

Microfarming techniques for yak producers in the Tibetan area of Muli in SW Sichuan, China

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Summary

The Pumi people of Sichuan Province are traditionally nomadic producers of the yak. Since 1949, they have relied more and more on soil based agriculture to produce subsistence crops. They survive on a diet based on cereal crops and yak products of milk, butter and yoghurt. The families graze their animals in the high Hengduan Mountains and rely on the grass produced naturally in the grazing area. This paper proposes the introduction of microfarming techniques into this region, a technology offered and introduced on a family by family basis. A microfarm is a one-hectare family farm that produces food and agricultural products using simplified hydroponics, fertigation and aquaculture. The first field of 435 m² can produce 1 ton of corn, 2 tons of corn fodder, 0.5 ton of broad beans, and a winter crop of alfalfa, wheat or other cover crops suitable for forage. This field uses gravity fed drip irrigation requiring about 500 L of water per day and an estimated 0.25 kg of fertilizer per day in growing period of 120 days. Using the rotation of a legume reduces the required nitrogen fertilizer. Rainwater should be collected to supply the system with its reliable daily source of water. Simplified hydroponics garden of 40 m² should provide an additional 5 kg of fresh vegetables per day for family consumption or a similar amount of commercial crops for local sale. The garden should require 100 L of water per day and 0.10 kg of hydroponics nutrient. A supplemental worm farm can reduce the need for chemical based nutrient. A larger garden should increase family income. A solar greenhouse can extend the growing season for daily food supply year round. A completed one-hectare microfarm with 5000 m² in fertigation and 600 m² in simplified hydroponics can produce much more animal fodder and vegetable produce. It can be diversified to satisfy individual family's preference and a more secure annual income. Establishing microfarming as an alternative form of income, the potential for higher income is present. This would allow an alternative to grazing animals as some forage can be produced in the microfarm.

Keywords: Microfarming, hydroponics, crop, fodder, yak

Introduction

This paper introduces the possibility of introducing microfarming technologies into Muli, with the Pumi population, as a sustainable technology that could offer an alternative to low paying employment or migration. The microfarm provided herein is a basic design to address the concerns of the Pumi people. The intention is to offer microfarming as a basic concept, rather than a complete solution.

This design is provided for the example village of Shuiluo in the Muli county of Sichuan Province. Muli, one of the two Tibetan autonomous counties in China, is one of the poorest counties in China. It is located in the southeastern edge of the Qinghai-Tibetan Plateau and in the Hengduan Mountains, 243 km from Xichang. The total area is about 13,246 km². There 28 townships, 112 villages and 604 rural groups. There are Tibetan, Han, Yi, Mongolian, Miao and Naxi nationalities of a population 120 thousands, of which 110 thousands are in agricultural sector and an estimated 15 thousands people are in poverty.

Muli, at 27.5 latitude and 101 longitude, is an area with low human density, rich pastures and a number of livestock and poultry breeds. In the region, average altitude is 3100 m, annual temperature

averages 11.5°C, annual rainfall 818 mm, and frostless period 220 days. There are 370 thousands hectare of forest, 400 thousands hectare of pasture. The growing season averages about 120 days a year in soil based agriculture.

The Pumi people are an indigenous people of about 30,000. Some families are seasonal nomads raising yak for a portion of their income. They also gather mushrooms and medicinal herbs. They live in wood two-story houses, ground floor for livestock and upper floor for people.

In 1949, more than 90% of the Pumis farmed land scattered on hill slopes. Presently, the Pumis raise corn, rice, wheat, broad bean, highland barley, oats, buckwheat, Chinese cabbage, carrots, eggplant and melons. However, their output, relying largely on natural conditions, was generally very low. Pumis also keep livestock, primarily cattle or yak and sheep, pigs and poultry. Non-farm activities include manufacture of wool sweaters, linen, bamboo articles, liquor, charcoal and medicinal herbs. They also practice bee keeping and hunting.

Agricultural reforms occurred in some of the region after 1949. Some irrigation was established and some raised beds or terraces on the rocky hillsides were constructed. An estimated 1120 hectare have been established as new paddy fields. New industries have been developed: ironwork and salt and aluminum mining. Highways have been built linking Pumi communities with neighboring areas.

There are about 5,630,000 mu (1 mu = 0.067 hectare) natural pasture, 2,740,000 mu forestry pasture and 70,000 tons of agro by-products which could support the livestock industry, ruminates in particular. Muli yak has been there for a long time, shows strong adaptation to the local humid, cold highland pasture environments and rough feeds and strong disease resistance. The yak provide the main livelihoods to the rural herders. There are 46,975 herd of yak living at the altitude of 3000 to 4000 m, of which 26,217 are found on nine state farms and 20,753 kept by farmers in several townships. The demand for livestock products is increasing during the economic development and green (no contamination) livestock products are particularly favored. Muli yak live in the natural environments without pollution, therefore the yak beef has a good marketing opportunity. Two hundred tons of yak beef are marketed to Shanghai, Guangzhou and Hong Kong every year.

Currently, a portion of the village population makes their living as nomadic shepherds raising yak, goats and sheep. The areas where they graze their livestock only can grow green grass about four months out of the year. Yak are produced using year round grazing without supplemental feeding. However, the period of grass growth lasts only about 4.5 months and only during June to September does the grass adequately meet the nutritional needs of the yak. Failure of the pasture to provide adequate nourishment during the majority of the year profoundly limits growth, production and reproduction (Zhang 2000).

At present, yak nutrition remains primarily dependent on natural forages in high mountain areas. Since yak are well adapted to this environment, their weight loss over the winter is natural and the yak is adapted to survive on reserves built up over the summer on natural forage alone.

Microfarming technology

The concept of a microfarm is proposed as an implementation of simplified low energy technologies that allow for intensive agricultural production on a single hectare of land. The overall purpose of this concept is to allow families to have an alternative to present technologies and to migration or accepting low income employment. The intention is to increase the overall independency and livelihood of the family, with the microfarm first providing food security for the family and then added income as a small family business.

A microfarm can be designed to first supply the family with basic food requirements and some supplemental animal fodder. It can begin as a portion of land used, only 0.10 hectare, and then increased as resources are made available. As an example, a microfarm for Mexico is designed to produce 50,000 US\$ in income on a single hectare (**Figures 1-3**). This amount of income is considered as the amount needed to offer an alternative to the male family members migrating to find employment. From the point of view of the family, they work to create the microfarm, step by step

expanding their farm and farm income from marginal poverty to competitive middle class. The microfarm technologies allow them to produce more agricultural products with less resource (Bradley and Katzir 2003).

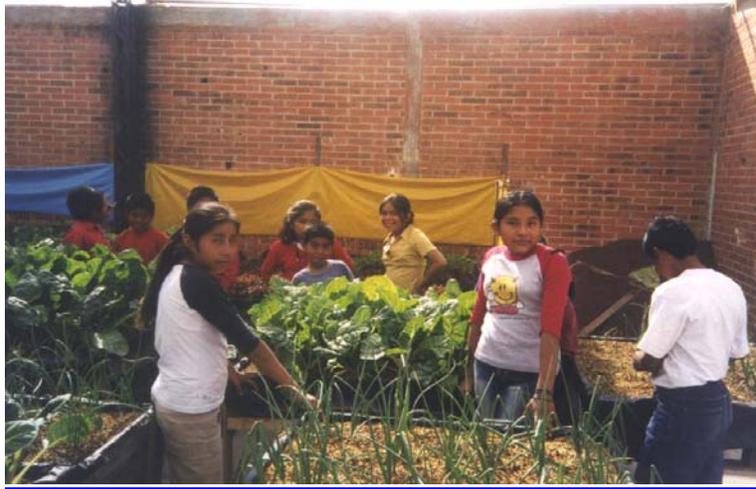


Figure 1. *Children in a Mexican homeless shelter grow their own lettuce in simplified hydroponic growers.*



Figure 2. *Growers of 2 square meters produce 2 lettuce a day. A 20 bed grower garden produces 40 head of lettuce every day.*

The introduction of the microfarm requires design of the farm to match the natural climate and agricultural conditions of the area, engineering and evaluation of the design for sustainability and long term financial security, plans to implement the introduction of this technology and concept in the Muli area.

This paper has the intention of introducing the overall concept to the conference participants and begins the dialogue about the possibilities. These microfarm solutions are offered as technological methods to reduce land and water required for agricultural practices in the Muli area. The sociological and cultural implications are outside the scope of this paper. Even the technological recommendation must be tested in the local conditions to verify the design parameters, the expected inputs and outputs of either system.



Figure 3. *A home garden can produce 5 kilos of food a day of familiar vegetables.*

Microfarm

The microfarm is inspired by the historical concept of a family farm. This farm concept is changed in that the microfarm uses intensive practices including hydroponics, fertigation, aquaculture and rainwater harvesting to increase productivity of the farm area.

Fertigation

In Israel, most farms now use the technology of micro-irrigation and fertigation to grow crops varying from corn to fruit trees. Fertigation uses a drip irrigation system, adding a fertilizer mix to the water supply (**Figures 4 and 5**). This technology has been effective in producing large agricultural productivity in areas where there was no plant productivity before. Large orange trees now line roads through the Negev desert, growing in fertigated fields. A special fertigation system was designed by Netafim at the request of funders in China. The 435 m² fertigated garden is fed from gravity from a 500 L water tank. The water tank must be filled each day and fertigation fertilizers mixed with the water. Mechanical devices and electricity are not required.

In experiments in Uganda, the microdrip system was successfully used to produce 100 tons of corn per hectare, and 200 tons of corn fodder (**Figure 6**). This is when it is used with fertigation, supplying nutrients to the plants through the microdrip lines. The normal amount of corn produced on a single hectare of land can be from 200 kg to 10 tons. Microdrip system can produce at least ten times the amount of corn as conventional planting in soil. In the microfarm, a single 435 m² garden should be able to support three crops a year, two in the growing season and one cover crop through the winter.

Simplified hydroponics

The vegetables grown in the microfarm use simplified hydroponics and have increased production when compared to soil based gardening. A single meter of surface can produce 360 lettuce in a year round growing season, or from 20 to 56 kg of vegetables. Just a 40 m² garden should be capable of providing 5 kg of vegetables per day for family consumption or some income. A 400 m² garden should provide ten times as much per day. This garden can be expanded to produce during the colder months if protected with solar greenhouse. It can also extend the growing season to the frost free months if rainwater is stored and available in dry frost free season.

The simplified hydroponic gardens recommended for microfarms are either hand watered or

irrigated with a gravity fed drip irrigation system.

Aquaculture and rainwater harvesting

Aquaculture can produce valuable food resources in fish production and can also provide a rich nitrogen source of nutrients for the farm, if blue green algae are produced. The storing of rainwater is important to provide a reliable dependable agricultural production. The rainfall in Muli is sufficient to provide the necessary rainfall, if it can be captured.

Development project experience has shown that an area needs an annual rainfall of 300 mm to be sufficient for gathering rainfall for agricultural purposes. The annual average rainfall of 800 mm is sufficient in Muli to make rainwater harvesting cost effective (Zhu 2003).



Figure 4. *Microdrip irrigation supplies a measured amount of water only to the roots. This conserves water and controls weeds.*



Figure 5. *Microdrip system includes a water tank and gravity fed drip irrigation lines.*



Figure 6. *Different nutrient formulations show different yields of corn.*

Designs for the Muli area

Many of the local residents are currently raising seasonal crops of steep hillsides. Normally only one crop can be raised in the 120-day period and this is limited to certain crops. The harsh environment can be problematic because torrential rain and hail storms have been reported in the area that have destroyed homes and caused extensive property damage. The microfarm for this area would take two basic forms. One is a farm that is on a valley floor, basically flat soil based land, and then mountain slopes. The mountain slopes can be adapted to terraced agriculture.

Because of the extreme conditions through eight months of the year, in microfarms, the basic crops for family and animal food support should be produced in the appropriate growing season. Crops or animals supported through the colder seasons can have some supplement production of food, including a small solar greenhouse using hydroponics technology for rapid intense production of fresh foods and fresh fodder in the winter season.

Some small greenhouse designs have been proposed that utilize solar energy and passive solar systems to retain plant growth in the non-growing season. These greenhouses can be incorporated in the microfarm. The Renewable Energy and Environment Group GERES developed a solar greenhouse specifically designed for vegetable production in winter in the high altitude areas of the trans-Himalayas, where night temperatures can fall to as low as -20°C or more. The greenhouse was tested by NGOs working with farmers in five different trans-Himalayan areas and practical improvements made that ensure that the design is appropriate for the resources available in these high mountain areas (Stauffer *et al.* 2004).

The climate of the area has sufficient rainfall for the greenhouse roof to offer rainwater catchments to provide enough water to produce hydroponics forage microfarm potential in the area. The area of the Muli has the potential to raise two crops a year without any climate control. The 120-days growing season can produce a single rotation of crops in a single fertigated field. This would be a field of 435 m^2 to be rotated between a fast growing legume crop to increase field nitrogen and then a field crop such as corn that requires the legume nitrogen. After the two harvests are completed, a winter cover crop can be planted that is harvested at the beginning of next year's growing season. A legume cover crop will preserve and increase soil nitrogen (Mannering *et al.* 1998). Alfalfa, also called lucerne (*Medicago sativa* L.), has been successfully grown in altitude of 4000 m (Duke 1983). If the soil is covered with snow during winter, winter wheat may be the only potential crop. A short summer legume crop might help but that need local plants that are common in the area. Perhaps a local native plant at differing altitudes could be used as a cover crop for the 435 m^2 field area during the non-growing season.

Each area and each established practice will provide a different crop, and the crop yields can vary year to year depending upon climate. But fertigation assures the crop both water and nutrients on a daily basis, which increases plant growth. Normal soil based growing period of 120 days can be reduced as much as by half (60 days). The single 435 m^2 field is expected to produce, in a single year, 500 kg of broad beans, 1 ton of corn, 2 tons of corn fodder, and 500 kg of winter crop. If corn and beans are used for human consumption, that is 2.74 kg of corn per day and 1.37 kg of broad beans per day. The remaining 2.5 tons of produce is available for animal fodder.

The simplified hydroponics garden of 40 m^2 can produce 5 kg of vegetables per day during the growing season, and this can be increased if a solar greenhouse is established.

The microfarm will require a reliable water source through the growing season as the water and fertilizer are supplied to the plants through a drip irrigation system. Either recesses of water catchments or fish ponds are required to store rainwater for use through the growing season. Currently, the Pumi gather medicinal herbs and mushrooms during the gathering season. These can be produced in the microfarm for supplemental food and income. The technologies of mushroom and herb production in simplified hydroponics can be established in the microfarm. Perhaps putting grapes and fruit with trickle irrigation might help the small farmer even more than growing fodder only.

A previous study (Reynolds 1998) introduced irrigated pasture production with alfalfa for nomadic people in China and this change appeared to be successful. The average family holding was

4 hectare and alfalfa was the primary crop produced. In the microfarm, specific crops need to be tested under the harsh conditions and climate challenges of each microfarm location. However, if the family wishes to continue nomadic pastures, the microdrip can be easily dismantled, packed and moved together with the wandering herd and can be easily installed in the new place just to support growing vegetables, like lettuce and fast growing leafy vegetables where the excretions of the herd could be used, if properly handled as a fertilizer, even for growing young wheat plants as forage for the herd. Again, without irrigation, you are fully dependent on climate conditions.

Expected capital required to begin a microfarm

The cost of a single gravity fed 435 m² fertigated field is 400.00 \$ in the United States. The system requires drip irrigation lines of 435 m, a 500 L storage tank, elevated at least one meter above the area being fertigated. The system also needs a larger line to deliver the water to the drip tubes, a valve and a simple water filter in the line. The cost of a simplified hydroponic garden averages 250.00 US\$ world wide. This is for 20 2 m² bed growers made of recycled wood or shipping pallets. This cost is reduced when the fields are constructed of available stones and elevated containers. Using recycled shipping pallets requires black plastic and sometimes shade cloth or a white plastic cover.

Nutrient cost is dependent upon the success of the nitrogen captured in the legume crop, and local cost of fertilizers used in hydroponics and fertigation. A pilot project in Muli is required to estimate actual cost of fertilizers and resulting productivity, but past projects average about 5 US cents per kg of food grown, when no nitrogen is supplied through a legume crop. The N from any organic sources will be used by the wheat. The potential usage of this N is very much dependent on P level and moisture in the soil, and rain during grain filling stage.

Alfalfa needs much larger amount of potassium in the soil to be established. A good normal plant contains 3.5% K in its dry matter and if it is harvested 8 to 10 times a year, it export huge amount of K from the soil as compared to wheat. The long standing of such a crop is very much dependent on K fertilizer supply. Is it available there? What would be the price? What would be the economic value of this crop?

Fish ponds are proposed for capturing rainwater and runoff. In hydroponic or fertigation, a fish pond or aquaculture pond can provide some of the nutrients for plants. The microfarm can use fish water for the nutrient rich irrigation of fields.

Each field requires 144 m³ of water a year and so a single water pond containing 144 m³ of water should provide year round water. This would not include the evaporation and is not reduced to supply only an eight month growing season. If rainwater is successfully captured during the year, there would be no need for additional irrigation water for a microfarm in the Muli area.

Fertigation from a tank can be set up on a terrace built along a slope or on a flat valley field. Soil is used as the growing support for plant and available mountain stream water or rainwater is used as the water source.

A custom designed fertigation formula that takes into account the available nutrients in the water supply and soil will reduce any runoff from excess fertilizer use. Even so, a container for runoff water can be gathered to be a growing space for an end product such as watercress, algae, or other wetlands crop that will take up excess nutrients rather than allowing runoff to a down slope farmer's fields.

Areas for further research

The yak raising farmers of the Pumi people in the Muli county are basically poor societies with low technological level. The objectives of introducing microfarm system and simplified hydroponics are to increase their income and level of living. As a result, the vicious circle of living in subsistence could be broken, which could bring progress into the Muli county. Another objective is to improve the daily diet of the people and their animal husbandry which will contribute to a social improvement and economical income. The present low technological level requires the establishing of regional support

services of agricultural research and extension.

The local climate conditions in this area are harsh and marginal for the existence of human and domestic animals. A special approach is needed to introduce agricultural innovations through research and development (R&D) system in order to adapt these technological innovations to the local human factors and environmental circumstances. Special agricultural extension methods have to be applied in order to gain the confidence of the farmers, their change of attitude and change of behavior to achieve a new track of progress. The technologies proposed in this article are not yet known in the Muli county and should be introduced very gradually while checking for their adaptation to the human and nature resources.

Regional agricultural research and development (R&D) system

Local agricultural research and extension teams have to cooperate with farmer leaders and representatives in order to identify the limiting factors of agricultural production and prepare a research working plan based on priorities. The research could take place in a local research station or in farmer's ranges and plots.

Under this scheme the new suggested technologies, crop varieties, animal husbandry issues and others should be studied in order to supply relatively rapid solutions to the identified problems. It is important to point out that the farmers should be fully partners in this plan, based on a participatory approach (Richard and Hoffmann 2002), which will help to gain their confidence and the rapid adaptation and introduction of the innovations.

Practical research objectives included in field experiments:

- 1 Identifying shrub plants to be use for forage crops.
- 2 Controlling overgrazing based on potential of biomass production.
- 3 Introducing soil conservation works to reduce rangeland degradation.
- 4 The sustainable management of rangeland.
- 5 Study the relationship of elevation (geographical altitude) and agricultural potential.
- 6 Checking greenhouse structure vis a vis climate hazardous.
- 7 The most adequate of local solar greenhouse (much experience exist in China).
- 8 Methods to capture (harvest) greenhouse roof's water.
- 9 Solving veterinary issues of the yak.
- 10 Yak's feedings issues for the winter season.
- 11 Forage growing systems under simplified hydroponics in greenhouses.
- 12 Plants propagating in greenhouse for summer crops.
- 13 The adequate species of medicinal plant varieties and mushrooms.
- 14 Types of fish to be cultivated in the fish ponds.
- 15 Various drip irrigation methods.
- 16 Introducing of fertigation technology.
- 17 Soil cover (mulch) of plastics and plant residues.

Governmental or provincial policy needed for the following:

- 1 More governmental commitment to pastoral area.
- 2 More commitment for establishing agricultural research and extension services in the Muli

county.

- 3 To enhance the study of range ecosystem processes in marginal areas.
- 4 To enhance the education and practice of rangeland specialists,
- 5 Special positive approach to the gender issue (the women is mainly who take care on the yak) and the education of the younger generations (potential human factor).
- 6 Facilitate micro-credits to yak farmers.
- 7 Marketing research for the Multi agricultural production.
- 8 Improving veterinary services for the yak.

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