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論　文
Articles

Cultivation Practices and Economics of the Major Crops in a Central Andean Village, Peru : A Case Study of Pucara in Junin Province in Mantaro Valley

By

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Summary : As a part of the Academic Frontier Research Project, Tokyo University of Agriculture, we conducted an agricultural survey in Pucara Village, Mantaro Valley, in September 2002. There are two types of land in this village, flat irrigated fields and slope fields. Intensive vegetable cultivation is practiced in the flat area for commercial purposes, whereas traditional potato farming under a crop rotation system is observed on the slope fields. This paper focuses on slope farming, which is an important part of the farm household economy in this village, while a detailed analysis of vegetable cultivation will be presented elsewhere. We conducted a series of intensive interviews with the villagers with respect to their land use, crop cultivation, and costs-and-returns. Based on these data, land tenure and land use will first be clarified in this paper, as the communal land located at parts higher than 3,800 m in altitude is used freely by the villagers. This will be followed by the clarification of crop rotation systems, and cultivation techniques and economics of the major crops. Seven crops, potato, corn, broad beans, green peas, wheat, barley, and mashua, are taken up for analysis. Budgeting analysis will show that the three main food items of the Andean farmers, potato, corn and broad beans, are grown in sustainable ways. However, potato appears to be a highly risky crop, due to the adoption of modern technology and price fluctuation, whereas mashua is considered to function as an insurance crop for the family need.

Key Words : land tenure, communal land, crop rotation, crop budgets, slope farming

Introduction

As a part of the academic frontier cooperative research project[1] (AFRC-TUA 2000, 2001, 2002, 2003), we conducted an in-depth interview survey with farmers in Pucara Village, Huancayo, Junin, Peru, in August 2001 and September 2002. This village is located at the southern edge of Mantaro Valley in Central Andes and farming is carried out on broadly two types of land : relatively flat areas in the valley and the slopes of the Andean mountains. It is also the village which first introduced vegetable cultivation in Mantaro Valley in the 1950s[2]. Our research is actually directed to the search for, and clarification of, sustainable vegetable farming systems, based on data obtained from 64 farmers by questionnaire survey[3]. The practice of

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[1] The project is entitled "Development of New Bio-Agents for Alternative Farming Systems," jointly sponsored by the Japanese Ministry of Education and Science, and Tokyo University of Agriculture for the period of 1999-2004. We also acknowledge the kind research cooperation from District Office of Pucara, Pucara Peasants Community and farmer members of the Waripukio Irrigation Association.

[2] Apparently some villagers went to Lima to work as wage labourers for Japanese horticultural farmers in the 1950s, and returned to the village with a sound knowledge of vegetable cultivation.

[3] Data collected through the questionnaire survey are still being processed and thus cannot be utilized in this paper. These data are concerned with the intensive cultivation of vegetables in the flat irrigated fields.

intensive vegetable cultivation on irrigated fields in fact makes this village rather unique in Mantaro Valley, but farming on rain-fed slope fields is considered to be typical of Central Andean agriculture. The former is commercialized, while the latter is basically subsistence oriented.

This paper focuses on crop cultivation generally practiced on slope fields, while vegetable cultivation on flat irrigated fields will be clarified elsewhere. Through a series of interviews with key officials and farmers in the village, we obtained valuable information on land use and crop cultivation practices on slope fields. There are three objectives in this paper : the first is to clarify land use patterns especially of communal land ; second, to conduct enterprise budgeting analysis for a total of 7 major crops, potato, corn, broad beans, green peas, wheat, barley, and mashua ; and third, to clarify profitability for these subsistence crops in order to examine economic sustainability of the traditional sector of agriculture in this village, which presents a useful case of Central Andean agriculture in general, centering around the cultivation of potato.

Location and structure of the village studied

As is shown in Fig. 1, Mantaro Valley is large, with 80,000 ha of farm land area, extending over four provinces of Jauja, Concepcion, Huancayo, and Chupaca. The Mantaro River, an upstream of the Amazon River, flows from northwest to southeast of the valley, in which other streams also join the main river. In terms of altitude, it extends from a low of 3,000 m to a high of 3,500 m, and the main city of Huancayo is located at 3,200 m above sea level. The valley produces not only potato but also wheat, corn, onion, garlic, leafy vegetables, milk and beef, and farming is quite commercialized, as the area is within 6 to 7 hours distance by road from Lima. The major crop is sweet corn on the left bank, while carrot, green peas and broad beans are more commonly planted on the right bank. In the southern part of the valley, leafy vegetables are popular, and onion becomes more common in the northern part of the higher altitudes. Needless to say, potato is the single largest crop planted in every corner of the valley.

Rainy season extends from October to March, while the dry season from April to September. The former is commonly called the “big growing season” in which planting usually takes place in September and October, and harvesting in February and March. The latter is the “small growing season” and cropping is carried out under irrigation from May to August, but it was estimated that the planted area in the latter season was a mere 10% of the former[4], indicating the traditional dependence on rainfall for cropping.

The District of Pucara is located at the southern edge

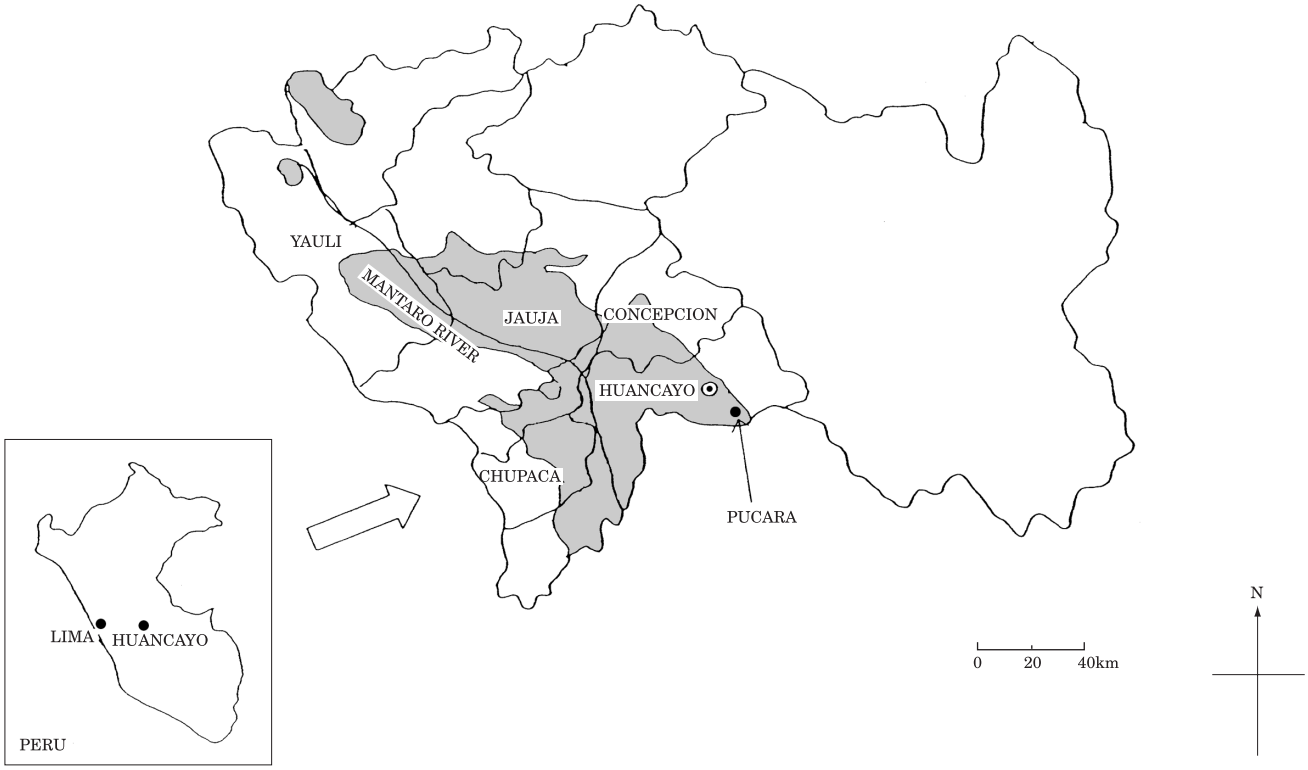

Fig. 1 Map of Mantato Valley

of the Mantaro Valley and Junin Region. The total area is 11,049 ha, with a population of 6,539 people in 1993 and estimated 8,000 people in 2002. The District Office is located at 75°9′14″ west longitude, 12°10′6″ in the south latitude, and 3,378 m altitude. The lowest point in the District is approximately 3,250 m, and the highest approximately 4,200 m above sea level.

The District consists of 13 communities : Pucara, Rakinya, Pacacaka, Markawai, Puka Puquio, Dos Damaiyo, Chukos, Aska, Patara, Mariscal Castilla, La Libertad, Sukia, and Taluis. The first seven communities have been recognized as independent Peasants Communities under the provision of the Ministry of Agriculture by the time of study, even though only Pucara Peasants Community existed in this district for many decades. The Peasants Community is a legally registered corporation, to which all farmers belong, and its jurisdiction includes management of communal land.

More than 80% of the area within the district was agricultural and pasture land, but there was a clear division in land ownership : those lands located lower than 3,800 m alt. were privately owned, while the higher altitude area belonged to the community. The communal land was basically natural pasture area for grazing and crops were seldom planted, while the private land was planted to various crops on a family farming basis. Further, the private land also consisted of two types : one was relatively flat and irrigated, at around 3,300 m above sea level, and the other, rain-fed slope fields extending over higher altitudes above the district office. In other words, the villagers had a secured access to both privately owned land and communal land, even though no land title had been issued by the Government[5]. It is also clearly noted that the exact acreage could not be ascertained for all types of land[6].

The traditional unit used for land area was *yugada* in this area. This corresponded to an area which was small enough to be prepared for planting by two bulls within a day and commonly interpreted as one third of a hectare[7]. In this paper, too, one *yugada* is taken to mean 33 a.

Land holding and utilization in pucara village

Pucara Peasants Community

Let us discuss the current state of land holdings and land utilization for the Pucara Peasants Community, which has been the only organization of farmers in the area. This Community was legally registered with the Ministry of Agriculture on 16 December 1941. At the time of re-registration in 1966, the total agricultural and pasture land area was stated to be 2,430.62 ha, but no distinction was made for private and communal lands in the registration form. The total number of members was 610. Because only one member was admitted from each family, this meant that there were 610 farm households in this village, indicating that the average land area per farm household was approximately 4.0 ha including communal land. In 2002, the number of members was estimated to be 700, including about 200 farmers in annex communities within the district. As no payment of membership fee was required for farmers, there did not actually exist a complete list of members.

Regarding the land area, the total 2,430 ha was eventually divided as six new peasants communities became established in recent years in the surrounding communities. Therefore, the area belonging to the Pucara Peasants Community must have been greatly reduced, but precise information on land area was again not available at any office. Farmers estimated that a typical farm household owned 0.3 ha of irrigated field in the flat area as well as 1.0 to 2.0 ha of rain-fed fields on the slope.

The Peasants Community is managed by the executive board, consisting of eight officers : President, Associate President, Secretary, Accountant, three Coordinators and Auditor. They are elected by the members and serve for two years. It is interesting to note that groups of eight members rather than individuals for each position stand for election, and the members elect one group for the office. These office holders do not get any salary, meaning that their work is carried out on a voluntary basis. According to the current President, Mr. Alfonso Laveriano, 50, the executive board carries

[4] Information obtained from Santa Ana Experiment Station, National Institute for Agricultural Research, Ministry of Agriculture, which is the main agricultural research station in Mantaro Valley ; 23, July 2001.

[5] This is one of the most serious issues in Peruvian agricultural development, as the lack of the land title means no guarantee for bank loans, severely limiting sources of capital investment. Although the Ministry of Agriculture recently began to issue the title, it is expected to take many years more before all private land ownership will get official recognition.

[6] Even the district office had no precise information on the number of land owners and the hectarage of farm land within its territory.

[7] In parts of Huanuco Province, one *yugada* was assumed to be 0.25 ha (FUJIMOTO, *et al.,* 2003).

the responsibility for two activities : organizing communal work and managing communal land. The former refers to the maintenance of irrigation facilities, and the latter to decision-making on the actual use of communal lands which are located in two sites.

Utilization of Communal Land

There are two areas of communal land in this village. One is a 10 ha block of land on the flat area adjacent to Sanpanga District. Irrigation has just been installed in this area as a communal work in 2002. The other is natural pasture land, located around 4,000 m above sea level, although the precise hectarage is unknown. In the following space, let us describe how these two areas of communal land are actually utilized.

The utilization of the 10 ha communal land is decided at the annual meeting of the community. For the crop year starting in September 2002, the members decided to divide the 10 ha into two blocks of 5 ha each. One of them was to be planted with corn and green peas under the responsibility of the executive board and this would constitute the single source of income for the community. The remaining 5 ha were to be further divided into six pieces and each would be freely used by a total of six neighbourhoods in the village. It appeared that most of the six pieces would be planted with potato on a communal basis.

For the preceding crop year from September 2001 to August 2002, as much as 8 ha of the 10 ha block was planted to barley under the management of the executive board in order to raise funds for the running of the community. Because there was no fund carried over from the previous board, they had to obtain a loan of 1,500 sols from a local NGO and a certain villager in order to cultivate the crop. They successfully harvested more than 10 tons of barley and made a net profit of about 2,000 sols.

For the other communal land, the members of the community were in principle assured of free utilization for grazing their animals. Vegetation on this land was very simple, consisting of natural pasture, to which nothing was artificially added or done. It is presumed that the area is as large as some 100s ha, to which all villagers were allowed to take their animals freely. However, only about 20 villagers actually did so in the year under the study. The low rate of utilization was due to the fact that only a few villagers raised a large number of animals, the largest being the owner of 300 sheep, and most of the animals such as cattle, horse and donkey were raised at lower parts with crop residues during the dry season. In the rainy season, pasture and weeds were abundant in the lower part as well, removing the pressure to feed them on natural pasture at the higher elevated area.

Table 1 List of Animals Raised in Pukara

Animals	No. raised by a family	Major usage
Bull	1~2	farming/land preparation
Milk cow	1~2	home consumption
Quy	10~15	home consumption
Sheep	3~4	wool for family
Donkey	1~2	farming/transporting
Hog	2~3 by some farmers	sale
Horse	1~2 by a few farmers	farming/transporting
Hen	5~6 by some farmers	home consumption

In other words, animal husbandry was conducted on a small scale and more or less for meeting family needs. Table 1 presents a general picture of animal husbandry in this village. Only a few points are added here. Usually one or two heads of cattle were raised by most of the families. If only one was raised, the farmers mutually exchanged services to conduct land preparation with two heads of cattle. Quy was the most important source of animal protein among the Andean farmers, and most families constantly raised 10 to 15 heads for home consumption. Needless to say, these animals were fed with crop residues and low quality products, while their manure was returned to the soil. However, raising animals in the village was basically by grazing, which means that the amount of manure collected during the night did not amount to a large quantity. In addition, farmers very often used fresh manure for farming, without proper fermentation.

Although the high altitude communal land was to be used for grazing in principle, the villagers were also allowed to cultivate crops there, reflecting the generally small area of privately owned land in this village. Especially when the villagers formed a group and wanted to plant crops, based on their communal sense, they were allowed to do this freely. In the crop year 2001 to 2002, there were four such groups, each cultivating about 1.0 ha. The crops planted were high altitude potato and ollucus (*Ullucus taberosus*), which were to be served at a village festival.

When the villagers wanted to plant crops on communal land on an individual basis, they were requested to apply to the community for permission. Apparently two villagers did so in 2001, with 1.0 ha each, to cultivate potato. The community maintained the basic policy of permitting individual villagers to cultivate about 1.0 ha of communal land, provided the applicants were active community members in that they regularly participated in communal work such as repair of irrigation canals. In addition, they were required to pay to the community 200 sols per ha for the individual use of communal land, but no villagers had actually

paid in the past. It seemed that the sense of free utilization of communal land had been firmly established among the villagers who therefore did not see any need to pay rental but contributed about 10% of the produce for festivities especially on Victory Day, 9 July.

Likewise, a total of six groups or individuals carried out crop cultivation on about 6.0ha of communal land from 2001 to 2002. This unexpectedly low rate of utilization of communal land was probably due to the fallen potato price and frost damage in 2000. Apparently as much as 20 ha were cultivated by many more farmers up to 1999.

It should also be added that traditional land use pattern had been strictly maintained in the case of high altitude communal land. This refers to crop rotation systems with potato being the center of the systems (YAMAMOTO 1995). In areas of low fertility, they grew potato once and fallowed the field for a minimum of 7 years, whereas three-year crop rotation of potato, legume (broad beans or green peas), and grain (wheat or barley), followed by a minimum of 5 years of fallow period, was adopted in relatively fertile soil. The use of communal land for cropping was certainly permitted on a yearly basis, but the three year rotation could be implemented, because the applicant villagers were sure to get it as very few villagers actually wanted to cultivate any crops there.

Cropping Patterns

As mentioned earlier, there are two types of farm land in this village : irrigated fields in the relatively flat portion of the village, and rain-fed fields on the slope. The former is further divided into two areas : those irrigated by water from Pucara River, and those by spring water. Our research project focuses on vegetable growing on those fields irrigated by the *waripukio* spring, for which detailed vegetable farm management data have already been collected by the questionnaire survey and are being processed.

Therefore, this time we collected information on the utilization of the slope land. Major crops grown on those fields located between 3,400 m and 3,800 m altitude were found to be potato, broad beans, green peas, corn, wheat and barley. In addition, such native crops as mashua (*Tropaeolum tuberosum*), ollucus, and oca (*Oxalis tuberosa*) were sometimes grown, but the planting of these crops had been decreasing in recent years. The prevailing crop rotation was a four-year cycle, with the planting of potato first, followed by corn, broad beans or green peas, and wheat or barley in that order (Fig. 2). With the increasing penetration of chemical fertilizer, a fallow period was no longer part of the rotation system. Needless to say, these crops were sown mostly in October and harvested in April or May, followed by a fallow period of about six months. Let us now turn to the clarification of cultivation methods of these major crops in the following section.

Cultivation techniques of the major crops

Potato

A budget for potato cultivation per *yugada* is presented in Table 2, assuming the traditional mixed planting of potato and broad beans. The following points deserve mentioning. First, the first rain normally starts in mid-September, and land preparation was carried out when the soil was softened approximately 10 days later. Since tractor or cattle could be used on relatively gently sloping land, this budget assumed the use of tractor and own cattle for land preparation. The tractor was given to the Peasant Community by the Government and used by the members at 40 sols per hour. One *yugada* could be prepared in one hour.

Second, potato seeds were planted one or two weeks

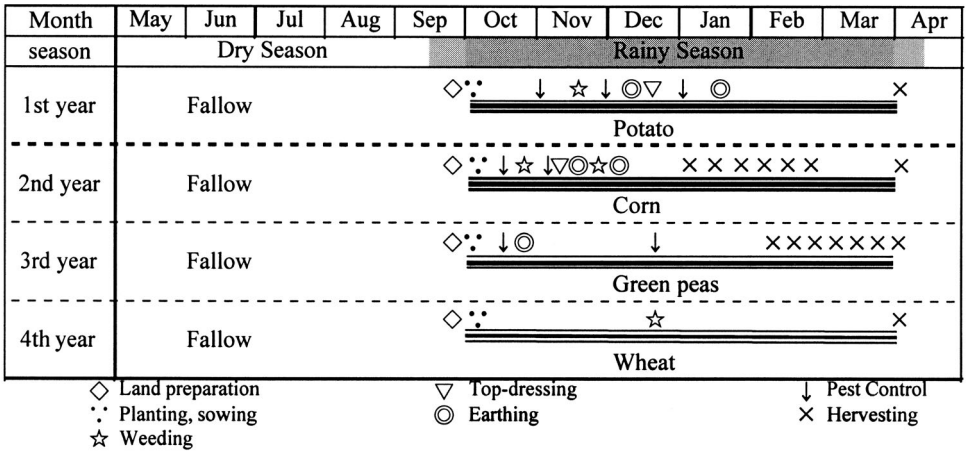

Fig. 2 Rotation System for the Major Crops in Pucara Village, Peru

Table 2 Budget of Potato and Broad Bean Cultivation per *Yugada* in Slope Field in Pukara

Operations	Description	Materials	Quantity	Labour input (m.d.)		Value
				Hired	Family	(Sols)
Total expenditure						
Land preparatioon	●Tractor ploughing after about 10 days of rain		40S/hr	0.2		40
	●Levelling and furrowing by two bulls; 1m intervals and 20cm in depth				4	
	●Line-manuring in furrow; place seed potatoes with 30-35cm distance; apply compound	seed potato	350kg			263
	fertilizer(NPK=20:20:20) in between hills; cover with soil by two-bulls	seed beans	5kg			10
	●Then, furrowing in cross way with 10m intervals for broad beans; line-manuring	compound	200kg			200
	●Place 2-3 seed beans with 20cm distance; chemical fertilizer not applied	manure	500kg			50
Pest control (1)	At 30 days after seeding, two kinds of insecticide are applied	Curater	2kg			100
		Parathion	500cc			30
Weeding (1)	45 days after seeding; hand weeding with pickel: weeds are buried.				4	
Pest control (2)	60 days after seeding; two kinds of insecticide are applied in the same way as before				1	
Top-dressing/Earthing up(1)	75 days after seeding, first earthing is done after applying top-dressing	Urea	100kg			90
					6	
Pest control (3)	90 days after seeding, two kinds of insecticide are applied in the same way as before				1	
Earthing up (2)	105 days after seeding, second earthing up; ritually most important operation;				6	
	festivity with music is held with workers and relatives					70
Harvesting	Start harvesting fresh broad beans at 120 days after seeding for about 2 months;					
	Potatoes are havested at 180 days after seeding; digging by two bulls				13	
Grading and storage	Grade potatoes into 3 size groups; Stored in bags at home				10	
Total (A)				0.2	45	853
Gross revenue						
Potato	5,500kg in total, of which about 10% are damaged; large 3,500kg, medium 1,000kg,					
	samll (seeds) 500kg; 0.40, 0.25 and 0.80 S/kg respectively. Damaged is 0.1 S/kg					2,100
Broad beans	100kg in total from 2 months harvesting; 0.40 S/kg					40
Total (B)						2,140
Net income (B-A)						1,287

Notes: Family labour input includes exchange labour. The quantity of insecticides refers to the total of three applications.

after land preparation. The planting was accompanied by the leveling of the field with cattle and basal dressing of manure and chemical fertilizer. A pair of cattle was used to break up the soil and dig furrows about 20 cm deep at one meter intervals. Seed potatoes were placed at a 30 to 35 cm distance on top of dry manure applied in the furrows. A handful of compound fertilizer was applied between the hills. Then, using the pair of cattle, the seeds were covered by soil. It is also noted that seed potatoes were self supplied and the most popular variety at the time of study was *yungay*, an improved variety introduced about 20 years ago.

The sowing of broad beans was carried out after completing the planting of potato seeds. Cross ways to the potato rows, furrows were prepared and manure was placed at an interval of 10 m, followed by seeding two to three beans per hill with a spacing of 20 cm in between. Chemical fertilizer was not applied to broad beans. Mixed planting of potato with broad beans appeared to be very common in this village, because both were eaten daily by the farmers. It is clearly noted that the planting of broad beans did not affect the planting density of potato.

Third, potato appeared to be the most intensively grown crop in the village. In addition to basal dressing, top dressing was carried out with chemical fertilizer, mostly urea. The total quantity of nitrogen applied per *yugada* amounted to about 100 kg, consisting of 40 kg from compound fertilizer as basal dressing, 46 kg from urea as top dressing, and assuming 10 kg from manure as basal dressing. Furthermore, an average of three sprays of pesticide application was carried out per season. Insecticide was directed toward cutworms, but fungicide was not applied because of negligible occurrence of late blight. The use of parathion was banned by the Government, but it was still commonly used in the village.

Fourth, the most important operation in potato cultivation appeared to be the earthing up of hills. Potato seeds were normally planted in the beginning of October, and the first earthing was carried out together with top dressing in the second half of December when rain became very heavy. The second earthing was done in late January. This operation was to protect potato from excess moisture, which was vitally important for its growing during the rainy season. Its significance could be seen from the fact that the farmers gave a party to relatives and workers to pray for good harvest after the second earthing. This tradition is being practiced even today and a music band was hired and invited guests enjoyed drinking and dancing. The party was organized on the basis of individual family, but because of high costs it was common for three or four families to organize it jointly at the time of study. The series of parties appeared to continue for about one month in the village square.

Fifth, the growing period of the *yungay* variety was six months, leading to harvesting in the beginning of April. The normal yield appeared to be 5,500 kg/*yugada*, or 16.5 tons/ha, of which about 10% were normally damaged and used as animal feed. Potatoes were graded by size, large, medium, and small, and separately put in bags for storage at the house. Andean mint leaves were first spread over the floor and on top of them the potato bags were piled up with more mint leaves between each layer in order to protect from the attack of potato tuber moth during storage. It is noted that potato was the staple food of Andean farmers, who therefore secured a sufficient supply until the next harvesting. Production was not aimed at selling, but gross revenue was calculated on the basis of the ongoing price level.

Although the per capita consumption of potato was about 65 kg per year in the country (Fujimoto, *et al.* 2002), the Andean farmers usually consumed much more than this level. However, one *yugada* of the slope field appeared to provide sufficient quantity of potato and other basic foods. Broad beans grown in mixture with potato were used for fresh consumption at home. Farmers usually started picking the beans around four months after seeding and continued for a period of two months, and the total harvest from the planting density adopted in the budget preparation was estimated to be 100 kg.

Corn

The crop immediately following potato cultivation appeared to be corn in the predominant crop rotation system in the village. Table 3 presents a budget for corn cultivation per *yugada*, assuming the use of *grey* variety. Once again the use of tractor was assumed, but land preparation could also be carried out by a pair of cattle. Whichever might have been adopted, seeding was carried out about 10 days after land preparation. For this purpose, a pair of cattle was used for leveling the field and digging furrows, in which manure was applied. No chemical fertilizer was applied as basal dressing, because of fertilizer residues from intensive potato cultivation in the previous year.

In order to protect crops from wandering animals, the fields were normally fenced, which regularly required some repair work. Around 25 days after seeding, the first weeding was carried out. One traditional practice was the use of kitchen ash, valued at about 2

sols, around the time of weeding, as synthetic chemical pesticide was rarely applied to corn. Ash was sprayed over corn leaves, expected to protect the crop from pests and diseases such as fungi, aphid and worms.

Earthing was carried out twice together with weeding. A unique tool, like a pickle, was used for weeding and was believed to soften the soil. At the first earthing, carried out about 40 days after seeding, urea was also applied as top-dressing.

Corn was usually harvested in two ways. The first was *choclo* or fresh sweet corn, which the farmers started harvesting and eating from about 90 days after seeding for a period of two months. The second was maize or dry corn. Around five to six months after seeding, in the case of *grey* variety, corn ears became dried and those standing in the field were harvested all together. Of the total harvest, about one third was consumed as fresh sweet corn, and two thirds maize.

Green peas

While potato and corn were stored and consumed at home, green peas could not be stored and therefore were sometimes grown for the purpose of selling. Because a relatively large area of land provided a quantity well in excess of family needs, the planting of green peas was usually done on a small area or often mixed with corn. Table 4 presents a budget for green peas cultivation on a per *yugada* basis, which means the planting for commercial purposes. The variety was called *common,* which had a mixture of white and purple flowers. If peas were planted immediately after potato cultivation, no chemical fertilizer was applied, but some amount of fertilizer was used if it was grown after other crops.

It was assumed that land preparation was carried out by a pair of hired cattle. As mentioned earlier, one *yugada* is the area of land which could be prepared by a pair of cattle, and it was assumed to be 33 a. One important point to be noted is that land preparation actually consisted of three-time walking by cattle. First, the pair of cattle ploughed the soil in a certain direction for the whole area. Second, they now walked in the cross way to break up blocks of soil and level the field. Third, they once again walked around the whole area in order to dig furrows at a 40 cm interval. One *yugada* is the area of land for which these three operations could be completed in one day.

Therefore, only one man was needed to operate the pair of cattle, but four other workers were also necessary to complete the operation of seeding in one day. The first of the four workers, usually a woman worker, walked behind the cattle and placed seeds in the freshly dug furrows at a spacing of 20 to 30 cm. The second worker, again a woman worker, placed a handful of chemical fertilizer in between hills, and the third and fourth workers, usually two men, covered up the furrows with soil. Cattle could be used for covering the furrows in order to reduce labour input, but the coverage tended to be uneven in this case and the farmers therefore appeared to prefer manual work. These four workers prepared corner parts of the field in the morning when the pair of cattle were still ploughing the field. In the budget presented in Table 4, family and exchange labour were assumed for this seeding operation, but hired workers were sometime employed. The on going wage rate was 10 sols for man and 8 sols for woman workers, but breakfast and lunch were also provided, adding another 4 to 5 sols per worker.

It is noted here that seeds of green peas and broad beans were sometimes soaked in water for two nights in order to facilitate a germination process. Then, they were seeded in the field but they would likely die if there was no rain for some days. Therefore, in order to avoid this risk, the farmers in the village did not generally practice the seed treatment.

For green peas, two sprays of synthetic pesticide application were carried out against cutworms and green hoppers. Often insecticide and fungicide were mixed and sprayed. The first spray was carried out about 15 days after seeding, and foliar fertilizer was also added this time if the crop growth was considered to be poor. Kitchen ash was not used for green peas.

Around four months after seeding, green peas grew into the stage where harvesting could be done. Farmers picked peas every 10 days or so and continued for about two months, giving a total harvest of 12 bags or 840 kg. About two bags were usually of poor quality and consumed at home, while the remaining 10 bags could be sold at around 0.9 sol/kg. In the prepared budget, family labour was assumed for harvesting but sometimes woman workers were hired. Wage rate was 7 sols per bag, and an experienced worker could harvest two bags a day. Harvested peas were transported by donkey to house, and then sold at Huancayo market on the following day.

Broad beans

In place of green peas, broad beans were often incorporated in the crop rotation system. Table 5 presents a budget for the cultivation of broad beans on a per *yugada* basis. Common varieties were *green* and *yellow,* both of which were sometimes mixed. In the same manner as green peas, chemical fertilizer was not used if broad beans were planted immediately after potato,

Table 3 Budget of Corn Cultivation per *Yugada* in Slope Field in Pukara

Operations	Description	Materials	Quantity	Labour input (m.d.)		Value
				Hired	Family	(Sols)
Total expenditure						
Land preparatioon	●Tractor ploughing after about 10 days of rain		40S/hr	0.2		40
	●Levelling and furrowing by two bulls; 40cm intervals and 10cm in depth				5	
	●Line-manuring in furrow; place 1-2 seeds with 10 cm distance;	seeds	30kg			30
	cover with soil by two-bulls	manure	500kg			25
Fence repair	To protect crop from animals, the existing fence is regularly repaired				0.5	
Pest control (1)	A few days before weeding, kichen ash is applied for preventing insect damage	ash	50kg		0.2	2
Weeding	25 days after seeding; hand weeding with pickel: weeds are buried.				6	
Pest control (2)	A few days before the first earthing up, ash is applied again	ash	50kg		0.2	2
Top-dressing/Earthing up(1)	40 days after seeding, first earthing is done by two bulls after applying top-dressing;	urea	50kg			45
	weeding is done at the same time				4	
Earthing up (2)	55 days after seeding, second earthing up is done by hoe				2	
Harvesting	Start harvesting fresh corn at 90 days after seeding;				1	
	at 180 days after seeding, all dry corns are harvested at once				12	
Total (A)				0.2	29.9	144
Gross revenue						
Fresh corn	One third of the total production is consumed fresh; 300 cobs					30
Dry corn	Two thirds of the total production; 600 kg in grain weight; 1 S/kg					660
Total (B)						690
Net income(B-A)						546

Notes: Family labour input includes exchange labour. Bull service is free of charge, as crop residue was given to the bull owner in the previous season.

Table 4 Budget of Green Peas Cultivation per *Yugada* in Slope Field in Pukara

Operations	Description	Materials	Quantity	Labour input (m.d.)		Value
				Hired	Family	(Sols)
Total expenditure						
Land preparatioon	After 5 rainy days, land preparation by two bulls; two ploughings in cross way, and furrowing			1		45
Seeding	4-5 seeds with 20-30cm distance in furrows of 8cm depth and 40cm intervals;	seeds	15kg			75
	manure is placed in furrows and chemical fertlizer in between hills;	compound	8kg			8
	one woman for seeding,one woman for fertilization, and two men for covering				4	
Pest control (1)	15 days after seeding, insecticide and fungicide are applied.	insecticide	250cc			18
		fungicide	100g			7
					0.3	
Earthing up	20 days after seeding, earthing is done together with weeding; no top-dresssing is applied				2.5	
Pest control (2)	80 days after seeding, insecticide and fungicide are applied				0.3	
Harvesting	Start harvesting fresh peas at 120 days after seeding; repeat every 10 days for 2 months				6	
Total (A)				1	13.1	153
Gross revenue						
Green peas	840kg in total, of which 140kg are of poor quality(valued 0.2S/kg); sell 700kg at 0.9S/kg					658
Total (B)						658
Net income (B-A)						505

Notes: Family labour input includes exchange labour. The quantity of insecticide and fungicide refers to the total of two applications.

but some amount of urea was applied if other crops were grown in the previous season. It is also interesting to note that kitchen ash was sprayed over leaves of broad beans around the time of weeding.

Broad beans were sensitive to root rot and late blight during the flowering stage. Therefore, the farmers usually applied fungicide twice after the second earthing by the use of hand sprayer. Spraying itself could be completed in a short time, but transporting water to the field was a time consuming work, for which child labour was often utilized.

In the same way as corn, broad beans were consumed fresh according to the family need, from about 90 days after seeding for a period of two months. The growing period of broad beans was more than seven months, after which dry beans were harvested at once. The plants were cut at the stem and brought to a flat area for threshing, which was also done by donkey or by hitting with sticks. Again child labour was considered a useful contribution to this operation. Total harvest was estimated to be 500 kg of dry beans and 200 kg of fresh beans which had been consumed by the family, with the gross value of 1,000 sols. Because of the hard nature of the dry beans, there was no problem for storage.

Wheat

Wheat and barley were the crops grown with minimum inputs in this area. They were never planted after potato. In relation to the budget for wheat cultivation as presented in Table 6, the following points should be noted. First, the most common variety was *estaquilla* with a growing period of six months. It is clearly noted that wheat must be seeded before 18 October, if any harvest was to be expected. One *arroba* or 11.5kg of seeds were broadcast over untilled land, regardless of whether crop residues from the previous season were still remaining or not. After broadcasting seeds, a pair of cattle was brought into the field to cover the seeds. Our budget assumed the use of hired cattle. Because careful operation was necessary for a proper coverage, this work normally required one whole day.

Second, neither fertilizer nor pesticide were applied to wheat. Even manure was not applied. This means that wheat cultivation did not require any crop care except one time weeding which was carried out around 80 days after seeding. The major weed was wild barley, which was to be pulled out by hand. Apparently some farmers applied 5 to 10 kg of urea after weeding, but this practice was not taken into our budget as it was rather exceptional.

Third, at six months after seeding, wheat was harvested by sickle and bundles were brought to the threshing site by donkey. Threshing was carried out by donkey or horse, walking over the bundles. This was followed by winnowing with natural wind, and clean grains were put in bags and stored at house. Straws were used as animal feed. If the family size was large, no workers were hired, but often the farmers employed hired workers in order to complete the harvesting and threshing work in one day. The average yield of wheat was around 400 kg, with the value of 400 sols.

It is noted that this budget was prepared for traditional wheat cultivation on the rain-fed slope fields. Wheat was a common crop on the irrigated fields as well, where combine harvester began to be used in the 1980s. No farmers owned the machine in this village but there were three units of large scale combine harvester in the neighbouring Sanpanga District, whose service was available at a charge of 60 sols per *yugada*. Because this charge was cheaper than wages for manual harvesting and threshing, all the farmers adopted mechanical harvesting in the irrigated area at the time of the study.

Barley

As is seen from Table 7, the method of barley cultivation and yield were practically the same as wheat. The common variety was *selvesella,* and used for home consumption, not for beer brewing. One major difference from wheat was that there was no time restriction for barley planting, which therefore could be sown in November or December. The growing period was five months, shorter than wheat by one month. Barley had a high threshability, requiring less labour than for wheat, but the selling price was about half that of wheat resulting in a small net income.

Mashua

One of the native root crops, mashua, was grown in the manner presented in Table 8. In fact, it was grown in a similar way to potato, but the growing period was longer by two and a half months. Because of its high drought resistance, it could be planted before the beginning of the rainy season. The actual method of seeding was practically the same as for potato, the only difference being a smaller quantity of chemical fertilizer applied to mashua. In addition, no pesticide was applied to mashua, which did not get damaged by any pests and diseases. The major operations therefore included weeding, earthing and fertilization. The expected yield was 1,400 kg per *yugada*, with a negligible

Table 5 Budget of Broad Beans Cultivation per *Yugada* in Slope Field in Pukara

Operations	Description	Materials	Quantity	Labour input (m.d.)		Value
				Hired	Family	(Sols)
Total expenditure						
Land preparatioon	After 10 rainy days, land preparation by tractor			0.2		40
Levelling/Seeding	One month later, levelling and furrowing by two bulls; 40 cm intervals and 10 cm depth;	seeds	50kg			75
	manure is placed in furrows and 1-2 seeds at10cm spacing; covered by two bulls	manure	500kg			75
					5	
Pest control (1)	21 days after seeding, kichen ash is applied over leaves for crop protection	ash	50kg		0.2	2
Weeding	25 days after seeding, weeding is done with a pickel; weeds are buried				6	
Pest control (2)	35 days after seeding, kichen ash is applied over leaves for crop protection	ash	50kg		0.2	2
Top-dressing/Earthing up (1)	40 days after seeding, earthing is done by two bulls after the application of top-dressing;	urea	50kg			45
	weeding is done at the same time				4	
Earthing up(2)	50 days after seeding, second earthing by two bulls; no more fertilizer				3	
Pest control (3)	60 days after seeding, fungicide is applied	Benlate	20g			2
					0.3	
Pest control (4)	70 days after seeding, fungicide is applied	Benlate	20g			2
					0.3	
Harvesting	Start harvesting fresh beans at 90 days after seeding for 2 months;				2	
Harvesting	At 220 days all dry beans are harvested at once and threshed by donkey; stored in bags at home				12	
Total (A)				0.2	33	243
Gross revenue						
Fresh beans	One third of the total production; 200kg in 2 months valued at 0.50S/kg					100
Dry beans	Two thirds of the total production; 500kg in dry beans weight valued at 1.8S/kg					900
Total (B)						1,000
Net income (B-A)						757

Notes: Family labour input includes exchange labour.

Table 6 Budget of Wheat Cultivation per *Yugada* in Slope Field in Pukara

Operations	Description	Materials	Quantity	Labour input (m.d.)		Value
				Hired	Family	(Sols)
Total expenditure						
Seeding	Seeds must be sown by 18 Oct; broadcast onto the non-tilled field and cover by two bulls	seeds	11.5kg			11.5
				1	1	45
Weeding	80 days after seeding, hand weeding; main weed is wild barley				3	
Harvesting	180 days after sowing, cut by sickle and thresh by donkey; store in bags after winnowing			4	5	80
Total (A)				5	9	136.5
Gross revenue						
Wheat	400kg in total, valued at 1.0S/kg					400
Total (B)						400
Net income (B-A)						263.5

Notes: Family labour input includes exchange labour.

Table 7 Budget of Barley Cultivation per *Yugada* in Slope Field in Pukara

Operations	Description	Materials	Quantity	Labour input (m.d.)		Value
				Hired	Family	(Sols)
Total expenditure						
Seeding	Broadcast onto the non-tilled field and cover by two bulls; can be in Nov. or Dec.	seeds	11.5kg			11.5
				1	1	45
Weeding	80 days after seeding, hand weeding; main weed is wild barley				3	
Harvesting	150 days after sowing, cut by sickle and thresh by donkey; store in bags after winnowing			4	3	80
Total (A)				5	7	136.5
Gross revenue						
Wheat	400kg in total, valued at 0.5S/kg					200
Total (B)						200
Net income (B-A)						63.5

Notes: Family labour input includes exchange labour.

Table 8 Budget of Mashua Cultivation per *Yugada* in Slope Field in Pukara

Operations	Description	Materials	Quantity	Labour input (m.d.)		Value
				Hired	Family	(Sols)
Total expenditure						
Land preparatioon	Operations start before the coming of rain; tractor ploughing		40S/hr	0.2		40
	●Levelling and furrowing by two bulls; 1m intervals and 20cm in depth				4	
	●Line-manuring in furrow; place seeds with 30-35cm spacing; apply compound	seeds	100kg			40
	fertilizer(NPK=20:20:20) inbetween hills; cover with soil by two-bulls	manure	500kg			50
		compound	50kg			50
Weeding (1)	45 days after seeding; hand weeding with pickel: weeds are buried.				4	
Top-dressing/Earthing up(1)	100 days after seeding, first earthing is done after applying top-dressing	urea	50kg			45
					6	
Earthing up (2)	120 days after seeding, second earthing up				6	
Harvesting	250 days after seeding; digging by two bulls				7	
Total (A)				0.2	27	225
Gross revenue						
mashua	1,400kg in total valued at 0.4S/kg; very little damage; grading not needed					560
Total (B)						560
Net income (B-A)						335

Notes: Family labour input includes exchange labour.

amount of damaged produce. No grading was made by size, and the low price would not attract the farmers to sell the produce.

Economic analysis of the major crops

Expenditure and income as well as labour input for the major crops were presented in the crop budgets in the preceding section. These data were restructured by cost item and put together in Table 9. Fig. 3 also shows net income and family labour input per *yugada* for the seven crops studied. It is clearly seen that potato provided the highest net income and barley the lowest. Among all the crops studied, potato was the most intensive one. While other crops required 200 to 600 sols per *yugada* for variable inputs, potato needed about 1,300 sols. Especially seed, chemical fertilizer, pesticide and labour costs were very high. It is quite understandable that many farmers pointed out potato could not be grown unless they had sufficient funds. This serious condition that the traditional staple food could not successfully be grown without funds was actually caused by the introduction of new technology,

Table 9 Production Costs and Profit per *Yugada* and Break-Even Prices of the Seven Crops in Pucara

Unit: sols

	Potato	Corn	Green peas	Braod beans	Wheat	Barley	Mashua
Material costs							
Seeds	263	30	75	75	11.5	11.5	40
Manure	50	25	0	75	0	0	50
Chemical fertilizer	290	45	8	45	0	0	95
Pesticide	130	0	25	4	0	0	0
Others	40	44	45	44	45	45	40
Sub-total	773	144	153	243	56.5	56.5	225
Hired labour cost	70	0	0	0	80	80	0
Family labour cost (a)	450	299	131	330	90	70	270
Land rent (b)	630	198	197	300	120	60	168
Capital interest (c)	168	58	37	75	29	27	64
Total variable cost	1,293	443	284	573	226.5	206.5	495
Total fixed cost (b+c)	798	256	234	375	149	87	232
Total cost (A)	2,091	699	518	948	375.5	293.5	727
Saleable production (kg)	5,000	600	700	500	400	400	1,400
Gross revenue (B)	2,100	690	658	1,000	400	200	560
Profit (B-A)	9	-9	140	52	24.5	-93.5	-167
Net income (C=B-A+a+b+c)	1,257	546	505	757	263.5	63.5	335
Net income ratio (C/B) (%)	59.9	79.1	76.7	75.7	65.9	31.8	59.8
B/C ratio (B/A)	1.00	0.99	1.27	1.06	1.07	0.68	0.77
Average prices (S/kg)	0.42	1.10	0.90	1.80	1.00	0.50	0.40
Break-even price (S/kg)	0.42	1.17	0.74	1.90	0.94	1.47	0.52

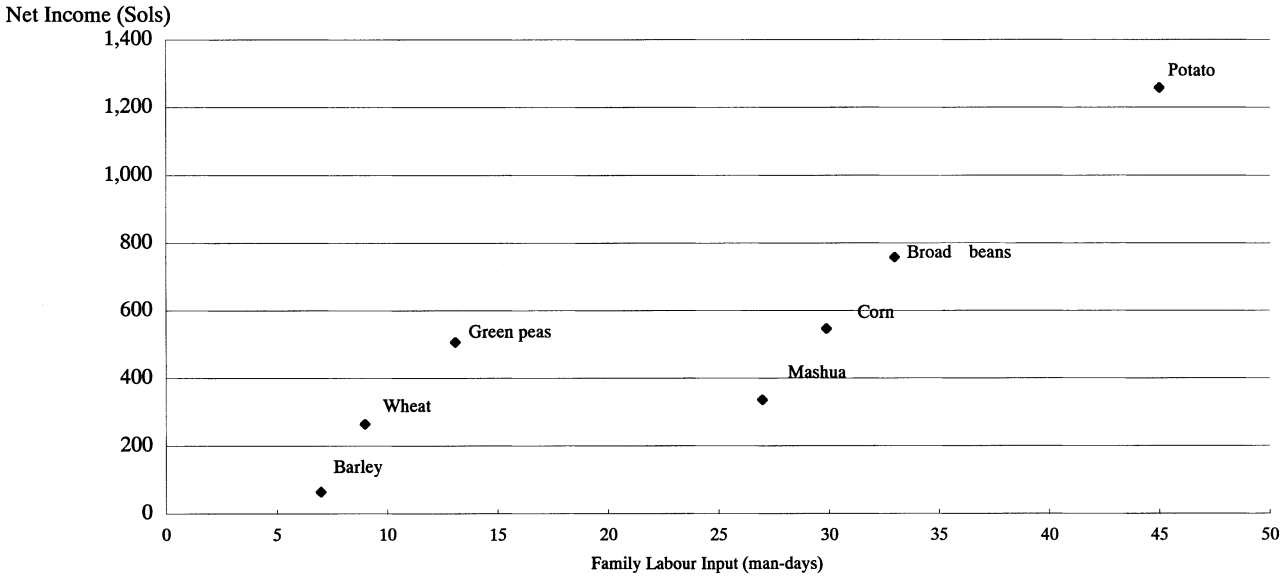

Fig. 3 Comparison of Net Income and Family Labour Input per *Yugada* of the Seven Crops in Pucara

consisting of new seeds, chemical fertilizer and pesticide.

Table 9 also presents other economic indicators such as production cost, profit, B/C ratio and break-even prices for the seven crops. It should be noted that the following three assumptions were adopted in the calculation of production cost. First, land rent was based on the on-going rental in the village. Fixed-rent tenancy was the major form of contract for irrigated fields on the flat land, but share-cropping arrangement predominated in the case of rain-fed slope fields. There were broadly two forms of share tenancy : 50% rental and 30% rental. The former was accompanied by cost-sharing arrangement between landlord and tenant, but in the case of 30% rental payment, all the production expenses were borne by the tenant. In this paper, we assumed the rental to be 30% of the total production. Furthermore, some of the produce, eg. corn and broad beans, were consumed freshly by the family and/or was too poor in quality for selling to market. This produce was certainly included in the gross revenue, but the land rent was calculated as 30% of the value of saleable production only.

Second, capital interest was obtained on the basis of 26% interest rate per year, or 13% for the period of six months under consideration, reflecting the actual rate adopted in informal loans in the village at the time of the study. This rate was applied to the total value of material and labour expenses in order to calculate capital interest.

Third, the on-going wage rate was 10 and 8 sols per day for man and woman workers respectively. In view of the fact that both breakfast and lunch were also provided, the wage rate was assumed to be 15 sols per day regardless of sex. The direction of bias was therefore toward an over estimation for hired labour cost. Family labour cost was estimated to be 10 sols per day, regardless of sex, again causing the possibility of over-estimation of labour cost.

With these assumptions, it cannot be denied that our cost calculation was not definite and of a preliminary nature. However, this estimation is hoped to contribute to filling partly the great vacuum in our knowledge concerning the economics of Andean farming. The following points specially deserve mentioning here.

First, new potato technology certainly increased the level of yield, but B/C ratio is exactly 1.00, implying that potato profitability was not necessarily high. Yield reduction due to pests and diseases, or slight decline in the price, would easily result in a negative profit. It is clear that the cultivation of the staple food, potato, had been carried out under great economic risk.

Second, mashua was grown in a similar way to potato, but it resulted in a negative profit, due to the low level of price : 0.40 sol/kg, compared to the break-even price of 0.52 sol/kg. However, neither new seeds nor intensive cultivation technology were adopted for this crop, resulting in a much lower cost than potato : only 35% of the total cost for potato. Since pesticide was not applied at all and the required amount of fertilizer was small, material cost was particularly small. In other words, if mashua was produced for home consumption by family labour on owned land, it could easily be reproduced economically. Total production from one *yugada* was large enough to feed the family for one whole year. In other words, mashua cultivation could function as an insurance crop for the family need for the staple food, in the face of highly risky potato cultivation under new technology.

Third, the other important staple food, corn, showed a delicate balance in cost and return. Because one third of corn production was usually consumed freshly by the family as *choclo,* our analysis here assumed the dry corn to constitute only two thirds of the total produce. If all the produce had been assumed to be dry corn, the saleable production and gross revenue in Table 9 would have been increased by 50%, leading to the B/C ratio of 1.42. In other words, the more corn the family consume freshly, the lower the profitability in the case of corn cultivation. In view of the fact that potato, fresh corn and fresh broad beans constituted the major daily food for Andean farmers, it appeared that the current consumption of fresh corn was somehow maintained at a level at which corn cultivation was economically sustained.

Fourth, broad beans were also partly consumed freshly by the family, and if we had assumed that all the beans had been harvested dry, the total saleable production and gross revenue would have greatly increased, leading to the B/C ratio of 1.27. That is to say, in exactly the same manner as corn, the more beans the family consume freshly, the lower the profitability for broad beans. This also implied that the current consumption level of fresh broad beans could economically sustain its cultivation.

Fifth, it must be noted that green peas could not be stored and thus had to be sold freshly. This crop was grown with strong commercial intention. The relatively high B/C ratio of 1.27 seemed to suggest economically rational cultivation of green peas. The break-even price was 0.74 sol/kg, much lower than the average selling price of 0.90 sol/kg.

Sixth, both wheat and barley were produced for home consumption, with similar technology and level

of yield. Due to the great difference in prices, however, wheat appeared to be a rational crop while barley resulted in a negative profit. Because of the positive net income, barley cultivation could be continued by family labour on owned land.

Likewise, our economic analysis of the major crops grown on rain-fed slope fields revealed some interesting facts. Three crops of green peas, broad beans and wheat seemed to make a reasonable profit. In contrast, barley and mashua appeared to produce a negative profit, although net income was certainly positive. The staple food crops of potato, corn and broad beans appeared to be economically sustainable. However, it is important to reiterate that these crops constituted the four-year crop rotation system, which as a whole has been sustaining the livelihood of the farmers in the village.

Conclusion

This paper aimed at clarifying land utilization of rain-fed slope fields, the cultivation technology and economics of the major crops, based on the detailed interview survey with farmers in one of the Andean villages in Peru. The village extended over a large area between 3,250 m and 4,200 m above sea level. Similar to other villages in the Andes, this village also maintained communal land mostly in the higher altitude area. Up to the level of 3,800 m, most land was privately owned and used for the cultivation of such crops as potato, corn, broad beans, green peas, wheat and barley under the rain-fed condition.

Sustainable use of the rain-fed fields was maintained by crop rotation system, and our budgeting analysis revealed that crop cultivation was mostly economically sustainable. In particular, potato, corn and broad beans constituted the main diet among the Andean farmers, and their cultivation appeared to be economically rational. However, potato cultivation was now carried out by new technology of cash inputs, bringing about the risk of losing economic surplus in the case of slight decrease in potato price and yield level.

In order to sustain the staple food production in the future, it seems vitally important to increase yield and reduce production costs. It may be worthwhile to introduce a longer span crop rotation system, in which more legume crops are incorporated. Not only repeating green peas and/or broad beans but also the introduction of forage crops should be considered. The more forage crops they grow, the more livestock they can raise, leading to an increased supply of manure for the land and animal protein for farmers.

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ペルー中央アンデス農村における主要作物の栽培技術と経済性

―マンタローー盆地プカラ村の事例研究―

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要約：東京農業大学学術フロンティア共同研究の一環として，ペルー中央部マンタローー盆地のプカラ村にて2002年9月に実施した実態調査に基づいて，主要作物の試算分析を行った。当村では平坦部に灌漑畑が存在し販売を目的とした集約的な野菜栽培が行われているが，背後の斜面に位置する天水畑ではジャガイモ栽培を軸とした輪作によって自給的な農業が行われている。われわれは農家質問票調査によって野菜栽培の技術・経営データを収集し現在分析中である。本稿は農家経済の重要な一部を成す斜面農業に限定した論考であり，農家インタビューで収集した情報に基づいて，輪作体系および主要作物の栽培技術体系と経済性を明らかにすることを狙っている。

当村には村有地が配分されずに残っており，3,800 m を上回る高標高地帯では村人による自由な作付けが保証されている。したがって，まず土地制度と村有地の利用状況を論述してから，主要作物（ジャガイモ，トウモロコシ，ソラマメ，エンドウマメ，オオムギ，コムギ）および在来根菜マシュアを取上げ，輪作体系下における栽培技術と経済性を解明した。その結果，アンデス農民の主食であるジャガイモ，トウモロコシおよびソラマメの栽培においては経済的持続性が確認できた。しかし，ジャガイモの生産リスクが著しく高いことが明らかになり，収量は低いが低コスト栽培のマシュアが家族の主食確保における保険機能を果たすと考えられた。

キーワード：村有地，輪作体系，ジャガイモ，斜面農業，試算分析

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