(4) Sample 4 (S-4) - existing arable land

On a river terrace on the left Bank of the Salado River at the end of a prospective area for irrigation development; No. 6 is surface soil (0 - 5 cm) and No. 7 subsoil (10 - 15 cm).

(5) Sample 5 (S-5) - existing pasturage

Near the entrance of the above-mentioned prospective area for irrigation development; No. 8 is surface soil (0 - 5 cm) and No. 9 subsoil (10 - 15 cm).

Generally speaking, the soil samples were mixed with large amounts of compact pebbles and the soil texture was rough. The soil is weakly acidic and, as mentioned below, there are problems concerning such factors as the CEC (ability of the soil to maintain nutrients), available phosphoric acid, and the exchangeable cations. There are the usual amounts of traces elements such as Zn, Cu and Mn, but the iron content is abnormally high. The ability of the soil to hold water presents some problem. The introduction of irrigation will be effective, and appropriate manuring control, especially the introduction of some organic substances such as manure is necessary. The findings were as follows for each sampling site.

(1) S-1 (Nos.1-2) soil

This soil has a low clay content, and there are many pebbles in the subsoil. The pH (H_2O) is a low 5.12 in the surface soil and Y_1 (the DAIKUHARA's acidity) shows a high value of 6.47 The ability of the soil to maintain nutrients (CEC) is a low value of about 10 and the exchangeable cations are also low. Therefore, the water content is a restrictive factor in the growth of crops and there is a possibility of acidic disturbances in the case of crops with low acid resistance. It will be necessary to provide irrigation facilities and apply dolomite and manure.

(2) S-2 (No.3) soil

This soil shows low CEC, exchangeable cation and available phosphoric acid values. Therefore, it will be necessary to introduce dolomite, phosphoric acid and organic materials.

(3) S-3 (Nos.4-5) soil

This soil contains many pebbles and the subsoil texture is SCL. The pH (H_2O) of the surface layer is high at 8.38 and there is a considerable amount of exchangeable Ca present. There are very low contents of trace elements, especially Fe. Therefore, it will be necessary to increase the water holding ability by providing irrigation equipment, adding organic materials, etc., and also adding trace elements. (At this site, only the surface soil is alkaline, which appears to be due to artificial influences because the area is paved.)

(4) S-4 (Nos.6-7) soil

The soil texture is SLC and there are many pebbles. The CEC is small and there are few exchangeable cations. Therefore, the same improvement measures as for S-1 will be necessary.

(5) S-5 (Nos.8-9) soil

This soil is fine, with a CL - L:C texture, but the surface soil contains many pebbles. There is a high Y_1 value of 6.17 and the available phosphoric acid is rather low. Therefore, the introduction of phosphate fertilizer and mixed layer cultivation (reversing) will be necessary as improvement measures.

3-1-3 Pasture Productivity

When pasture is introduced into the Project Area, it will be impossible to make a corroborative investigation concerning the productivity of pasturage grass (amount produced per hectare) since there has never been any cultivation of grass within the region. Therefore, an attempt is made here to estimate a theoretical value based on the meteorological conditions in the region using as a reference existing cases at various places in the Andes region.

Meteorological conditions are the most important factor in the growth of pasturage grass and the most important among these conditions are the air temperature and the amount of sunlight. Precipitation is also important, but large scale regulation is possible by artificial means such as irrigation. Other land conditions can also be easily regulated artificially.

The pasture introduced into the region will have to be of the cold-type because of regional characteristics. From the results of various experiments and surveys, it has been found that the growth limit of cold-type pasturage grass is an averages monthly temperature of at least 5°C, while the normal limit is at least 10°C. The high temperature limit is 22°C. In the case of sunlight, normal growth of pasturage grass appears to require a monthly average of about 180 hours.

When the possible amount of growth of pasturage grass is estimated, it is proposed that the number of days during which the grass can grow per year can be calculated by the following formula based on monthly meteorological conditions. This is then multiplied by the amount of dry material produced per hectare per day, based on experimental results. The amount which can be produced annually per hectare is then estimated[1/]

(1) No. of days grass can grow = $\Sigma(a_{1\cdots12} + \frac{b_{1\cdots12}}{2})C_{1\cdots12}$

a = No. of days with average monthly temperature of at least 10°C (No. of days of normal growth)

b = No. of days with average monthly temperatures of 5 - 10°C and 22°C or over (No. of days of half growth)

c = Hours of sunlight in months concerned/180 hours (coefficient of hours of sunlight on normal growth days)

(2) Amount of dry material produced per hectare per day = 68 kg/day/ha

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(Note) 1/ I. Harada <u>Bokuso no Eiyo to Shehi</u> Yokendo, pp. <u>174 - 179</u>

For greater accuracy, a trial calculation of the amount of grass which can grow per day was investigated using 150 g.cal/ cm^2 /day as the amount of solar radiation (amount of solar radiation effective for photosynthesis) shown by a wavelength of 380 - 710 mμ effective for photosynthesis. It was found that the calculation by the above-mentioned numerical formula using the air temperature and hours of sunlight has a rather high level of agreement. Therefore, Table 8-5 shows the results of a trial calculation of the amount of pasturage grass which can grow in the Project Area based on Yauri meteorological data (hours of sunshine from Huancayo).

This amount is the possible amount of growth when soil conditions (including water content) and fertilizing conditions do not represent any restrictive factors. Therefore, in the Project Area, it will be necessary to make up for insufficient precipitation by means of irrigation, etc.

When the same calculations were made for the other four areas in Table 8-3, the possible amounts of growth (live grass) per hectare per year were determined as follows:

Huancayo	121,400 kg
Denmark	80,500 kg
Switzerland	79,300 kg
Kushiro	49,100 kg

In Huancayo, the Instituto Veterinaria de Investigaciones Tropicals y de Altura (IVITA) of the University of San Marcos performed experiments on and undertook the spread of pasture dairy farming in 1973 through 1975 (in conformity with the meteorological data) with technical cooperation from West Germany. There were excellent grazing results as shown in Table 8-6. According to the sample survey, the annual yield of grass per hectare was 90,000 - 100,000 kg, which is more than 75% of the above-mentioned possible amount of growth. The possibility of the growth of pasturage grass throughout the year gave rise to these good results.

In Denmark and Switzerland, the actual amount growing under normal farming conditions appears to be about half of the possible growth values calculated here, but in the case of the best farms and experimental farms, results of 70,000 kg/ha have been reported and the results obtained in the trial calculations of possible amounts of growth seem appropriate. In Kushiro, there are few hours of sunshine in the summer because of the dense fog and this greatly decreases the possible amounts of grass growth. Here also, production results of 40,000 kg/ha are obtained in the best cases and this indicates the suitability of the above calculations.

To promote livestock raising in the Andes mountain region, there have been projects concerning the introduction of pasturage grass as well as the improvement of pasturage in various areas with foreign assistance. Experimental farms have been established in various mountainous regions by universities and other organizations and research is currently underway. Typical of such projects are the IVITA of San Marcos University in Huancayo (mentioned above) at an altitude of 3,000 - 3,500 m;

Table 8-5 Possible Quantity of Grass Growth viewed from Temperature and Sunlight Hours

(1) Possibly Days of Grass Growth

Condition \ Month	1	2	3	4	5	6 9	10	11	12	Total
Days of Normal Growth Temperature(10-22°C)	-	-	-	-	-	-	-	-	-	(a)
Days of Half Growth Temperature(5-10°C)	31	28	31	30	31	-	31	30	31	(b)
Coef of Normal Growth Sunlight Hours	$\frac{140}{180}$	$\frac{126}{180}$	$\frac{167}{180}$	$\frac{192}{180}$	$\frac{242}{180}$	$\frac{234}{180} \sim \frac{205}{180}$	$\frac{205}{180}$	$\frac{198}{180}$	$\frac{174}{180}$	(c)
Possible Normal Growth Days	15.5 x 0.8	14.0 x 0.7	15.5 x 0.9	15 x 1.1	15.5 x 1.3	0	15.5 x 1.1	15 x 1.1	15.5 x 1.0	122

(2) Possible Quantity of Grass Growth

Dry Basis Quantity/ha/year = 68kg x 122 = 8,296kg DM/ha/year

Grass Production Quantity/ha/year = 8,296kg $\div \frac{18}{100}$ = 46,090kg/ha/year

Table 8-6 Grazing Days of Milk Cow and Milk Production Per Head in Huancayo

Experiment Period	Month	Grazing Heads: Milking Cow (Head)	Grazing Heads: Total (Head)	Grazing Capacity: Grazing Days per 8 ha (Day)	Grazing Capacity: Grazing Heads per ha (Head)	Milk Production: Milking Cow per Day Production (kg)	Milk Production: Per Day Production per ha (kg)
I	5	41	44	11	2.0	10.4	19.4
	6	36	40	16	2.7	10.7	26.0
	7	38	43	18	3.1	11.3	30.9
	8	39	41	26	4.3	11.6	47.4
	9	41	44	13	2.4	11.0	24.5
	10	38	42	22	3.7	11.9	40.0
	11	38	44	17	3.1	12.1	32.4
II	12	42	46	25	4.6	11.0	46.2
	1	45	50	31	6.3	10.0	56.7
	2	44	47	29	5.9	9.3	51.4
	3	38	43	31	5.4	8.8	42.0
	4	35	39	30	4.9	9.3	40.9
	5	33	38	31	4.8	9.3	38.8
III	6	34	38	30	4.8	9.0	38.6
	7	35	39	31	4.9	8.4	37.0
	8	34	37	31	4.6	7.2	30.4
	9	34	39	17	2.8	8.2	20.0
	10	34	38	28	4.3	8.4	32.3
	11	31	36	28	4.2	8.0	29.0

(Source) IVITA, Milk Production on Permanent Irrigated Pastures at High Altitude.

the New Zealand Mission at Puno at an altitude of 3,500 - 4,000 m[2] and the experimental station of the IVITA at La Raya (Table 8-7) at an altitude of more than 4,000 m. Table 8-8 shows a compilation of the actual yields of pasturage grass obtained.

The results obtained at the La Raya experimental station provide the best reference concerning grass productivity in the Project Area since the altitudes are similar. From these results and the trial calculations of possible growth mentioned above, it is estimated that a grass yield of about 30,000 kg per hectare can be expected annually if irrigation is used.

3-2 Principles and Methods of Pasture Introduction

3-2-1 Principles of Pasture Introduction

For smooth introduction of pasture, it is first necessary to clearly understand the characteristics of pasture when compared to wild grass as well as regional characteristics such as meteorological conditions. It is essential to select varieties of grass which are most suitable for regional conditions for each method of introduction based on the location conditions, and to prepare, manage and utilize the pasturage so that the characteristics of the grass can be put to practical use.

There are differences between pasturage and wild grass, but originally, pasturage grass results from selection of the varieties of wild grass most suitable for artificial control. These varieties are further improved and then cultivated as a crop. Therefore, the characteristics of pasturage grass are basically those which make it suitable for artificial control, i.e. excellent utilization of fertilizers (fertilizer absorption) for high productivity and regenerative capacity. It is also important that pasturage grass be appetizing for domestic animals and have strong resistance to heat and cold. With respect to the temperature properties, there are cold and warm region type grasses.

Wild grass grows naturally in all parts of the world and varieties which are very well adapted to the natural environment of a region survive as part of a ecologically stabilized climate. Therefore, there is very little chance of pasturage grass being introduced as a new variety. The natural pasturage in the survey region consists of short grass type grasslands formed in the Andes Mountains, especially in cold regions at high altitudes. The annual precipitation is not so low, but since it is all concentrated in the rainy season, the grasslands are ecologically of the type which appear in arid regions.

(Note) 2/ Based on an agreement between the governments of New Zealand and Peru, a project concerning experiments on and the spread of pasturage grass cultivation, pasturage improvements and livestock improvements started in 1974 using the experimental stations of the Sociedades Agricolas de Interes Social (SAIS) and other organizations in the highlands of Puno State. It is planned that this project will continue until 1980. Three or four technicians have seen sent from New Zealand and they are working in cooperation with 5 - 6 Peruvian technicians.

Table 8-7 General Description of La Raya Experimental Station

Location	Apartado 76 Sicuani-Cuzco On the boarder line between Cuzco and Puno Provinces, and 30 km along the railway to the south of Sicuani.
Competant Authorities	The Experimental Station is under the jurisdiction of Puno Direction Regional de Agricultura y Almentacion but the Instituto Veterinaria de Investigaciones Tropicals ye de Altura (IVITA) of San Marcos University under an agreement with Agricultural Experimental Institute manages the station as a Centro Nacional de Camélido Americanos. (Centro Nacional de Camelids Americanos)
Area in ha	12,139 ha (Covering both Cuzco and Puno Provinces. At an altitude of 4,100 - 5,200m)
Number of Employees	IVITA 60 (10 Engineers out of 60) Ministerio de Agricultura (4 Engineers out of 20) Total 80 (14 Engineers out of 80)
Domestic Animals	Alpacas 7,000, Llamas 300, Sheep 100, Cattle 50, Horses 20,

(Source) Instituto Veterinaria de Investigaciones Tropicals y de Altura.

Table 8-8 Actual Grass Production by Altitude

(Annual Grass Production kg/ha)

Altitude (m)	Name of Project	Kind of Grass	Water Supply	Production (kg)
3,000 - - 3,500	1) IVITA Huancayo Project	Mixture Sawing of Perenial Ryegrass and White Clover	Irrigation	80,000 - 110,000
3,500 - 4,000	2) New Zealand Mission	Mixture Sawing of Alpha Alpha and Orchard Grass	Non-Irrigation	Average 30,000 Maximum 75,000
	Pono Project	Mixture Sawing of Perenial Ryegrass and White Clover	Irrigation	60,000 100,000
Over 4,000	3) IVITA La Raya Test Farm	Mixture Sawing of Perenial Ryegrass and White Clover	Irrigation	25,000 - 35,000

(Source) 1) New Zealand Agricultural Aid Project, Puno-Peru 1974 - 78.

2) IVITA Pasturas Permanentes Cultivadas para la Produccion Lechera.

3) La Laya Livestock Experiment Station

The natural conditions in this region were as described in the previous section and the meteorological conditions, which are most closely related to grass variety selection, were indicated in comparison with those of other regions. Because of the meteorological characteristics of this region, the most important point to be considered in the selection of grass varieties to be introduced is resistance to cold. If no irrigation is provided, resistance to drought is the most interesting factor. In cases of pasturage preparations and improvement without cultivation, competitiveness with indigenous wild grasses also presents a problem.

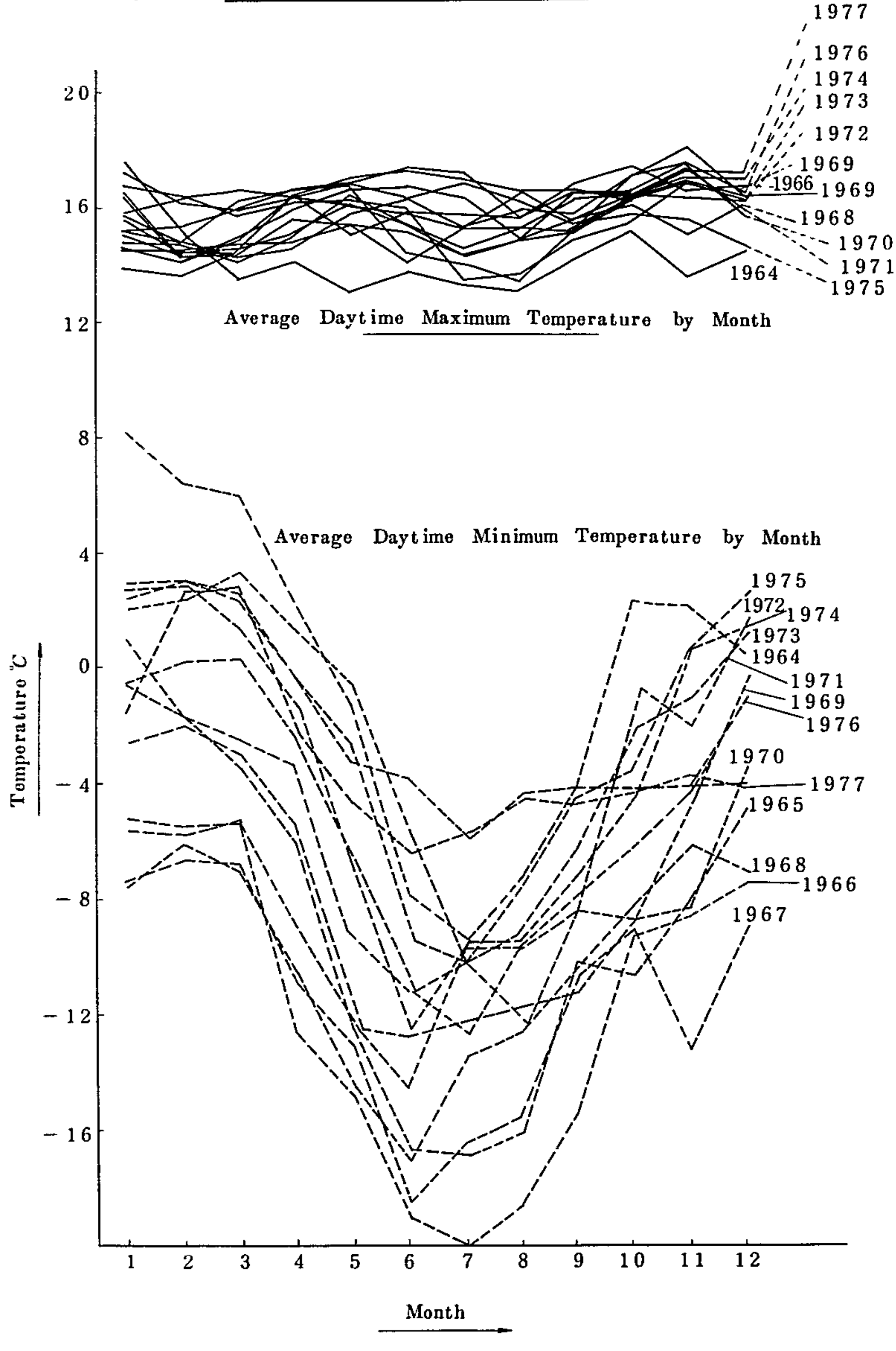
In the dry season, which is winter in the Project Area, the custom is to take the livestock to graze higher in the mountains where the cold is more severe, but the reason for this is that there are many swamps in such areas and the grass continues to grow even in the winter because of the higher water content. Concerning this point, the changes in average daily maximum and minimum air temperature each month as shown in Fig. 8-2 are of interest.

The average daily maximum air temperatures show little change thoughout both the summer and winter. The most common values are 14 - 15°C in winter. This phenomenon is considered to be the reason why wild grass can grow in the winter. However, the average daily minimum temperature is often at least -10°C and there are years when it reaches close to -20°C. There are many cold-type pasturages which can resist this degree of cold and continue to survive, but basically, the underground root becomes dormant, while the part above ground dies. When the part above ground due to sudden cold, it can be effectively utilized as foggage.3/

When pasturage grass is introduced into the Project Area, the main problem will be to find varieties of grass which will not become dormant during the winter except in especially cold years, since the limiting temperature at which the grass above the ground dies is comparatively low. There are many varieties of grass which are resistant to cold, including Festuca arundiacea, Phleum pratense, Bromus inermis and Alopecurus pratensis. Other varieties also show cold resistance according to breeding and genealogy. For example, pasto brasilero (Phalaris tuberinacea) introduced from Columbia (orginating in Brazil) showed good results in a trial growth at the La Raya experimental station and it has been found to grow well at high altitudes of 5,000 m.

(Note) 3/ Foggage: In England, the part of the pasturage grass above ground which survives until winter and then dies because of the cold is known as foggage. It is used for grazing of domestic animals. In Japan, studies on foggage have been performed at experimental stations in Hokkaido and it has been found to be good feed for beef cattle with respect to both nutrition and palatability.

Fig. 8-2 Maximum and Minimum Temperature in Yauri



(Source) SENAMHI (Yauri)

If no suitable varieties from outside the region can be found, a variety with a high fertilizer absorption capacity and a high yield will have to be selected from among the wild grasses indigenous to the region. However, in such cases, collection of plants is easy but it will require a long time before they can be improved and established as pasturage grass.

The most important artificial control for success in putting the characteristics of pasturage grass to practical use and achieving pasturage improvement in the case of a wild grass is fertilization. In addition, irrigation and multiple harvesting are also effective. The indigenous wild grass in the Project Area has often withstood multiple harvesting in the form of excessive grazing or plundering and this must be considered to be a minus point. To increase the productivity of pasturage grass in this region, both fertilization and irrigation will be necessary. When pasturage grass is cultivated without irrigation, the amount of fertilization is decreased and priority should be given to the selection of drought resistant varieties.

3-2-2 Selection of Pasture Introduction Methods

There are various methods by which pasture can be introduced into the region in accordance with the various conditions of location. The two main factors are land conditions and water utilization conditions. In areas where the land conditions are good, it is possible to use the field (cultivation) method and in areas where the water utilization conditions are good, the irrigation method can be used.

Table 8-9 shows a compilation of the four types of introduction methods which can be used with both good and poor land and water utilization conditions. Naturally, there are cases where the conditions of location are midway between such conditions and there are also midway cases in the introduction methods according to a combination of conditions. For example, in the case of an area with favorable land conditions which seems to have been used for a long time as pasturage, there are cases where pasturage can be prepared by overall cultivation.

Table 8-9 Regional Condition and Grass Introduction Methods

Division	Water Utilization Conditions (Good)	Water Utilization Conditions (Poor)
Land Condition (Good)	Irrigation System in Fields	Non-Irrigation System in Fields
Land Condition (Poor)	Irrigation System in Grass Land	Non-Irrigation System in Grass Land

3-3 Selection of Varieties for Each Type of Introduction Method

3-3-1 Field Irrigation Method

This method of introducing grass involves planting the grass in cultivated fields which are irrigated. If this method can be used in the Project Area, the most reliable establishment of pasturage grass will be possible and the maximum yields can be expected. Cold-type pasturage grasses are best suited to this method, which supplies an appropriate amount of water and makes sufficient fertilization possible. This is the only method by which it is easy to get the most out of the productivity of the grass.

Therefore, there are many varieties of grass suited to this method, as shown below, and these can be chosen in appropriate combinations according to meteorological conditions, soil conditions (soil texture and ground water level), amount of irrigation water, aim of utilization, etc.

(1) Forage grass

Perennial rye grass (Lolium perenne)
Italian rye grass (Lolium multiflorum)
Meadow fescue (Festuca elatior)
Tall fescue (Festuca arundiacea)
Timothy (Phleum pratense)
Meadow Foxtail (Alopecurus pratensis)

(2) Forage legumes

White clover (Trifolium repens)
Red clover (Trifolium pratense)
Alfalfa (Medicago sativa)

Among these varieties, experience at Huancayo, Puno and La Raya has shown that a mixed sowing of rye grass and clover (treboles) should be the most suitable for this method of introduction. In this case, mainly perennial rye grass is used, but it is desirable to add some Italian rye grass. White clover is the main variety used but it is also desirable to add some red clover.

Italian rye grass and red clover normally live for one to two years, but because of the meteorological conditions (little difference in temperature and length of day between seasons) characteristic of the Project Area, these grasses should become perennial and their lifespan should present no problem. Effective utilization of these varieties, which show a good yield 1 - 2 years after sowing, is possible. Pasturage grass cultivation using this method of introduction should be incorporate a rotation system with other crops as much as possible to increase the level of land utilization and, therefore, it is best to select varieties which will be effective in short-term pasturage.

The amount of seed used in mixed sowing of rye grass and clover has varied widely in various projects and at experimental stations, as shown in Table 8-10, but it appears from previous results, that 20 - 25 kg of rye grass and 3 - 5 kg of clover per hectare are suitable. Since there are no clover root nodule bacteria in the soil of the survey area, such bacteria will have to be inoculated into the soil before sowing.

Table 8-10 Sowing Quantities of Fertilization Quantities of Rye

(kg/ha)

	Huancayo Project	Puno Project	La Raya Experimental Station	FAO Project
1) Sowing Quantity				
Perennial Rye Grass	15	15	15	10
Italian Rye Grass	15	-	5	5
Hybrid Rye Grass	-	-	5	5
White Clover	3	4	3	2
Red Clover	-	1	-	-
Total	33	20	28	22
2) Fertilization Quantity(When Sowing)				
N	50	-	50	N.A.
P_2O_5	150	200	120	N.A.
K_2O	75	-	-	N.A.
S	-	-	10	N.A.

(Note) A Grass introduction project in Cuzco Province supported by free seed supply from FAO.

Fertilization at the time of sowing should consist of about 50 kg of N, 150 kg of P_2O_5 and 50 kg of K_2O. If the sowing takes place during the dry season, irrigation is indispensable, but the sowing should be performed between December and March because of the possibility of frost damage to the young plants.

3-3-2 Field Method with no Irrigation

This method involves the introduction of the grass in cultivated fields which cannot be irrigated. This includes the preparation of new pastures by the tilling method. The grass introduced by this method must be strongly resistant to drought. The following varieties meet this condition:

(1) Forage grass

Orchard grass (Dactylis glomerata)
Red fescue (Festuca rubra)
Smooth brome (Bromus inermis)
Rescue grass (Bromus catharticus)

(2) Forage legumes

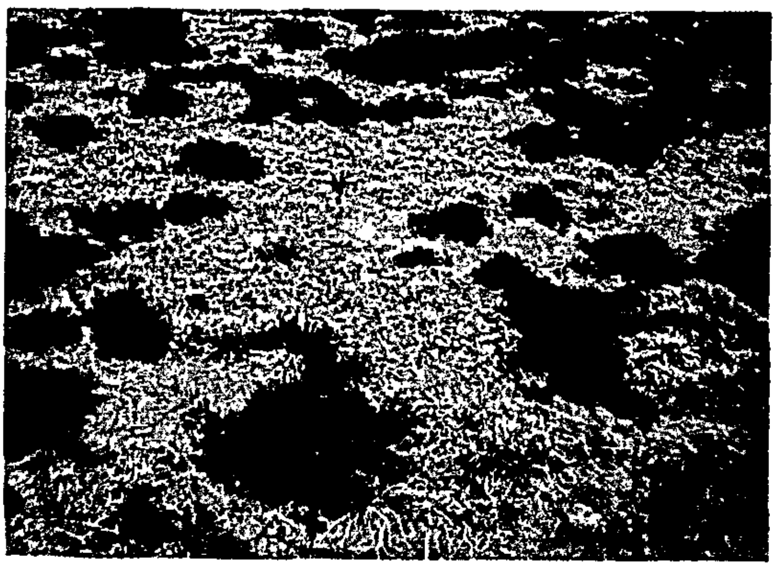
Alfalfa (Medicago sativa)
Subterranean clover (Trifolium subterraneum)

Among these varieties, alfalfa is decidedly the best with this method. Alfalfa has excellent root depth and is therefore draught resistant. It is not suitable where the soil layer is thin and growth is also bad in areas when the ground water level is high. Alfalfa is highly affected by acidity and it is necessary to adjust the acidity by such means as the use of lime. The sprouts cannot be well established unless the seed beds are carefully prepared.

The varieties of grass introduced by this method in the New Zealand project at Puno consisted of a mixed sowing of alfalfa and orchard grass. The amounts were 10 - 15 kg per hectare of alfalfa and 6 kg of orchard grass. As in the case of clover, it is necessary to inoculate the soil with alfalfa root nodule bacteria.

A mixed pasture using this method was inspected at the Buena Vista farm of the SAIS near Puno. The alfalfa appeared to be in good condition, but the orchard grass was dried out and portions of it were dead (refer to Photo 8-2). In the cultivation of orchard grass using this method of introduction, fertilization control is difficult (death of the grass is promoted when a lot of fertilizer is applied to soil with insufficient water content) in cases where water is not added artificially and there appears to be some relation between the two factors. Therefore, the results of the New Zealand project showed that the yield of grass was considerably less than that obtained in a rye grass and clover pasture using the irrigation method.

Photo 8-2 Mixture Sowing Pasture of Alfalfa and Orchard Grass



Sociedades Agricolas de Interes Social Buena Vista Farm in the suburb of Puno

3-3-3 Grassland Irrigation Method

The introduction of pasture by this method is in principle the same as the field irrigation method but irrigation is apt to be incomplete with respect to uniformity of the water quantity and there is the problem of competiveness with indigenous wild grass. These points must be taken into consideration when choosing the kind of pastures. This results in more confinement on the selection of grass varieties than in the field irrigation method, and the legumes show more aptitude for this method than the grasses. From the results of the New Zealand project, the most suitable variety for use with this method is white clover, followed by red clover and alfalfa.

Forage grasses such as rye grass and fescue can be mixed with legumes (for example, 15 kg of rye grass and 5 kg of clover per hectare) from the beginning, but it is more desirable to first sow only 6 - 8 kg of clover per hectare and after this is established, and the pasture is sufficiently fertile, to sow the rye grass, etc. The necessity of inoculating clover root nodule bacteria and providing sufficient fertilization especially in cases of mixed sowing with grass) is the same as for the field irrigation system.

3-3-4 Grassland Method with No Irrigation

Pasturage grass introduction by this method does not have much possibility of success except in cases where the soil has a comparatively high water content. The most suitable variety for use with this method is white clover. It is relatively easy for the sprouts to become established and there is strong resistance to competition from wild grass because of the creeping stems.

Even though more work is required, if care is taken until the sprouts become established by such measures as careful preparation of the soil surface when sowing, introduction of alfalfa should also be possible. No experiments have been performed to date to determine if it is possible to introduce forage grasses once the clover or alfalfa have become established and there is sufficient fertility.

4. Agricultural Irrigation and Irrigation Development Plan

4-1 Regional Characteristics and Irrigation

As described in previously, the Survey Area has very severe natural conditions, especially meteorological conditions, because of the high altitude. These severe meteorological conditions have an even greater effect on crops which require fruition than on forage grass. As was discussed in detail in the report of the previous year's survey, the cultivated crops are limited mainly to potatoes with a little canihua and wheat, but the wheat can often not be harvested because of adverse meteorological conditions, and even in the case of potatoes, there is only extensive cultivation of existing varieties of low productivity because of the limitations imposed by the meteorological conditions with no introduction of improved varieties.

Such effects of meteorological conditions on crop cultivation are based mainly on effects of low temperature, since the minimum air temperature can be below freezing even in the summer, and on frost damage. The fact that water control, which is indispensible for crop cultivation, is entirely dependent on natural water supply cannot be overlooked. Concerning this point, it was pointed out in the previous year's survey report that the introduction of artificial water control and irrigation should speed up crop sowing time and promote growth, and this would result in the spread of improved varieties of potatoes.

The use of irrigation in the Survey Region will also probably result in the gradual introduction of crops which can be cultivated economically. There is also a strong possibility that irrigation will allow the cultivation of vegetables such as onions, in which the region is only partially self-sufficient. This is because intensive controls such as fertilization and plastic insulation will be easier in conjunction with irrigation.

In this region, where the main agricultural activity is livestock raising, it is highly desirable that agricultural improvements such as the cultivation of pasturage grass and other feed crops with the products used mainly as storage fodder for the winter season be adopted when cultivation becomes possible due to irrigation. If pasturage grass is cultivated, there should be no problem since greatly increased yields can be expected from irrigation.

The basic point in agricultural and livestock raising development is increasing the productivity of the land, but in case of regions with severe meteorological conditions, the only solution appears to be to find the proper course of action while aiming at related effects by the introduction of irrigation. Temperature control is impossible (excluding hothouse control), but control of precipitation conditions in the dry and rainy seasons by irrigation will make possible regional improvements. Improvements in productivity by increased application of fertilizer will also be effective in conjection with soil water control.

Under such conditions, the introduction of agricultural irrigation should be considered as a basic development strategy for agricultural improvement in the Survey Area. Although irrigation is not vital as it is for agriculture in the coastal region, where almost no rain falls throughout the year, if at least some crop cultivation restrictions can be eliminated by irrigation, this will result in a major qualitative change in regional agriculture, which will have greater significance than mere quantitative changes (increased yield).

Fortunately, this region is located at the head of the Amazon River and there is considerable precipitation during the rainy season. Even in the dry season, there are rivers which do not dry up scattered about the region. Therefore, once the real value of irrigation is proven, it should be possible to disseminate irrigation methods throughout the region. Since this area is not a source for rivers flowing to the coastal area, where water is in great demand, there should be no trouble in downstream areas even if maximum water utilization is undertaken.

4-2 Irrigation Methods and Cropping Systems

There are various methods for field irrigation, but they can be generally classified into three methods: surface irrigation, spray-type irrigation and underground irrigation. Surface irrigation consists of the surface and furrow methods; spray irrigation of the sprinkler and drip methods; and underground irrigation of the open and closed channel methods. The drip method (dripping of water through holes in a pipe or hose) is also used in underground irrigation.

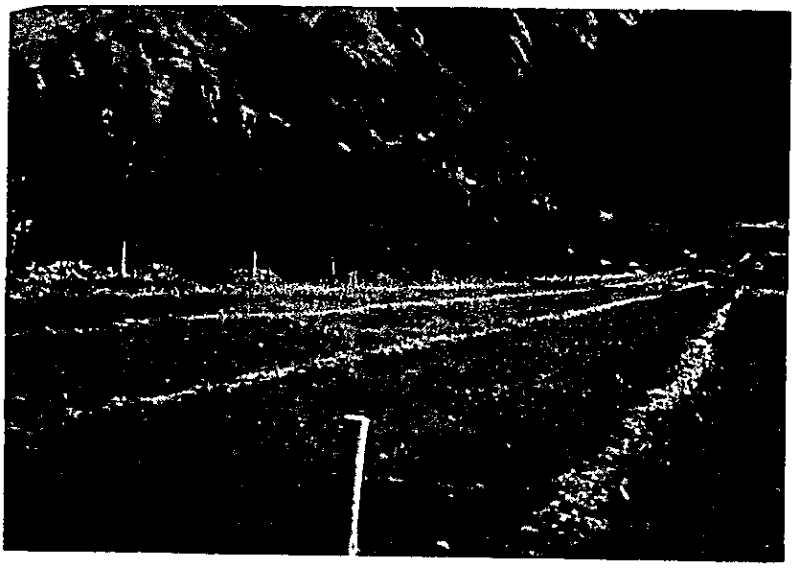
Among these methods, spray and underground irrigation systems have a comparatively short history, but the sprinkler method is widely used in many countries. In Peru, sprinkler irrigation was started in irrigation projects in the coastal region (such as the La Joya and Majes plans in the vicinity of Arequipa), but the method of irrigation to be introduced in the Project Area should be surface irrigation because of regional characteristics.

Sprinkler irrigation has the following advantages: land conditions such as soil texture and topography are not decisive, water supply efficiency is good (with only a small amount of water), and it can be used for many purposes (in addition to water supply, distribution of fertilizer and agricultural chemicals and for the prevention of frost damage). However, the irrigation costs per unit area are high because of equipment depreciation and other expenses. In the Project Area, water is abundant, land conditions are favorable, and if selective irrigation is introduced, there will be no problems if sprinkler irrigation is not used. In any case, irrigation methods which require as little money as possible are desirable because of the low economic resources of the local farmers.

The surface and furrow methods of surface irrigation are selected mainly according to the type of crop cultivated. Surface irrigation is suitable for grass and cereal crops, but in the case of crops such as potatoes, where furrowing is needed, furrow type irrigation is best. Surface irrigation consists of several methods such as the uncontrolled natural flow method, the spaced furrow method, the wave-form method, the contour groove method, the obstruction method and the basin method, according to topography and the type of crop. In this region, the spaced furrow method will generally be used (refer to Photo 8-3).

Agricultural irrigation is comparatively widespread in the Andes region and in particular Tinta, where work on an irrigation project was recently completed (near Sicuani; irrigation area of 1,200 ha; main crops, potatoes, corn and broad beans; furrow irrigation method), is not far from the Survey Area and there are examples of irrigated pasturage grass cultivation using spaced furrows in the vicinity. Therefore, the irrigation method can be selected on the basis of existing conditions.

Photo 8-3 Grass Cultivation by Separate Furrow Belt Method



OROPESA Sociedades Agricolas de Interes Social in the suburb of Cuzco.

The crops cultivated when irrigation is introduced in this region will mainly potatoes on the basis of cultivation performed to date. When canihua and wheat are included, it is desirable that the weight be gradually shifted to the cultivation of pasturage grass. In such cases, continuous cultivation of the same crops should be avoided as much as possible and a cropping system for planned crop rotation should be established.

The establishment of a crop rotation system would be hindered somewhat by the irrigation methods if there was a combination of surface irrigation for grass and cereals and furrow irrigation for potatoes. However, there should be no major problem if the gradient of the surface irrigation is made slightly steeper from the beginning to permit furrow irrigation and the potatoes are planted in the spaced furrows for surface (strip method) irrigation.

4-3 Irrigation Techniques and Effects

In field irrigation, as can be seen in Fig. 8-3, the normal method is to irrigate by continuous repetition before the soil water content reaches the initial withering point of the crop until the[4/] field water capacity is reached. Therefore, the[5/] problem is to decide irrigation intervals (days of stoppage) and the amount of irrigation water each time. It is also necessary to take into consideration the water demand in accordance with the crop, the effective water capacity of the soil, meteorological conditions (especially[6/] precipitation) and irrigation water reserve conditions, and to carry out theoretical studies to determine the correct amount of water by means of measurement of pF values[7/]. However, the actual

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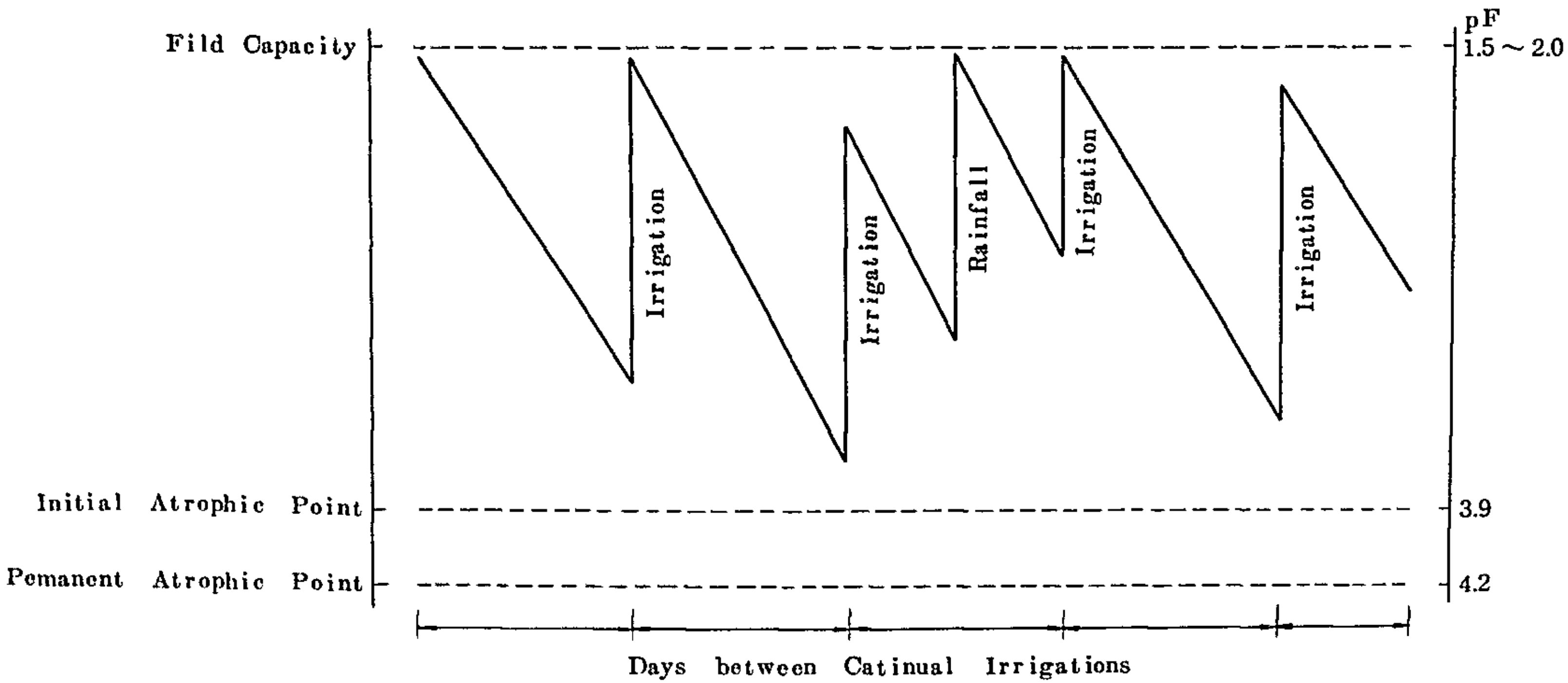
Fig. 8-3 Transition of Soil Moisture Content during Irrigation Period to Crop Field (Pattern Figure)

(Original drawing by Nakagawa)



(Note)
1. If a supplementary irrigation after a rainfall is disregarded, the soil will get so dry in the following intermittent non-irrigation period.
2. The soil moisture does not always recover to the level of field capacity after irrigation

problem involves choosing the most suitable method by studying previous cases where similar conditions existed and experience accumulated.

Since the water requirements increase in the growth period of cereals and in the final growth period of edible roots such as potatoes, the establishment of a crop rotation system combining these factors will be good for water allocation. Irrigation from autumn through winter is also possible to provide temporary water reserves for raising the ground water level (water table). This will also aid in promoting germination and growth the following spring and appears to be especially effective in the case of pasturage grasses. There are various other practical techniques for increasing the effects of irrigation, but in the beginning, it is better to make gradual improvements according to accumulated experience, with the stress on safety, rather than aiming at high level techniques.

The increased in crop yields with irrigation (irrigation effects) is generally 20 - 30% in Japan, but according to the results of the Tinta project mentioned above, there was a two to three-fold increase in potato yields of from 4,000 kg/ha to more than 10,000 kg/ha (related also to change in variety), wheat cultivation shifted to potatoes and corn and the cropping system was improved to the stage where test cultivation of other vegetables was started. In the Survey Area, there is a possibility of obtaining even more remarkable irrigation effect. There is the possibility of introducing improved varieties of potatoes, and the possibility of fruitful cultivation of cereal grains can be expected to bring more than just increased yields. There are also an unknown number of other indeterminate factors which cannot be understood unless cultivation is actually attempted.

Fig. 8-4 shows the results of experimental irrigation cultivation of potatoes in the United States. There is a close relation between the amount of irrigation water and the yield and quality. The yield increases the greater the soil water content (amount of irrigation water) and the increase is about 40% higher with larger amounts of water than with smaller amounts. The percentage of first grade potatoes also increased according to soil water content. Comparisons are impossible since no non-irrigated controls were provided, but since the yield differences

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Note : 4/ Initial withering point: Water content at which the lower leaves of the plant wither and growth stops.

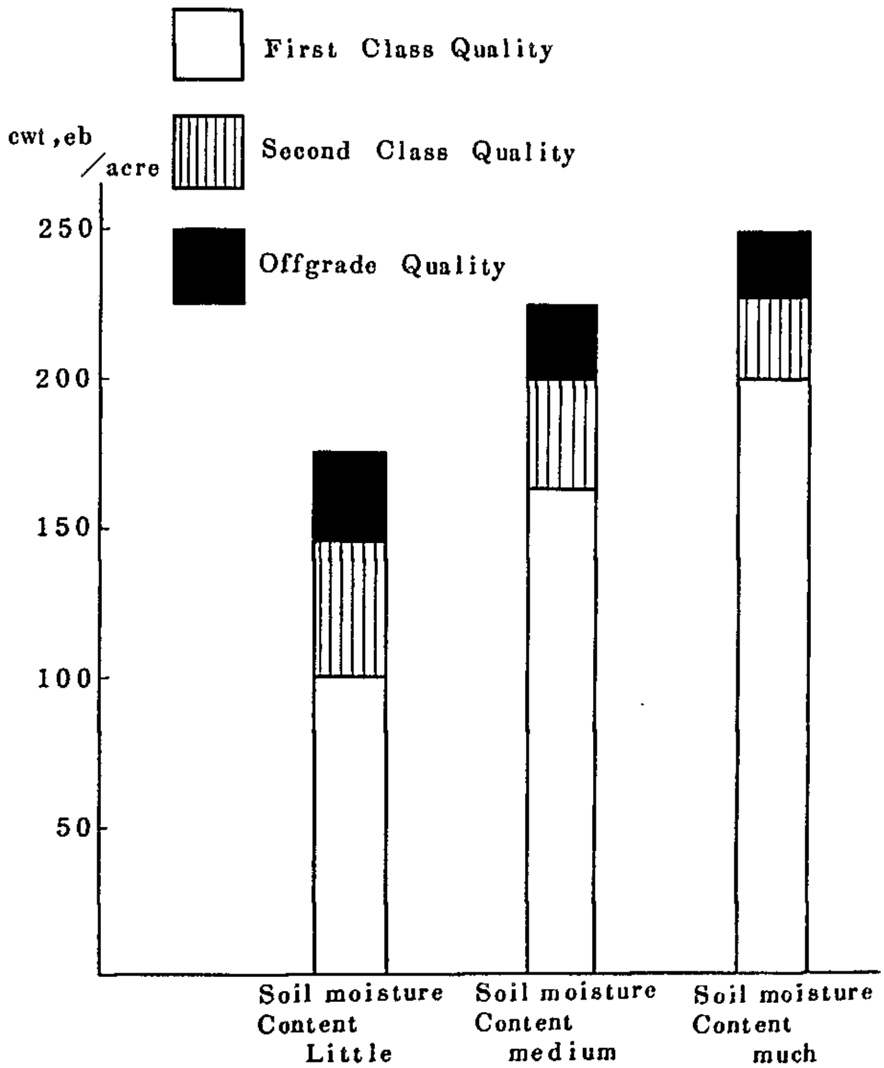
5/ Field water capacity: Soil water content when gravity water which cannot be maintained by capillary pressure after heavy rains or large amounts of irrigation drops to zero and the water content shift is extremely small.

6/ Effective water capacity: Soil water content from the field water capacity to the initial withering point.

7/ pF: Soil water content tensile force (force per unit surface area required for removal of the water content from soil containing a fixed amount of water) expressed as water column height (logarithmic value)

Fig. 8-4 Irrigation Water Quantity, and Yield and Quality of Potatoes

(J. E. Box et al)



(Source) Agronomy Journal, Vol 55 (1963) were greater between small and medium soil water contents than between medium and large contents, there should also be considerable differences between the yields with no irrigation and those with small amounts of irrigation. Therefore, when irrigation is provided, increased yields of at least 50% can be expected when compared with non-irrigated cultivation (natural water supply).

4-4 Irrigation of Grasslands

In October, when this survey was performed, the Project Area was in the transition stage between the dry and rainy seasons. When the region was inspected by jeep, grass on the plateau and slope regions was still dead, while grass on the low ground, where there was water flowing from rivers or springs or percolating water, was green and livestock grazing was observed. Since the temperature had risen, it seemed that the grass was giving out new shoots and in this region where the temperature during the day is rather high even in the dry season (winter), such conditions probably continue through the dry season.

If water were added to the soil, it would be possible to assure grass for grazing animals even in the dry season when the grass in the natural grasslands dries up or at least in the early spring and late autumn. This clearly indicates that the artificial supply of water to the soil, i.e. the irrigation of the grasslands would result in regional livestock development. Since grass in the dry season has a scarcity value when compared with the rainy season, it is especially important for improving the nutrition of livestock and increasing livestock production.

On the slopes throughout the region, it is possible to see clearly the dividing line for the living grass (refer to Photo 8-4) from afar, but this reflects the efforts of farsighted farmers in individual utilization of river and spring water. It is well known that farmers have had many years experience in increasing the appetizing "coya" grass and decreasing the less appetizing "ichu" grass by irrigation[8/].

Grassland irrigation in this region would produce considerable effects on the grass in the rainy season. This is because even in the rainy season, the amount of precipitation and especially the number of days of rain are not the great. Tables 8-11 and 8-12 show the results of tests (the effects of irrigation combined with burning and fertilization on yields and vegetation in natural grasslands) at the La Raya experimental station which is at about the same altitude as this Survey Area. The irrigation effects were very high. It not only increases the amount of the grass, but also increases the proportion of

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Note : 8/ Ichu is not eaten much during the season when the more appetizing "coya" grass is abundant. (In the list of naturally growing grasses in La Raya given in the previous year's survey report, "Ichu" was entered among the appetizing abundant grasses.) However, when grass becomes scarce, it can be eaten. It is known as "paja dulce" (sweet straw) locally. There is also a grass known as "paja bravu" (fierce straw) which looks exactly like ichu, but has hard pointed leaves like needles and livestock never eat it.

Table 8-11 Irrigation Effect on Natural Grassland under Combination of the Burning and the Fertilization

(Green Grass Yeald kg/ha)

Division	Only Natural Water	Irrigation
Only Burning	2,540	12,130
Fertilization after Burning	9,840	16,450
Burning after Fertilization	7,320	14,720

(Note) Fertilized Quantity (kg/ha) N=60, K_2O_5=100, K_2O=38

(Source) La Raya Stock Animal Experiment Station

Table 8-12 Vegetation Change of Natural Grassland by Irrigation under Combination of the Burning and the Fertilization

		Only Natural Water (Non-Irrigation)			Irrigation		
		Only Burning	Fertilization after Burning	Burning after Fertilization	Only Burning	Fertilization after Burning	Burning after Fertilization
Vegetation Land		65	80	85	94	95	98
	Favorable Grass	12	40	40	74	85	80
	A little Favorable Grass	23	15	20	15	9	15
	Unfavorable Grass	30	25	25	5	1	3
Bare Land		35	20	15	6	5	2
Vegetation by Grass Height	Tall Grass (Grass Height in cm)	40(10)	45(25)	45(20)	55(30)	70(50)	80(40)
	Short Grass (Grass Height in cm)	60(4)	55(7)	55(7)	45(5)	30(10)	20(10)

(Source) La Raya Stock Animal Experiment Station

Photo 8-4 Grass Growing along the Waterside near Coroccohuayco

(Grasses near the waterside is colored green even in dry season and there is no room for such grass as Ichu to grow)

appetizing grass and sharply decreases the barren areas. The effects of fertilization are also great but it is interesting that in the case of fertilization after burning, the grass yield is better, but the barren areas are greater and the vegetation worse than in the case of fertilization before burning.

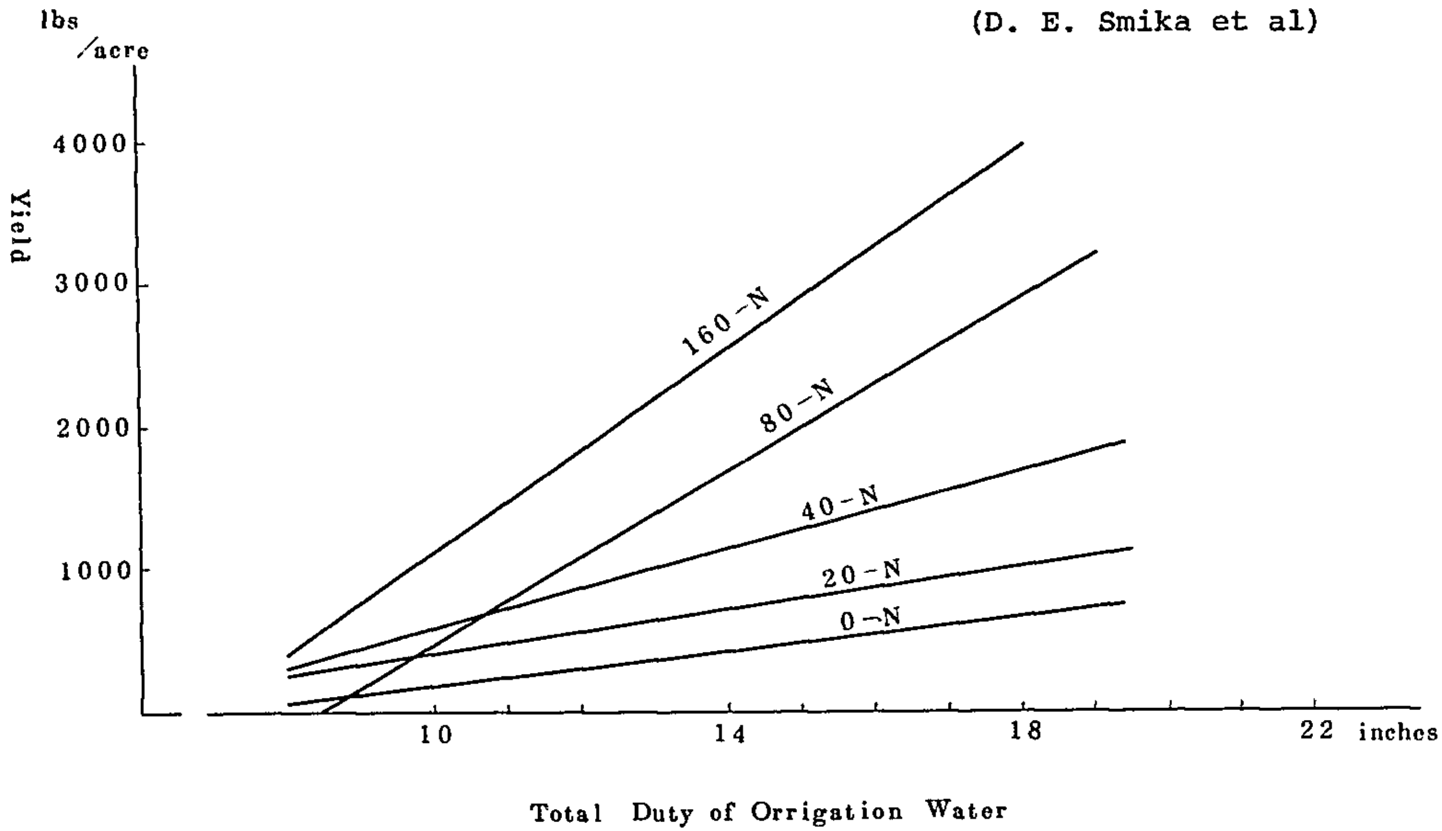
The American experimental results shown in Fig. 8-5 suggest that there is a good multiple effect when both fertilization and irrigation are applied to natural grasslands. There are major differences in the increased yields of grass due to the amount of irrigation water in accordance with differences in the amount of fertilizer. When little fertilizer is used, the yield of grass is not increased very much even when the amount of irrigation water is increased, but the greater the amount of fertilizer used, the more effect increased amounts of water has.

As described above, when grasslands are irrigated, wild grass remains the same, but there are changes in desirable vegetation. If irrigation is performed in combination with fertilization, improvements should be made in grasslands by the introduction of varieties of forage grass with a good fertilizer utilization rate. The selection of grass varieties and other related factors were described previously. The only irrigation method which can be considered for grasslands is the surface method, but this is not limited to incontrolled natural flooding and uniform overall grassland irrigation should be possible by a suitable combination of the contour groove and obstruction methods according to water flow.

4-5 Field Irrigation Plan

As has been described in Part 2, the field irrigation development site in the Survey Area covers 500 ha. The following is a simple investigation of a plan for the facilities and water supply for such irrigation and a short discussion of the development results. The water will be obtained from the Ocoruro River and a reservoir will be constructed at a point just before it flows into the Salado River. The reservoir facilities and

Fig. 8-5 Effect on the Yield of Natural Grassland Affected by Duty of Irrigation Water With Annual Nitrogen Fertilization Quantity



(Source) Agronomy Journal, Vol 56 (1984) storage capacity (flow rate), as well as the division of expenses and utilization between mining and agriculture are described in Chapter 4.

In this water plan, the dry season flow rate of the water which can be used for agriculture (irrigation) is 0.2 m^3/sec, which means that when this amount is used to irrigate 500 ha, the rate will be 0.4 ℓ/sec or a unit amount of 3.4 mm/day. This value is within the range of the organized capacity of normal supplementary irrigation, and it will be suitable for an ordinary agricultural plan. Since the above-mentioned dry season flow rate was calculated on the basis of a standard draught year, it should be possible to increase the amount supplied slightly in normal years. Since the possibility of adapting to circumstances (liberalization of water utilization) is desirable with respect to the water requirements based on the actual agricultural plan, it will be necessary to provide some margin in the capacity of the headrace channel (headrace elasticity).

Based on these considerations, a plan for the facilities is shown in Figs. 8-6 and 8-7. The headrace channel is located along the road in the direction of Yauri from the water intake station. Its total length is 7 km to the entrance of the irrigation site and 12.4 km up to the end of the irrigation site. The gradient is 1/1,000 and it is a concrete trapezoidal channel. There are many points to be investigated ocncerning the terminal facilities in relation to field preparation, but these will be left until the subsequent detailed survey together with a detailed investigation of the agricultural plan.

The following is a trial calculation of the development effects when field irrigation of 500 ha is planned. The initial construction costs of the irrigation facilities will include 11 million soles for reservoir costs including those for weir construction, half of which will be born by agriculture. The construction costs of 22 million soles for the irrigation water intake station and headrace channel will all be born by agriculture. Therefore, the total will be 27.5 million soles. If the depreciation period is 30 years, the depreciation per hectare calculated at a rate of 8% annually will be 4,895 soles/ha (27,500,000 soles x 0.089/500 ha). The terminal facilities and field preparation plan have not been investigated, but it will be possible to keep the costs low by having the farmers making a profit supply the required labor. From the results of other irrigation projects in Peru, it can be assumed that the annual depreciation of the investment related to the field will be 3,000 soles/ha and the water rate and water pipe maintenance charges will be 2,000 soles/ha. Based on these assumptions, the added expenditures directly related to irrigation will be about 10,000 soles per hectare.

With the introduction of irrigation, there will be many other changes in such items as the crop cultivation methods and cropping system, but in the case of potatoes, which are cultivated at present, the change to irrigated cultivation should result in the introduction of improved varieties and the application of intensive fertilizing cultivation. From a comparison of the production costs for the existing variety (papa amarga) and improved varieties (papa color and papa blanca) in the previous

Fig. 8-6 Showing Water Intake to Irrigation Planned Area

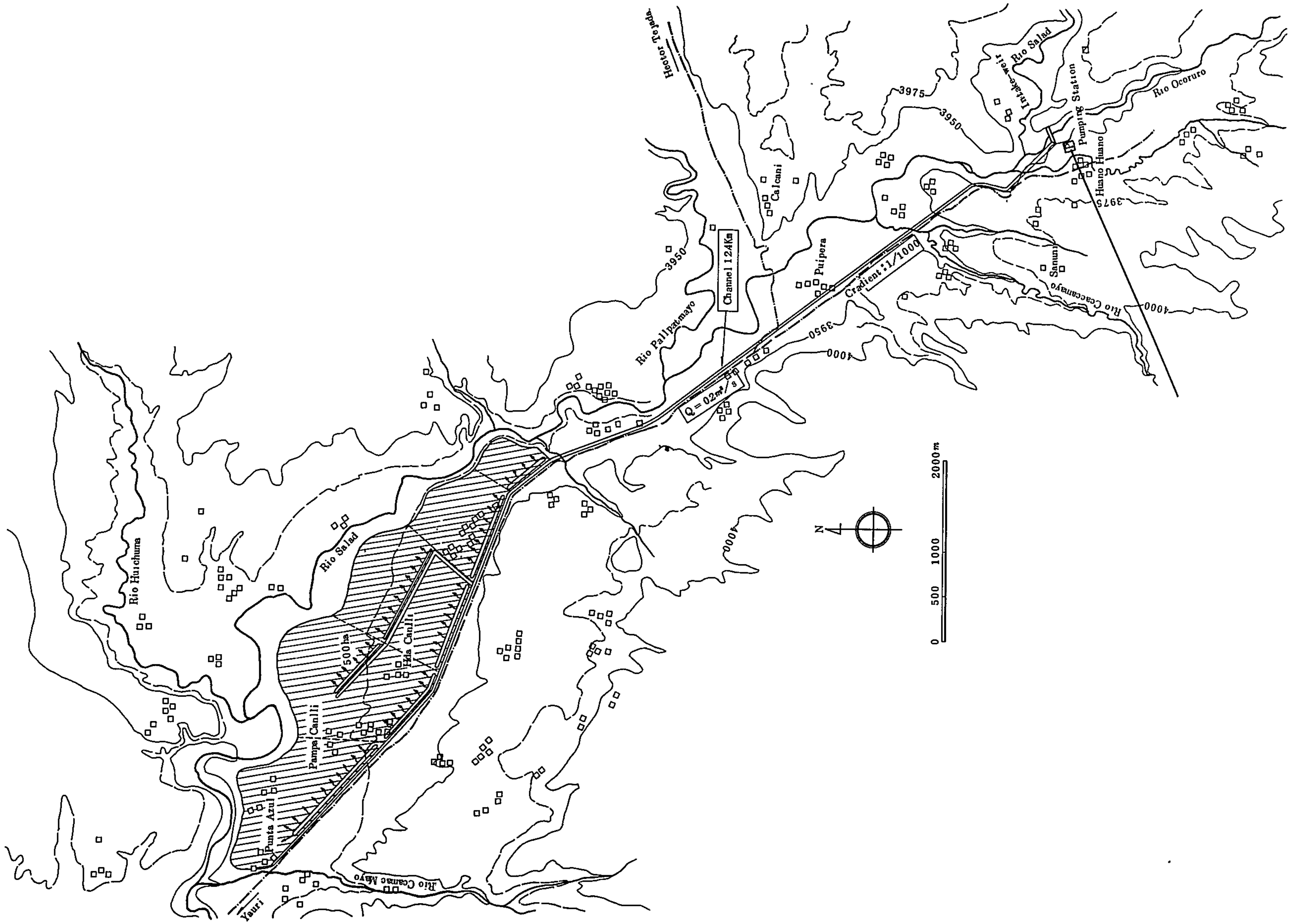
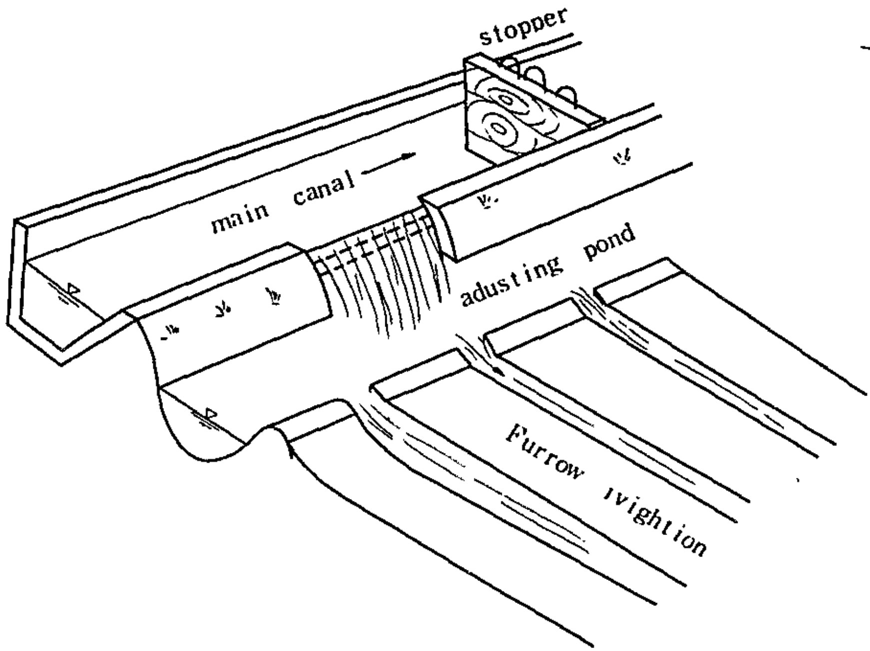
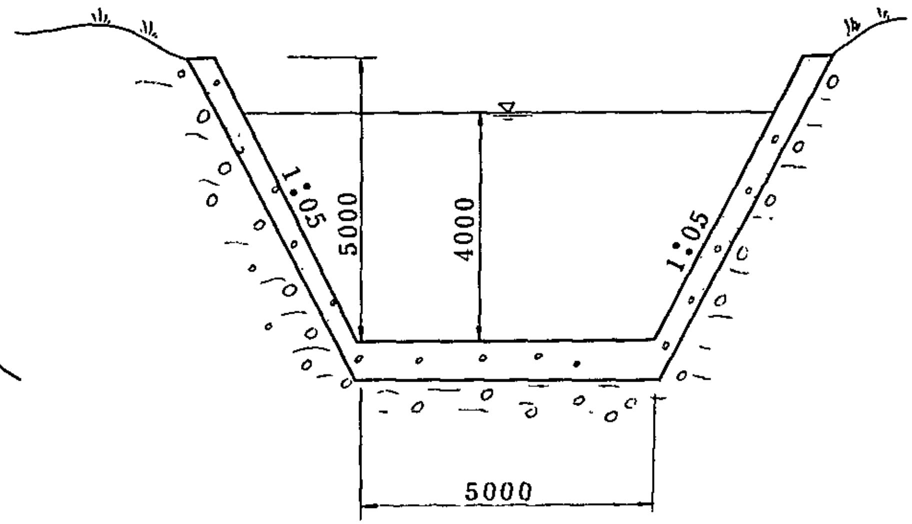


Fig. 8-7 Cross-Section of Waterway and End Facility

main cannal and tuigation method



main canal



$I = 1/1000$

$A = 028\,m^2$ ho $04m$

$R - 0201$, $n - 0.013$

$V = \frac{1}{0013}(0201)^{2/3}\ 0001 = 083m/S$

$Q = AV = 0233\,m^3/S$

year's survey report, it can be assumed that the increased expenditure for irrigated cultivation of the new varieties will be about 30,000 soles per hectare (15,000 soles for seed, 10,000 soles for fertilizer and 5,000 soles for miscellaneous expenses). When the above-mentioned costs related directly to irrigation are included, the total will be about 40,000 soles per hectare.

The increase in the yield of potatoes required to cover these added expenditures will have to be only 1,000 kg if the unit price is taken as 40 soles per hectare. The yield with non-irrigated cultivation using the common varieties at present is 2,500/ha and the increased yield due to irrigation should be at least 40%. This indicates that even if introduction of the improved varieties is impossible (the seed costs of 15,000 soles will be unnecessary), the introduction of irrigation will have a major developmental effect when sufficient preparation of the fields is combined with irrigation and fertilization in the cultivation of the existing variety.

5. Agricultural Utilization of Terrestial Heat

5-1 Regional Development and Geothermal Utilization

In last year's survey, it was strongly suggested by the geothermal development survey section that the agricultural utilization of terrestial heat which is expected to be developed in Quisicollo within this survey area be investigated. In the report of the agricultural development survey, the section describing future prospects of the development of agriculture and livestock raising in the high mountainous areas touched on the problem of self-sufficiency within the region by introduction of hothouse vegetable farming utilizing terrestial heat to meet the rapid increase in vegetable demand accompanying mining development. The problem points which require investigation in this connection were pointed out. Therefore, an investigation of the agricultural utilization of terrestial heat became one of the main survey items in this year's agricultural development survey.

Utilization of geothermal energy is of extreme importance, together with the utilization of solar energy, for man's survival at a time when it is expected that the utilization of fossil energy will taper off. However, even though there is no room for objections to this from the standpoint of the long-term development of national and international resources, it cannot be adopted unconditionally from the standpoint of regional development.

Among the various social and economic postulates of regional development, it is essential that there be integrated development with harmony among all of the actual sectors involved, and it is first necessary to look into this point thoroughly. To begin with there are several actual examples in various countries where the utilization of terrestial heat has promoted successful integrated regional development. A typical example is the utilization of terrestial heat in Iceland for regional heating. There are also many cases of results being achieved in regional agricultural development.

Since there are abundant geothermal resources in Peru, there is no objection to the proposal that attempts be made to utilize such energy. The suggestion that the terrestial heat to be developed in the survey region be used for the hothouse cultivation of vegetables for which regional self-sufficiency is impossible by outdoor cultivation because of the cold climate cannot be approved unconditionally since it would present problems with respect to the present regional agricultural development plan. If this were promoted as one aspect to regional development, the beneficiaries should be the local residents and it would be desirable for the local farmers, but there is a problem of how to introduce highly intensive hothouse farming on farms in the survey region where there is only very extensive cattle raising and farming.

In this case, these are also some problems related to the administrative and technical aspects of hothouse farming, but the technical problems can be solved by various methods. The main problems which cause concern are the economic resources of the farmers and the economy of producing vegetables in hothouses. It is necessary to perform an investigation of the comparative benefits between bringing the vegetables in from outside the region or producing them within the region by utilizing terrestial heat. Another important point which should be pointed out is that it is necessary to make comparisons of the interrelated development results among the various development plans when planning different types of agricultural and live-stock development. This will require thorough investigation from the viewpoints of both the individual farmers and the country as a whole.

5-2 Current Conditions of Vegetable and Fruit Distribution

5-2-1 Interregional Distribution of Vegetables and Fruit

Peru consists of three regions, the coastal, Andes and Amazon regions, each of which has very different climatic conditions. Therefore, there are many types of fruit and vegetables and there is considerable distribution among the various regions even though the transport facilities are inadequate. Naturally, the great majority of fruits and vegetables are produced in the warm coastal region where production is possible throughout the year. Many of these vegetables are transported to the Andes region where vegetable production is limited to the summer months. In addition to cool vegetables such as cabbage, seed potatoes and other vegetables are brought from the coast to the Andes region by road. Since there is almost no fruit produced in the Andes region, most of the demand is supplied from the coast, with part also coming from the Amazon region.

Table 8-13 shows the supply and demand balance in the various agricultural regions of Peru for two typical vegetables, garlic and onions (1979 plan of the Ministerio de Agricultura y Alimentacion). From this table, the general distribution conditions among the various regions can be estimated. The excessive amounts brought into the Lima region, the biggest consumer area, are not only the result of the large population but also because the amounts consumed per person are higher than in other regions as shown in Table 8-14. The Arequipa region, which has

Table 8-13 Supply and Demand Plan of Garlic and Onions (1979)

(Unit: 1,000 kg)

	Garlic			Onions		
	Supply*	Demand	Balance	Supply	Demand	Balance
Tumbes-Piura	-	243	- 243	9,098	5,656	+3,442
Chiclayo-Cajamarca	388	454	- 66	5,414	10,564	-5,150
Trujillo-Ancash	402	369	+ 33	3,704	8,576	-4,872
Lima	1,919	8,192	-6,273	13,378	80,243	-66,865
Ica	-	121	- 121	2,179	2,829	- 655
Arequipa	9,068	153	+8,915	66,627	3,560	+63,067
Moquegua-Tacna	36	47	- 11	5,216	1,088	+4,128
Iquitos	-	118	- 118	-	2,766	-2,766
San Martin	-	102	- 102	-	2,366	-2,366
Junin-Huanuco	757	323	+ 434	28,485	7,520	+20,965
Cuzco - M.de Dios	72	230	- 158	5,030	5,346	- 316
Puno	-	194	- 194	-	4,508	-4,508
Apurimac-Ayacucho - Huancavelica	108	186	- 78	2,174	4,337	-2,168
Total	12,750	10,732	+2,018**	141,300	139,359	+1,942**

(Notes) * 15% is subtracted from total due to famers' own use, diversion for seeds, loss in weight, etc.

** For export

(Source) Ministerio de Agricultura y Alimentacion

Table 8-14 Per Person Consumption of Main Vegetales

(Unit: kg/year)

	Lima	Other Districts
Garlic	1.71	0.23
Onions	16.75	5.35
Beans	11.64	6.30
Tomatoes	12.81	1.80
Carrots	6.42	3.60
Pumpkins	2.71	2.51

(Source) Ministerio de Agricultura y Alimentacion the highest supply figures, is the biggest producing area in Peru.

The diagram in Fig. 8-8 from the Ministerio de Agricultura y Alimentacion indicates that vegetables are handled by a distribution system from wholesalers in the wholesale markets to retailers in the consumption areas, but this system is found mainly in Lima and normally, commission agents who deal directly with the producers play a major role. They handle everything concerned with collection and marketing of the produce, including distribution between the various regions. There are many cases of dealings between the producers and retailers via these commission agents, since the provision of wholesale markets has been delayed. However, there has been widespread expansion of municipal retail markets even as far as regional cities, and markets (faria) of various sizes held once a week in rural towns provide a place for contact between the producers, the consumers and commission agents.

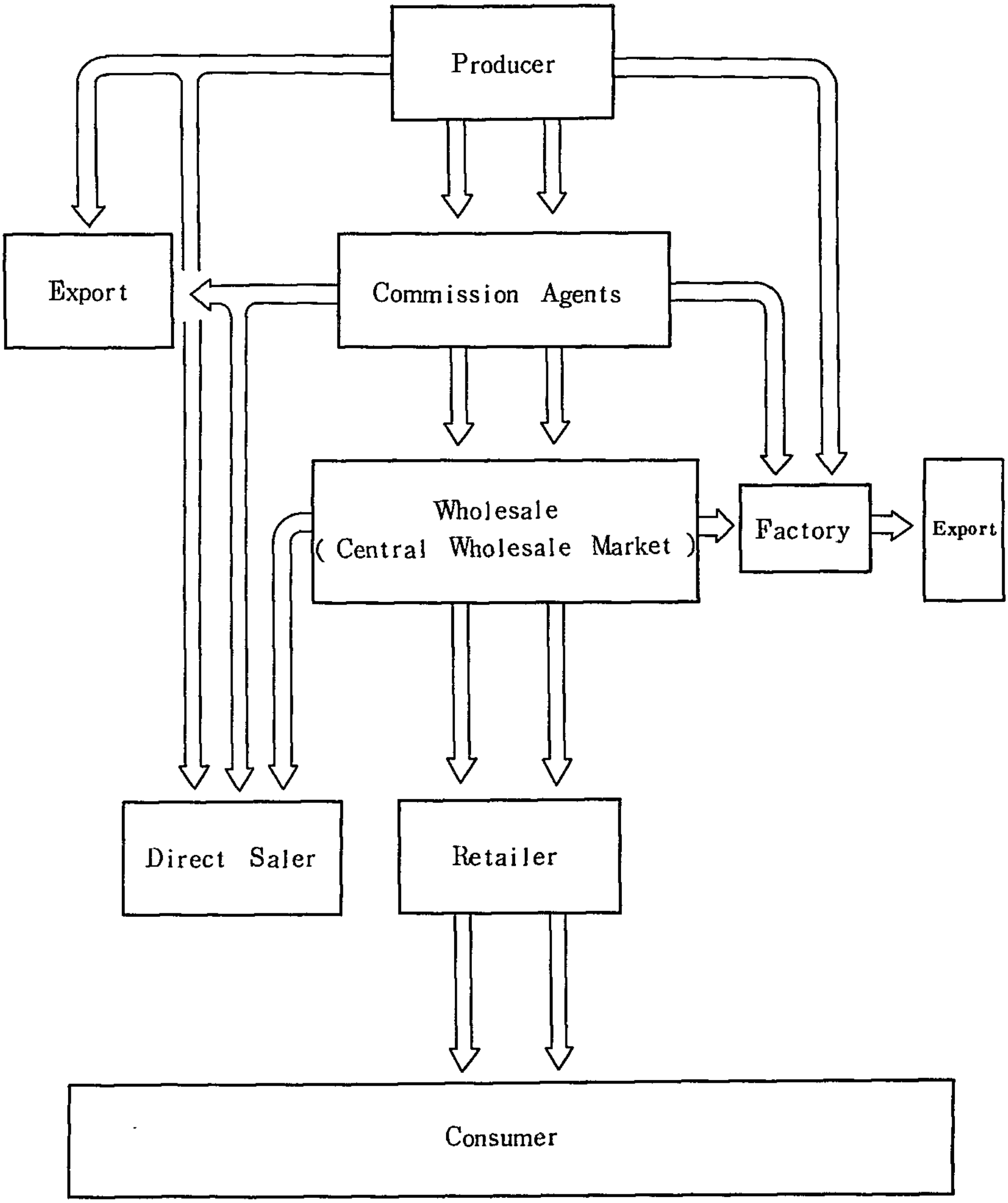
5-2-2 Government Guidance Concerning Vegetable Distribution

Agricultural food products in Peru can be divided into three types: those which have a regulated price throughout the country by government decrees, designated items with the market prices decided by local price regulating committees, and items which are distributed freely. In the first category there are five items regulated by government decree: rice, flour, sugar, edible oils and milk. These government specified prices are strictly adhered to because of regulated distribution handled by public corporations, etc. Items with prices determined by Junta Reguladora de Precios de Productos Alimenticio (Jurpal) are mainly vegetables and because of recent rapid inflation, the prices designated by the committees are often somewhat lower that the actual market prices.

These committees are formed in each area where there is a Direction Regional de Agricultura y Alimentacion and they are composed of five members including one each nominated by the Ministerio de Agricultura y Alimentacion, the Ministerio de Interior and the local mayor, as a representative of the producers and of the consumers. These committees decide on weekly wholesale and retail prices for each designated item and make these prices public. The items handled by the committees differ in accordance with local conditions and are not uniform with respect to number and type. Table 8-15 shows an example of prices specified by the Arequipa committee, which controls the largest number of items of any area within this survey range. In the Arequipa area, there are 24 designated items compared with 9 in Lima, 15 in Cuzco, 19 in Sicuani and 12 in Puno. The smallest value is for the Lima area.

The notices of the price regulation commitees are posted prominently in the municipal retail markets, but transactions occur without regard to these designated prices in spite of supervision by the employees of the local municipal offices. Vegetables are not normally sold in supermarkets, but some survey results showed that only items with prices designated by the committees were marketed without any price indication and these prices appears to be effective in name only.

Fig 8-8 Distibution Channel of Vegetables



(Source) Ministerio de Agricultura y Alimentacion

Table 8-15 An Example of a Price List Designated by the Price Adjustment Committee

Ministerio de Agricultura y Alimentacion

No. 6 Regional Office

Jurpal

Effective Period: From Oct. 17, 0 hours to Oct. 23, 24 hours

41st Week

	Marketing Unit	Marketing Price					
		Wholesale Price			Retail Price		
		1st Class Item	2nd Class Item	3rd Class Item	1st Class Item	2nd Class Item	3rd Class Item
A. Vegetables							
1. Leaf Vegetables							
Lettuce	kg	14.0	12.0	-	18.0	16.0	-
Cabbage	kg	27.0	-	-	32.0	-	-
2. Edible flower							
Cauliflower	kg	22.0	19.0	-	26.0	23.0	-
3. Vegetable fruits							
Peas	kg	20.0	18.0	-	24.0	22.0	-
Broad beans	kg	42.0	39.0		46.0	41.0	-
Tomatoes	kg	41.0	36.0	-	49.0	41.0	-
Tomatoes (No stems)	kg	45.0	40.0		53.0	45.0	-
Pumpkins	kg	42.0	38.0	-	47.0	42.0	-
Lemons	kg	115.0	-	-	125.0	-	-
4. Root Vegetables							
Carrots	kg	16.0	12.0	-	20.0	15.0	-
5. Bulbous vegetables							
Onion (No stems)	kg	27.0	24.0	-	31.0	28.0	-
Onion (With stems)	kg	21.0	19.0		24.0	22.0	-
B. Potatoes							
Sweet Potatoes (Yellow)	kg	27.0	-	-	30.0	-	-
Sweet Potatoes (White)	kg	22.0	-	-	25.0	-	-
Potatoes	kg	35.0	32.0		39.0	36.0	-
Potatoes (Seed)	kg	36.0	-	-	40.0	-	-
C. Beans							
Frijoles	kg	110.0	-	-	125.0	-	-
Quinua	kg	100.0	-	-	105.0	-	-
Quinua (washed)	kg	105.0	-	-	110.0	-	-
D. Fruits							
Papayas	kg	67.0	-	-	77.0	-	-
Pineapples	kg	62.0	-	-	69.0	-	-
Bananas	unid.	8.0	7.0	6.0	8.5	7.5	6.5
Orange (Valencian)	kg	53.0	-	-	60.0	-	-
Orange	kg	43.0	-	-	50.0	-	-

(Source) Junta Reguladora de Precios de Productos Alimenticio.

5-3 Comparisons of Vegetable Prices in Each Region

A survey was performed concerning the actual retail prices in the municipal retail markets of Lima, Cuzco, Sicuani, Yauri and Arequipa for five items: frijoles, potatoes, garlic, onions and tomatoes. The results were as shown in Table 8-16, but since there was not always agreement with respect to quality and standards, an accurate comparison was impossible. However, it is possible to understand the general trends.

The major regional differences are between frijoles and tomatoes and there are few variations for potatoes, garlic and onions. The prices are cheapest in producing areas which shipped vegetables to other areas and they are highest in areas where the vegetables had to be brought in from other areas. The prices are generally in the medium range for areas where there was self-sufficiency. The low price of frijoles in Cuzco results from cheap produce brought in from the Amazon region.

In Yauri, all vegetables except potatoes must be brought in from other areas, and the prices are the highest for all items except onions, which show maximum prices in Lima. The prices for frijoles and tomatoes are especially high but this is not a special phenomenon since the demand for these vegetables by the local residents is not high. The prices of garlic and onions are each ten soles higher than those in Arequipa, but this difference appears to be related to the interview survey results, which indicated that the costs of truck transport between the two areas was about 7 soles per kilogram.

When the price regulating committees decide the specified prices in each region, they take into consideration not only the supply and demand conditions within the area, but also the transport costs in and out of the area. Every three months, interregional meetings are held. Among the items in each region designated by the committees, potatoes, onions and sweet potatoes do not have much in common, but the regional differences between the specified prices of these items tend to be less than the differences in the above-mentioned actual price survey. However, there are various differences from the market prices in accordance with the item (refer to Photo 8-5).

5-4 Economical Efficiency of Introduction of Hothouse Farming

5-4-1 Procedures and Methods of Economic Investigations

There are no results available concerning hothouse farming in Peru. Therefore, it is impossible to perform reliable investigations concerning indoor production of vegetables (especially hothouse cultivation) in comparison with outdoor cultivation. Therefore, conditions in Japan where hothouse cultivation is widespread have been used as a reference and the basic items involved in the investigation of the economy of hothouse cultivation are given first. An investigation of the special conditions in Peru and the conditions of location in the survey area with respect to the introduction of hothouse farming provides the key to determining the economy of such farming.

Table 8-16 Comparison of Vegetables Retail Prices by Area

(Unit: Soles/kg)

	Frijoles	Potatoes	Garlic	Onions	Tomatoes
Lima	150 (-)	40 (-)	100 (-)	60 (-)	120 (-)
Cuzco	120 (-)	35 (±)	105 (-)	47 (±)	80 (±)
Sicuani	200 (-)	33 (+)	105 (+)	45 (+)	100 (-)
Yauri	260 (-)	40 (±)	110 (-)	50 (-)	150 (-)
Arequipa	130 (+)	35 (+)	100 (+)	40 (+)	53 (+)

(Note) (+) Export to other area, (-) Import from other area,
(±) Self-sufficiency

(Source) Public Retail Market (Lima, Cuzco, Sicuani, Yauri, Arequipa)

Photo 8-5 Greengrocery at Market (Arequipa)

To begin with, the concept of the introduction of hothouse farming in the survey region is based on self-sufficiency within the region for vegetables by the utilization of terrestial heat, in accordance with the development plan in order to cope with increased demands in conjunction with mining development, for vegetables which cannot be grown outdoors in the region. Therefore, the economy of introducing hothouse cultivation in the survey region is based on a comparison of the production costs of hothouse cultivation within the region and the costs of purchasing vegetables brought in from outside the region. In this case, reference must be made to the above-mentioned market survey of actual vegetable prices conducted in this survey, and since it is difficult to correctly estimate the various items of expenditure, only a relative comparison can be made with outdoor production by conversion from results obtained in Japan.

5-4-2 Hothouse Cultivation of Vegetables and Cost of Facilities

Generally, indoor cultivation of vegetables is avoided in seasons when vegetables produced outdoors are on the market, and forced or restricted cultivation is performed to raise the market price. This is especially true in the case of hothouses. The costs required per unit area for hothouse cultivation of tomatoes and cucumbers are almost double those for outdoor cultivation, and about 25% of these costs are required for facilities. With the labor costs, which account for about 50%, excluded, facility costs have a much greater weight than the lighting expenses and fertilizer costs, which account for about 10 and 5% respectively. Therefore, although the initial construction cost of a hothouse and house type differ, there is almost no difference between the two in annual depreciation with respect to years of service.

Even with such high costs for facilities, the establishment of indoor cultivation will result in shipments aimed at high market prices in accordance with seasonal variations and this will make it possible to recover the costs of the facilities. According to another viewpoint, there is a partial increase in yield in comparison with outdoor cultivation so the gross profit increases in accordance with the selling price and the increased management expenses, involving such items as the costs of facilities, are covered.

The above comments are based on results in Japan, but there are more basic items in the investigation of the economy of the introduction of hothouse cultivation in this survey region to determine if the same conditions are applicable in Peru.

5-4-3 Factors Affecting Economy

When hothouse farming is introduced in the survey region and regional self-sufficiency is achieved in vegetables, consideration should be given to what advantages and disadvantages result in comparison with general conditions in other countries such as Japan. The following are the main plus and minus factors influencing the economy of the introduction of hothouse farming.

(1) Plus factors

i) Because of severe climatic conditions, outdoor production of vegetables is impossible at present.

ii) Because road networks are inadequate, the costs required to bring in vegetables from other regions are high.

iii) It should be possible to utilize a cheap heat source in conjunction with geothermal development.

(2) Minus factors

i) Peru is divided into three regions, the coastal, Andes and Amazon regions, which have very different climatic conditions, and it is possible to produce vegetables throughout the year by means of adjustments among the various areas and there are many areas which are suitable for producing vegetables which require hothouse cultivation.

ii) In connection with factor i), the merits of forced cultivation of vegetables in hothouses cannot be obtained because of the lack of seasonal price changes in vegetables.

iii) Because the local farmers have few economic resources, the capital required for introduction of hothouse farming (or the recovery of expenses on facilities) is not easy to obtain, and the construction cost would be relatively high in Peru, where there is no previous experience with hothouse farming.

In the case of plus factor i), there is a possibility that the production of various vegetables will become possible outdoors in the future with the introduction of irrigation. The main possibilities are leafy vegetables such as cabbage and lettuce and edible roots such as carrots. Normally, plastic coverings and mulch are also effective.

With respect to plus factor ii), it can be expected that road development will progress gradually in the future and this will reduce transport costs for bringing in vegetables. The development of roads is also necessary for transport and marketing of regional produce outside the region and demands will be strengthened from the social standpoint.

In the case of plus factor iii), the advantage of using heat is decreased because of the conditions in Peru as given in minus factor i). Even if heat sources are cheap, the accumulation of costs of related facilities is undesirable from the standpoint of minus factor iii).

From the above considerations, it appears that there are many very difficult problems associated with the introduction of hothouse farming within the survey region. Therefore, although the case is very complex, an effort has been made to perform a simple economic investigation.

5-4-4 Comparative Benefits With Bringing Vegetables

In Japan, an increased yield of about 20% can be expected in the hothouse cultivation of tomatoes compared with outdoor cultivation. The increased yield per 0.1 ha is estimated at 1,200 kg (a total of 7.200 kg as compared with 6,000 kg by outdoor cultivation). However, there are the costs of the facilities, and even with the house-type method where there are no initial construction costs, the total construction costs related to facilities are 6 million soles per 0.1 ha (house: 3.5 million soles, piping, etc.: 2.5 million soles). With a 20-year depreciation period, an annual depreciation of 300,000 soles (excluding interest) is reqired. These values are in good agreement with the results of a production survey by the Ministerio de Agricultura y Alimentacion.

In hothouse cultivation, the lighting and labor expenses are higher than in the case of outdoor cultivation, but when the differences due to the free heat source and the low labor costs in Peru are subtracted, the costs are actually about the same with the exception of the cost of the facilities.

Since the retail price of tomatoes (grown outdoors) in Arequipa is 53 soles/kg (Table 8-16), the comparative benefits of the introduction or hothouse farming in the survey region would be good if the retail price in the survey reqion was 87 soles/kg or more (the unit price at which facility costs of 300,000 soles could be covered by the increased yield and price difference). This is a little lower than the price of 150 soles/kg given for Yauri in Table 8-16. Under such conditions, economy in the introduction of hothouse farming would require a higher price, but the following points must taken into consideration.

Hothouse farming in the survey region is aimed at a self-sufficiency in vegetables within the region, but if the production is intended only for such items as tomatoes, for which hothouse production has merits, the surplus which could not be consumed within the area would have to be transported to and marketed in other regions. In such cases, transport costs would arise and there would be other problems such as a correction of the above-mentioned trial calculation on the basis of the retail price and an investigation to determine if the increased yield of 1,200 kg is correct.

In the case of tomatoes, there are major price differences between the regions, but for vegetables as a whole, it can be assumed from Table 8-16 that there are not such high differences. The following point should also be considered.

With respect to coping with the increased demand for vegetables in accordance with mining development, there will naturally also be increased demands for foods other than vegetables and for various types of materials required in daily life. The mine currently in operation near the survey site has established a branch office in Arequipa for the procurement of various types of materials and goods, but vegetables account for only about 10% of the total amount of the materials procurred. The materials are regularly transported by truck once a week. Therefore, if only vegetables are considered, there is not all that much merit in cultivating them locally. The transport costs of 30,000 soles with a 4 t truck is only about 7 soles per kilogram and the above-mentioned calculated price for tomatoes is rather high.

5-5 Policies Concerning the Introduction of Hothouse Farming

As described in the previous section, the economy of introduction of hothouse farming into the survey region is faced with too many minus factors, and careful investigations are required concerning the implementation of such farming. The following two points are considered to be the minimum essential conditions.

(1) It must be possible to use geothermally heated water from geothermal power generation. It would probably be impossible to cover the costs of excavation of such water by the profits of hothouse farming only. In hothouse farming, it is necessary to have spray water and pure water for the heat exchange required for protection of the piping, but the electric power required for pumping-up the water in the area of the proposed geothermal development can only be obtained from geothermal power generaiton.

(2) To assure stabilized management when hothouse farming is introduced, there must be direct management by the enterprises involved in the geothermal or mining development. The low economic resources of local farmers is also a weak point concerning the introduction of hothouse farming techniques.

6. Recommendations for Further Detailed Studies

6-1 Actual Understanding of the Management and Economics of Regional Agriculture

When the areas suitable for regional agricultural development are decided, it is necessary to have a concrete development plan based on a thorough understanding of not only the natural conditions of location, but also the relation between land ownership and utilization and the management conditions in the case of farmers making a profit. With respect to land ownership and utilization, efforts must be made to understand the actual conditions in relation to agricultural land reform concerning such groupings as communal cooperatives and farming cooperatives. Concerning agricultural management, it is necessary to clarify not only the details of the agriculture at each management stage but also the details of other businesses which the farmers engage in to determine if they can handle the investment required for development.

6-2 Governmental Assistance and Guidance in Agricultural Development

The actual conditions of governmental assistance and guidance in the promotion of regional agricultural development must be understood in relation to administrative structures and budget preparation in accordance with national, regional and local systems. The possibilities of the degree to which such support and guidance can be achieved and the methods used must be investigated with respect to the agricultural development plan in the survey area. Concerning governmental assistance, the actual methods used, i.e. subsidy type or credit type assistance, must be clarified and with respect to agricultural guidance, it will be necessary to investigate current conditions and future possibilities concerning guidance systems and methods.

6-3 Trial Cultivation to Select Suitable Varieties of Grazing Grass

In this year's survey, there was a provisional selection of suitable varieties with reference to projects carried out in other regions in the Andes Mountains and data obtained from experimental sites, but when the grazing land development plan is made concrete, it will be necessary to make a final selection by trial cultivation of the best varieties for each method of grazing grass introduction. Since there are points concerning climatic conditions (average monthly air temperatures and hours of sunshine) which were only estimated as a basis for trial calculations of theoretical values, reinvestigations will be necessary to clarify such points and corroborative investigations by trial cultivation will be required.

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