaghan et al., 1994) and have sensitivity of over 91% (Costello et al., 1997). The control programme which is based on the tests, isolation, and slaughtering of infected animals have allowed for a dramatic decrease in the prevalence of bovine tuberculosis in the developed and some of the developing nations (Pollock and Neill, 2002; Cosivi et al., 1998).

Although clinical cases of bovine tuberculosis in cattle have not been reported in Bhutan, it was not studied systematically in the past. Recently many animals have been brought into periurban dairy project area from India where high prevalence of bovine tuberculosis due to *M. bovis* infection is reported (Prasad et al., 2005; Mukherje, 2006). This poses high risk to our cattle population in risk areas. Therefore, a survey of this nature is initiated.

Tuberculin test when done on a wider scale, may help to know about bovine TB disease status. Therefore, the main objective of this study was to carry out a survey to detect and determine the prevalence of bovine tuberculosis in dairy cattle in peri-urban dairy project farms, Thimphu which supplies fresh milk to the consumers in the city.

## **MATERIALS AND METHODS**

### **Selection of animals**

All peri-urban dairy project farms under Thimphu Dzongkhag were selected for this study. There were 151 animals registered with the project during April 2006. A sample frame was developed consisting a list of animals with cow ID, owners' name and source of cows. The criterion about the number of animals to sample within the project farm was that of detecting at least one positive reactor animal. The sample size was calculated using an expected prevalence of 3 % with a confidence level of 95% and desired absolute precision of 5%. The formula used to detect at least one positive reactor animal was (Martin et al., 1987)

$$n = [1 - (1 - \alpha)^{1/d}] * [N - \frac{(d-1)}{2}] = 68$$

where n is the number of animals required to sample;  $\alpha$  the probability of observing at least one positive reactor animal in the sample when the infection affects at least d/N of the animals in the farms; d the expected number of infected animals in the farms; N the total animals in the project farms. The 68 animals were randomly selected from the sampling frame, using computer random number generator in Microsoft excel.

### Single intradermal tuberculin test (SID)

Using the method described by OIE 2004, single intradermal tuberculin (SID) test was conducted in each of the study animal. The injection site on the middle neck of each animal was clipped and shaved. A fold of skin within each shaved area was measured with Vernier callipers, recorded the skin thickness and marked the site prior to injection. A 0.1 ml of bovine tuberculin containing 2000 IU per ml of purified protein derivatives (PPD) which was obtained from Indian Veterinary Research Institute (IVRI), Izatnagar, India was then injected into the dermis of the marked site of each animal using sterile syringe and needle. The skin-fold thickness of each injection site was re measured three days ( $72 \pm 2$  hours) post injection for recording any change in skin-fold thickness for interpretation. The difference between the original skin thickness and the post-test skin thickness was calculated for each injection site (Table 1).

The result of the test were then classified as : (i) *negative*, if only limited swelling is observed, with an increase of no more than 2 mm and without clinical signs, such as diffuse or extensive oedema, exudation, necrosis, pain or inflammation of the lymphatic ducts in that region or of the lymph nodes; (ii) *inconclusive*, if none of these clinical signs is observed and if the increase in skin-fold thickness is more than 2 mm and less than 4 mm and (iii) *positive*, if clinical signs, as mentioned above, are observed or if there is an increase of 4 mm or more in skin-fold thickness (OIE, 2004).

## RESULTS AND DISCUSSION

A total of 68 animals were randomly selected from a sampling frame of 151 animals registered with the peri-urban dairy project. Out of 68 animals, only sixty six animals have participated in this study. The other two animals were not available in the farm premises during the time of study. Table 1 shows the result of the tuberculin test in 66 animals and the difference in skin-fold thickness between the initial reading and post-injection reading. None of the animals showed any signs of inflammation at the site of injection and no swelling of skin more than 2 mm was noticed in any of the study animal 72 hrs post inoculation (Table 1)

**Table 1:** The difference in skin-fold thickness between the initial and post-injection reading

Difference in skin fold thickness between tested the initial (at 0 hour) and $72 \pm 2$ hours post injection (mm)	No. of animals
0	38
0.1	2
0.5	9
1.0	14
1.25	1
1.5	2

## **DISCUSSION**

The survey results indicated that the difference between the initial (0 hour) reading of skin thickness and post injection reading after 72 hours ranged from 0 to 1.5 (Table 1). As per the standard interpretation guidelines of the OIE 2004, less than 2mm skin swelling 72 hours post injection is considered as negative. The result obtained indicates that not a single animal tested positive to bovine TB, thus confirming the absence of infection in the study animals. However, the disadvantage of the tuberculin test is that it gives false negative responses that may occur in the early stages of the disease and in severely infected animals. To overcome this limitation, new diagnostic tests like gamma interferon assay, lymphocyte proliferation assay, and enzyme-linked immunosorbent assay are available, but the logistics and laboratory execution of these tests are the limiting factor (OIE, 2004). Besides, post-mortem investigations of lesions in slaughterhouses and trace back, where possible, would also give further information concerning the prevalence of bovine tuberculosis (Laval & Ameni, 2004). In addition, collection of lymph node from the local slaughter houses and bacterial identification using acid fast staining would provide information about the disease status in cattle.

## **CONCLUSION**

All animals of peri-urban dairy project in Thimphu tested negative to bovine TB based on the methods used. Additionally, the sample size for the present preliminary study was small and concentrated to small cattle holder farms. Therefore, similar studies may have to be conducted in different parts of the country particularly where there are functional dairy farmers groups supplying milk or milk products and those that are risk prone.

At present more number of organized and backyard dairy farms are being established in different parts of Bhutan. Some farmers import cattle from India while others try to get it from within Bhutan. Those animals that are imported from India are tested only for some diseases and are not screened for bovine TB. Therefore, it can be recommended that the imported cattle are also screened against bovine tuberculosis using tuberculin test at the quarantine station as an initial screening requirement.

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## **Goats in sub-tropical Bhutan: poor farmer's choice to enhance livelihood**

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### **ABSTRACT**

*A study was undertaken to improve the understanding on existing goat farming practices and its importance to resource poor farmers in Bhutan.*

*Findings revealed that average flock size per household was five goats. Flocks were managed with simple housing and feeding. In mid-altitude areas majority of farmers stall-fed goats with less palatable forage, while in low-altitude they were mostly tethered. This alternative feeding systems compared to open grazing is more environments friendly.*

*Goat has good reproductive efficiency. Mean age at puberty and age at first kidding were  $6.8 \pm 0.12$  and  $12.2 \pm 0.14$  months respectively. The kidding interval was about  $6.5 \pm 0.04$  months and number of kids born per year was  $2.5 \pm 0.08$ .*

*Goats played a significant socio-cultural and economic role to rural farmers in the study area. Quick returns from goats helped the farmers to generate income in less than a year to enhance their livelihood. It provided social security as goat could be sold to overcome financial crisis in a household.*

*From this investigation, it was found that promotion of goat farming has a great potential for poverty alleviation. However, research and development efforts have to be made to identify appropriate technologies for sustainable goat farming; and disseminated to the farmers as a community development program so that they can take up a profitable and sustainable enterprise.*

### **KEYWORDS:**

Goat, poor farmers, livelihood, poverty alleviation

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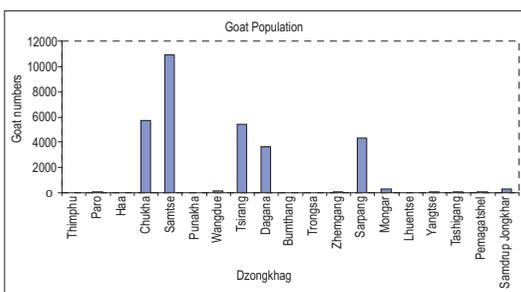
<sup>3</sup> RNR Research Sub-Centre, Dharla, Chukha.

## INTRODUCTION

Worldwide goats (*Capra hircus*) are kept for milk, meat and fine fibres (mohair and cashmere). Goats are also being used for biological control of troublesome weeds in many countries (e.g., in Australia and New Zealand (Pierce, 1990; RIRDC, 1997) and in USA (Jensen and Williams, 2002).

Goats in Bhutan are used for meat, manure, religious offerings and commercial purposes. They are generally reared along with other livestock. These animals have ability to utilize and survive on otherwise wasted fodder resources such as weeds (*Artemisia*, *Eupatorium* and other wasted plants) which are not palatable to other livestock. However, because of browsing habits, goat may destroy tender plants/sapling if grazing goes uncontrolled.

The goat population in Bhutan is about 31,000 heads with maximum concentration in sub-tropical belt viz. Chukha, Samtse, Sarpang, Tsireng and Dagana *dzongkhag* (district) (MoA,2000). The *dzongkhag* wise distribution of goat population is presented in Fig. 1.



**Fig.1:** Goat population distribution in Bhutan (Source: MoA, 2000)

About one third (32%) of the Bhutanese population are below the poverty line and poverty is more severe (38%) in rural areas compared to about 4 % in urban centers (Poverty Analysis Report, Bhutan August 2004). In the 10th Five Year Plan (FYP) (2008-2013), Bhutan places a strong emphasis on poverty reduction. Principal way is by supporting income generating schemes. Goat farming is an alternative income generating activity practiced by small-holder resource poor farmers. Promotion and supporting such a farming practice will enhance the income generating capacity on the farm.

However, as of now, research and development interventions on small livestock especially goats had been very minimal. Accordingly information available on goat farming is also scanty. Therefore, this study was undertaken:

- To document existing goat management practices;
- To look at the socio-cultural and economic impact of goat farming on resource poor households; and

- To look at the potentials that goat farming has on alleviating rural poverty and enhancing rural livelihood.

## **MATERIALS AND METHODS**

### ***1. Study area***

Study was carried out in Jigmechoeling and Gelephu *geog* (block) under Sarpang *dzongkhag*, Rangthangling and Tshendagang under Tsirang *dzongkhag*; Goshi and Tashiding *geog* under Dagana *dzongkhag*; and Pachu-Sadumadhu under Phuntsholing *geog* in Chukha *dzongkhag*. These *geogs* were selected by purposive sampling based on population density and farmers involvement in goat rearing.

### ***2. Sampling techniques and data collection***

A stratified two stage sampling techniques was adopted. In the first stage, villages with high goat population within goat rearing *dzongkhags* of Bhutan were selected.

In the second stage, 25 goat rearing households each from Sarpang, Tsirang, Dagana and Chukha were purposively sampled.

Semi-structured questionnaires were used to collect information from selected households on goat farming practices and the socio-cultural-economics impact of goat farming. Informal discussion was also held with resourceful farmers to validate information.

### ***3. Data Analysis***

- Quantitative variables were entered in spread sheet. Mean, Standard Error (SE) for flock size and reproductive parameters were calculated
- Chi squared ( $\chi^2$ ) test was used to see if there is differences in goat feeding system in low and mid altitude areas
- Qualitative data acquired through informal discussion were coded and put it into spreadsheet. The frequency of each answer was sorted, counted manually and, when practical, converted to a percentage.

## **RESULTS AND DISCUSSION**

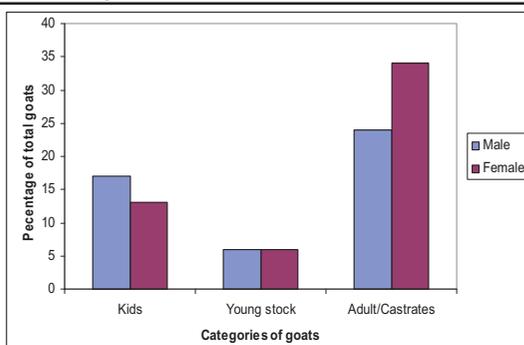
### **Existing goat management practices**

#### ***1.1 Flock size***

All household surveyed owned goats. Average flock size was four goats in Jigmecholing and six goats in other study areas. The latter is despite the

policy restrictions to limit goats to four. This is indicative of the profitability of goat and farmer's wish to maximize profit from this enterprise.

In most villages, the proportion of adult female was higher than the male (Fig.2) because males were often castrated and slaughtered for home consumption, sacrificed during the festivals and also sold live.



**Fig. 2:** Porportion of goats in study areas

### 1.2 Goat housing

Most of the farmers sheltered goats in their homestead for manure production as goat and sheep manure was considered best for growing crops. Housing was simple with enclosure made out of bamboo, poles or roughly finished timber. Wall of stalls were made from solid bamboo or wood and thatched with rice straw. The floor was often slatted for faeces and urine to pass through as goats reportedly love to live on dry shed and often avoids dampness and rain. Goat houses were small and there is hardly any space to move around. Bigger floor space would make goats comfortable.

### 1.3 Feeding management

Chi squared ( $\chi^2$ ) test revealed that the feeding management has strong association with geographical location where goats are reared ( $p < 0.003$ ). In mid-altitude areas significantly higher numbers of farmers tethered their goats on fallow land while in low-altitude areas more farmers stall-fed them. Farmers in both areas however also open grazed goats. This conveys that majority of farmers practice environment friendly feeding system and common notion that goats are let loose to browse the plantations by all farmers, at all times is not always true.

On stalls, goats were mostly fed with weeds such as *Artemesia vulgaris* (*tetay pati*), *Eupatorium adenophorum* (*kala zhar*) in the mid-altitudes while in low-altitudes they were fed with *Buhari Jhar*, *Bayar*, (thorny plants), *Cromolaena odorata* (Siam weed), lopped fodder trees, aracnut leaves and grasses. Crop by-product such as maize hull was also fed to adult goats. Compound feed as concentrate were seldom fed but whole cereal grains and salt were fed to fatteners. Kids were generally fed with gruel made out of

cereals. The above feed stuffs however appears to be fibrous and less nutritious. For better growth, protein sources such as oil cakes have to be supplemented in the diet.

#### **1.4 Reproductive management**

Farmers either maintained their own breeding stock or use bucks from neighbouring households or villages. The breeding stock if maintained are selected within local population and crossbred among the existing breeds. One or two males were kept in the community for breeding and rest of them are castrated at an early age to fatten for sale. Most mating took place from September to October and kidding from February to March- April. Use of limited number of breeding bucks and selection within a closed population would lead to inbreeding. Regular exchange/supply of unrelated breeding buck from elsewhere is warranted.

Goats had high reproductive efficiency with mean age at puberty and age at first kidding of  $6.8 \pm 0.12$  and  $12.2 \pm 0.14$  months respectively. The kidding interval was about  $6.5 \pm 0.04$  months and number of kids born per year was  $2.5 \pm 0.08$ . (Table 1).

**Table 2.** Reproductive parameters of goats

<i>Parameters</i>	<i>n</i>	<i>Mean</i>	<i>SE(mean)</i>
Age at puberty(months)	15	6.8	$\pm 0.12$
Age at first kidding (months)	15	12.2	$\pm 0.14$
Kidding interval (months)	15	6.5	$\pm 0.04$
Kids per year (nos.)	15	2.5	$\pm 0.08$
Life expectancy of Doe (yrs)	15	12.8	$\pm 0.23$
Productive life of Doe (years)	15	9.8	$\pm 0.13$
Total kids during lifetime(nos.)	15	19.6	$\pm 0.51$

Twin birth was very common. Triplet and even quadruplet births were also reported. Kids (young ones) were weaned at about four months of age. It is therefore obvious that high prolificacy of goats would result in birth of more than five or six kids before a doe (female goat) are three years old. This result is consistent with the finding from Philippines, where a doe is reported to give birth to at least five kids before it attained the age of three years (MBRLC, 1990). Thus, ability of goats to give birth a couple of years earlier than cattle and buffaloes would mean that farmers are able to get faster returns on their investments.

### **1.5 Goat health**

Goat suffered from circling/gid disease (*Coenurus cerebralis*) that often results in death and is detrimental to farmer's income. Faecal samples of sick goats tested in laboratory showed heavy worm burden especially with *Moniezia spp.* Inadequate sanitation has resulted in it. Advocacy on regular deworming and health care is necessary.

## **2. Socio-cultural and economic importance of goat farming**

### **2.1 Socio-cultural importance**

Among goat rearing communities, goats played significant religious and social role apart from providing meat and manure. They were sacrificed on special occasions such as annual Hindu festivals (*e.g.*, *Dasai*) to appease local deities, and also during social occasions *e.g.*, New Year celebration and weddings. Similar practice of slaughter and consumption of goat meat at Easter and Christmas and as a substitute for lamb at the various Muslim holidays is reported from Western and Middle East countries (MBRLC, 1990). However, for people following these faiths, goats may not be slaughtered for religious reasons.

### **2.2 Economic importance**

**Economic benefit from goats was multifaceted:**

#### ***Quick economic returns***

As evidenced in (table 1) high prolificacy of goats resulted in birth of about three kids in a year. Farmers reported that within a short period of one to two years, kids born are ready for sale and cash flow to farmers commences. Quick economic returns have enabled farmers to reduce time lag and to avoid accumulation of interest on loans if availed. ICIMOD (2005) supplemented the view that goats are of significant advantages to marginal farmers over cows and buffalo because of faster returns.

#### ***Better income to enhance livelihood***

Goat rearing farmers derived income ranging from Nu.1800-Nu.17,000 (1US \$= Nu.40) from sale of goats/goat meat annually with an average of Nu.9500 (n=10). Unlike large ruminants, this income earned was with very small investment made in feeding and management.

Goats were usually sold on the basis of approximate live weight. Price per kilogram of dressed meat is Nu.150-220 (2007 rate) which was better than other types of meat. This helped farmers to get better income to enhance their

livelihood. Higher market price fetched by chevon (goat meat) in the locality and major towns could be because unlike pork and beef, there are no religious sentiments attached to its consumption. Moreover, for customers accustomed to chevon consumption, it is a delicacy and they are willing to pay the price tagged.

### ***Goat for social security***

Goats provided social security to smallholder resources poor farmers as it can be sold as and when there is urgent need of cash. Because of high demand both for live as well as dressed goats; sale could be accomplished at the farmer's doorsteps most of the time. Some farmers believed that keeping goats is as good as having cash in hand. In the words of 76 years B.B. Daurali, "*Goat keeping is as good as having cash in your coffer, unlike sheep, cattle and other livestock it can be instantly sold however you want and whenever you need cash at home*". (Daurali, *Pers.comm.*, 2006).

### ***Goats contributes to poverty alleviation***

Goat farming has the potential to address some of the symptoms of poverty: inability to own decent house, vulnerability to food shortage and lack of funds to send children to school as highlighted in Renewable Natural Resources (RNR) Research System Strategy 2006 (MoA, 2006). Farmers reportedly used cash earned from goats, which constitute about 60 percent of their household income, for schooling of children, overcome food shortage, pay taxes, repair houses helping them to alleviate poverty and improve the quality of life.

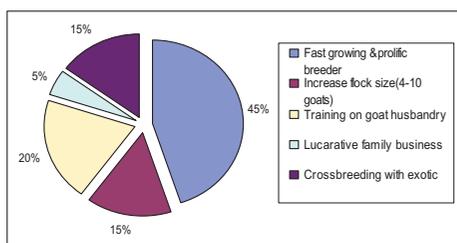
### ***Medicinal value of goat meat and milk***

Though it is not scientifically proven, local people believed that goat meat and milk has medicinal property to cure sub-tropical diseases including Malaria. The preparation of chevon is served to people suffering from this disease with positive results. According to Karma Nidup "*Consuming chevon has miraculously saved my life when I critically suffered from Malaria during my tender age*". (Nidup, K., *Pers. comm.*, 2006). Medicinal value of goat milk to cure sub-tropical disease (*ragi om choepai nye lu phen*) which literally means "goat milk can cure sub-tropical disease such as malaria" is documented in Bhutanese literature.

### ***Farmer's vision to exploit economic opportunities from goats***

The existing goat breed is not a fast grower and prolific breeder. To maximize production and income from goats, 45% of farmers (n=40) wished that their stock should be fast growing and a prolific (Fig. 4). About 20% of farmers felt that training on improved goat management practice could

enhance their income. About 15% however thought that crossbreeding with exotic meat breeds of goat or allowing them to keep up to ten heads of goat could increase their income.



**Fig.4:** Farmers vision to increase

Experiences from Nepal indicate that importing exotic Boer breed of goats for crossing with local breeds have helped farmers to increase their income (ICIMOD, 2005). Further, studies conducted in India suggest that to earn livelihood and profit from goat keeping about 4-10 goats have to be maintained (Gokale, *et al.* 2002). It is evident therefore that there is a need to provide fast growing and prolific breed of goats besides imparting training on improved goat management practices to the farmers. Such endeavour could go a long way in reducing rural poverty, which is the theme of Royal Government of Bhutan (RGoB)'s 10<sup>th</sup> FYP.

### 3.3 Challenges and scope of goat farming

#### 3.1 Challenges

In view of influence goats could have on vegetative degradation, RGoB's has passed a regulation to limit number of goats per household. Forest and Nature Conservation Rules of Bhutan (2006) states that '*Bhutanese nationals are allowed to rear four goats per house for domestic use and they shall be kept tethered in vicinity of houses and stall fed and shall not be allowed to enter plantation areas or forest or let loose on highways*'. However, this rule has restrained the economic opportunities that could be harnessed from goat farming. Given the potentials that can be tapped, sustainable method of goat farming will have to be worked out to effect appropriate policy changes.

#### 3.2 Scope to use goat to control weeds

Goats were mostly fed with noxious weeds such as *Artemisia vulgaris*, *Eupatorium adenophorum*, *Buhari Jhar*, *Bayar*, (thorny plants), *Cromolaena odorata* making effective use of such unwanted plants. Utilization of goat to control different weeds such as Blackberries (*Rubus fruticosus*), Saffron thistle (*Carthamus lanatus*) is reported from Australia and other countries in the West (Pierce, 1990). Such scope of goat farming

can be capitalized in Bhutan for biological control of weeds either through controlled grazing or cut and carry system. This could provide a continuous pressure on these weeds while farmers are able to derive some economic return.

## **CONCLUSION**

Goats are used mainly for meat purpose in goat rearing areas of Bhutan. There is favourable consumer demand for goat meat. Thus it fetches premium price than meat from other livestock. Provision of fast growing and prolific meat purpose breed, made available either through selection from existing flock or import of goat breeds for crossbreeding could improve the value of animal and bring higher returns.

Goat rearing is much easier than large ruminants as housing is simple, management is easy and it can survive on feed sources that are not usually utilized by other ruminants. Support goat farming by way of making technologies available, training on improved management practices, research on sustainable goat farming practices is desirable.

High prolificacy and short generation interval of goats as compared to large animal helps poor farmers to generate income within a short period to overcome financial difficulties.

As goats are stall-fed with weeds and other less succulent fodder, it could be reared to provide a biological (non-chemical) option to suppress noxious weeds especially *Eupatorium*. Research, however, needs to be carried out to validate available information on utilization of grazing goats to control weeds.

In summary, a goat farming specific project targeted towards poverty alleviation is suggested to:

- Establish sustainable goat farming practices through research and development efforts, such as:
  - Defining carrying capacities of goats at different agro-ecosystems including number of goats that can be reared in a particular geographical location;
  - Look into increasing the growth rate of goats through crossbreeding with better performing breeds; and
  - Understand feeding habits of goats *vis-a-vis* their complementarities with other livestock and their usefulness to control weeds.

## ACKNOWLEDGEMENT

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## **Prevalence and treatment efficacy of humpsore in cattle in Sarpang**

Kinzang Dukpa<sup>1</sup>, Lokay Thapa<sup>1</sup>, Karma Tshering<sup>1</sup>, Thinlay Tobgay<sup>1</sup> and Chime Gabur<sup>1</sup>

### **ABSTRACT**

*A study was carried out to look at the prevalence of humpsore in cattle under Sarpang Dzongkhag. A treatment efficacy trial was also carried out to come up with an effective treatment regime. A questionnaire was circulated to all the Livestock extension centres in Sarpang in 2003 to find out the prevalence of humpsore cases. For the efficacy trial, the animals were divided into two groups, treatment group consisting of 16 cattle and control group consisting of 4 animals. Samples such as deep skin scrapings, blood smears, swabs, whole blood and stool were subjected to various laboratory tests.*

*The study revealed that humpsore is widely prevalent in the cattle population of Sarpang Dzongkhag with herd prevalence of about 36.3 % in surveyed geogs. Gelephu geog reported the highest prevalence at 57.9% while Dekiling geog (13.6%) reported the lowest herd prevalence. No *Stephanofilaria* parasites could be isolated during the study period. Among the four treatment regimes advocated, the combination of Ivermectin injection and Zinc oxide ointment proved to be the most effective with 85% efficacy followed by levamisole injection+zinc oxide ointment (80% efficacy); Salycilic acid and butox ointment (75% efficacy) and Coumaphous ointment (70% efficacy).*

*From the study it was found that if the treatment regimes advocated are properly followed up, then humpsore cases can be treated successfully.*

### **KEYWORDS:**

Humpsore, Cattle, Sarpang, Prevalence, Treatment efficacy trial.

### **INTRODUCTION**

Humpsore is a chronic focal skin disease of cattle and buffaloes occurring mostly in the tropical regions of the world (Rai *et al*,1990). The name is derived based on the premise that the lesions are found mostly around hump area. In Bhutan, the disease, locally called as “*Dath*” is prevalent mostly in

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the southern belt because of the hot (34-35°C) and humid conditions. It is estimated that about 20 to 30 percent of cattle living in the bordering southern Dzongkhags, where the temperature is very hot and humid are affected with this disease. The lesion on the skin causes severe irritation and wound to animals due to frequent rubbing. Sometimes the draft animals cannot be used for ploughing due to severe lesions on the hump region. Therefore, directly or indirectly, this disease affects production and growth rates of animals.

The study was conducted with the following objectives:

- ✓ To find out the prevalence of humpsore in Sarpang
- ✓ To find out the causative agents of the Humpsore through laboratory diagnostic tests and to correlate the laboratory findings with the clinical signs.
- ✓ To find out the most effective treatment regime for this disease through a drug efficacy trial.

## **MATERIALS AND METHODS**

### **Prevalence study**

Two semi-structured questionnaires were circulated to all the livestock extension centres under Sarpang *Dzongkhag* in the year 2003 to find out the actual herd prevalence and epidemiology of this disease in all *geogs*. The questionnaire sought to find out the actual herd prevalence i.e. total number of cattle affected with the disease in a herd/household.

### **Treatment efficacy trial**

The treatment efficacy trial was conducted from August 2004 to March 2005. A total of 20 animals, comprising of cross breeds and local breeds, (16 in treatment and 4 in control group) randomly selected from the two villages of Pelrithang and Purano Basty under Gelephu *geog* were included in the study. A list of all cattle affected with humpsore was prepared and the animals were then selected using simple random sampling method irrespective of their sex, breed and age. The treatment efficacy was evaluated based on the condition scoring of the humpsore wound after every two weeks.

### **Data Collection**

A pre-designed survey format was circulated to all livestock extension centres under Sarpang *dzongkhag* to find out the disease prevalence. For the treatment efficacy trials, field registers were used to record detail information such as the breed, sex, age of animals; type of samples collected;

the condition of wound and type of treatment given. All results were recorded in a separate register. During the follow up visit, the condition of the wound was noted in terms of size and healing status.

### **Sample collection**

Samples such as deep skin scrapings, whole blood, blood smears were collected once every month from all the animals for eight months. Initially, all 20 animals were sampled once every month for 3 months. Later on, samples were collected only from the control group and from other animals of near by *geogs*. This was done since, the treatment group was being advocated treatment and it was not appropriate to collect samples.

The animals in the control group were not given any treatment and sample collections from these animals were continued till the end of study. This was done to study the seasonal incidence and severity of this disease. Samples were also collected from animals of other nearby *geogs* of Sarpang *Dzongkhag* to find out the overall incidence of the disease.

### **Laboratory tests**

#### ***Haematology***

Blood smear were stained with Giemsa and Leishman stains and subjected for tests to find out Differential Leucocyte Count and eosinophil count. The eosinophil count was correlated with the disease severity. Blood smears were also stained with Giemsa stain to screen for other blood parasites such as *Babesia*, *Theileria*, *Anaplasma* and *Trypanosoma*. The blood haemoglobin level was estimated using the sahli's haemoglobinometer method. The Packed cell volume was estimated using the microhaematocrit method.

#### ***Parasitology***

- Faecal samples were subjected for endoparasite screening by Stolls, Sedimentation & Flotation methods.
- Deep Skin scrapings (allow bleeding) were tested using 10% KoH boiling test to detect mange mites.
- Deep skin scrapings preserved in normal saline were used to detect adult parasites and larvae. The samples were first centrifuged and then the sediment was observed under low power microscope.
- Similarly, blood smears collected directly from the wound area

(collected when the wound was bled by scraping) were stained with Giemsa to look for *stephanofilaria larvae*.

### **Bacteriology**

- Deep skin swabs collected from the humpsore wounds were cultured in sheep blood Agar & MaConkey Agar to isolate any bacteria involved in the disease. The plates were incubated at 37° Celsius for 24 hours after which bacterial identification was done as per the methods described by Barrow *et al.* (1993).

A total of 1656 samples were collected and analysed during the study period.

### **Treatment methods**

The sixteen animals in the treatment group were divided into 4 groups, each group consisting of 4 animals. Each group was assigned the following treatment.

- ❖ Group 1, Ivermectin was given @ 1 ml for 50 kg subcutaneously and thereafter the injection was repeated at 28 days. Zinc oxide ointment was applied to the wound daily for duration ranging from a week to about a month depending on the severity of cases.
- ❖ Group 2, Levamisole was injected @ 1 ml per 10 kg body weight Subcutaneously complemented with daily application of Zinc oxide ointment.
- ❖ Group 3, Salicylic acid ointment with Butox (2 gm Salicylic acid, 4 ml Butox & 94 ml paraffin) was applied to the wound daily for 1 month.
- ❖ Group 4, Coumaphos 10% ointment (Coumaphos 10 gm & 90 ml paraffin) was applied daily for 1 month.

The animals in the treatment group were treated with above drugs from October 2004 and this trial continued for 3 months.

## **RESULTS AND DISCUSSIONS**

### **Prevalence**

Humpsore is widely prevalent in the cattle population of Sarpang *Dzongkhag* with an overall herd prevalence of 36.3% in the surveyed area (Figure 1). The herd prevalence of Humpsore was highest in Gelephu geog (57.9%) followed by Lhamoyzingkha (37.8%) and lowest prevalence was reported in Dekiling geog (13.6%). The treatment efficacy in the *geogs* was

reported to be very low with only 2.3% of the treated animals having recovered from the disease. The herd prevalence was highest in adult age groups (31%) as compared to the younger animals (5%). The high prevalence in the adult age groups could be due to the fact that adult bulls are used for ploughing and this predisposes the animal to this disease.

Hump sore is known to be caused by various agents including the nematode *Stephanofilaria* spp. and hence the disease is often termed as Stephanofilariasis (Rai *et al*, 1990 and Urquhart *et al*, 2003). Several factors such as hot and humid weather, abundant biting-flies, indiscriminate ploughing and bad management predispose the animals to suffer from this disease (Rai *et al*).

Humpsore cases in Sarpang *Dzongkhag* are seen more in summer and autumn season when the fly population is abundant. Although, cases are much less during winter, it is seen that birds such as crows and pigeon are found to aggravate the wound by biting the wound and delaying the healing process.

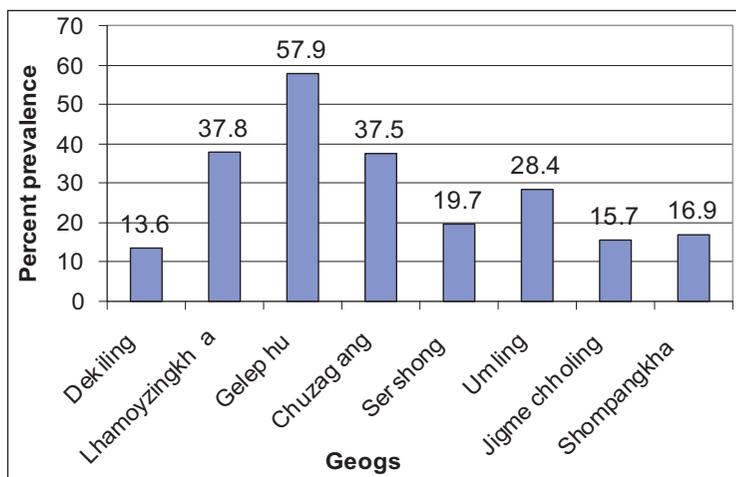
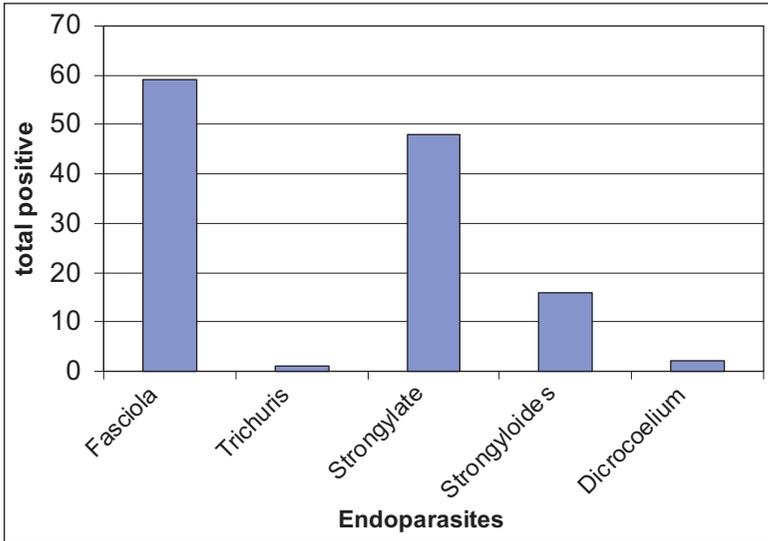


Figure 1. Geog-wise prevalence of Humpsore in Sarpang

### Endoparasite screening

A total of 68.5% of the samples collected (126/184\*100) were found positive to different parasitic ova. Liverfluke accounted for 49% of the total positive cases of endoparasitic infestation in the sampled animals. *Trichuris* was the least prevalent endoparasites in the sampled animals (Figure 2)



**Figure 2.** Prevalence of different endoparasites

### Ectoparasite screening

All 268 deep skin scrapings examined were found negative for *stephanofilaria* as no larvae or worm could be detected. This could be attributed to the difference in techniques employed as well as because of the cooler season for sample collection (Autumn-Winter) when the fly activity would have been at the lowest. The skin scrapings were also found to be negative to mange mites infestation. Studies elsewhere (Urquhart *et al*, 2003) have also shown that adult worms and microfilaria are rarely present in the lesions and therefore many scrapings prove negative.

The parasite, *Stephanofilaria*, has two hosts, the animals as the direct host and fly as intermediate host (Rai *et al*, 1990). The parasites complete its initial development in fly and later enter the definitive host for further development. Thus there are two main developmental stages, microfilariae and adult parasites. The flies in which the parasite completes its developmental cycle are mostly of *Musca* species.

### Parasite screening in blood

Not a single larva could be detected from the blood smears collected from the wound area. Since the microfilaria are rarely isolated from the lesions, diagnosis of humpsores is usually presumptive in endemic areas and is based on the appearance and site of lesions (Urquhart *et al*, 2003)

### **Packed Cell volume (PCV)**

The PCV values during the study period were found to be well within normal range in all sampled animals. The PCV is a measure to quantify the degree of anaemia (lack of blood). The mean monthly PCV values ranged from as low as 26.41 % in August 2004 to as high as 28.5% in February 2005. The overall mean PCV value for the entire study period was about 27.45%.

### **Haemoglobin values**

As with PCV Values, the Hb levels of the animals were found to be ranging within the normal levels. The Mean monthly Hb levels ranged from as low as 8.77gm % in August 2004 to as high as 9.52 g% in February 2005.

### **Differential Leucocyte Count**

The eosinophil count was within normal range in almost all sampled animals. The mean monthly eosinophil count ranged from as low as 3.12% in September 2004 to as high as 5.17%. The differential leucocyte count was mainly done to detect eosinophilia so that the same could be correlated with the severity of humpsore lesions. Though chronic irritation caused by wound results in increase in eosinophil count it was not so in this case.

### **Bacteriological tests**

Of the 184 wound swabs cultured on sheep Blood agar and MaConkey Agar, not a single sample yielded pure non-contaminated growth indicating that no bacterial infection was found in the humpsore wound.

### **Treatment efficacy results**

Of the four treatment regimes, the combination of Ivermectin injection and zinc oxide ointment proved to be the best one with an efficacy rate of 85%. The second (Levamisole and zinc oxide) and third (Salicylic acid and butox) treatment regime showed an efficacy rate of 80% and 75% respectively. The fourth treatment regime consisting of coumaphous showed an efficacy rate of 70%. Hence, the first three treatment regimes were effective in treating humpsore cases in this study as found elsewhere (Rai *et al*, 1990).

The use of 4% Butox ointment was found to be equally effective when compared to the use of Ivermectin and Levamisole injections. It would be more economical to use combination of butox and salicylic acid in the field. Fresh wounds were found to recover within one to two weeks of treatment as compared to long standing cases.

It was seen that most farmers dis-continued applying the ointments once the wounds have partially healed. This was found to result in relapse of the

disease especially during summer season and when scavenging birds fed on the wound. Since most of the farmers did not abide by the treatment regime, this led to varying success rates for treatment efficacy.

Since flies are the biological vector for this disease, no amount of treatment and control of this disease in the host animals will be a success unless we control the fly population. Therefore, good management is the key towards reduction and ultimately eradication of this disease.

## **CONCLUSIONS**

The study has revealed that humpsore is widely prevalent in Sarpang *Dzongkhag* owing to the hot and humid climate. The reasons for not being able to isolate the etiological agent could be due to the difference in the techniques employed as well as the relatively cooler weather for the study period (October-March) during which time the fly activity would have been at the lowest. The combination of Ivermectin injection and zinc oxide ointment was found to be the best method of treating humpsore cases with an efficacy rate of 85%. However, to have a comprehensive understanding of the disease epidemiology, studies need to be undertaken for a much longer duration with more number of animals.

This study recommends that for effective treatment and control of this disease:

- It is important to create awareness about humpsore and its control measures to the cattle owners.
- The combination of Ivermectin injection and zinc oxide ointment and combination of Levamisole injection with zinc oxide ointment should be used to treat clinical cases of humpsore in cattle. If there are any relapse cases, then treatment should be repeated.
- It may be worthwhile to use fly repellent oils on the body of animals when they are sent for grazing in the forest to avoid contracting the infection from the flies.

## **ACKNOWLEDGEMENT**

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extension colleagues under Sarpang *Dzongkhag* for their support in data collection.

Lastly, we thank all those farmers involved in this study for their active participation and support.

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## **Silvo-Pasture: An Alternative Land Use Option for the Temperate**

Kesang Wangchuk<sup>1</sup>, Walter Roder<sup>2</sup>, Andras Darabant<sup>1</sup> and Prem B. Rai<sup>1</sup>

### **ABSTRACT**

*Dhur community has reduced the area used for cultivating crops due to inherent low soil fertility and frequent crop damages by wild boars. Therefore, it demands new production system to optimize land use at Dhur. Systems combining livestock and timber production are considered to have good potential for temperate regions of Bhutan. A study integrating fodder legumes with blue pine and larch trees was initiated at Dhur, Bumthang in 1996 on marginal land previously used for the traditional fallow rotation system with buckwheat. The study aimed to quantify fodder and timber production and interactions of species and species combination in the silvo-pastoral system.*

*It was found that the average annual height increment was over 65cm for larch and 52cm for blue pine trees. Average annual dry matter production was 5.2, 4.7 and 2.8  $\text{tha}^{-1}$  for white clover, lotus and control plots, respectively.*

*Therefore, this study suggests that the silvo-pastoral system with white clover is an efficient land use system that brings increased productivity per unit area and increased income from timber and fodder yield.*

### **KEYWORDS:**

White clover, lotus, blue pine, larch, dry matter production, tree growth.

### **INTRODUCTION**

Constrained by the inherent low soil fertility and frequent crop damages by wild boars, farmers of Dhur community have reduced the area used for cultivating crops. Beside livestock, their income depends largely on off-farm labor including road constructions and logging. The practice of pangshing cultivation (grass fallow system) (Roder *et al.* 1992) required large fallow areas, with poor regeneration of fodder species. This system is characterized by fallow periods of 10-15 years alternating with cropping

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<sup>2</sup>Bhutan Potato Development Programme, Department of Agriculture, Semtokha, Thimphu.

periods of 1-2 years. It is well adapted to the prevailing conditions and has been self-sustaining for generations. Based on the growth rates observed for blue pine (Rosset and Rinchen 1997) it was suggested that silvo-pastoral systems combining timber and dairy production could generate annual returns of US\$1,000 to US\$2,000 per hectare (Dukpa *et al.* 2005).

However, higher economic expectations, rising labor costs and regulations on land use demand new production systems. Therefore, this study will attempt to evaluate a silvo-pastoral system that will provide options for increasing productivity of a marginal land and generate income for farmers. An assessment to quantify tree growth and fodder dry matter production in the silvo-pastoral system, and evaluate the interaction effects of fodder and tree is carried out for evaluation of the silvo-pastoral system.

## **MATERIALS AND METHODS**

### **Design, layout and treatments**

Located at an altitude of 3100masl, the Dhur silvo-pastoral trial incorporates the use of blue pine (*Pinus wallichiana*) and larch (*Larix griffithiana*) with perennial fodder legumes. The experimental design was a split-plot design with four replications. The main plot treatments consisted of (1) larch and (2) blue pine planted on a regular grid of 3 x 4 m. The subplot treatments consisted of (1) Control (No legume) (2) White clover (*Trifolium repens*) and (3) Lotus (*Lotus pedunculatus*). 24 trees were planted in each subplot treatment. Seeds of fodder legumes were broadcast sown in individual subplots. No legume seeds were sown in control plots. Individual plots were fertilized at the rate of 68.4kg ha<sup>-1</sup> of P<sub>2</sub>O<sub>5</sub> during establishment and the same fertilization rate was applied in each year.

### **Measurements of dry matter production**

Herbage was harvested and removed 2-3 times annually. For each harvest, herbage yield was measured from four quadrates of 0.25m<sup>2</sup> placed randomly in each subplot. The herbage inside each quadrate was harvested and weighed. The herbage from four quadrates was bulked and thoroughly mixed. The bulked materials were sub sampled and a representative sub sample weighing over 300g was collected from each subplot for subsequent dry matter analysis. Sub samples were oven dried at 60°C for 24 hours before being weighed for dry matter.

### **Observations on tree performance**

After 2 years of establishment, a few blue pine and larch trees either died or had stunted growth. Such trees were replaced with the new saplings. The tree

height was measured every two years up to 2000 and the final height was measured in 2006. Diameters of trees were not measured. The trees which had to be replaced were excluded from the statistical analysis.

### Farmers' perception

Farmers' views and comments were collected in 2005 through informal interviews to understand their perception on silvo-pastoral system.

## RESULTS

### Tree growth

The tree treatment effects were significant in all the years when measurements were recorded and the larch trees were significantly taller than blue pine (Table 1). Legume treatment had no significant effect on tree growth but tree growth was better in white clover plots in the initial years. However, after nine years of planting good tree growth was observed in lotus plot. The annual height increment for the years 1996-2006 was slightly higher when combined with lotus.

Table 1: Effect of legume treatment on tree growth

	Plant height (cm)						Annual growth (cm)
	1996	1998	2000	2002	2004	2006	1996-2006
<i>Legume species</i>							
White clover	14.8	58.3	95.2	209.8	324.3	482.0	57.28
Lotus	15.6	57.1	92.9	212.6	332.2	493.0	59.83
Control	14.1	50.7	86.8	195.8	304.8	460.0	54.49
<i>Tree species</i>							
Blue pine	9.5	37.4	67.5	173.1	278.7	422.0	52.81
Larch	20.2	73.3	115.7	247.5	378.2	534.2	65.88
<i>Significance</i>							
Legume	ns	ns	ns	ns	ns	ns	ns
Tree	<0.01	<0.01	<0.01	<0.00	<0.001	<0.00	<0.05
				1		1	
Legume*Tree	ns	ns	ns	ns	ns	ns	ns

ns- non significant

### Dry matter yield

Compared to the control treatment, the dry matter yields were substantially higher (<100%) for the legume treatments except in 2001 and 2003 (Table 2). White clover plots gave higher dry matter yield during the initial years.

The dry matter yield of lotus treatment increased gradually from 2001 to 2006. Although, significance difference was observed between sub plot treatments, the dry matter yield between lotus and white clover treatments did not differ significantly in the later period. The dry matter yield from control plots was significantly lower than the legume treatments. The results showed general decline in dry yield of legume treatment.

Tree treatment had no significant effect on the dry matter yield of white clover and lotus treatments and there was no significant effect of interaction between tree and fodder species on the dry matter production.

**Table 2:** Yield of fodder under silvopastoral system

	Dry matter (tha <sup>-1</sup> ) (Average of 2-3 cuts per year)									
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
<i>Tree species</i>										
Blue pine	6.70	8.87	3.10	4.67	2.39	2.87	2.89	3.18	3.53	3.70
Larch	5.56	9.33	3.06	4.98	2.51	2.89	3.03	3.41	3.49	3.63
<i>Legume species</i>										
White clover	8.42	12.1	3.83	5.82	2.68	3.47	3.31	3.42	3.83	3.70
Lotus	7.11	10.3	2.99	5.25	2.69	3.11	3.13	3.96	4.04	4.35
Control	2.89	4.89	2.40	3.40	1.98	2.07	2.44	2.52	2.66	2.74
<i>Significance</i>										
Tree		ns	ns	ns	ns	ns	ns	ns	ns	ns
	<b>ns</b>									
Legume	<0.001	<0.001	<0.05	<0.05	ns	<0.05	ns	<0.001	<0.01	<0.01
Tree*Legume	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

ns- non significant

## DISCUSSION

### Tree height and dry matter yield

Considering the elevation, tree growth was good with an average annual height increment of over 65cm for larch and 52cm for blue pine trees. Generally, blue pine is better adapted and displays better growth than larch below 3000m. The findings of this study indicate that the site (3100m) chosen for the study was slightly above the optimum range for blue pine. The findings also indicate better response of larch trees to suitable management

interventions especially the inclusion of appropriate legume and fertilizer. Better growth of larch tree was observed in white clover plots in the initial years. However, in the later part of the study period, better tree growth was observed in the lotus plots. This is attributable to the invasion of lotus plots by white clover in the succeeding years. Therefore, the better growth of larch trees in lotus plots in the later period is less likely to be the effect of lotus. The better tree growth is more likely to be the effect of white clover.

Dry matter yields varied substantially over the years but it is not likely that the tree cover affected dry matter yields in the initial years. However, white clover plots consistently gave the highest dry matter yield. The average yield of lotus and control treatments across the years was only 45% to 85% respectively of the yield observed with the white clover. The persistence of lotus declined over the years and this appears to have affected the dry matter yield. The poor persistence of lotus especially under severe dry winter in temperate environments was reported by Roder (1983) and Wangchuk *et al.* (2006). In the later part of the study period, lotus plots were invaded by white clover (personal observation). Therefore, the gradual increase in dry matter yield of lotus treatment in the later part of the study could be attributed to the presence of white clover. Wangchuk *et al.* (2006) reported higher dry matter yield of white clover mixture over lotus mixture in a study on temperate pasture mixtures.

### **Farmers' perception on silvo-pastoral system**

It was difficult during the initial stages to motivate farmers to take up the activity. Over the years, farmers have realized the benefits of silvo-pastoral systems. Trees and fodder were found equally important to them. Farmers mentioned that the system could be beneficial to the future generation in providing firewood and timber for construction. They found that the system would be an example for their neighbors. Besides providing green fodder, they make hay to be fed to the animals during the lean season. Among the fodder species, farmers preferred white clover due to its good acceptability to the animals. Generally, farmers are willing to allot a certain portion of their land to establish such systems. The necessity to explain farmers about the need to thin out plantations as trees grow older seems to be really important. With the spacing 3 x 4 m, thinning needs to be carried out before the trees attain a diameter deemed useful by farmers, otherwise the under story fodder species will be shaded out besides a reduction of growth increment of individual trees.

## **CONCLUSIONS**

The silvo-pastoral system is one of the suitable options serving dual purposes of providing fodder and timber besides offering cost effective means to maintain soil fertility and minimize soil erosion. The results of nine year study provide evidence that silvo-pastoral systems can be attractive land use options for conditions similar to Dhur since silvo-pasture has been used to optimize production at marginal sites across the globe.

White clover has good yield potential and positive effects on tree height but the use of white clover will require adequate application of  $P_2O_5$ . However, it is obvious that the increase in canopy size and tree height under the present spacing will be detrimental to fodder production. Species differ in their adaptation to the reduced light intensities but there will be no alternatives to white clover for the given conditions. Silvo-pastoral system will be a reliable source of quality timber in case proper stand tending measures (thinning, pruning) are applied when the natural forests are deteriorating in quality. Thus, under such circumstances, silvo-pastoral systems can offer better economic benefits.

## **ACKNOWLEDGEMENT**

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## Variation of Total Litter Weight among Sow Breeds from Farrowing to Weaning

M. P. Timsina<sup>1</sup>

### ABSTRACT

*Mothering ability of sow is considered an important parameter to obtain heavier litters at weaning to enhance farm productivity. However, among sow breeds, there exists a variation in total litter weight (TLW) under commercial farm conditions and some factors could be responsible to cause this difference. Therefore, a study was conducted to investigate the variation of total litter weight (TLW) and some factors affecting this parameter from farrowing to weaning at Trang Wattana farm, Thailand.*

*Trial included eighty Large White x Landrace (LWLR) sows and forty five Landrace x Large White (LRLW) sows (Parity 3-6). TLW and litter size (LS) at  $12 \pm 1$  hour (TLW<sub>12</sub> and LS<sub>12</sub>) and at  $36 \pm 1$  hour (TLW<sub>36</sub> and LS<sub>36</sub>) after farrowing and at weaning (TLW<sub>w</sub> and LS<sub>w</sub>) were recorded from individual sow. Results showed a significant increase in TLW<sub>12</sub> and TLW<sub>36</sub> after farrowing and TLW<sub>w</sub> ( $P < 0.001$ ) from LWLR sows than from LRLW sows. A significant increase in LS<sub>36</sub> after farrowing ( $P < 0.05$ ) and LS<sub>w</sub> ( $P < 0.02$ ) were also observed from LWLR sows. However, there was no significant difference in pre-weaning survival (PWS) of litters ( $P > 0.05$ ) between breed groups. Parities and barns and their interaction effects did not significantly effect on TLW ( $P > 0.05$ ).*

*This study suggests that to reduce the variation in TLW and to produce better commercial crossbred animals it is beneficial to maintain Landrace breed as maternal dam and Large White breed as sire. Such an approach to breeding will help to capitalize on the heterosis, wean heavy litters and thus optimize farm profitability.*

### KEY WORDS:

Variation, Mothering ability, Total litter weight, Farrowing, Weaning

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## INTRODUCTION

Good Mothering ability of female is important for early growth of offspring in many species. The primary indicators of mothering and milking ability are number of piglets weaned per litter and heavier weaning weight. Sows with good maternal ability produce adequate milk to support early litter growth (Grandinson, 2003). Wulbers-Mindermann *et al.* (2002) reported faster piglet growth and small variation in the litter weight as characteristics of good mothering ability. Selection for mothering ability can improve total litter weight (TLW) and litter survival rate (Verheijen, 2001). However, publications on the effects of maternal ability of sow on TLW during critical periods (12 to 36 hours after birth) after farrowing are limited. Therefore, the objectives of this research were to:

- a) Investigate variation of TLW among sows in commercial farms;
- b) Assess the factors affecting TLW from farrowing to weaning

## MATERIALS AND METHODS

### Selection of experimental sows

The study was conducted at Trang Wattana Farm, Southern Thailand during the year 2006. The sows in late pregnancy i.e. 1 to 2 days before farrowing were randomly selected from two farrowing sheds. Records from hundred and twenty five sows were taken consisting of eighty Large White x Landrace (LWLR) sows and forty five Landrace x Large White (LRLW) sows (parity 3-6).

### Housing and management of sows and litters

The sows were kept in an intensive housing system of open building type with natural ventilation. The individual farrowing crate was made from slatted floor having space of 2.5 m x 2.0 m, which includes creep box. Each shed had four big fans located at strategic points for ventilation. The shed also contains water- drip cooling system to reduce heat stress and maintain sow body temperature during hot weather. Besides that, sow had an access to individual feeder and a nipple drinker.

All sows were administered with synthetic Prostaglandin F2 one day before farrowing. Antibiotics and antipyretic drugs were administered during farrowing and oxytocin after farrowing. On the day of farrowing, (Day 0), sows were not given any feed but they had adequate access to drinking water. On Day 1, they were fed at 1 kg/sow/day and gradually increased to 5 kg/sow/day until Day 5 after farrowing. From Day 6 onwards until weaning, all the sows were fed *ad libitum*. The farm followed routine vaccination

program to all the experimental sows. Cross fostering was practiced few hours post partum. The litter size was standardized between 11 to 13 piglets per sow based on number of functional teats. The temperature inside creep box was maintained using 100 Watt bulb. Creep feeding was done to all litters from Day 10 after farrowing until weaning. Litters were weaned on an average of  $24 \pm 1$  day after farrowing.

### **Performance parameters**

TLW and LS at  $12 \pm 1$  hour (TLW12 and LS12) and at  $36 \pm 1$  hour (TLW36 and LS36) after farrowing and TLW, LS at weaning (TLWw and LSw) were recorded from individual sows. The pre- weaning survival (PWS) of the litters were also recorded. The TLW12 and LS12 were taken from the time the last piglet was born until 12 hours. The weighing balance was used to measure TLW. TLW was calculated by taking total weight of live piglets within the same litter. The main treatments consisted of breeds. The main traits considered in this fixed model were TLW12 and TLW36 after farrowing and TLWw. Other traits included were LS12, LS36, LSw and PWS of litters.

### **Statistical model**

**The statistical model for the study was:**

$$Y_{ijkl} = \mu + \text{Breed}_i + \text{Parity}_j + \text{Barn}_k + \text{Breed} * \text{Parity}_{ij} + e_{ijkl}$$

The terms of the model were:

$Y_{ijkl}$  = Dependent variables

$\mu$  = overall mean

$\text{Breed}_i$  = Fixed effect of  $i^{\text{th}}$  breed ( $i$ = LWLR, LRLW)

$\text{Parity}_j$  = Fixed effect of  $j^{\text{th}}$  parity ( $j$ = 3, 4, 5, 6,)

$\text{Barn}_k$  = Fixed effect of  $k^{\text{th}}$  barn ( $k$ = 1, 2)

$\text{Breed} * \text{Parity}_{ij}$  = effect of  $ij^{\text{th}}$  interaction of Breed\*Parity

$e_{ijkl}$  = Random error . NID ( $0, s^2$ )

### **Experimental design and data analysis**

Data were analyzed in Completely Randomized Design (CRD) using General Linear Model (Proc GLM) Procedures of Statistical Analysis System (SAS, 1999). There was no significant loss of piglets after cross fostering until records on LS12 was taken in both breed groups. In addition, this farm practiced cross fostering program so the data from litter size after fostering (LSAF) and LS12 were not subjected to statistical analysis. The results on TLW and other production parameters are summarized in different

tables as Least Square Means (LSM) and Standard Errors (SE). Duncan's Multiple Range Test was used for mean comparison according to Cody and Smith (1997).

## RESULTS AND DISCUSSION

### Effect of breed components on TLW and LS

There was significant increase in TLW12 and TLW36 after farrowing and TLWw ( $P < 0.001$ ) from LWLR sows than from LRLW sows (Table 1). A significant increase in LS36 ( $P < 0.05$ ) and LSw ( $P < 0.02$ ) were also observed from LWLR sows than from LRLW sows. However, there was no significant difference on PWS ( $P > 0.05$ ) between breed groups. In addition, no significant decrease in LS within breed was observed between LSAF to LS12, LS12 to LS36 and LS36 to LSw ( $P > 0.05$ ) in both breed groups. Moreover, when data from both the breed lines were pooled and analyzed, no significant decrease in LS ( $P > 0.05$ ) was found during the recording period.

The figures 1, 2 and 3 illustrates that LWLR sows weaned heavier litters compared to LRLW sows during the recording period from farrowing to weaning. The findings indicated that LWLR sows raised and weaned heavy litters compared to LRLW sows. Moreover, LS36 and LSw were found higher from LWLR sows than from LRLW sows. This shows that LWLR sows provided better mothering ability to improve weight gain in the piglets. It is also possible that variation in TLW among sow breeds within population does exist. The significant increase in TLW from LWLR sows could be that the piglets from these sows suckled more as she provided better mothering and milking ability. The findings of this study agrees with that of Holtmann *et al.* (1975) who proved that Landrace breed is one of the best breeds available compared to Yorkshire in reproductive performance and mothering ability.

**Table 3.** Effect of breed components on TLW and LS (LSM  $\pm$  SE)

Production parameters	Breed components	
	LWLR*	LRLW**
TLW12 (kg)	19.22 $\pm$ 0.19 <sup>a</sup>	17.40 $\pm$ 0.25 <sup>b</sup>
TLW36 (kg)	22.08 $\pm$ 0.24 <sup>a</sup>	19.46 $\pm$ 0.32 <sup>b</sup>
TLWw (kg)	80.23 $\pm$ 1.25 <sup>a</sup>	69.86 $\pm$ 1.33 <sup>b</sup>
LSAF (piglets)	12.12 (11-13)	12.00 (11-13)
LS36 (piglets)	11.90 $\pm$ 0.88 <sup>x</sup>	11.61 $\pm$ 0.12 <sup>y</sup>
LSw (piglets)	11.09 $\pm$ 0.10 <sup>j</sup>	10.67 $\pm$ 0.14 <sup>k</sup>
PWS of litters (%)	91.71 $\pm$ 0.81 <sup>a</sup>	89.80 $\pm$ 1.06 <sup>a</sup>

LS was standardized between 11-13 piglets each per sow in both groups few hrs post partum.

<sup>a,b</sup> LSM in the same row with different superscripts differ significantly at ( $P < 0.001$ ).

<sup>j,k</sup> LSM in the same row with different superscripts differ significantly at ( $P < 0.02$ ).

<sup>x,y</sup> LSM in the same row with different superscripts differ significantly at ( $P < 0.05$ ).

\*Crossbred sows from sire of Large White and dam of Landrace ( $n = 80$ );

\*\*Crossbred sows from sire of Landrace and dam of Large White ( $n = 45$ );

TLW = Total litter weight; LS = Litter size; LSM = Least square mean; SE =

Standard error; TLW12 = Total litter weight at  $12 \pm 1$  hour (hr) after

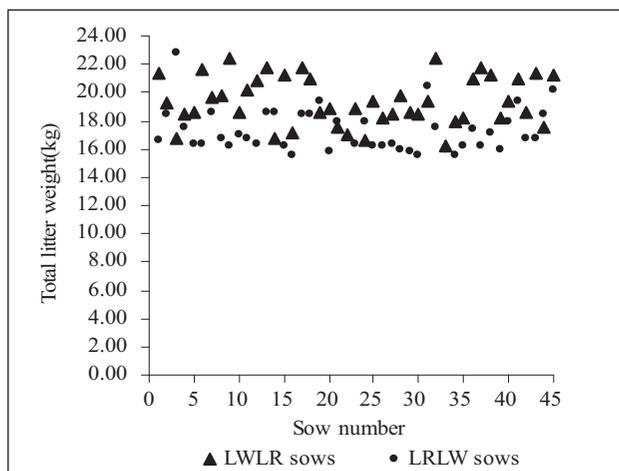
farrowing; TLW36 = Total litter weight at  $36 \pm 1$  hr after farrowing; TLWw =

Total litter weight at weaning; PWS = Pre weaning survival; LSAF = Litter

size after fostering i.e. few hrs post partum; LS36 = Litter size at  $36 \pm 1$  hr

after farrowing; LSw = Litter size at weaning.

The findings indicated that LWLR sows raised and weaned heavy litters compared to LRLW sows. Moreover, LS36 and LSw were found higher from LWLR sows than from LRLW sows. This shows that LWLR sows provided better mothering ability to improve weight gain in the piglets. It is also possible that variation in TLW among sow breeds within population does exist.



**Fig. 5** : TLW12 after farrowing between LWLR and LRLW sows

The significant increase in TLW from LWLR sows could be that the piglets from these sows suckled more as she provided better mothering and milking ability. The findings of this study agrees with that of Holtmann *et al.* (1975) who proved that Landrace breed is one of the best breeds available compared to Yorkshire in reproductive performance and mothering ability.

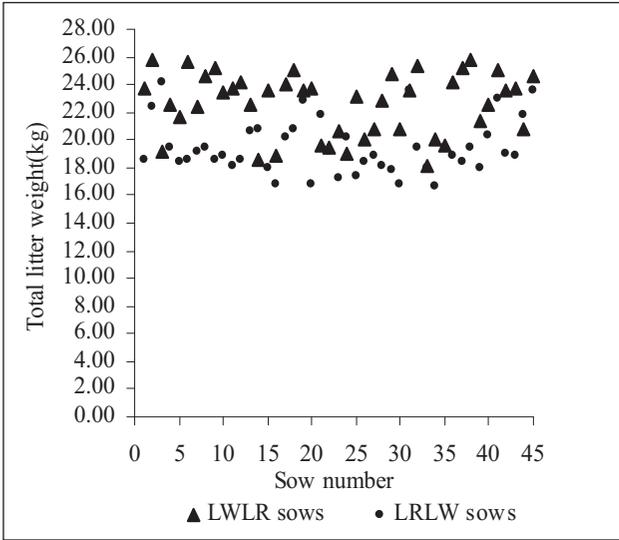


Fig. 6 : TLW36 after farrowing between LWLR and LRLW sows

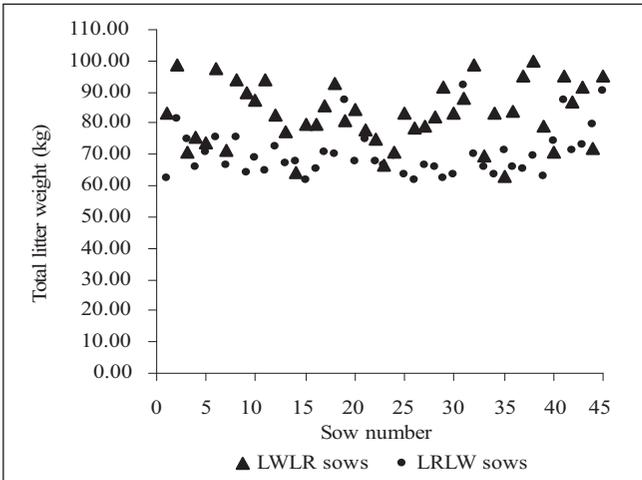


Fig. 7 : TLW between LWLR and LRLW sows

The current finding also concur with Moeller *et al.* (2004) who explained that primary indicators of sow mothering and milking ability are the number of piglets weaned and litter weaning weight. The present work also agree with Wulbers- Mindermann *et al.* (2002) who showed that good mothering

sows is characterized by high piglet growth rate and small litter weight variation. Grandinson (2005) also reported that selection of sow for breeding program could be determined using indicators like increased TLWw and litter survival rate. The current study indicates that increase in TLWw relative to mature sow body size irrespective to LS is critical to optimize farm profitability.

### **Effect of parity on TLW**

There was no significant effect of parities on TLW12 and TLW36 and TLWw ( $P>0.05$ ) between breeds. However, a strong correlation exists between parities and TLW12, TLW36 and TLWw (Table 2).

**Table 2:** Effect of parity and its correlations on TLW of sows (LSM  $\pm$  SE)

Parity no	TLW12 (kg)	r	TLW36 ( kg)	r	TLWw (kg)	r
3 (n= 18)	18.19 $\pm$ 0.32	0.73	20.73 $\pm$ 0.27	0.93	75.75 $\pm$ 1.11	0.81
4 (n= 34)	18.03 $\pm$ 0.27	0.76	20.19 $\pm$ 0.35	0.91	76.51 $\pm$ 1.45	0.80
5 (n = 59)	18.97 $\pm$ 0.38	0.78	21.40 $\pm$ 0.49	0.91	76.15 $\pm$ 2.04	0.80
6 (n = 14)	18.06 $\pm$ 0.40	0.74	20.04 $\pm$ 0.52	0.92	71.76 $\pm$ 2.12	0.73

r = represent parity's' correlation with TLW12, TLW36 and TLWw; n = Number of animals in each parity; TLW = Total litter weight; LSM = Least square means; SE = Standard error; TLW12 = Total litter weight 12  $\pm$  1 hr after farrowing; TLW36 = Total litter weight 36  $\pm$  1 hr after farrowing; TLWw = Total litter weight at weaning.

The result showed that parity did not influence TLW from farrowing to weaning. However, there was a linear increase in TLW from 3<sup>rd</sup> -5<sup>th</sup> parity. The litter performance was also found maximum from 5<sup>th</sup> parity sows. The result concur with Yen *et al.* (1987) who reported that mid parity sows produced heavier litters than 1<sup>st</sup> parity and older than 6<sup>th</sup> parity sows. Milk yield increases with parity number and sow produces its maximum by 5<sup>th</sup> parity and then decline with increasing parities (Whittemore, 1998). The sows with increasing parity are considered better mother, produces higher milk and wean heavy litters. Further, a positive linear relationship over parities could be attributed to increased milk yield and better mothering ability in sows. This study agrees with Rodriguez Zas *et al.* (2003) who confirmed that TLW at birth and TLWw increased from 1<sup>st</sup> to 4<sup>th</sup> parities and decreased in subsequent parities.

The difference between 1<sup>st</sup> parity sows with 3<sup>rd</sup> and 4<sup>th</sup> parity sows were 3 kg of TLW at birth and 4 kg of TLW at weaning (Rodriguez Zas *et al.*, 2003).

Unlike 1<sup>st</sup> and 2<sup>nd</sup> parity sows which utilize large portion of body energy for cell growth and body maintenance, mature sows partition most of their body energy into milk production and wean heavy litters (Yen *et al.*, 1987). In general, the study indicated that there exist variations in TLW among sows within a population under commercial farms. Moreover, there could be factors responsible to cause variation in TLW between breeds. Additionally, the study provides evidence that there exist a strong correlation between parities and TLW of sows.

### Effect of barn on TLW

The barn did not significantly influence on TLW12, TLW36 and TLWw ( $P>0.05$ ; Table 3). This could be because all the experimental animals were raised under similar housing and feeding practices.

**Table 3:** The effect of barn on TLW (LSM  $\pm$  SE)

Barn no	TLW12 (kg)	TLW36 (kg)	TLWw (kg)
1 (n = 65)	18.41 $\pm$ 0.22	20.86 $\pm$ 0.29	74.80 $\pm$ 1.19
2 (n = 60)	18.22 $\pm$ 0.21	20.04 $\pm$ 0.28	71.76 $\pm$ 2.12

n= Number of sows in each barn; TLW = Total litter weight; LSM = Least square means; SE = Standard error; TLW12 = Total litter weight 12  $\pm$  1 hr after farrowing; TLW36 = Total litter weight 36  $\pm$  1 hr after farrowing; TLWw = Total litter weight at weaning.

### Effect of breed x parity interactions on TLW

There was no significant breed and parity interactions effect on TLW12 and TLW36 after farrowing and TLWw ( $P>0.05$ ; Table 4). However, parity 4-5 LWLR sows raised and weaned heavier litters compared to parity 4-5 LRLW sows. This indicated that parity 4-5 LWLR sows provided better maternal characteristics to litters compared to parity 4-5 LRLW sows. The breed, parity and barn interactions did not show any effect on TLW12 and TLW36 after farrowing and TLWw. In general, breed component i.e. LWLR sows had a marked effect in raising and weaning heavy litters.

**Table 4:** Effect of breed and parity interactions on TLW (LSM  $\pm$  SE)

Breed	Parity no	n	TLW12 (kg)	TLW36 (kg)	TLWw (kg)
LWLR	3	36	18.94 $\pm$ 0.26	21.73 $\pm$ 0.33	79.85 $\pm$ 1.39
LWLR	4	21	19.25 $\pm$ 0.34	22.83 $\pm$ 0.43	83.89 $\pm$ 1.81
LWLR	5	14	20.01 $\pm$ 0.41	22.70 $\pm$ 0.53	81.32 $\pm$ 2.23
LWLR	6	09	18.68 $\pm$ 0.51	21.14 $\pm$ 0.66	76.16 $\pm$ 2.78

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LRLW	3	23	17.53 ± 0.32	19.90 ± 0.41	74.24 ± 1.73
LRLW	4	13	16.61 ± 0.43	18.58 ± 0.55	67.80 ± 2.30
LRLW	5	04	17.59 ± 0.78	20.14 ± 0.99	70.96 ± 4.17
LRLW	6	05	17.61 ± 0.63	19.14 ± 0.81	67.76 ± 3.40

LWLR = Crossbreds sows from sire of Large White and dam of Landrace; LRLW = Crossbreds sows from sire of Landrace and dam of Large White; n = Number of sows in each group; TLW = Total litter weight; LSM = Least square means; SE = Standard error; TLW12 = Total litter weight 12 ± 1 hr after farrowing; TLW36 = Total litter weight 36 ± 1 hr after farrowing; TLWw = Total litter weight at weaning.

## CONCLUSION

The present study suggests that the effect of the mothering ability of sow on TLW is pronounced when Landrace breed is used as maternal dam and Large White breed as sire in the commercial cross breeding program. This could be due to better ability of Landrace breed in transmitting genes of good maternal ability to her offspring when used maternal dam than used as sire. The sow with good mothering ability is expected to transfer her maximum metabolic energy to produce large quantity of milk for their litters to nurse. Therefore, LWLR sows are reasonable good dam with better mothering ability. The LWLR sows in the current study might have improved weight gain in the piglets through increased milk production. Thus, it is advantageous to maintain Landrace breed as maternal dam and Large White breed as sire to produce commercial crossbred animals. This will further help us to capitalize on their heterosis, reduce variation in TLW, wean heavy litters and optimize on farm productivity.

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## Village Chicken Farming and Newcastle Disease Vaccination Status in Darla Geog

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### ABSTRACT

*The study was conducted to document village chicken farming practices, record occurrence of Newcastle Disease (ND) and to assess the status of ND vaccination in Darla geog under Chukha dzongkhag. Fifty households were selected from seven randomly selected villages. The data were collected using structured questionnaires and participatory rural appraisal methods. It was found that each household in Darla geog owns 15 to 16 birds with a sale of at least 31 eggs per month and 5 live birds in every three months. Cash incomes generated are used for children's education, purchasing additional food items, cloths, agriculture inputs, and pay off rural taxes. About 68% household rear chickens under scavenging system, 26% in semi-intensive, and 6% household use permanently enclosed system. The local feed ingredients such as grains, wheat, buckwheat, rice, millet, and kitchen scraps are provided as supplements. Without doubt, ND was found to be one of the major constraints of village chicken production in Darla geog. Of the nineteen households who vaccinated their chickens, eleven have observed that vaccination can completely prevent ND while eight have observed reduced mortality cases. This reveals positive impact of vaccination in controlling ND in village chickens. Vaccination using thermostable I-2 vaccine must be encouraged as this has proved to be the best and viable option for controlling ND in village chickens in many countries. Bhutan needs to develop a strategic I-2 vaccination programme for village chicken to effectively control ND in Bhutan. It is also important to conduct farmers training on improved chicken management practices so as to enhance village chicken production and prevent ND in the country.*

### KEYWORDS:

Darla geog, village chicken, Newcastle disease, thermostable I-2 vaccine, Vaccination

### INTRODUCTION

Darla geog is located approximately 57 km from dzongkhag headquarter, Chukha, and 40 km from bordering town of Phuntsholing. It has 17 villages and 625 households with a total population of 7000 people. The system of farming is subsistence and mixed farming. Farmers not only raise chickens but also rear other

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farm animals to generate income. Beside chickens, 49 households rear cattle, 40 households goats, 23 households rear pigs, 10 households rear sheep, and 3 households rear ducks. Each household has family members of 4-5 adults ( $\geq 18$  years) and 2-3 children ( $< 18$  years).

Village chickens or “rural chickens” occupy a unique position in rural communities through their capacity to provide valuable protein for the families of smallholder farmers. They scavenge for survival, their diets sometimes supplemented by household scraps. About 63% of the households in Bhutan raise chickens. Like in many developing countries (Kitalyi, 1997), village chickens in Bhutan play extremely important socio-economic roles. A simple cost benefit analysis study in Dop Shari geog under Paro Dzongkhag suggests that raising backyard chickens is a profitable farming activity (Wangmo, 2005; Wangmo *et al.*, 2006). Each farmer has generated net benefit or income of Nu. 8738.37 from the sale of eggs with average of nine laying birds (Wangmo *et al.*, 2006).

However, one of the major limiting factors to village chicken production in developing countries (Spradbrow, 1988; Alexander, 1991; Alders *et al.*, 2000; Alder 2002; Nidup *et al.*, 2005) is occurrence of Newcastle disease (ND). ND is a sudden and severe, rapidly spreading disease, with respiratory symptoms, nervous manifestations, and high mortality rates. It is caused by a group of closely related viruses, which form the avian paramyxovirus type 1 serotype. The sero-prevalence survey of the disease in western Bhutan had revealed high prevalence rate of 57% of which only 16% had a protective antibody titre (Rinzin, 2001). ND is reported to be the single greatest pathological constrains in village chickens of north, west and central Africa (Bell, 2002; George, 2002; Musiime, 2002) and south Asia (Gunaratne *et al.*, 2002; Lwin, 2002; Nguyen, 2002). It is also the major problems faced by chickens industries throughout the world. In most cases, ND wipes whole flocks belonging particularly to farmers who do not have access to ND vaccines.

There are two methods to control ND i.e. sanitary prophylaxis and medical prophylaxis. Sanitary prophylaxis followed in the commercial industries cannot be practiced in rural areas because chickens are mainly reared as scavengers, which can have contact with infectious agents. The medical prophylaxis particularly vaccines have been considered more appropriate. Vaccination is one of the most commonly used methods to prevent ND. However, regular ND vaccination of village chickens has been very difficult as the vaccines were not thermostable and needed stringent cold chain conditions. Additionally, in Bhutan, most villages are far away from extension centres or related livestock service support centres. For these reasons, the Royal Government of Bhutan (RGoB) with technical assistance from ACIAR and AusAID has introduced the production of I-2 thermostable vaccine in 1999 at the National Centre for Animal Health (NCAH), Serbithang. The vaccine was officially released on 11<sup>th</sup> May 2001 (MoA, 2001). This thermostable I-2 vaccine does not require elaborate cold chains for storage and transportation. The administration procedures are simple and even farmers will be able to vaccinate their chickens through ocular or nasal route. Since then, more than 77400 doses of

thermostable I-2 vaccine were distributed to all twenty dzongkhags. The on-station trial (Chamling, 2000 cited by Rinzin 2001) suggests that the vaccine elicits immunity in the vaccinated birds. But there is a need to provide booster vaccination at three months to maintain a protective antibody titre for longer duration. However, thermostable I-2 vaccine efficacy for village chickens and its impact in controlling ND was not assessed in the past. Further more, beside the study conducted by Wangmo *et al.* (2006) on backyard chickens; there is a need to document village chicken farming practices formally. Hence, this study was conducted to:

- Document briefly the rural chicken farming practices in Darla geog
- Record the occurrence of ND outbreak
- Assess an impact of vaccination particularly that of thermostable I-2 vaccine.

## MATERIALS AND METHODS

### Study Areas and Sampling

Villages in Darla geog having chicken farmers were identified. Seven villages were randomly selected from identified villages. From these, 50 households that rear chickens were further randomly selected as shown in Table 1.

**Table 1:** Number of households interviewed from seven villages

SI No	Village	No. of households
1	Upper Soureni	7
2	Lower Soureni	3
3	Bich Soureni	6
4	Bich Tala	2
5	Gurung Goan	10
6	Damdara	12
7	Tabjee	10
	<b>Total</b>	<b>50</b>

### Data Collection

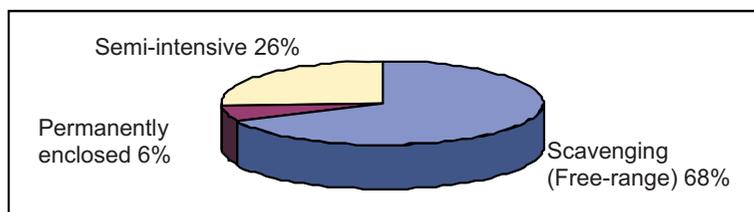
A structured questionnaire and participatory rural appraisal methods were used to collect data. Using these two methods, information on village chicken production aspects such as flock size, feeds and feeding, housing, roles of chickens to household livelihood, health management, ND, and vaccination particularly the use of thermostable I-2 vaccine were recorded. Basic geog profiles and other relevant data were collected from extension centre. Data was quantified and analysed in *MS Excel*. The study was carried out from 26 January to 10 March 2006.

## RESULTS AND DISCUSSION

### Farming Practices

*Production:* Technically, egg production commences from 18-22 weeks of age. The production peaks at 32-35 weeks and declines gradually after 35 weeks. Considering cost involved, it is advisable to replace flock at the end of 72 weeks of age (Nidup, 2005). Many farmers are not aware of recommended production cycle. For instance, 50% farmers believe chickens will stop laying at three years of age, 24% at 18-24 months, and 26% think that chickens lay eggs throughout their life. Unlike observation by Wangmo (2006), 60% of the farmers cull their birds at the end of production cycle, 30% sell live, and few (6%) rear until birds die of old age. Most farmers in Darla are Hindu and slaughtering chickens is not viewed as religious or any form of social taboos. For these reason, each household rears up to 15 to 16 chickens. Farmers consume chicken meat, entertains guests, perform rituals, and generate cash income. Each household sell at least 31 eggs in a month and 5 live birds in every three months. The cash generated are used for paying children's school fees, buy school materials, additional food items, cloths, agriculture inputs, and pay off rural taxes.

*Rearing system:* The three main types of rearing systems found are scavenging system (free range), permanently enclosed system, and semi-intensive system (Figure 1).



**Figure 8 :** Shows different systems of chickens rearing in Darla geog.

It was observed that 68% household rear chickens in scavenging system with little or no care. Scavenging system is one of the most economical and sustainable feeding systems to utilize feed resources in the villages for production of high quality animal proteins through meat and eggs. The study by Gunaratne *et al.* (1993) in Sri Lanka has shown that productivity of scavenging village chickens is higher as compared to other systems. However, this system has its own disadvantages. Birds are left to search their own food, scratching and picking on the ground. Young chicks are left scavenging together with adult birds, having to compete for feeds and becoming easy prey for predators and spread of diseases. Very often, it is associated with high mortality due to predators and unclean water.

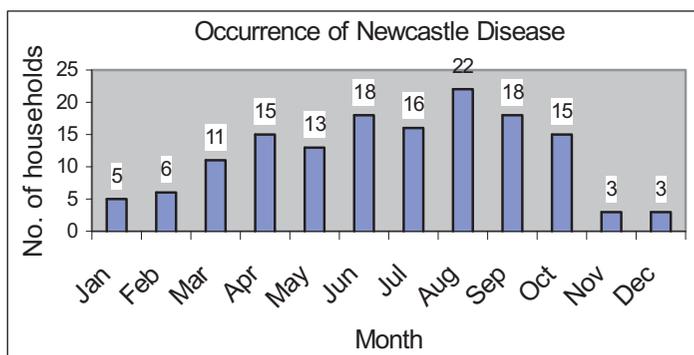
In a permanently enclosed system, birds are confined in sheds and fed with concentrates. Because of cost and labour implication only 6% household use this system. Another system which is less popular than scavenging is semi-intensive

system (combined semi-free range & permanent enclosure) in which birds have enough room to roam outside the shed and within the enclosure. It was seen that 26% household rear chickens under this system, which is associated with low mortality rates.

*Feeding and watering:* Feed alone accounts for 60-65 percent of total farm expenses. It is in the interest of every farmer to be able to get as much meat or eggs from a kg of feed. In village chicken production system, it is extremely difficult to estimate economic and physical value of this input. There are no direct methods of estimating scavenged feeds, which constitute most of the feed input. The village chickens scavenge around household compounds feeding on earthworms, crop residues, or any available feed resources. Because of high cost involved, only 12% household feed their chickens with concentrate. About 84.44% household supplement scavenging chickens with home produced local feed ingredients such as maize, grains, wheat, buckwheat, rice, millet, and kitchen scraps. Farmers are aware of importance of cleaning feeders and watering equipments (plates, bamboo made trough, plastic container). Some households provide water one to three times a day while other provide only occasionally. In 58% of the households, it was females who fed, watered, and carried out daily managerial activities of chickens. This situation is similar to many developing countries where village chickens are generally managed by women (Chiligati *et al.*, 1997; Gueye, 2001).

### Occurrence of ND

ND was found to be one of the major constraints of village chicken production in Darla geog. Although it is evident that disease diagnosis in relevant laboratories to confirm ND outbreak is important, farmers are very much aware of signs and symptoms of this disease. For instance, farmers of 56% households have seen green watery pooh, 58% farmers observed drooping wings and twisted head, and 2% farmers have observed bluish discoloration in combs and wattles. Twenty five households have experienced ND wiping whole flocks. ND in Darla normally occurs throughout the year but peaks in hot and wet periods (Figure 2). This occurrence trend is similar to study carried out by Chiligati *et al.* (1997) wherein they found occurrence of ND during humid months of June to September.

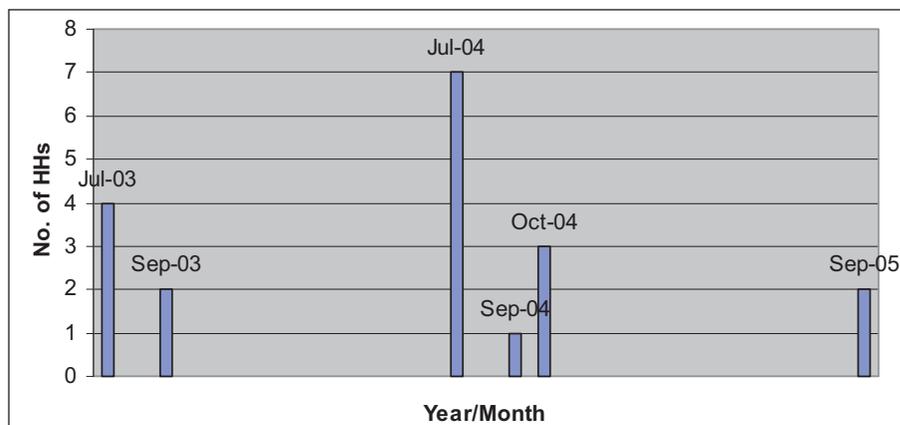


**Figure 2:** Occurrence of ND in Darla geog.

During the last six months, there was high mortality of chickens due to diseases. As many as 52% household believe mortality was due to ND. About 78 adult birds ( $\geq 5$  months), 44 growers (2-5 months), and 69 chicks (0-2 months) have died due to ND. Most households (94%) do not know main causes of ND. Only 6% believe it could be due to infected birds brought from outside their village.

### ND Vaccination and Its Impact

Since July 2003, only 19 households have vaccinated their birds against ND (Figure 3). Of this, 8 households have used thermostable I-2 ND vaccine (eye route) and 11 households have used *La-Sota* (drinking water).



**Figure 3:** ND vaccination in Darla geog

Of the 19 households, 6 have observed reduced mortality cases while 13 household felt that ND has been totally prevented in their flock. This reveals positive impact vaccination has in controlling ND in village chickens. However, only one household with model backyard farm is continuing vaccination. The vaccination for 18 households was discontinued. Farmers do not know why vaccination was stopped. Some believe it could be due to control of ND and reduced threat of further ND occurrence. It could also be due to limited thermostable I-2 ND vaccine which is now given priority to model backyard chicken farms. It was found that farmers lacked skills and knowledge of vaccination, which was normally carried out by geog livestock extension agent. Only 4% household can vaccinate using eye drop method while 2% household can vaccinate birds other than chickens (ducks, goose, etc). In addition to this, most farmers do not know how many times birds should be vaccinated in a year. Only 2% household believe birds should be vaccinated at least twice a year in order to prevent ND outbreak.

### CONCLUSION

Vaccination can protect farm animals from various diseases. ND control in village chicken promotes sustainable livelihoods in rural areas in several ways. If ND is not controlled, there will be huge losses.

ND was found to be one of the major constraints to village chicken production in Darla geog, beside predators, parasitic and other diseases,. To prevent ND, thermostable I-2 ND vaccine and *La-Sota* have been used. Most farmers have observed that vaccination can totally prevent ND. This reveals positive impact of vaccination. Vaccination using thermostable I-2 vaccine must be encouraged as this has proved to be the best and viable option for controlling ND in village chickens in many countries. Therefore, distribution of thermostable I-2 vaccine and ND vaccination programme must be reintroduced in Darla geog. It should not be limited to backyard chicken farms but must further extend to whole or a larger population of village chickens in the country. Additionally, from this study, with the experiences gained by the team through field observation and interactions with farmers, the team further suggests the following recommendations:

- Use of thermostable I-2 vaccine in the field needs to be promoted and strictly implemented especially in the ND vulnerable areas of the country.
- Government must work towards having strategic ND vaccination programme for village chickens.
- For preventive and control measures of ND, people should be educated through various media such as radio, TV, and newspapers.
- Training farmers on sustainable village chickens production and management would be very important step towards enhancing production and prevention of ND.
- Similar studies must be conducted throughout the country in order to get holistic picture of village chicken farming practices and status of ND vaccination.

## **ACKNOWLEDGEMENT**

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# *General*



## **Inorganic Fertilizer Distribution trend in Bhutan: After Privatization**

Chencho Norbu<sup>1</sup>

### **ABSTRACT**

*Distribution of inorganic fertilizers that was once directly handled by the government agencies was privatized during the seventh plan. The distribution trend of inorganic fertilizers that provided major plant nutrients (Nitrogen, Phosphorus and Potassium) in the last ten years after privatization was examined. Increased inorganic fertilizer distribution was recorded with the eastern region taking over 39% of the national total followed by the western region with 24%. Urea appeared to be the most preferred fertilizer followed by an increase in the ratio of nitrogen to phosphorus to potassium over the years, leading to imbalance use of imported plant nutrients. One way to address this increasing ration trend is to educate farmers through on farm trials and demonstrations on the importance of balance use of these three major plant nutrients.*

### **KEYWORDS:**

Privatization, inorganic, mineral, fertilizers, plant nutrients, distribution,

### **INTRODUCTION**

Inorganic fertilizers were first introduced to Bhutan in the early 1960s with the start of the first five year development plan. The import of inorganic or mineral fertilizers increased from 300 MT in 1960s to over 1000 MT in 1970s/1980s (FAO, 1988). A Nitro-Phosphate with Potash compound fertilizer called Suphala (15-15-15), and single plant nutrient carriers like Calcium Ammonium Nitrate (25% N), and Urea (46% N) were some of the most popular inorganic fertilizers procured from India. According to the fertilizer use survey carried out in 1987, the western region consumed about 57% of the national total followed by the eastern region with 19 % while central and southern region took about 17 % and 7% shares respectively. The fertilizers were mostly applied to potato (53% of the total consumption), apples (25%), paddy (9%) and other cereals took the rest (13%) based on 1986/87 distribution pattern. This amount was roughly about 6 kg of

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fertilizer materials per hectare of cropped land corresponding to 2.6 kg of plant nutrient (N, P<sub>2</sub>O<sub>5</sub>, and K<sub>2</sub>O) per hectare (FAO, 1988). One of the projects during the fifth plan period (1981-87) that introduced inorganic fertilizers to farmers' field extensively was the '*Yield increase through the use of Fertilizer and other Inputs*' supported by FAO from 1986 through 1989. The project implemented over 600 on-farm fertilizer trials on rice, wheat, potato, maize and mustard in 12 out of the then 18 dzongkhags (districts) in collaboration with the agriculture extension services (FAO, 1990). The fertilizer recommendation guidelines for rice, maize, potato and wheat crops were produced. Urea became the most popular fertilizer followed by Suphala and Single Super Phosphate (SSP) with 16% P<sub>2</sub>O<sub>5</sub> by weight in the 1990s. The total fertilizers procured from 1989 to 1997 reached to 11,436 MT. The share of Urea distribution was 45% of the national total followed by Suphala with 33% and SSP with 15% (SSF&PNM, 1998).

## **MATERIALS AND METHODS**

The procurement and distribution of inorganic fertilizers that were once directly handled by the government agencies was privatized during the seventh plan (1992-97). The fertilizer wholesale distribution in the country was handed over to the Druk Seed Corporation (DSC), and the sales in dzongkhags were handed over to the trained commission agents. The government provided subsidies that included 10% of commission paid to private retailers who sell directly to farmers, and the transportation cost for shipping fertilizers from the central Fertilizer Store in Phuntsholing, Chukha dzongkhag to other dzongkhags. Information on the fertilizer distribution pattern from 1997- 2006 for the whole country was obtained from DSC record and analyzed at NSSC using spreadsheet (Microsoft Excel). These records were, however not analyzed after the privatization of this important input in food production.

This paper examines the distribution trend of the inorganic fertilizer materials carrying nitrogen, phosphorus and potassium plant nutrients in the last ten years (1997-2006) at the national, regional and dzongkhag levels. The inorganic fertilizers procured and distributed to dzongkhags were Urea (46% N), Suphala (15-15-15), SSP (16% P<sub>2</sub>O<sub>5</sub>), Triple Super Phosphate (46% P<sub>2</sub>O<sub>5</sub>), Muriate of Potash (60% K<sub>2</sub>O) and Calcium Ammonium Nitrate (25% N). Diammonium Phosphate (DAP) that carries N and P<sub>2</sub>O<sub>5</sub> at 18% and 46% respectively by weight was introduced in the last two years. This

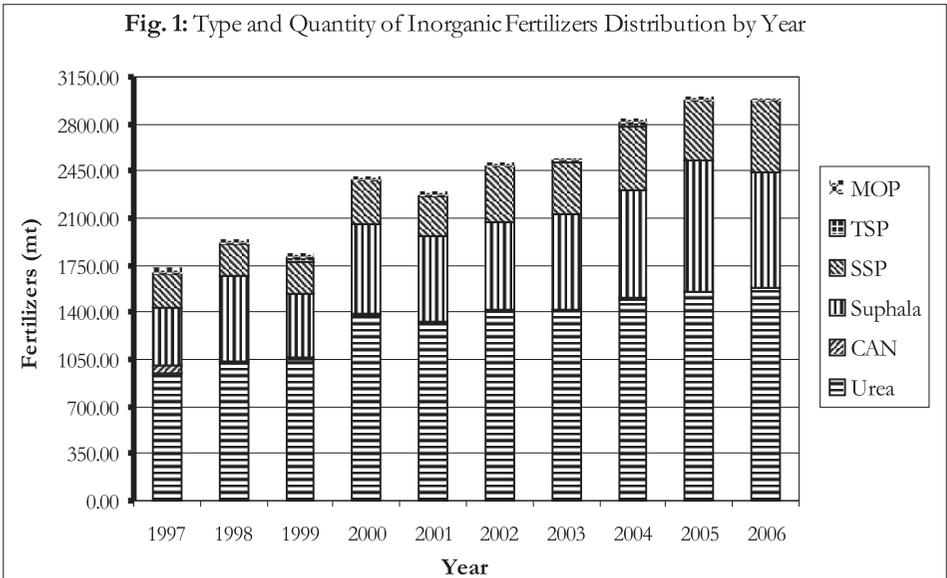
product was not included in this trend analysis.

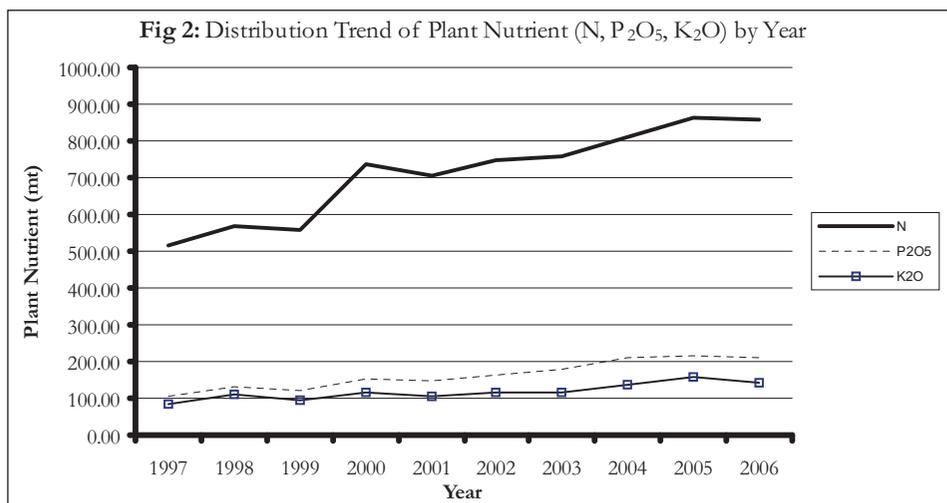
## RESULTS AND DISCUSSION

### 1. National Inorganic Fertilizer Distribution Trend

The type and quantity of fertilizers distributed by DSC are shown in figure 1. The single plant nutrient carriers distributed were Urea, Calcium Ammonium Nitrate, Single Super phosphate, Triple Super Phosphate (TSP) and Muriate of Potash (MOP). The two types of compound fertilizers distributed were Suphala and Di-ammonium Phosphate (DAP). The most popular fertilizer distributed was Urea with 55% of the national total followed by Suphala with 28%, SSP 15% and MOP with 1% in the last ten years. The distribution of CAN and TSP decreased over the years mainly because CAN being highly hydroscopic poses a problem for storage while TSP was not produced anymore in India.

The distribution increased from the lowest 1726.65 MT in 1997 to 2998.14 MT highest in 2005. This fluctuation between the years could be due to left over or not sold out materials from the previous year of procurement. The trend of plant nutrients derived from these fertilizer materials is shown by figure 2. The gap between N and PK is widening over the years with increase in fertilizer distribution. This is an indication of imbalance use of fertilizer materials carrying plant nutrients showing preference of nitrogenous





fertilizer materials over others.

The total fertilizer materials distributed in 2004 was 2832.83 MT and this amount was roughly equivalent to about 23 kg of fertilizer materials per hectare of cropped land (RNR, 2004) corresponding to 9 kg of plant nutrient (N, P<sub>2</sub>O<sub>5</sub>, and K<sub>2</sub>O) per hectare. In Sub-Saharan Africa, about 10 kg of plant nutrients (N, P<sub>2</sub>O<sub>5</sub>, and K<sub>2</sub>O) per hectare per year was reported in 2001. These figures were very low compared to the world average of 90 kg, and 130 kg/ha per year in Asia. (FAO, 2001).

## **2. Regional Distribution Trend.**

The country is zoned into four regions with each zone covering a wide range of farming systems. The main cereal crops grown are maize, rice and wheat. Potato, oranges and apples are the main cash crops where inorganic fertilizers are widely applied. The fertilizer material distribution was recorded highest in the eastern region which is composed of six dzongkhags (Trashigang, Pemagatshel, Samdrup Jongkhar, Trashiyangtshi and Mongar) with 39% of the national total, followed by the western region composed of five dzongkhags (Thimphu, Paro, Chukha, Haa and Samtshi) with 24%, the west central region composed of five ( Punakha, Wangduephodrang, Gasa, Dagana and Tsirang) with 19% and the east central region composed of four dzongkhags ( Bumthang, Trongsa, Zhemgang and Sarpang) with 18% (figure 3).

Fig.3: Regional Share of Fertilizer Materials distributed from 1997 to 2006.

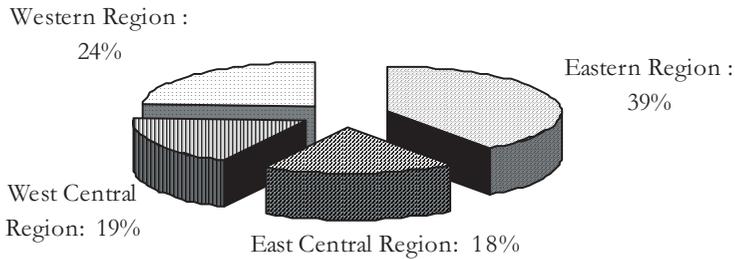


Table 1 provides the total plant nutrients (N, P<sub>2</sub>O<sub>5</sub>, and K<sub>2</sub>O) distributed in the regions. NPK ratio at the national level is recorded at 6 : 1 : 1. These ratios varied among the regions. NPK ratio for the eastern region was highest with 16: 1 : 1. followed by the east central with 8 : 5 : 1. The high N for the east and P for the east central were result of the large share of nitrogenous and phosphatic fertilizer distribution respectively. These values were very high and indicated imbalance use of fertilizer materials carrying N, P and K plant nutrients in these regions. The NPK ratio had also deteriorated in India with the withdrawal of subsidies from phosphate and potash fertilizers while N (urea) remained highly subsidized in 1990s. The N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O ratio for India increased from 6: 2.4 : 1 in 1990/91 to 8.5 : 2.5 : 1 in 1995/96 ( Maene, 1998). The preferred or ideal ratio is reported to be around 4 : 2 : 1. (FAO,2001)

Table 1: Share Plant Nutrients by the Region from 1997 to 2006.

Region	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	Total	Ratio (N: P <sub>2</sub> O <sub>5</sub> : K <sub>2</sub> O )
East	3789.4	280.3	239.3	4309.0	16 : 1 : 1
East Central	736.6	459.5	96.8	1292.9	8 : 5 : 1
West Central	1243.6	387.0	313.1	1943.7	4 : 1 : 1
West	1351.8	508.8	504.7	2365.3	3 : 1 : 1
<b>Total</b>	<b>7121.33</b>	<b>1635.62</b>	<b>1153.94</b>	<b>9910.89</b>	<b>6 : 1 : 1</b>

### 3. Dzongkhag Distribution Trend

The fertilizer distribution varied widely among the 20 dzongkhags in the past ten years. The top five dzongkhags (Trashigang, Wangduephodrang, Bumthang, Thimphu and Paro) recorded highest fertilizer distribution among other dzongkahgs during the period reported. The highest amount of

fertilizer was procured by Trashigang dzongkhag with 28% of the national total followed by Bumthang with 16%, Wangduephodrang with 14%, Thimphu with 9% and Paro with 7%. Gasa was the only dzongkhag that did not feature under DSC distribution list. The dzongkhags like Dagana, Tsirang, Zhemgang, and Samtsi where the commission agents were not appointed procured less than 2% of the total fertilizer distributed in the last ten years. Trashigang dzongkhag has the highest number of commission agents distributing fertilizers and other agriculture inputs to the farmers. A total of 724.23 MT of fertilizers was distributed in 2004 corresponding to 70 kg of fertilizers per cropped land. This was equivalent to 33 kg of plant nutrients per ha of cropped land. Table 2 provides the distribution of plant nutrients in the top five dzongkhags. On average Trashigang distributed 300 MT per year of plant nutrients followed Wangduephodrang with 146 MT of plant nutrients.

Table 2. Distribution of Plant Nutrients (NPK) by the top five dzongkhags from 1997 to 2006.

<b>Region</b>	<b>N</b>	<b>P<sub>2</sub>O<sub>5</sub></b>	<b>K<sub>2</sub>O</b>	<b>Total</b>	<b>Ratio (N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O)</b>
Trashigang	2560.66	242.97	199.73	3003.36	13 : 1 : 1
Wangdue Phodrang	851.25	337.74	268.61	1457.60	3 : 1 : 1
Bumthang	626.90	418.20	56.76	1101.86	11 : 7 : 1
Thimphu	475.70	180.59	202.92	859.21	2 : 1 : 1
Paro	535.65	115.31	111.71	762.67	5 : 1 : 1
<b>Total</b>	<b>5050.16</b>	<b>1294.81</b>	<b>839.75</b>	<b>7184.70</b>	<b>6 2 1</b>

## **CONCLUSION**

The type of fertilizer materials imported from India has not changed over the years. The quantity procured has increased and highest was recorded in 2005 with the distribution figure of 2998.14 MT. Urea accounted about 55% of the national total distributed in the last ten years. The fertilizers were used in 19 out of 20 dzongkhags and the quantity distributed among dzongkhags varied widely. Trashigang topped the list followed by Bumthang and Wangduephodrang dzongkhags. Accessibility and availability appeared to be the main reasons for this variation. The rate of fertilizer application per hectare of cropped land has increased and the increase was highest in those dzongkhags where potato is the main cash crop. The plant nutrient (N, P<sub>2</sub>O<sub>5</sub>, and K<sub>2</sub>O) ratios over the years have also changed as a result of preference for nitrogenous fertilizer materials among other materials imported. These information suggest that knowledge on the balanced use of fertilizers

appeared to be limited particularly among the farmers from the east and east central regions. As reported by Norbu (2001), these information confirm the need to address these problems at the extension level by on-farm trials and training farmers with respect to the benefits in terms of crop yield and soil health and the use of more balanced fertilizers. One way to reduce this gap is by focusing on balance use of fertilizers through on farm trials and demonstrations. A good example is FEFUT (Farmer Extension Fertilize Use Trial) promoted by the National Soil Services Centre (NSSC).

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## Research Need Assessment in Goshing Geog Using Participatory Rural Appraisal

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### ABSTRACT

*Participatory Rural Appraisal was carried out in Goshing geog of Zhemgang to study the farming practices, identify rural farming problems and formulate appropriate research and extension intervention. Goshing is comprised of six villages and 208 households. The geog is located in a far flung area. Transportation is a major challenge for implementing developmental activities. Steep terrain continues to pose challenge for mechanization of Agricultural farming. Ban on tseri cultivation by the government has encouraged crop intensification and increased pressure on the land use system. Maize is the staple cereal while citrus is the main cash crop. In spite of the gradual improvement in the socio-economic condition of the people in these remote areas, a short period of food scarcity still exists. Livestock such as horses, cattle, pigs and poultry are reared for their livelihood. There is no improved pasture. Age old practice of free-grazing of livestock still exists. This paper discusses historical time line, calendar of activities, sources of livelihood and priority ranking of the farming problems of Goshing.*

### KEYWORDS:

Participatory rural appraisal, farming system, livelihood, crop intensification, cereal, livestock, forestry, Goshing, Zhemgang, Bhutan

### INTRODUCTION

Goshing is one of the remote geogs under Zhemgang Dzongkhag. It takes two days walk from the nearest road point in Gongphu and three days walk from Panbang. Track from Gongphu to Goshing-Ngalatong-Panbang requires climbing on to the valleys and down to the rivers. Transportation is one of the biggest hurdles in carrying out any developmental activities. Horses and mules are the main mode of transportation. Goshing is comprised

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of six villages; Litchibi, Lamtang, Samcholing, Limapong, Budashi and Mewagang. There are 208 households and the houses are sparsely located.

The participatory rural appraisal (PRA) has been reported as an effective tool in identifying rural problems for formulating effective research and extension intervention (Yeshey & Bujel, 2006; RC-Wengkhar, 2006). Grobбен and Schouten (1995) reported resource mapping, historical timeline, livelihood ranking, seasonal calendar and consultative priority setting as an appropriate PRA method for understanding rural needs. Poverty in Bhutan is predominantly a rural phenomenon (DoP, 2004). In order to reduce rural poverty, it is important to reach out research technologies to the poorest of the poor in remote areas. As an initial step for research intervention to address rural poverty, PRA was carried out in Goshing geog with the following objectives:

- Understand the holistic village profile and the overall existing farming practices
- Assess the socio-economic, food security status and sources of livelihood of the selected villages
- Identify constraints, issues, needs and look into the possibilities of research-extension interventions for enhancing food security and income generation

## **MATERIALS AND METHODS**

### **The Process**

A team comprising of forestry, livestock, farming systems, horticulture and field crops from research visited the study area. PRA was conducted in Litchibi, Lamtang, Samcholing and Limapong covering 146 households. Budashi and Mewagang were not included since these villages are located away from the above villages. The date and purpose of the visit were informed in advance to the concerned Gup (Block leader) and Extension Agent through the help of District Agriculture Sector, Zhemgang. On arrival of the team in the block, the objectives of the visit were explained to the Gup and Tsokpas (village head man). Gup and Tshogpas further helped to arrange the meeting with the community.

### **Historical time line**

Information on historical time line was collected to investigate reasons and causes for important changes in land use, crop production, animal husbandry and use of different resources. Crops, livestock, non-wood forest products, fodder and the general farming systems of 10 years ago (past), present and

future were discussed. Reasons for cultivating crops or taking up different activities for future were also recorded.

### **Seasonal calendar**

Seasonal calendar was prepared to determine the cropping cycles, animal husbandry activities, availability of labour, food, non-wood forest products, off-farm and non-farm activities. Calendar was prepared on the chart paper with crop/subject in the first column and 12 other columns for the Bhutanese months. Calendar of each activity was asked and recorded to generate baseline information for future planning purposes.

### **Livelihood ranking**

Different sources of livelihood were written on the chart paper, relative importance of the sources for subsistence and cash were rated in separate columns as high, medium and low in importance. This exercise was expected to understand sources of livelihood for subsistence or cash and to determine the relative importance of the different sources.

### **Priority setting**

Priority ranking of the issues or problems related to the farming systems was carried out in consultation with the communities. This was important to investigate to what extent research and extension can contribute in finding solutions to the problems and develop appropriate action plan. The constraints were ranked as either low, medium and high based on the severity of the problems as expressed by the communities. Accordingly, possible solutions were also discussed and listed down for each of the identified problems. Collaborative and tentative plan of action was developed at the end of the meeting.

## **RESULTS AND DISCUSSION**

### **Field Crops**

Farming is largely subsistence in nature characterized by mixed farming comprising of livestock, horticulture and field crops. Crops are cultivated on steep slopes without using chemical fertilizers and pesticides. Soil nutrients are primarily maintained by tethering of livestock in the fields. Maize is their staple cereal. In the past, maize was cultivated in *tseri* (shifting cultivation). However, due to the ban on *tseri* cultivation by the government (MoA, 1995), maize is cultivated in the dry land. Exercise on seasonal calendar (Table 1) indicates that ban on *tseri* cultivation encouraged intensification of crop cultivation.

Table 1. Seasonal calendar of farming activities in Goshing Geog (month in lunar calendar)

Crop/activity	1	2	3	4	5	6	7	8	9	10	11	12
Maize	S		W		H	S	H	W		H		
Finger millet		W		H		S		W		H		S
Foxtail millet		W		H								S
Dry land rice		S	W				H					
Wheat		H						S				
Mustard								S				H
Buckwheat	S			H				S			H	S
Mung bean						S				H		
Amaranth		S									H	
Soya bean				S	W			H				
Tapioca					W				H			S
Mandarin			W	P	W				W	H		
Potato		W		H								P
Ginger	H	P		W		W						H
Chilly			P	W	H							
Fodder shortage		✓									✓	
Livestock diseases					✓				✓			
Mushroom collection				✓								
Non wood forest products		✓										
Off-farm labor	✓									✓		
Non-farm				✓								
Bambo Work										✓		
Weaving									✓			
Food shortage			✓									

Legend: S=sowing, W=weeding, H=harvesting, T=Transplanting, P=Planting

Unlike in the past, farmers cultivate two maize crops in a year. Further, exercise on livelihood ranking of sources (Table 2) and priority setting of the farming problems (Table 3) revealed that maize will continue to play an important role in the farming systems for subsistence as well as in generating some cash through sale of *kharang*. Farmers have been cultivating their local varieties, *chungkurme* (white), *khartela* (white) and *sertela* (yellow) for years. The study also found out that maize yield have been declining which could be attributed to seed degeneration due to poor seed selection practice and loss of nutrients over the years. At present, decline of maize yield is a concern for the farmers. Improved varieties; Yangtsepa, Khangma Ashom 1 & 2 may be introduced to enhance production and provide more variety options.

Table 2. Livelihood sources ranking of Goshing Geog

Constraint	High	Medium	Low	Suggested solution
Wild animal damage			✓	Proper fencing, review, revise and develop farmer friendly forestry and conservation rules
Pests & diseases			✓	Use of pesticide & improve management
Soil fertility		✓		Contour bending, apply FYM
Maize variety problem		✓		Exchange seeds, cultivate improved varieties
Orchard management			✓	Basin making, demonstration orchard required
High price for orange & mango seedling			✓	Free or subsidized seedlings from government
Fodder shortage	✓			Fodder seeds required
Poor breeding bull (poor Cattle breeds)		✓		Bull free of cost or at subsidized rate
Seed potato not available in time			✓	Support from EA, advance payment required, government support for transporting seed potatoes
Low yield and declining yield of maize		✓		New/improved variety required, apply manure, training/demonstration on composting
Lack of paddy varieties			✓	New/improved variety require, trial on rice varieties under rain fed condition
Lack of mustard, wheat and buckwheat seed			✓	New/improved variety required
Low quality citrus seedlings			✓	Demo orchard with grafted seedlings and management aspects
Lack of avocado seedlings		✓		Trial on improve Avacado
Groundnut and lentils seed scarcity		✓		Conduct trial on groundnut and lentil varieties
Lack of awareness in mushroom cultivation			✓	Training cum demonstration
Low soil fertility			✓	Fertility management

Other crops such as buckwheat, foxtail millet, finger millet, upland rice, wetland rice, mustard (*Brassica* spp.), sesame (*Sesamum indicum*) and perilla (*Perilla frutescens*) are grown. Foxtail millet cultivation has decreased over the years due to the ban on *tseri* cultivation and also due to low preference over maize. It is reported to be less palatable and ranked low importance for subsistence. However, it supplements maize and other crops during the lean season like other minor cereals (Dukpa, 2005).

Table 3. Priority ranking of the farming problems of Goshing Geog

Crop/activity	Low		Medium		High	
	Subsistence	Income	Subsistence	Income	Subsistence	Income
Maize		✓			✓	
Foxtail millet		✓	✓			
Finger millet		✓	✓			
Buck wheat	✓	✓				
Amaranth	✓	✓				
Tapioca	✓	✓				
Mandarin	✓					✓
Ginger	✓			✓		
Potato			✓		✓	
Mushroom	✓			✓		
Chilly					✓	✓
Livestock					✓	✓
NTFP			✓	✓		
Off-farm labor				✓		
labor						
Bamboo work/weaving				✓		
Wild yam	✓	✓				
Weaving		✓				
Non-farm				✓		
Dry land rice		✓	✓			
Portering				✓		

Farmers have stopped cultivating common millet (*yuán*) due to the difficulty in threshing and low preference over other cereals. The cultivation of up-land rice has also been declining due to restriction in *tseri* cultivation and extensive labour requirement. Encouraging up-land rice would add pressure on the land use system. Wetland rice cultivation is constrained by the lack of assured irrigation and suitable varieties for rain-fed condition.

Buckwheat is of low importance to the community for subsistence. However, lack of varieties has been ranked as the prime constraint. Perilla and sesame are cultivated on a small scale for cultural and religious purposes. Although tapioca (*Manihot esculenta*) is rated as in low importance both for subsistence and income generation, almost every household has tapioca plantation clearly indicating its role for food security. It is consumed after boiling, cooked with rice and maize and also used for brewing *ara*.

Improving the existing nutrient management practice by introducing fertilizers may not be feasible at present due to the transportation problem. Making of compost, using locally available materials is seen as practical and viable option for improving the soil nutrients, enhancing production and

food security. Food self-sufficiency over the years is reported to have increased due to the intensification of crops (double cropping of maize), income generation from mandarin and reduction of the quantity of grains for making *ara* and *banchang*. Due to the increase in food self-sufficiency, fewer people go and collect wild yam (*Dioscorea* spp.) unlike in the past. However, some households still suffer from food shortage during 2<sup>nd</sup> to 3<sup>rd</sup> Bhutanese months and this issue still needs to be addressed.

### Forestry

The PRA revealed that there is fodder shortage for five months from October to February. However there are local fodder tree species which could be planted along the contour on the sloping land. The evergreen fodder trees like *Ficus* species and broom grass (*Thysanolaena maxima*) are reported to be suitable as winter fodder. The broom grass is a multipurpose plant which serves as fodder and good for soil and water conservation. Planting broom grass along the contour will lead to terrace formation and maintain the moisture in the soil. Therefore, land management demonstration by planting broom grass along the contour line is suggested. Farmers can earn extra income through the sale of broom.

Soil fertility is reported to be declining over the years which could be due to leaching (steep terrain), high rain fall and poor nutrient management practice. Nutrients are washed away by heavy rain during the monsoon. Some farmers have adopted contour bunding using napier grass (*Pennisetum purpureum*) to reduce nutrient losses. However, grasses are not properly maintained and contouring is not laid out properly. Improving the existing contour bunding with proper layout and using other fodder grass species would be useful.

Lower Kheng is rich in non-wood forest product resources. Majority of people live in a house solely constructed by non-wood products such as bamboo for construction and wild palm or wild banana leaf for roofing. Bamboo shoots (*Bambusa clavata*), wild yam, cane shoot (*Calamus acanthospathus*), wild asparagus (*Asparagus officinalis*), *damroo* (*Elatostema lineolatum*), *pan* (*Piper betle*), wild mushrooms, ferns (*Diplazium polypodiodes* and *Diplozium esculantus*) and nuts are collected and consumed. It was reported that due to conversion of *tseri* land into permanent cultivation, wild asparagus is declining from their locality. Since it is a nutritious and delicious wild vegetable, its domestication is suggested for household consumption and as a cash crop.

There are about 26 species of wild mushrooms, which are usually collected from February starting with wild Shiitake followed by others till September. Participants felt that wild mushroom production has reduced over the years due to restriction of *tseri* cultivation. Goshing has ideal temperature with adequate raw materials for growing different mushrooms throughout the year. Farmers are busy from April till October and there is relatively less work during winter months. Therefore, supporting these rural communities to grow mushrooms from autumn through winter could provide self-employment, assist them to generate cash income and increase nutrition in their diet. Shiitake and Jew's ear mushrooms can be tried on chestnut tree species in Litchibi while oyster mushroom can be promoted in Samcholing and Lamtang villages. The products can be dried and sold as high value low volume product.

### **Horticulture**

A wide range of horticultural crops such as mandarin, cassava, guava (*Psidium guajava*), mango (*Mangifera indica*), banana (*Musa* spp.), colocasia, sugarcane, passion fruit etc. are grown. Arecanut (*Areca catechu*) is one of the new crops that the farmers are taking up. According to one of the elderly participants of the village, there has been a positive change in the village during the past ten years. Accessibility and procurement of vegetable seeds have been improved. Unlike in the past, vegetable seeds can be availed from the geog RNR center and few farmers sell vegetables to the school (Goshing Community School) and some even take the chilli to Panbang which is a day walk. Vegetables such as chilli (*Capsicum* spp.), colocasia, sag (*Brassica* spp.), beans (*Phaseolus* spp.), brinjal (*Solanum melongena*), radish (*Raphanus sativus*), turnip (*Brassica rapa*), cabbage (*Brassica oleracea*) and pumpkin (*Cucurbita maxima*) are grown in sporadic locations and thus, there is a potential to upscale vegetable production both for household consumption and income generation.

Currently, mandarin is the only fruit crop widely grown for cash income. The formation of Panbang Farmers Citrus Association Group has helped farmers marketing their produce. On an average, each household have 140 mandarin trees including non bearing plants. Farmers reported that the production is quite low compared to the other mandarin growing areas, which is believed to be due to the poor quality seedlings and lack of awareness on pests and disease control measures and orchard management. Therefore, it is imperative to provide trainings on citrus orchard management and develop modalities of supplying quality seedlings on time to boost citrus farming.

## **Livestock**

Livestock production is largely subsistent in Goshing geog. An exercise on trend analysis revealed that the livestock activities were confined to less productive animals in the past. However, positives changes have taken place over the years and households are gradually realizing the potential of livestock farming. Farmers have adopted jersey cattle, improved pigs and poultry. There is a common agreement to take up livestock activities on a larger scale and future activities proposed by households included adoption of jersey cows, poultry farms, fish farms, beekeeping, improved horse and pigs. At present, the only income generated from livestock activity is through the use of horses for transportation. The utility of horses will continue even in future for the livelihood of the people in Goshing.

The lack of improved livestock breed was a major constraint and received the highest ranking. The availability of improved breed will strongly influence the households' plan to reduce the number of local cattle. Households suggested that jersey breeding bulls be supplied to the villages as *kidu* or at a subsidized rate. The department of livestock's strategy of cattle exchange program will facilitate livestock development in the area. However, the fodder resource situation should be equally considered.

Improved fodder species was non existent in the past and the fodder requirement was mostly met through grazing in the forest. Crop residues and fallow land grazing are major source of fodder resources. However, farmers are becoming aware of the improved forage species and started to adopt improved species. Similarly, few fodder trees were also planted. The area under native grassland seems to have decreased due to the ban on *tseri* cultivation and encroachment of grassland by forest. Households expressed their willingness and the necessity of planting improved forages on a larger scale. Considering the limited land for pasture development planting of fodder trees around their fields and evergreen fodder grass Guatemala in their backyards are feasible options.

## **Farming Systems and Support Services**

The livelihood of the people of Goshing is largely dependent on maize based farming system. The major production constraint reported was the post harvest losses of maize. The storage losses due to weevils (*Sitophilus zeamais*) and grain moth (*Sitotroga cerealella*) are more for the maize harvested in summer. Farmers reported that the loss due to these insect pests in storage is about 35 %. Hygiene and sanitation of grain storage is reported to be a safe and healthy control measure (Bergvinson, 2000). However, it was observed that the post harvest management of maize by farmers

including hygiene condition was generally poor. Considering the magnitude of damage caused by these insect pests it warrants detail studies on storage losses. Cost-effective technologies against these storage pests for small-scale subsistence farmers need to be generated.

## **CONCLUSION**

The villages in Goshing are far flung and the lack of motor able road makes their access to developmental activities difficult under present conditions. The farming system is largely subsistent, less diverse offering and less economic opportunities to the people. It is envisaged that the steep terrain will be a challenge while implementing research technologies. With the changing times and aspiration to benefit from economic opportunities, people are becoming receptive to the developmental activities. However, it is crucial to plan the activities in line with the existing farming systems for successful implementation of the activities.

In spite of the gradual improvement in the socio-economic condition of the people in these remote areas, a short period of food scarcity still exists. In order to promote alternative cash generating technologies and enhance food self-sufficiency, the communities will require concerted support from research and extension. It is imperative for RC-Jakar and relevant sectors of Zhemgang to work closely and make joint efforts to improve the livelihood of the farmers and address rural poverty.

Through the survey, a few research and extension intervention were identified that could be taken up to spark off community development activities. The proposed activities are:

- Provide technical support in mandarin orchard management to increase production, productivity and quality through establishment of demonstration orchards where improved management practices could be disseminated;
- Wherever possible and potential is identified, livestock farming like provision of jersey cows, poultry, improved horse and pigs, beekeeping and fish farming in some cases could be promoted; and
- In collaboration with Horticulture researchers, some other potential horticultural crops, from vegetables to fruit crops could be encouraged.

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## **Effect of plant nutrients on early stage yellowing of the rice variety “Khangma Maap” in Paro**

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### **ABSTRACT**

*The rice variety “Khangma Maap” is an introduced high altitude variety grown in many parts of Bhutan. This variety has a typical early stage leaf yellowing similar to some plant showing nutrient deficiency symptoms. The early tillers senesce, rot and drop off after yellowing. As the crop matures, yellowing disappears. An on-farm trial was conducted in Paro to look at the plausible causes of the yellowing in Khangma Maap. In this study, proper soil nutrient management aimed to improve soil potassium status and water temperature were considered. There were six test farmers each representing a replication and each with two treatments – (1) farmer practice i.e. the usual practice of an individual farmer and (2) recommended practice with the recommended NPK rates of 40-20-40 kg ha<sup>-1</sup> along with the usual amount of farm yard manure applied by the farmers. Soil and plant samples were analysed for nutrient status and farmers were interviewed on their observations and views on the early stage yellowing of Khangma Maap.*

*Potassium was not limited at the early stages of the plant growth when the yellowing actually takes place. Minimum water temperature was within the acceptable range for growing rice. This study therefore indicates that the yellowing in Khangma maap is not related to potassium deficiency or low water temperature. The yellowing could probably be related to the extreme levels of Mg and Fe in the plant tissues detected. Yellowing could also be related to the temporary deficiency of nitrogen caused by high C:N ratio.*

### **KEYWORDS:**

Yellowing, Rice, Nutrient, Deficiency, Yield, Symptom, Temperature

### **INTRODUCTION**

The yellowing problem in the rice variety “Khangma Maap” was first reported in 1997 from the high altitude rice growing areas of Paro and Thimphu valleys. The main visible symptom is the yellowing of the leaves in the early tillering stage progressing to late tillering to booting stage, when

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the problem becomes acute. This problem with increased severity was reported in 1998-rice season.

Following the reports from the Dzongkhags, an investigation and monitoring exercise was carried out by the RNRRC Bajo, Yusipang and Dzongkhag Extension in Thimphu and Paro.

It was speculated that the yellowing problem was the effect of cold water temperature, nutrients deficiencies, poor nutrient uptake due to abiotic stress, and improper water management practices.

The National Soil Services Centre (NSSC) in collaboration with the RNRRC Yusipang, RNRRC Bajo, and Dzongkhag Extension in Paro set up an experiment to look into the factors contributing to the yellowing symptom. From the investigation, it was found that the potassium (K) content of the soil taken from the experimental site was very low and the plants also showed a nutrient deficiency symptom similar to that of K deficiency symptom characterised by yellowing and scorching along the margin of the older leaves. Therefore, it was suspected that the yellowing might be due to low K content in the soil. Following this, an on-farm trial was conducted to establish:

1. If application of recommended fertilizer dose for rice controlled yellowing problem in Khangma Maap.
2. If improving soil K status controlled yellowing problem in Khangma Maap.
3. If the temperature of the irrigated water affected the plant nutrient uptake thereby resulting in nutrient deficiencies in rice plant.

## **MATERIALS AND METHODS**

The trial was conducted in Wangchang and Dhop Shari geogs in the main valley of the Paro Dzongkhag. Both the geogs have vast flat lands, which are mainly under irrigated rice. After the rice harvest, some farmers grow crops like potatoes and winter fodders like wheat and oats. Both improved and local rice varieties are grown in Paro. To maintain soil fertility, farmers mainly use farmyard manure along with urea in rice. Urea is applied about a month after transplanting especially if the crops show signs of yellowing. On an average, farmyard manure is applied at the rate of 5 baskets ( $\approx 20$  kg/basket) per “seon drey” ( $\approx 200$  msq) area of land (i.e.  $\approx 500$  kg FYM per langdo). To control weeds in rice, butachlor (punch) is applied at the time of transplanting.

Six interested farmers growing the rice variety “Khangma Maap” were selected in Wangchang and Dhop Shari geogs. Each geog had three test farmers and each of these farmers represented one replication. Each farmer selected two terraces next to each other for the two treatments *viz.* Farmer Practice (FP) - usual practice of an individual farmer and Recommended Practice (RP) – practice recommended by the research. The RP had the recommended NPK rate of 40-20-40 kg ha<sup>-1</sup> along with the usual amount of FYM applied by the farmers. Fertilizer materials used as the sources of NPK were Single Super Phosphate (SSP), Muriate of Potash (MoP) and Urea. The entire dose of SSP and half of MoP and urea were applied as basal and based on IRRI's recommendation, the remaining half of MoP and urea were top dressed about 5 weeks after transplantation. The FP applied only FYM along with the usual two urea top dressings. Seedlings were transplanted between 4<sup>th</sup> June (earliest in Shari geog) and 25<sup>th</sup> June (latest in Wangchang geog) 2003. Following assessments were made:

- Soil nutrient status before and after the trial
- Crop nutrient contents (of test and non-test farmers)
- Water temperature (twice a week)
- Yield (at harvest)
- Farmers' feedback on the trial at harvest.

The cultural practices such as weeding and water management in the trials plots were all done as per farmers practice.

### ***Soil sampling and analysis***

A composite soil sample with 7 to 10 sub-samples were collected from each trial site prior to the establishment of the trial and fertilizer application. The Samples were collected from the depth of 0-20 cm. Soil samples were again collected from different treatments plots at each site after the crop harvest. Samples were analysed at the Soil and Plant Analytical Laboratory (SPAL) for soil chemical properties such as the soil pH, carbon and nitrogen percent (C & N %), C:N ratio, available P and K, exchangeable bases, total exchangeable bases (TEB), cation exchange capacity (CEC), base saturation (BS), and soil texture.

### ***Plant sampling and analysis***

Starting around the time of the mid tillering stage, leaf samples were collected from both RP and FP plots once every week till the flowering stage. Six batches of leaf samples were collected between 5<sup>th</sup> August and 3<sup>rd</sup> September 2003. Fresh weights of the samples were recorded soon after

collection and the samples were submitted to SPAL for nutrient content analysis. The plant samples were analysed for total nitrogen, phosphorus, calcium, magnesium, potassium, sodium, copper, zinc, iron, manganese, dry matter and moisture content percentages. Samples were also sent to IRRI in the Philippines for analysis particularly for those elements (Al, plant S, B and crude Si), which are not analysed at SPAL.

During the harvest, 5 to 10 plants (grain and straw intact) selected randomly in each treatment plot were cut just above the ground, weighed and submitted to SPAL for nutrient analysis.

### ***Water Temperature***

Water temperatures of both the FP and RP plots were recorded twice a week soon after transplanting in June and continued till the end of October. Temperature readings were taken either early in the morning or late in the evening to record as much as possible the lowest temperature for the day. The trial results were analysed using Genstat 5 for windows, SPSS and excel.

## **RESULTS AND DISCUSSION**

### ***Soil nutrient status***

Table 1 shows the important chemical properties of the soil samples collected both before and after the trials. For pre-trial soils, the soil pH of 5.76 is within the optimum range while the CEC is within the low range. Pre-trial soils had low available K and P status of 54.9 mg kg<sup>-1</sup> and 11.5 mg kg<sup>-1</sup> respectively. The soil organic matter content of 3.4% and exchangeable Ca of 9.11-me/100g are within the optimum ranges. Ca deficiency is likely when soil exchangeable Ca is <1 me/100g. Exchangeable Mg of about 1 me/100g indicates very low soil Mg status. Magnesium concentrations of >3 mg/100g of soil are generally sufficient for rice.

*Table 6: Pre-trial soil nutrients status.*

<b>Parameters</b>	<b>Pre-trial</b>	<b>Post trial</b>
pH	5.76	5.76
Available K (mg/kg)	54.91	27.2
Available P (mg/kg)	11.46	16.2
OM%	3.44	4.9
Ca (me/100g)	9.11	8.31
Mg (me/100g)	1.09	0.96
CEC (me/100g)	11.38	13.24

There was no significant effect of the treatments on the soil properties. However, the available K after the trial was lower by about 27.7 mg kg<sup>-1</sup>

while the available P was higher by about 4.74 mg kg<sup>-1</sup>. Critical concentrations of about 78 mg K kg<sup>-1</sup> soil and about 15 mg P kg<sup>-1</sup> soil are often used for growing rice (Dobermann and Fairhurst, 2000). Therefore, P and K were low both before and after the trial. Both Ca and Mg had decreased after the trial and CEC although slightly higher after the trial was still within the low range. The overall soil nutrient status both before and after the trial was low and comparable as shown in Table 1 above.

### ***Crop yield (Grain and Straw)***

The effect of treatments on both the grain and straw yields was not significant. The RP and FP yielded about 2.9 t ha<sup>-1</sup> and 2.8 t ha<sup>-1</sup> of grains respectively. Both these yields are slightly higher than the estimated national average rice yield of 2.42 t ha<sup>-1</sup> for improved high yielding rice varieties. The RP had higher straw yield of 8.54 t ha<sup>-1</sup> while the FP yielded 7.87 t ha<sup>-1</sup> straw.

### ***Nutrient contents of the grain and straw***

Table 2 shows the average nutrient removal through grain and straw of Khangma Maap rice variety. The effect of treatments on the nutrient contents of the grain was significant for K (p=0.02), Fe (p<0.001) and Zn (p=0.019) and only for P (p=0.087) in straw. Concentrations of these nutrients were slightly higher with the RP than with the FP. Since the effect of the treatments on most nutrients concentrations in the plant tissues was not significant, nutrient removal by the grains and straw from the FP and the RP were comparable. Apart from K, other nutrient removals are comparable to those reported by others for rice plants (e.g. Dobermann and Fairhurst, 2000 and Datta, 1981). Potassium removal, particularly through the straw of the Khangma Maap variety is shown to be quite high in this trial.

**Table :** Average nutrient removal and mineral concentrations in grain and straw from farmer practice (FP) and recommended practice (RP) plots

	N	P	K	Mg	Ca	Fe	Mn	Zn
<b><i>Total nutrient removal with grain + straw (kg t<sup>-1</sup> grain yield)</i></b>								
FP	12.5	4.2	31.1	2.2	1.8	0.30	0.44	0.09
RP	12.8	5.2	32.1	1.4	2.5	0.31	0.41	0.22
<b><i>Nutrient removal with grain (kg nutrient in grain t<sup>-1</sup> grain yield)</i></b>								
FP	8.0	2.7	4.0	1.3	-	0.08	0.05	0.01
RP	7.8	3.3	5.3	0.4	-	0.09	0.05	0.02
<b><i>Nutrient removal with straw (kg nutrient in straw t<sup>-1</sup> grain yield)</i></b>								
FP	4.5	1.6	27.1	0.9	1.9	0.17	0.39	0.08
RP	5.0	1.9	26.8	1.0	2.5	0.22	0.36	0.2

*Effect of plant nutrients on early stage yellowing of the rice.....*

<b>Mineral content in grain (%)</b>								
FP	0.80	0.27	0.39	0.13	-	0.008	0.005	0.001
RP	0.78	0.33	0.53	0.04	-	0.009	0.005	0.002
<b>Mineral content in straw (%)</b>								
FP	0.45	0.16	2.71	0.09	0.19	0.017	0.039	0.008
RP	0.50	0.19	2.68	0.10	0.25	0.022	0.036	0.02

*Note: data - average of six test farmers.*

When comparing the nutrient removals by the grain and straw, a greater amount of N was removed by the grain (i.e. FP - 8.0 and RP - 7.8 kg N t<sup>-1</sup> of grain) than by the straw (i.e. FP - 4.5 and RP - 5.0 kg N t<sup>-1</sup> of grain), while more K was removed through the straw i.e. FP - 27 and RP - 26.8 kg K t<sup>-1</sup> of grain harvested. A greater amount of P was removed through the grain and other nutrients such as Ca, Fe, Mn and Zn were mostly removed through the straw harvest. If only the grain is removed and the straw is returned to the field, the removal of most nutrients such as K, Ca, Fe and Mn would be minimised.

***Nutrient concentrations in leaf samples***

The plant nutrient concentrations reported here are of the mid-tillering to flowering stages only. The effect of different treatments on the nutrient concentration of the plant tissue (leaf) was not significant at any stage of the plant growth except for N (p=0.07) during the mid-tillering stage and Cu (p=0.07, p=0.03) during the panicle initiation and flowering stages. The change in the nutrient concentrations in the plant tissue with time was significant for most nutrients as shown in Table 3 below.

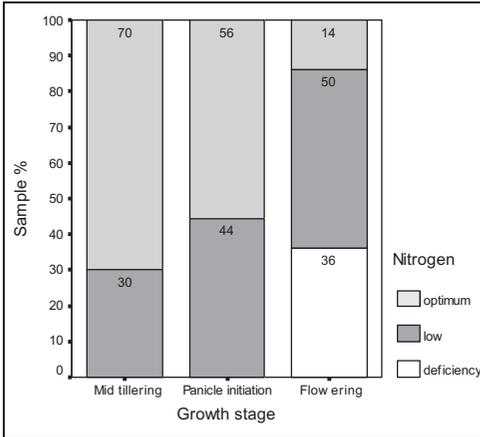
*Table 8 : Significance of changes in nutrients concentrations with time.*

<b>Nutrients</b>	<b>Significance</b>	
	<b>Recommended</b>	<b>Farmer</b>
N	p=0.055	p<0.001
K	p<0.001	p<0.001
P	p<0.001	p<0.001
Ca	p<0.001	p<0.001
Mg	p=0.917	p=0.318
Na	p=0.011	p<0.001
Fe	p=0.221	p=0.409
Mn	p<0.001	p<0.001
Zn	p<0.001	p<0.001
Cu	p=0.185	p=0.183
B	p=0.017	p=0.601
Al	p=0.333	p=0.019
Si	p=0.052	p<0.001
S	p=0.036	p=0.014

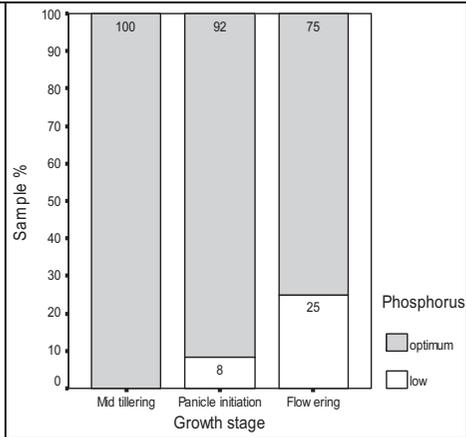
Percentage contents of nitrogen during the tillering and panicle initiation were within the optimum range of 2.9 to 4.2% for most samples collected. By the time, the plant started to flower; nitrogen content was less than 2.5%. However, at flowering, the critical level of nitrogen for deficiency to set in should be about 2.0% and the optimum range of nitrogen required during flowering should be about 2.2 to 2.5%. Therefore, these levels indicate that the plant nitrogen content was adequate at the time of flowering.

The concentration of P was within the optimum range of 0.2 to 0.4% at the early growth stages and decreased as the growth progressed. During the flowering stage, about 25% of the plant had low P level of 0.2 to 0.3%. Potassium concentration decreased with time. At tillering, K was within the low (1.5 to 1.8%) to optimum range (1.8 to 2.6%) while at panicle initiation stage most plants were deficient in K with its level less than 1.5%. However, for K deficiency to set in, the critical level of K should be about 1.2%. Since K was not acutely limited at the early growth stages of the plant, the yellowing problem in Khangma Maap due to K deficiency could be ruled out. Plant uptake of N, P and K at different growth stages in this study is very similar to that reported by others e.g. Ishizuka (1965).

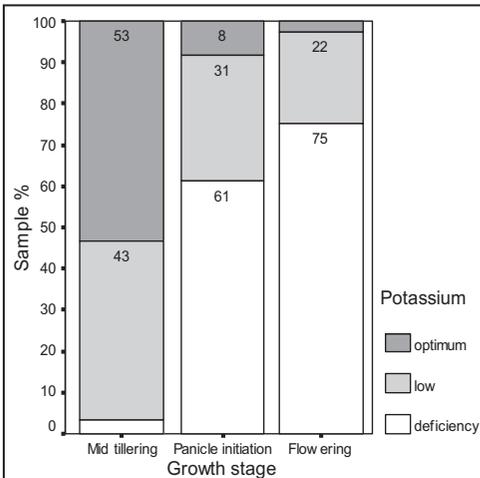
Calcium concentration was within the optimum range of 0.2 to 0.6% during the early growth stages. At flowering stage the Ca concentration in 53% of the samples was within the toxic range of more than 0.7%. Magnesium was deficient throughout the growing period. At tillering stage, 80% of the samples were deficient in Mg (<0.12%) and as the growth progressed, Mg status tended to improve. Mg deficiency can be caused either by low availability of soil Mg or decreased Mg uptake due to a wide ratio of exchangeable K:Mg (i.e. >1:1). Upland soils with low pH and CEC are prone to Mg deficiency. Iron concentration was high (150 – 300 mg/kg) and as the plant growth progressed, Fe concentration continued to increase to levels higher than 300 mg/kg (toxic level). Iron toxicity is more pronounced where Mg and K are deficient. Figures 1 to 8 below show the status of some nutrients in the rice plant.



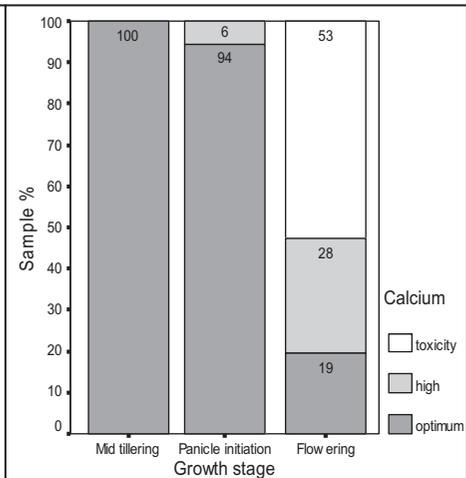
**Figure 1:** Level of N within plant tissue at different stages of growth.



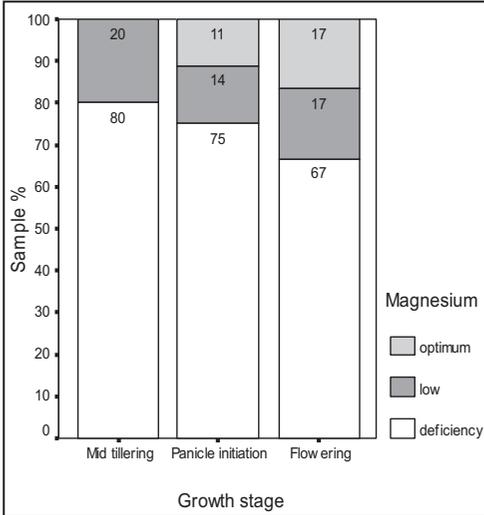
**Figure 2:** Level of P within plant tissue at different stages of growth



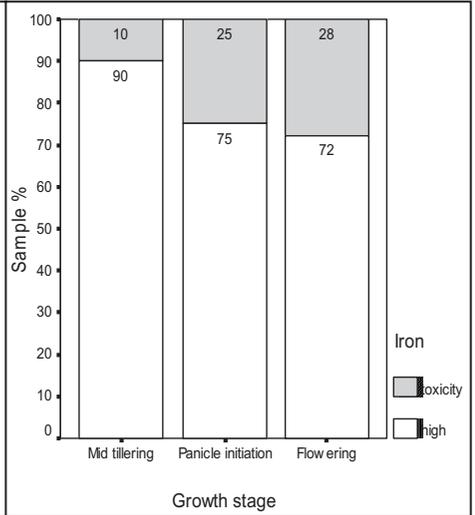
**Figure 3:** Level of K within plant tissue at different stages of growth



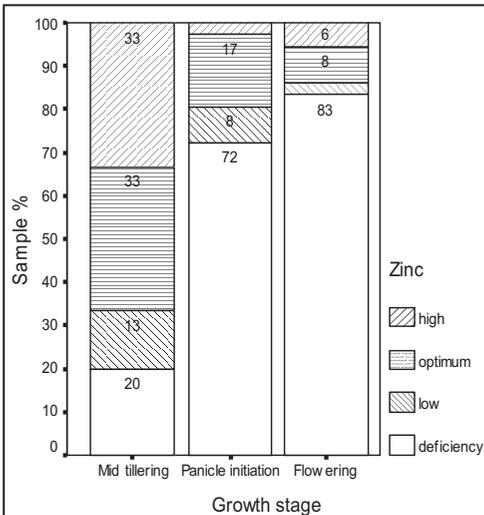
**Figure 4:** Level of Ca within plant tissue at different stages of growth



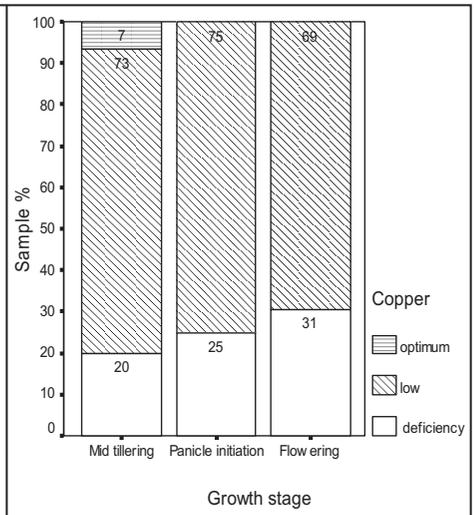
**Figure 5:** Level of Mg within plant tissue at different stages of growth



**Figure 6:** Level of Fe within plant tissue at different stages of growth



**Figure 7:** Level of Zn within plant tissue at different stages of growth



**Figure 8:** Level of Cu within plant tissue at different stages of growth

### Water temperature

Figure 9 shows the lowest water temperatures recorded for both the FP and RP. There is no significant difference between the water temperatures of the FP and RP plots. The minimum water temperatures recorded ranged from 22.9°C in July to about 16°C in October. Nutrient uptake is adversely affected by low (<15°C) water temperature (Bhattacharyya and De Datta, 1971). In our study, the minimum water temperatures especially during the active growing stages did not fall below 16°C and therefore the nutrient uptake would not have been affected. The optimum temperature for growing rice is reported to be about 25 to 30°C (De Datta, 1981). Injury due to low temperature is apparently a major constraint to rice production in the hill areas and is ultimately reflected in reduced yields. Two factors which cause cold injury to rice are cool weather and cold irrigation water (De Datta, 1981) causing symptoms like poor germination, slow growth, discolouration or yellowing, withering after transplanting, reduced tillering and stunted growth. The trials conducted earlier by the RNRRC Yusipang in collaboration with the RNRRC Bajo and NSSC to study the intensity of yellowing using different irrigation sources (spring and river water) and to study the effect of intermittent irrigation scheduling on yellowing problem showed no significant effect of the water temperature on rice yellowing.

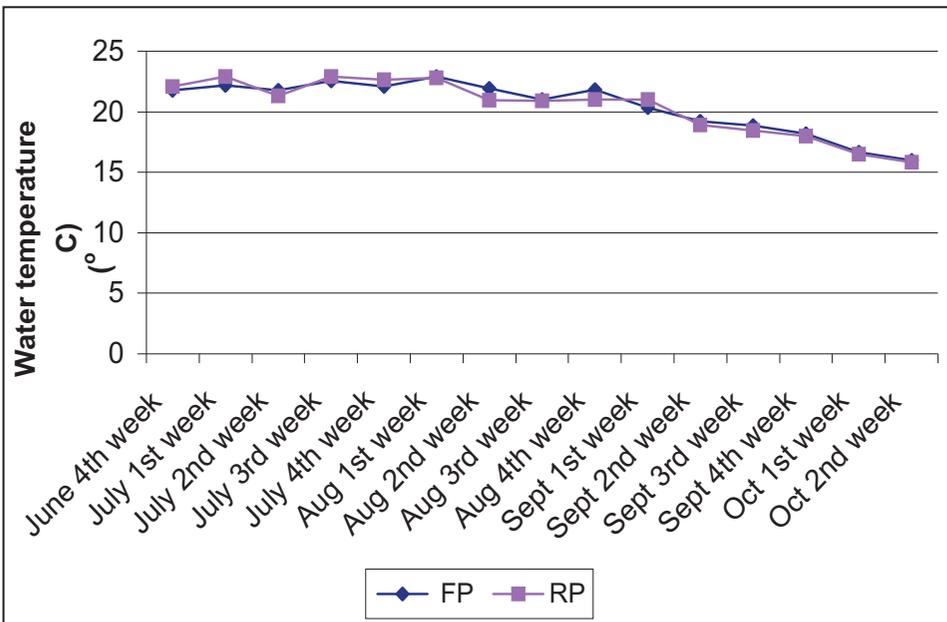


Figure 9: Water temperature of the trial plots

## **CONCLUSION**

The study conducted indicates that yellowing in Khangma maap rice is not caused by K deficiency because K was not limited at the early growth stages. If at all, the yellowing problem could be related to the status of either Mg or Fe or both in the plant. The concentration of Mg in the plant tissue was very low and that of the Fe was within the high to toxic ranges throughout the growing period. Yellowing symptoms and the time of yellowing observed are similar to those of either Mg deficiency or Fe toxicity. Magnesium deficient plants are pale-coloured, with interveinal chlorosis first appearing on older leaves, and later on younger leaves as deficiency becomes more severe. In severe cases, chlorosis progresses to yellowing and finally necrosis in older leaves. Iron toxicity symptoms appear one to two weeks or within 2 months after transplanting. Rice plants are apparently more susceptible to Fe toxicity during early growth stages when root oxidation capacity is small.

The minimum water temperatures recorded during the active growing stages were within the acceptable range therefore restriction to plant nutrient uptake could not be associated.

The yellowing problem could also be related to the temporary deficiency of nitrogen caused by high carbon to nitrogen (C:N) ratio. Initially, soil microbes are active in breaking down the organic matter during which they require a good supply of nitrogen which, if insufficient, will be taken from the plants' share of nitrogen causing nitrogen deficiency temporarily. Microbes are more efficient than crops in obtaining nitrogen from the soil. Once the decomposition of the organic matter is complete, the microbes die and the nitrogen is released into the soil, which is then available to the plants.

In Khangma map, yellowing is not much of a concern to the farmers. According to them, the plants recover after sometime and does not affect the crop yield. They have always associated early stage yellowing with this rice variety, as they have never seen a Khangma maap crop without yellowing ever since its introduction into the valley. Farmers have accepted the early stage yellowing as a trait of this rice variety.

However, it would be interesting and useful to find out to what degree the yellowing affected the crop yield. Due to the lack of yield records from crops without yellowing, it has been difficult to associate yellowing to crop yield.

It is suggested that in future, studies should address the researchable areas:

1. To look into magnesium deficiency and iron toxicity in rice;
2. To see the affect of supplying adequate nitrogen at the initial stages of crop growth.
3. To assess the yields from crops with and without yellowing (yellowing intensity recording to see levels of differences in yield) to see the affect of early yellowing on yield.

## **ACKNOWLEDGEMENT**

We would like to thank Ms. Deki Pem (Shari EA, Paro), Mr. D. P. Sharma (EA Wangchang, Paro) and P.L. Giri (Research Assistant, RNRRC Yusipang) for their assistance in collecting the field data.

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# *Brief Communication*



## The Collectors' Dilemma: Constraints and Opportunities for Community Based Cordyceps Management in Lingzhi

Sonam Wangmo<sup>1</sup> and Kelzang Wangchuk<sup>2</sup>

### **Cordyceps is valuable - is collection sustainable?**

*Cordyceps sinensis* (Yartsa Guenbub) occurs in the remote northern parts of the country at an altitude 3400m-4100 m. It is a restricted species, enlisted in the Schedule I- which is legally totally banned from collection and trading. With the legalization of *Cordyceps sinensis* collection in 2004, one member from each household is permitted to collect *Cordyceps*. Thus, collecting and selling *Cordyceps* has become a major source of income to the high altitude inhabitants. On the other hand, with the legalization of *Cordyceps* collection, the collection intensity is reported to be on the rise annually. As the information on *Cordyceps* biology and ecology is scarce, the sustainability of this valuable resource is an issue. Although, the collection rights are bestowed to the communities, there is hardly any initiative or a regulated system of promoting sustainable harvesting of *Cordyceps*. The concern that is raised is that the present trend will not only degrade the *Cordyceps* resource and natural pastures but also threaten the livelihoods of the highlanders.

*Cordyceps* may appear valuable but the tedious process of locating and collecting *Cordyceps* reflects the hardships the collectors undergo. The collection skills involved careful and painstakingly patient observation for *Cordyceps* in the very cold weather with wet earth underneath requiring strong determination and will power to persevere. At times, the collectors were unable to locate more than 2-3 *Cordyceps* in a day. The removal of *Cordyceps* was done either by bare hands or with the iron pegs. The removal by latter method was observed to be destructive to the soil environments.

Therefore, the existing scenario demands intervention to mobilize communities for sustainable management of *Cordyceps*. A consultative exercise was carried out with the communities of Lingzhi Geog to:

- Understand the trend, constraints and identify areas for improvement of *Cordyceps* collection and management

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- Explore the potential for Sustainable Management and Conservation of *Cordyceps* through community mobilization.

### **PRA and Observations**

Participatory Rural Appraisal (PRA) method was adopted to understand the background, identify existing resources, potentials, opportunity and challenges relating to *Cordyceps* resource and collection. The PRA tools used were trend analysis, participatory resource mapping, problem ranking, informal interview and field visits of the many concerns raised the most important one was the security of the harvesting communities. In the recent past, there were reported cases of life threatening clashes between the illegal collectors and the community. The issues on illegal collectors are two -folds. On one hand, the communities were unable to prevent the inflow of illegal collectors from across the border mainly due to fear of straining the traditional trade relations between communities for household necessities. On the other hand, the illegal collectors within the country were difficult to be barred from entering the collection sites in Lingzhi. Should the illegal collectors within the country face collection restrictions from the Lingzhi geog, then they either resort to threatening the lives of Linzhips or steal the yaks.

A common concern was also raised on the legal collection period of one month (15 May – 15 June). The communities expressed the need to revise the collection period particularly in light of the inconsistency in maturity of *cordyceps*. The emergence of fungal fruiting bodies was sometimes delayed by weeks often leading to prevalence of good number of *cordyceps* after the expiry of collection period.

The communities expressed dissatisfaction over the current law of allowing only one person per household for collection during the season. This appeared impractical due to large number of illegal collectors that outnumbered the community. Further, the small community against the vast collection areas does not seem to justify the current rule of allowing one person per household. The communities also expressed their concern over the environmental safeguard. It was reported that some traders –mostly non-Bhutanese, camp at the collection site and do brisk business by selling liquor and ready-made food item which are the main source of pollutants to the environment.

The vast area coupled with difficult terrain poses great difficulty for the forestry officials to monitor and protect the resource from illegal collectors.

The officials at times face life-threatening risks. Therefore, the present monitoring could be improved a lot better by deploying additional forestry officials in those areas. The frequent monitoring is needed mainly to prevent illegal Tibetan collectors, who are believed to harvest over 50% of *Cordyceps* in Lingshi geog.

With the ever increase in the number of illegal collectors, the communities are skeptical about the future prospects of *Cordyceps* from the sustainability point of view. The existing scenario therefore demands intervention to mobilize community of Lingzhi for sustainable management of *Cordyceps*. Upon knowing the benefits of forming the management group, the community expressed interest to form a group for *Cordyceps* management. Once the groups are formed, the communities would shoulder the responsibilities in managing the resources. There are possibilities of minimizing the illegal poaching by developing sound management plan and bye-laws. With the possible community organization into groups for managing the *Cordyceps* resources, the extensive government support that the communities seek currently and the regulation and control that the government enforces could be decentralized to the communities for sound and sustainable management.

## Village chickens can alleviate poverty: Must be protected from bird flu

Karma Nidup<sup>1</sup>

### INTRODUCTION

Village chickens also termed as 'family poultry' play a vital role in poor rural households. They provide scarce animal protein (in the form of meat and eggs) and can be sold/bartered to meet family needs such as clothes, school fees, and essential household commodities. Village chickens also fulfil a wide range of other functions for which it is difficult to assign monetary value. They are active in pest control, provide manure, and are essential for many traditional ceremonies, beliefs, and treatments of illness. It is obtained with minimum input in terms of housing, disease control, management and supplementary feeding.

### *Village Chickens Alleviate Poverty*

Wangmo *et al.* (2005) reveals rearing village chickens can be a profitable farming activity. The study which was conducted in Dop Shari geog, Paro Dzongkhag, analysed simple economic or cost benefit (Table 1) of village chickens amongst randomly selected seventeen farms.

**Table 1:** Cost benefit analysis of village chicken farming. (Source: Wangmo *et al.*, 2005)

Items	Quantity (No.)	Rate (Nu.)	Amount (Nu.)	Total Amount (Nu.)
Average Total Income from eggs	2546.82	5.00	12734.10	<b>12734.10</b>
(a) Average Gross Income or Average Total Revenue				
(b) Average Total Variable Cost (ATVC)			3105.41	
(c) Average Total Fixed Cost (ATFC)			890.35	
(d) Average Total Cost –ATC (b + c)			3995.76	
(e) Average Net Surplus (Benefit) (a - d)				<b>8738.37</b>

Each farmer has earned an average total net benefit of Nu.8738.37 per year with an average of nine laying birds. This is much higher than average annual income of Bhutanese farmers (HRD, 2003). The price tag for each egg was then Nu. 5.00. Now, chicken-egg situation has changed. The cost of locally produced eggs has increased to Nu. 300.00 for a tray (thirty eggs). Given

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similar situation, farmers of Dop Shari geog would earn Nu. 17476.76 per year. This is very good income, which is generated through very little input. The management of village chickens does not require as much physical or energy input as that of other agricultural activities. They are normally managed by women and children in many developing countries (Farooq *et al.*, 2000; FAO, 2004; Wangmo *et al.*, 2005). Considering all these, village chickens are potential source of wealth, development, promotion of gender equity, food security, and alleviation of poverty.

## **Bird Flu**

***Blessing in disguise:*** Bhutan imports huge amount of chicken meat and eggs from India (BAFRA, 2007). Record show five official entry points in southern border. Phuentsholing alone registered imports of 168,738 kg of chicken and about 2,240 cartoon boxes of eggs in the past year (BAFRA, 2007). Due to report of bird flu (H5N1) in India, complete ban on import of poultry related products are continuously enforced. The unprecedented scarcity of eggs and chicken meat in the country has been a blessing in disguise for village chicken owners, who can sell eggs at an extortionate price as compared to normal market rate. Now, even farmers who were initially hesitant to raise chickens (extension agents, *personal communication*) are demanding pullets from Government breeding farms. This indicates for a radical need to formulate appropriate programmes to support village chicken production in the country.

***Village chickens and gross national happiness:*** Village chickens which consists 95% indigenous flock (MoA, 2000; Nidup *et al.*, 2005; Nidup & Tshering, 2007) play important traditional and cultural roles in the livelihood of many Bhutanese people, particularly the Hindu *Lhotshampas*. Cultural practices such as offerings to local deities, celebration of annual religious festivals by different casts among Hindu Bhutanese requires sacrifice of special lines of indigenous chickens. For instance, Pradhan group of *Lhotshampa* cast need *Dhum-shay* (Frizzle) line for *Bhim Singh pooja* while Adhibasy group prefers white indigenous chickens for *Chot pooja*. Wiping these invaluable national and cultural resources due to outbreak of bird flu would hamper social and cultural livelihood of Bhutanese Hindu society. It would also mean adversely affecting holistic achievement of Gross National Happiness (GNH) because preservation of culture and tradition is one of the pillars to achieve GNH.

***Protecting village chickens:*** Bird flu will have minimal impact on Bhutanese economy but threat to indigenous chicken population and

possible human health hazards are imminent risk. The regular surveillance program does not indicate evidence of any incursion of bird flu virus into the country. However, given porous border with India, importation of poultry and their products, country being located in important flyways (central Asia flyway) for migratory birds, and the nature of integrated livestock farming system, Bhutan cannot afford to remain complacent. This is because Bhutan is bordered by two giant neighbours (China and India) and the risk of getting infection largely depends on status of these two neighbours and the involvement of migratory birds in spreading virus. The Ministry of Health and Ministry of Agriculture have drawn National Contingency Plan or National Influenza Pandemic Preparedness Plan (NIPPP) in 2004 to prevent and control bird flu in Bhutan (Tshering, 2007; Nidup & Tshering, 2007). This plan will be implemented in two phases: i) Prevention of incursion of HPAI virus, and ii) Emergency response to outbreak of HPAI. As recommended by FAO (Harris, 2006), Bhutan is focussed on first phase but also covering much of second phase in terms of containing disease and averting human diseases.

## **CONCLUSION**

Economic analysis of village chickens in Dop Shari geog indicated that rural poultry farming is a profitable farming activity and a promising alternative source of income for rural households. Beside socio-cultural and traditional importance, village chickens are potential tools to alleviate rural poverty. National Contingency Plan or NIPPP to prevent and control bird flu in the country should be strictly implemented. At the same time, it is important to encourage farmers, particularly rural poor, to raise chickens. Strategies and research to conserve, promote, and sustainable utilization of village chicken resources in the country should be considered.

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