Manual for Prevention of Desertification
in Arid and Semi-arid Areas in Asia

Technical manual

-Manual for technical instruction and extension by local engineers -




J-Green

Incorporated Administrative Agency

Japan Green Resources Agency (J-Green)

On publication

Japan Green Resources Agency (J-Green), an incorporated administrative agency, receives an Official Development Assistance budget from the Japanese government (Ministry of Agriculture, Forestry, and Fisheries) and conducts surveys of natural resources, social economies and agricultural conditions, and collects related materials and data, in order to contribute to agricultural and rural community development in developing countries.

Efforts to address global environment problems are the primary theme for J-Green's activities. From a perspective of global environmental preservation, serious problems have arisen, including land degradation caused by population growth, food shortages, poverty and other factors, and the exhaustion of water, natural vegetation and other natural resources.

In arid and semi-arid areas in Asian countries such as China, desertification caused mainly by human activities related to agriculture and livestock farming with forestry, such as overgrazing and salt accumulation, has progressed together with severe natural conditions similar to those found in West African countries. The effects are especially serious in China, where sustainable development and social progress are being prevented by falling ground water levels, drainage of water in rivers, the disappearance of vegetation and occurrences of sand and dust storms.

To address these problems, J-Green has been conducting a study in the Altay Administrative Office Area, Xinjiang Uygur Autonomous Region since 1999, under grants from Japan's Ministry of Agriculture, Forestry, and Fisheries. The goal is to promote measures for prevention of desertification in arid and semi-arid regions in Asia by establishing sustainable technologies for agricultural and rural community development, using the experiences and techniques from measures for prevention of desertification in the Sahel of West Africa.

Agriculture and livestock farming in the Altay Administrative Office Area, Xinjiang Uygur Autonomous Region are centered on agriculture around the oases located at the green periphery of deserts, which are fed by snowmelt from the Altay Mountains, and livestock farming by nomadic pasturing that moves seasonally among mountain pastures. Devastation of natural grasslands as a result of overgrazing – that is, the problem of desertification – has arisen as a result.

J-Green has conducted this study in cooperation with the local pastoral peoples, in order to clarify the causes of such overgrazing, and verify and establish technologies for reducing the devastation of natural grasslands through promotion of sustainable agriculture and livestock farming, based on settlement of these nomadic groups.

This Manual summarizes the results obtained from this study. Consisting of “Guidelines,” a “Technical Guide Manual” and a “Handbook for Agro-pastoralists,” the format is designed to enable local pastoral peoples, along with technicians working at government agencies and other institutions, to utilize the findings easily and achieve practical results.

We earnestly hope this Manual will be used in the Xinjiang Uygur Autonomous Region and similar areas in Asia where agricultural and rural community development aimed at reducing grasslands devastation is being planned or carried out, and will help solve the problems of overgrazing and contribute to sustainable farming by pastoral peoples.

When compiling this Manual, we received guidance and cooperation from many people in both Japan and other countries. In particular, we wish to express our appreciation to the Japanese Ministry of Agriculture, Forestry and Fisheries, the Japanese Embassy in China, the Beijing office of the Japan International Cooperation Agency, the domestic Technologies Investigation Committee, the Ministry of Agriculture of the People’s Republic of China, the Animal Husbandry Office in Xinjiang Uygur Autonomous Region, the city of Altay, Habahe County, and the residents of the survey sites.

March 2006

Japan Green Resources Agency
Director, Overseas Activities Department

Toru Ikeuchi

Preface

Protecting the ecological environment and achieving social development are serious problems that currently are attracting attention from the international community. Achieving sustainable development, through measures such as prevention of desertification and protection of the global environment, is an urgent, serious responsibility on a global scale. Two-thirds of the world's countries or regions, one-fifth of the world's population and one-quarter of all land have suffered damage from desertification. Desertification is directly destroying the foundations of human survival and social development, and has become a factor causing poverty and preventing economic and social development.

The Xinjiang Uygur Autonomous Region, which is located in western China, has the largest, most widespread and most seriously devastated land area as a result of desertification in China, and can be called one of the most severely damaged areas in the world. Xinjiang covers an area of 166km^2, of which deserts, rocky sandy soils and devastated land already exceed 80km^2, or more than 48% of the total land area. Pasture land turned to desert has reached 80 million ha. The task of preventing desertification, and comprehensively restoring land turned to desert and degraded grasslands, is critically important. To control degradation of the environment, the Xinjiang government utilized the opportunity provided by large-scale development in the western area to take effective measures, and during the period from 2000 to 2005 intensively implemented measures to prevent desertification and improve the ecological environment and achieved extensive experience and results in the areas of improving the ecological environment and preventing desertification in Xinjiang. These efforts also laid an excellent foundation for international partnership from the standpoint of prevention of desertification.

To study measures for prevention of desertification through agricultural and rural community development in Asia, beginning in 1999 Japan Green Resources Agency (J-Green) performed a two-year baseline study in areas such as the Altay Administrative Office Area in Xinjiang. The slogan "Human Progress Will Defeat Desertification" in the Xinjiang Uygur Autonomous Region (reduce the amount of devastated land through human efforts), and fundamental concepts such as achieving the prevention of desertification through comprehensive agricultural development and settlement projects, are consistent with the J-Green principal of "promoting the prevention of desertification through agriculture and rural community development." Therefore on September 18, 2001, J-Green and the Animal Husbandry Office of the Xinjiang Uygur Autonomous Region concluded a Memorandum on a Verification Study on Measures for Prevention of Desertification in Asia.

Based on the Memorandum, J-Green conducted verification studies at two sites, in Alahake in the city of Altay and Kerdala in Habahe County.

The studies included two activities. One was research on measures and techniques for prevention of desertification. In cooperation with technicians from China, the study group performing the study conducted extensive research in a broad range of sectors, including irrigation, meteorology, soil, afforestation, diffusion of new varieties of crops, and livestock feeding management. The other activity was preparation of model fields. Fields totaling 18,000 mu were prepared for feed production, windbreak forest belts, irrigation canals and farm roads, and 180 agro-pastoralist households were settled at the sites. As a result of a five-year effort, remarkable results were achieved, and the Verification Study on Measures for Prevention of Desertification in Asia was successfully concluded.

The results obtained by the Verification Study on Measures for Prevention of Desertification in Asia have been compiled in a Manual for Prevention of Desertification in Arid and Semi-arid Areas in Asia. The manual includes “Guidelines, a “Technical Guide Manual” and a “Handbook for Agro-pastoralists.” The Manual, which incorporates the knowledge and efforts of both Japanese and Chinese experts, provides positive guidance and valuable references for projects to prevent desertification in Xinjiang and Western China. We believe publication of this volume will make a positive contribution for promoting exchanges between Japan and China.

On the occasion of the publication of this manual, we wish to express our appreciation to the leaders and experts of the organizations involved, and to the residents in the study areas, including the Japanese Ministry of Agriculture, Forestry, and Fisheries, the Japanese Embassy in China, the Japan International Cooperation Agency, Japan Green Resources Agency, the Ministry of Agriculture of the People’s Republic of China, Foreign Affairs Office in Xinjiang, and the Altay Administrative Office.

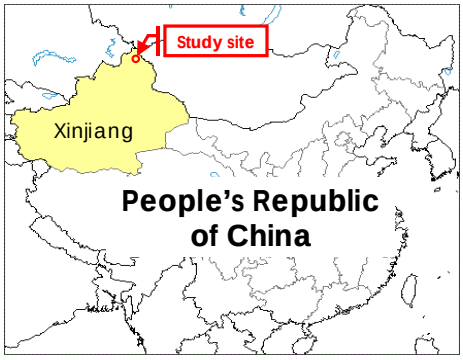
March 2006

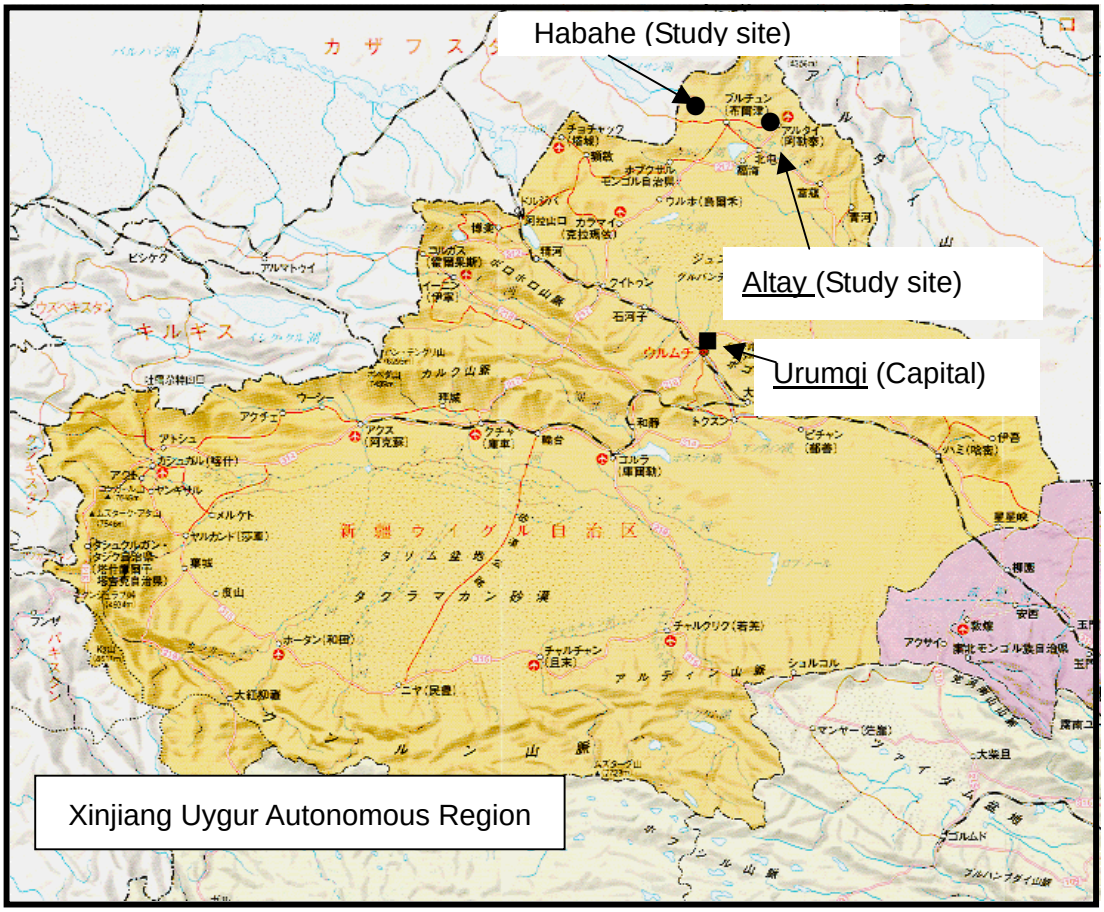
Director, Animal Husbandry Office
in Xinjiang Uygur Autonomous Region

Hubaidoula Hasaiyin

Study on prevention of desertification in arid and semi-arid areas in Asia

Site map





Manual on prevention of desertification in arid and semi-arid areas in Asia
Technical guide manual Contents

Volume 1 Introduction

Chapter 1 Study on Prevention of Desertification in Arid and Semi-arid Areas in Asia

1.1 Background of the study

In arid and semi-arid areas in Asian countries such as China, desertification caused mainly by human activities related to agriculture, livestock farming and forestry, such as overgrazing and salt accumulation, has progressed along with severe natural conditions similar to those found in West African countries. Especially in China, which accepted the United Nations Convention to Combat Desertification in February 1997, desertification is expanding at an average rate of 2,460km^2 per year, and China is one of the countries in the world suffering most seriously from desertification.

Desertification is a serious environmental problem that is preventing China from achieving sustainable development and social progress. Because of drainage of water in rivers, falling ground water levels, a decrease in vegetation density and frequent occurrences of sand and dust storms, the amount of arable land is decreasing, and desertification is spreading. As a result, desertification has a tremendous affect on agriculture and livestock farming, and establishing measures for prevention of desertification rooted in the local society and economy has become an urgent need.

On the basis of this background, Japan Green Resources Agency (J-Green) conducted a study on the present status of desertification and measures for prevention of desertification in China and the countries in Central Asia over a six-year period beginning in 1993, with a grant from Japan’s Ministry of Agriculture, Forestry, and Fisheries. As a result, degradation of natural grasslands caused by overgrazing of livestock was found to be expanding, especially in the Xinjiang Uygur Autonomous Region in China where nomadism, the typical farming pattern in arid and semi-arid areas, is practiced widely.

There are a number of reasons for these circumstances. In the traditional nomadic cycle, livestock farmers will let their herds graze even in seasons with insufficient grass resources because they have no arable farmland. Moreover, although settlement programs enable such farmers to produce winter feed, growth in the number of livestock is not halted because farmers continue a farming pattern that depends only on the sale of livestock.

Based on the results of this study, J-Green initiated a Study on Prevention of Desertification in Arid and Semi-arid Areas in Asia (referred to below as the “verification study on prevention of desertification") over a five-year period from FY2001 through FY2005, which took into consideration the problems in previous settlement programs, with the objective of examining development methods and

verifying techniques aimed at the development of sustainable agriculture, livestock farming and forestry based on the settlement of agro-pastoralists.

The Altay Area in the Xinjiang Uygur Autonomous Region in China was selected as the study site. Although some settlement programs have been conducted in this area, these have not reduced overgrazing, and degradation of natural grasslands is still expanding.

In this study, we use the expression “agro-pastoralist” to describe settled nomads who are engaged in agriculture and livestock farming in a settlement.

1.2 The traditional nomadic system and degradation of natural grasslands in the Altay Area

Nomadism in the Altay Area takes the form of seasonal migration, utilizing the differences in vegetation and weather depending on altitude. Its range and routes are mostly invariable. The nomadic routes lie between the lowlands and low altitude mountainous locations. For topographical reasons it involves horizontal migration over long distances, rather than vertical migration, with farmers covering a distance of about 500km per year. The range and routes of this migration basically are determined by the local government, giving consideration to the quantity and conditions of grass in each season, and nomads migrate to natural grasslands based on grassland use rights granted from the local government. In the traditional nomadic system, however, nomads would graze their herds even in autumn, winter and spring, when grassland vegetation is scarce, because they did not own feed crop farmland, and this had led to excessive loads being placed on the respective autumn, winter and spring pastures.

1.3 Problems of previous settlement programs in the Altay Area and the need for new measures

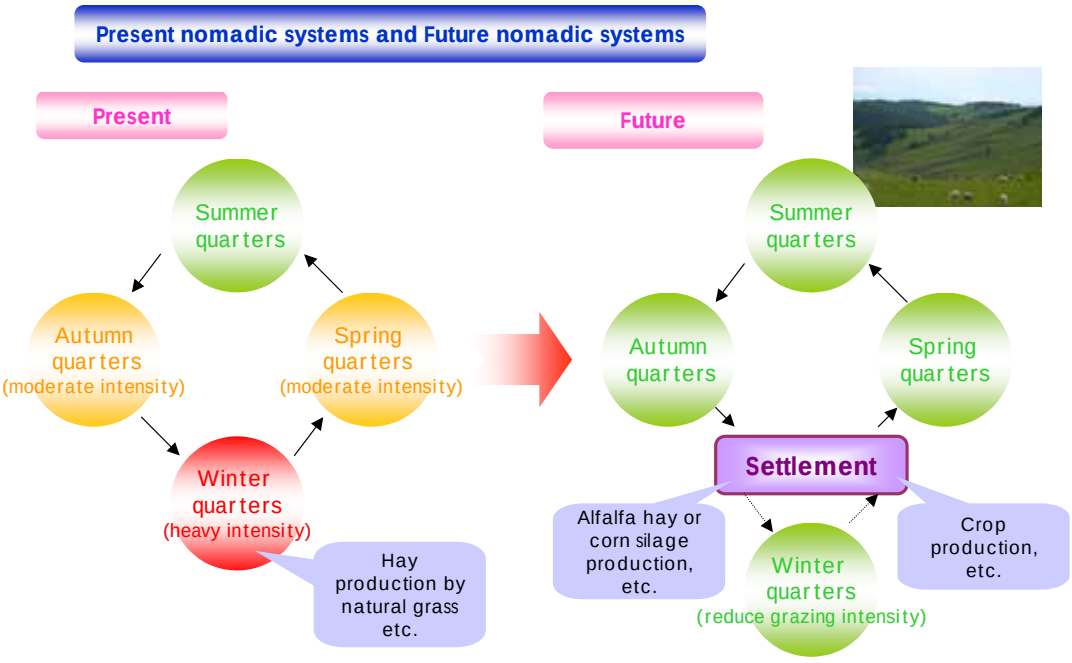
For agro-pastoralists who live through nomadism with sheep and other animals, natural grasslands are an important basis of production. For sustainable nomadism, grasslands conservation is vitally important. As described above, however, degradation of natural grasslands is expanding because of overgrazing from an increase in livestock, and previous settlement programs have partly promoted such overgrazing.

That is, because of a lack of awareness concerning degradation of grasslands from overgrazing, the production of feed crops and cash crops in the producing areas created in previous settlement programs functioned to promote growth in the number of livestock, and this increased the load on natural grasslands. The primary cause of such circumstances was the fact previous settlement programs were implemented as measures to reduce the number of nomads and alleviate poverty, and this can be said to have produced the following issues.

Issues identified in previous settlement programs

(1) Production of winter feed in settlements led to an increase in the number of livestock.
(2) Production of cash crops in settlements was not linked to a reduction in the number of livestock. (Continuation of grazing by herders)
(3) Agriculture and livestock techniques to preserve natural grassland were not applied. (Lack of supportive technology and execution models)
(4) Creation of infrastructure in settlements was not based on the wishes of those living in the settlements. (Lack of basis for livelihood after settlement)
(5) A nomadic system giving consideration to natural grasslands preservation was not created. (Lack of commitment to observance of laws and regulations)

To address such circumstances, measures to enable agro-pastoralists to maintain stable agricultural production activities without placing a load on natural grasslands and a mechanism for cooperation with governmental agencies managing natural grassland, are needed. Therefore the objective of the study was to propose measures towards development of sustainable agriculture, livestock farming and forestry by agro-pastoralists, based on a pasturage system that would not place a load on natural grasslands from settlement, while overcoming the problems found in previous settlement programs.



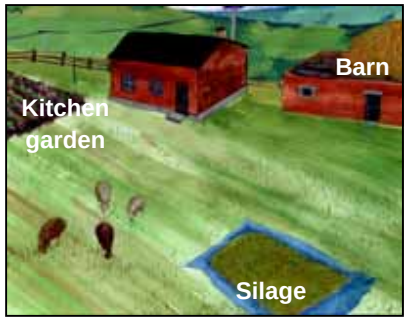
[Previous settlement programs]

Monoculture production system

Nomadism in violation of regulations

Spring, autumn, winter pastures

[This settlement program as a measure for prevention of desertification]



Development of settlement

Establishment of agriculture, livestock farming and forestry in the settlement

Promotion of observance of laws

Pastures with 3 types of functions

Chapter 2 Concept of Measures for Prevention of Desertification in the Altay Area

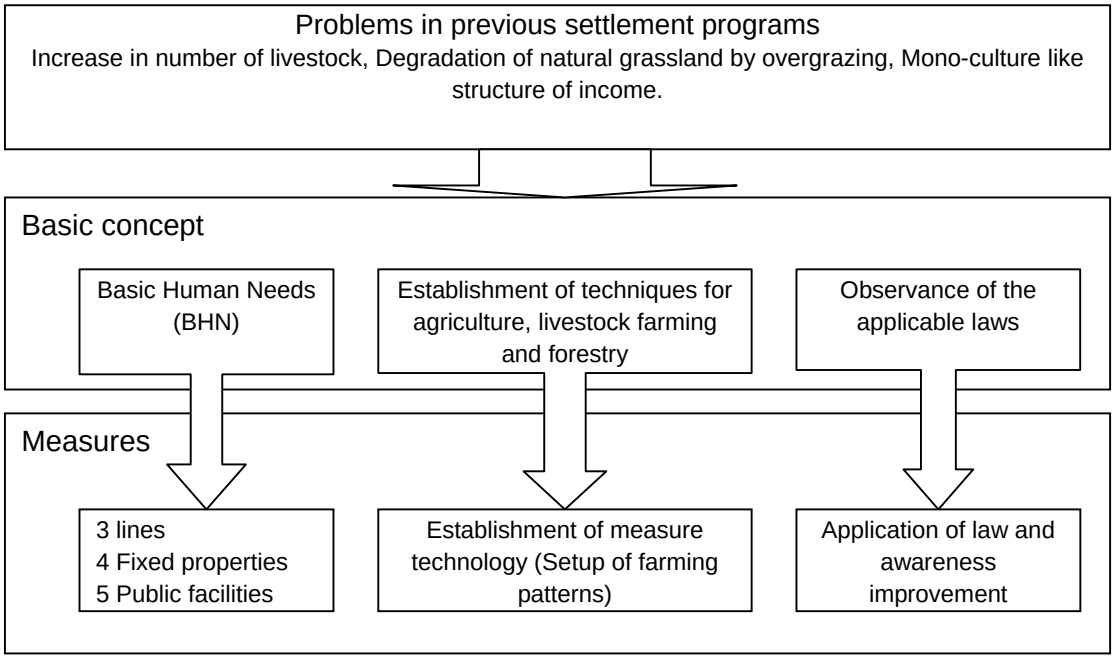
2.1 Concept of measures for prevention of desertification

To control the natural grasslands degradation caused by overgrazing in the Altay Area, creation of infrastructure to support settled agro-pastoralists' livelihood, and management of stable production activities such as self-sufficient winter feed production and diversification of incomes in the settlements, are both necessary. This will help restoration of vegetation in spring, autumn and winter pastures, which will lead to prevention of desertification.

Therefore to develop sustainable agriculture, livestock farming and forestry based on settlement of agro-pastoralists, while taking into consideration the problems under previous settlement programs such as growth in the number of livestock, overgrazing and a mono-culture income structure, for the verification study on prevention of desertification we formulated a basic concept for creation of the infrastructure (BHN, Basic Human Needs) for lives in the settlements, establishment of techniques for agriculture, livestock farming and forestry and observance of the applicable laws for regulation of overgrazing and tree felling, as shown in the figure below. We then implemented measures based on this concept.

The content verified by this verification study on prevention of desertification was the development of techniques to engage in sustainable agriculture, livestock farming and forestry. These techniques consisted of production and field management techniques, such as "self sufficient production of winter feed" and "conservation and management of farmland," and guidance techniques such as "organized activities" for spreading these techniques. These techniques also reduce the loads on natural grasslands, and secure a source of income for agro-pastoralists as an alternative to increasing the number of livestock.

Furthermore, construction of the infrastructure for basic human needs (BHN) by local government agencies and other entities and observance of related laws by agro-pastoralists also are requisites for smoothly promoting this concept.



2.2 Pillars of the basic concept

2.2.1 Infrastructure construction (Basic Human Needs, BHN)

To achieve stable production and lives through settlement, daily lives must be improved based on construction of the necessary infrastructure. As shown in the following table, the organizations implementing the settlement project in the Altay Area are creating the so-called “3 Lines, 4 Fixed Properties and 5 Public Facilities.” Of these, agro-pastoralists must build a house and livestock shed using their own funds, with assistance (materials for building) from the local government.

3 Lines	Roads, service water, electricity
4 Fixed Properties	Houses, sheds, feed production fields, protective forests
5 Public Facilities	Hospitals (clinics), schools, shops, public halls, extension training and technical centers

2.2.2 Establishment of agriculture, livestock farming and forestry techniques

In order to establish the agriculture, livestock farming and forestry techniques by which sustainable farming activities can be conducted without an increase in the number of livestock after settlement, the following contents were confirmed in the verification study on prevention of desertification, and techniques were developed.

Classification	Contents	Method
Production techniques Field management techniques	Self sufficient winter feed production	Forage production
	Income diversification	Cash crop production
	Livestock feeding improvement	Decentralization of sheep breeding, fattening of sheep, year-round feeding of cows
	Farmland conservation and management	Decision on irrigation plan
		Farmland reclamation
		Construction of windbreak forest belts
	Farming improvement	Improvement in farming awareness
Extension and guidance	Farming guidance	Acquisition of farming technology
	Organized activity based on improved awareness	Joint use of machinery
		Cooperative marketing of products
		Establishment of a water management association

Establishing farming patterns is an effective means for employing the agriculture, livestock farming and forestry techniques established to achieve prevention of desertification. The workforce and management capabilities of the settled agro-pastoralists must be considered when setting up such patterns. In the verification study on prevention of desertification, the following three patterns were established. The effect of each pattern in mitigating loads on natural grasslands (the effect contributing to desertification prevention) can be estimated based on the crop cultivation area in the fields (refer to the following table).

	Livestock farming type I	Livestock farming type II	Diversified farming type (livestock farming and agriculture)
(1) Contents of management	Breeding / sale of sheep	Breeding / fattening of sheep, feeding of cows	Combined livestock farming and agriculture
(2) Improvements	Out-of-season breeding of sheep	Silage, fattening of sheep, feeding of cows	Production and sale of cash crops
(3) Land use	Alfalfa	Alfalfa, maize	Alfalfa, maize, soybeans, vegetables
(4) Load mitigation effect on natural grassland (spring, autumn, winter pasture)	Can expect load mitigation of 1 sheep for 180 days per 1 Mu of alfalfa production	Can expect load mitigation of 2 sheep for 180 days per 1 Mu of maize production	Will obtain income equivalent to 2 sheep per 1 Mu of soybean production and sale (Can expect load mitigation of 2 sheep for 180 days = equivalent to reduction of 2 sheep)

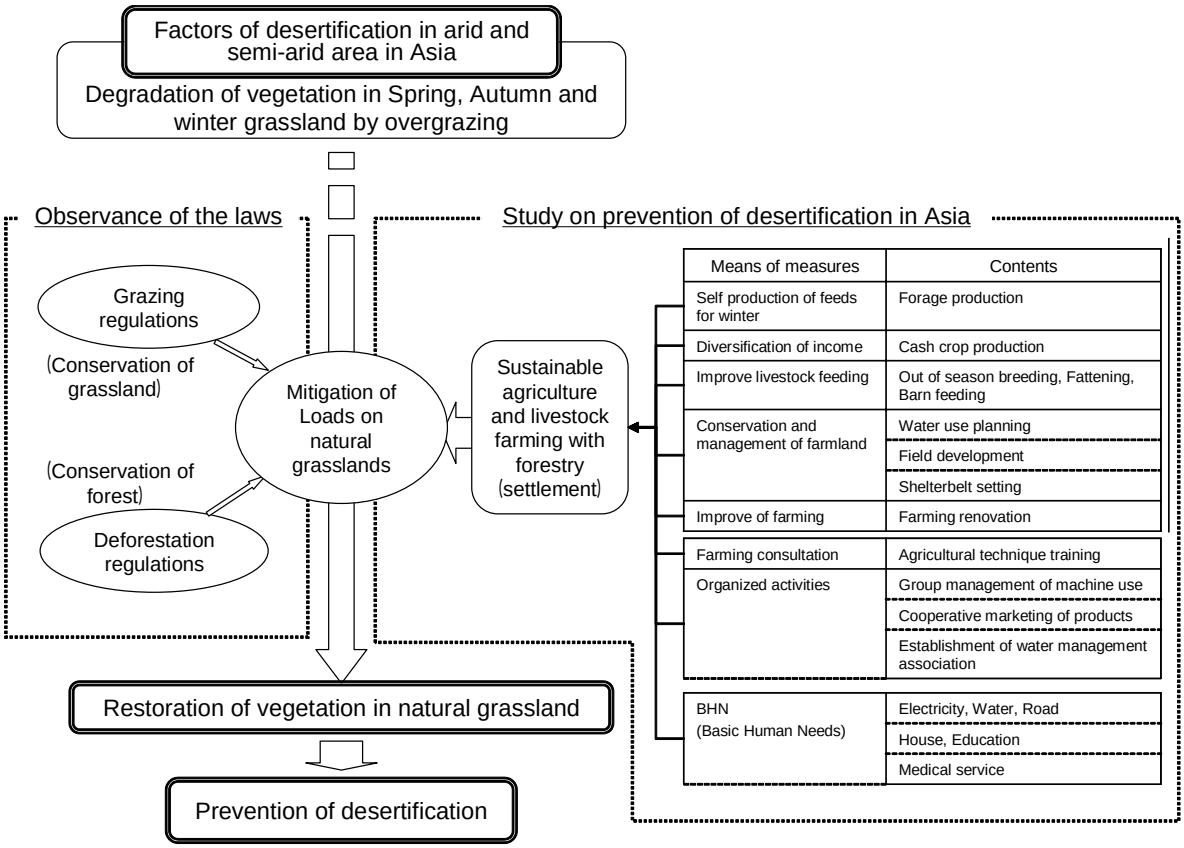
Feeding duration in settlements: 180 days, 1 Mu = 667m^2

2.2.3 Observance of laws

Observance of the legal system is a prerequisite for controlling overgrazing and destructive timber cutting. While laws apply to the entire country, in actual application laws are applied with meticulous detail in accordance with rules that are prescribed corresponding to actual local conditions. Therefore, both appropriate application of laws and enhanced awareness of legal compliance are important.

2.3 Basic concept

The following figure shows the basic concept described so far.



Chapter 3 Manual on Prevention of Desertification in Arid and Semi-arid Areas in Asia

3.1 Objective

This policy manual has been compiled for the purpose of contributing to sustainable agricultural and rural community development, by providing the information necessary for technicians who are responsible for preparation and implementation of measures for prevention of desertification. The goal is to establish measures for prevention of desertification in regions where desertification is progressing as a result of human factors such as overgrazing in addition to natural causes.

Areas where this manual will be applied are assumed to be arid and semi-arid areas in Asia where nomad settlement programs will be carried out and where irrigation agriculture is feasible.

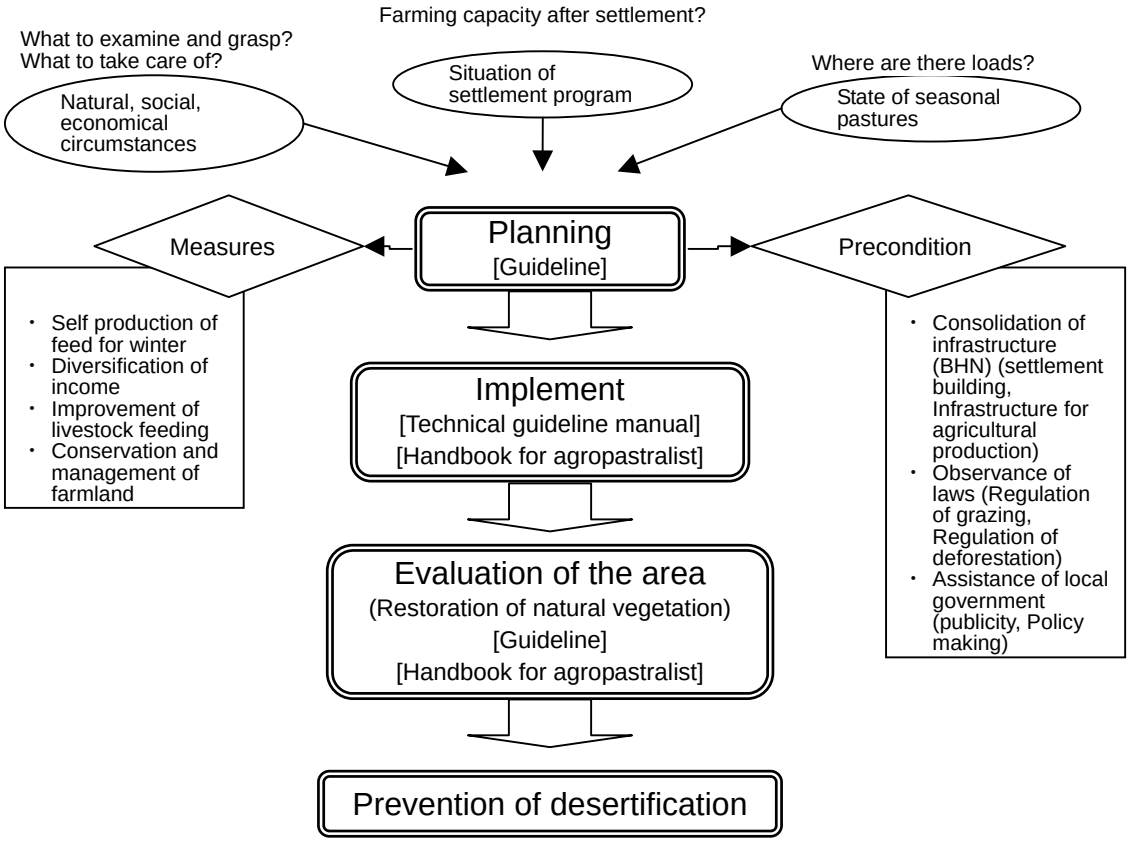
We hope the manual also will be utilized by international organization or NGOs undertaking similar programs.

3.2 Structure

The Manual on Prevention of Desertification in Arid and Semi-arid Areas in Asia is divided into three parts consisting of the Guidelines, a Technical Guide Manual and a Handbook for Agro-pastoralists, which can be applied separately depending on the needs of individuals using the manual.

3.2.1 Role of each component of this policy manual

The following figure shows the role of each component of the Manual on Prevention of Desertification in Arid and Semi-arid Areas in Asia at each work stage. The Guidelines should be used mainly when preparing plans, while the Technical Guide Manual and the Handbook for Agro-pastoralists should be used when implementing and managing plans. The Guidelines and Handbook for Agro-pastoralists can be used when conducting land evaluations for restoration of vegetation on natural grasslands.


Farming capacity after settlement?
What to examine and grasp?
What to take care of?
Natural, social, economical circumstances
Situation of settlement program
Where are there loads?
State of seasonal pastures
Measures
Planning
[Guideline]
Precondition
・ Self production of feed for winter
・ Diversification of income
・ Improvement of livestock feeding
・ Conservation and management of farmland
Implement
[Technical guideline manual]
[Handbook for agropastralist]
・ Consolidation of infrastructure (BHN) (settlement building, Infrastructure for agricultural production)
・ Observance of laws (Regulation of grazing, Regulation of deforestation)
・ Assistance of local government (publicity, Policy making)
Evaluation of the area
(Restoration of natural vegetation)
[Guideline]
[Handbook for agropastralist]
Prevention of desertification

3.2.2 Procedures and points for practical use of the Manual on Prevention of Desertification

The procedures and points for practical use of this Manual are as follows.

Component	Procedures and points for practical use
Guidelines	1. Procedure for practical use Utilize as guidance for planning measures for prevention of desertification. 2. Users Technicians in charge of planning and execution of measures for prevention of desertification 3. Points ・Comprehensively explains matters concerning situations and problems to be understood before planning (eco-environmental, sociological and economical conditions of an area, settlement program circumstances and seasonal pastures for pasturage, issues concerning the programs and pastures). ・Not only a general outline, but guidelines containing examples in the Altay Area. ・Both environmental preservation of an area and stable farming activities in settlements are considered. That is, the Guidelines are not merely for projects for settlement but illustrate measures to enable control of spring, autumn and winter pastures through production in settlements and stabilization of livelihood, and address rehabilitation of natural grasslands and large-scale prevention of desertification (considers the dual aspects of environment and settlers' lives). 4. Structure Chapter 1 Structure of the Guidelines Chapter 2 Main Points for Designing a Plan Chapter 3 Procedure for Designing a Plan Chapter 4 Introduction to Verification Case Studies by Japan Green Resources Agency (J-Green) Chapter 5 Reference Data The flow from planning to execution is as follows. ・Survey of present conditions ・Extraction of problems ・Selection of the project area ・Survey of water, other resources ・Clarification of measures ・Application of techniques on agriculture, livestock farming and forestry ・Execution of the project ・Area evaluation

Component	Procedures and points for practical use
Technical Manual	1. Procedures for practical use Utilize as a technical instruction book when providing farming guidance to settled agro-pastoralists. 2. Users Local technicians who provide farming guidance to settled agro-pastoralists 3. Points ・Establishes farming patterns that enable farming management in accordance with the management skills of settled agro-pastoralists and the natural grasslands situation (balance dual aspects of environment and settlers' lives). ・Explains production techniques and field management techniques for improvement of yields and income from farming activities in the settlement, in order to secure winter feed and diversify income. ・Describes means to improve each agro-pastoralist's farming techniques and the effectiveness of organized activities. ・Is highly adaptable for many situations because it summarizes both newly developed techniques as well as local techniques. 4. Structure Chapter 1 Setup of Farming Patterns Fundamental thinking for setup of farming patterns Introduction to farming patterns Chapter 2 Production Technique Activities in the settlement Livestock farming type I Livestock farming type II Multiple farming (livestock farming and agriculture) type Chapter 3 Field Management Techniques Matters to consider for reclamation of fields on degraded land Water use for maintenance and improvement of production Windbreak forest belts for land conservation Field management calendar Chapter 4 Organized Activities Farming guidance Organized activities Organization and management of a water users association

Component	Procedures and points for practical use
Handbook for Agro-pastoralists	1. Procedures for practical use This is a booklet designed to enable settled agro-pastoralists to conduct farming activities for themselves. 2. Users Settled agro-pastoralists. To be used effectively, guidance provided by local technicians will be necessary. 3. Points ・Briefly explains points concerning farming and other activities. ・Uses numerous illustrations to visualize the contents for easier understanding. ・Prepared in monochrome to facilitate printing and wider use. ・Produced as separate volumes, making it easy to carry to work sites. 4. Structure [Environment] ・Aims at agriculture and livestock farming that protect natural grasslands ・Aims at environmentally-friendly farming [Livestock farming type I, II] ・Guidance on herbage cultivation and hay processing ・Guidance on forage crop cultivation and silage processing ・Summer mating and winter lambing of sheep ・Fattening of sheep ・Cow milking method [Multiple farming (agriculture and livestock farming) type] ・Guidance on soybean cultivation ・Guidance on oil sunflower cultivation ・Guidance on kitchen gardens [Field management techniques] ・Efficient irrigation procedure (Preparation before planting) ・Efficient irrigation procedure (Irrigation work after planting) ・Windbreak forest belt management procedure [Life in the settlements] ・Farming management ・Towards realization of life with enhanced roles for women

Volume 2 Technical Manual

Chapter 1 Setup of Farming Patterns

1.1 Fundamental thinking for setup of farming patterns

In providing technical guidance for agro-pastoralists, a local technician has to consider what kind of agriculture and livestock farming system is suitable based on the agro-pastoralists' financial condition and future intentions. For this purpose, it is desirable to set up a farming pattern to be used as an indicator for farming management.

A farming pattern should show the orientation of the management format most appropriate to develop in order to realize farming management according to a plan, and should be widely shown to the people engaged in farming in the area. It should be set up as a useful and feasible management pattern, based on the agro-pastoralists' present conditions and future intentions, with consideration of factors such as the labor force and annual target income.

In the study in the Altay Area, the main issue was that degradation of natural grasslands by overgrazing is progressing, but in settlement programs in the past feed production has led agro-pastoralists to increase their livestock. To solve this problem, we set up farming patterns to decrease the load on natural grasslands through sustainable agriculture and livestock farming by agro-pastoralists.

1.2 Introduction to farming patterns

In the study in the Altay Area, three farming patterns designated "Livestock farming type I," "Livestock farming type II" and "Multiple farming type" were established, based on the fundamental thinking described above. These patterns are introduced below.

When setting up of these farming patterns, we studied the various technologies constituting each type and verified their effectiveness by observing agro-pastoralists' farming activities. As a result, these technologies are being utilized steadily by the target agro-pastoralists. More importantly, local government administrators and technicians recognize the importance of using these farming patterns to prevent desertification, and anticipate substantial results from trials aimed at promotion of agriculture and livestock farming and prevention of desertification in the area.

Although three farming patterns were set up based on agro-pastoralists' current farming management, it is believed that if farming patterns can be converted ultimately to "Multiple farming (livestock farming and agriculture) type," management

that balances mitigation of loads on natural grasslands in the area and development of sustainable agriculture, livestock farming and forestry can be anticipated.

1.2.1 Livestock farming Type I

This type is based on livestock farming but not leaving natural cycle of breeding and selling as a traditional way. The core technology is summer mating and winter lambing. Aiming to earn profit without increasing the number of sheep by staggering sales seasons.

Therefore, forage is a main product and alfalfa will be mainly cultivated. The effect to mitigate of grazing on natural grassland is that one sheep will be avoided grazing on spring, autumn and winter quarters by producing one mu of alfalfa.

1.2.2 Livestock farming Type II

This type is based on livestock farming but not only raising sheep. The core technology is breeding and fattening of sheep and raise of cows. Aiming to earn profit without increasing the number of sheep by raising cow.

Therefore, alfalfa and maize will be mainly cultivated. To increase milk yield, maize will be ensilaged and be feed to sheep and cows. The effect to mitigate of grazing on natural grassland is that two sheep will be avoided grazing on spring, autumn and winter quarters by producing one mu of maize.

1.2.3 Diversified farming type (livestock farming and agriculture)

This type is based on combining agriculture and livestock farming. The core technology is cultivating cash crops. Aiming to implement

In order to realize a management not dependent on increase in number of livestock, this farming pattern shifts to the multiple farming employing cash crop production from the traditional livestock farming to secure income sources other than livestock farming. Therefore, it employs not only cultivation of forage crop but also soybean and oil sunflower that are easy to cultivate and have high demand in the area.

With this farming pattern by 1 Mu of soybean production and sale, 2 sheep by 180 days of load mitigation on natural grassland will be expected.

	Type I	Type II	Type III
	Livestock farming	Livestock farming	Agriculture and stock raising farming
Business model	Breeding and selling of sheep	Breeding and fattening of sheep, Raising of cows	Combine of livestock farming and agriculture
Core technology	Out-of-season breeding of sheep	Silage feeding, Fattening of sheep, Milking of cows	Produce and sales of cash crops
Cultivation	Alfalfa	Alfalfa, Maize	Alfalfa, Maize, Soybean, Vegetables
The expected Terms not grazing on natural grassland.	180 days of one sheep by producing one mu of alfalfa.	180 days of two sheep by producing one mu of maize.	180 days of two sheep by producing one mu of soybean. The income of soybean production of one mu is equivalent to selling of two sheep.

The feeding terms at shed in the settlement: 180 days, 1 Mu = 667m^2

(Reference) The farm management indicator.

Based on agropastoralist's farming situation and intention, the example of trial calculation about the farmhouse management after settlement according to the each farming pattern is shown below.

(Before settlement)	Livestock farming (Large scale)		Livestock farming (Average scale)	
Livestock (head)	Sheep	100	Sheep	30
	Goats	15	Goats	10
	Cows	10	Cows	5
	Horse (or Camel)	4	Horse (or Camel)	1

(After settlement)	Livestock farming type 1		Livestock farming type 1		Diversified farming type (Agriculture and livestock farming)	
(1) Planted area (mu)	Alfalfa	(100)	Alfalfa	(90)	Alfalfa	(20)
			Corn	(10)	Corn	(10)
					Soybean	(50)
					Sunflower	(20)
(2) Livestock (head) (The largest number of feeding livestock)	Sheep	(92)	Sheep	(82)	Sheep	(29)
	Goat	(12)	Goat	(12)	Goat	(12)
	Cow	(12)	Cow	(12)	Cow	(5)
	Horse or Camel	(1)	Horse or Camel	(4)	Horse or Camel	(1)
(3) Sales (head, kg)	Sheep	(30)	Sheep	(32)	Sheep	(5)
	Goat	(4)	Goat	(4)	Goat	(4)
	Cow	(4)	Cow	(4)	Cow	(2)
	Cashmere	(4)	Cashmere	(4)	Cashmere	(2)
	Wool	(60)	Wool	(60)	Wool	(20)
			Milk	(1,800)	Soybean	(10,000)
(4) Home consumption (head)	Sheep	(3)	Sheep	(3)	Sheep	(3)

Fig. 4.6.2 Typical management models.

Although each farming pattern is based on the family labor consisting mainly of the manager (householder) and his wife, when the labor force is short, auxiliary labor force (employment etc.) shall be utilized for the management.

Trial calculation is made with the same working hours a day as the present condition (8 - 9 hours).

Chapter 2 Production Techniques

2.1 Activities in the settlements

Stabilizing and improving production activities in the settlement is essential for development of sustainable agriculture and livestock farming that does not promote desertification. For this purpose it is important to accurately address matters such as reservation of winter feed for livestock, improvement of livestock feeding with the goal of increasing income and production of cash crops to diversify income, as a measure to reduce dependence on winter pastures.

Reservation of winter feed for livestock requires techniques of the production and processing of good quality herbage and forage crops. For improvement of livestock feeding, techniques such as diversification of the sheep breeding season currently followed in the Altay Area, efficient use of livestock feeding facilities during the severe cold winters and breeding of cows are necessary. For production of cash crops, techniques for the production of good quality soybeans and vegetables are needed.

The acquisition and stable use of these techniques by agro-pastoralists will require not only the agro-pastoralists' own efforts but also accurate guidance and advice by the individuals responsible for guidance and dissemination of techniques.

To aid in this effort, the intent, procedures, methods, points of concern and other matters concerning the typical techniques for each farming pattern are described below.

2.2 Livestock farming type I

Livestock farming Type I is a farming pattern based on production and processing of good quality herbage. It is a farming pattern in which breeding and sale of sheep is the main activity, with the introduction of techniques for off-season breeding of sheep (summer mating and winter lambing). When utilizing off-season breeding of sheep, mating on the natural grasslands (August - September) and lambing in settlements (January - February) have to be carried out earlier than the traditional autumnal mating and spring lambing, which leads to different livestock feeding management. This section describes the production and processing of good quality herbage, which is fundamental for livestock feeding, the efficient use of feeding management facilities and off-season breeding of sheep. For the production and processing of good quality herbage, refer to this section for the techniques common to each farming type.

2.2.1 Forage production

(1) Objective

Forage production is the most important technique among livestock feeding techniques that do not rely on grazing. To produce good quality winter feed, cultivation of good quality roughage is essential. This section summarizes the kinds of typical roughage and their characteristics, and points to note for their cultivation management.

(2) Roughage varieties

Roughage is a crop which stem and leaves are mainly used as the livestock feed. Roughage is classified into herbage plant and forage crop. Herbage plant is classified into legume and gramineae, and forage crop is classified into grain crop and root crop (refer to Table 2.2.1.1).

Table 2.2.1.1 Roughage varieties.

Roughage	Herbage plant	Legume	:Alfalfa, Red clover
		Gramineae	:Perennial ryegrass, Orchardgrass
	Forage crop	Grain crop	:Maize, Sorghum
		Root crop	:Sugar beet, Jerusalem artichoke

(3) Characteristics

Typical roughages and those characteristics are shown in Table 2.2.1.2.

Table 2.2.1.2 Typical roughages and their characteristics.

Crop	Characteristics
Legume	• Forage legume contains a lot of protein and is excellent feed. Legume is suitable for cultivation in low nitrogen content land because of its nitrogen fixation by root nodule bacteria. A typical legume alfalfa grows well in arid areas since it's originated in the Central Asia. • Alfalfa can be cut three times per year from the next year of established. Pasture establishment by only seeding clover is difficult because of its slow initial growth.
Gramineae	• The annual yield per area is relatively high compared with forage legume. Therefore the grassland productivity is higher than forage legume. The adaptability to environment and capacity of regrowth are different among varieties, selection of variety is the important to adapt the target environment. • Perennial ryegrass which is perennial grass has a character of fast initial growth and a bush-like grass type. Utility value is high as bottom grass in shelterbelt or cover grass.
Maize	• Maize is an annual gramineous crop. When come to maturity, the height is almost 2m. Not only grains but also stem and leaves can be used as a feed by processing of silage. Maize is cultivated all over the world since the adaptability to environment is wide ranging from tropics to cold climate

	area. • The relative maturity (days from emergence to maturity) of maize is from 120 to 130 days as popularly cultivated varieties in Altay area.
Sorghum Sudan grass	• Sorghum and Sudan grass are annual gramineous crops. When com to maturity height sometimes exceed 3m. Since they have high drought resistance and regrowth capacity, two or three times cutting a year are possible. • Characteristics are similar between Sudan grass and sorghum, but their species are different. Since stem of Sorghum is thicker than Sudan grass and the shape is similar to Maize, silage processing is also possible beside fresh forage feeding. Since initial growth of Sudan grass is faster than Sorghum, products can earn in a short time. However, Sudan grass is not suitable for silage due to its thin stem.

(4) Alfalfa cultivation

1) Procedure

Flow chart of alfalfa cultivation is shown in Fig. 2.2.1.1. Since alfalfa is a perennial plant, cultivation process of the first year differs from the second or subsequent years. Three times cutting per year is possible. However, in some environmental condition of the target area, two times cutting are desirable for the high persistency of the pasture.

	Apr.-May	May-Jun.	Jul.-Aug.	Sep.
First year	Irrigation→ Basal dressing→ Sowing			Cutting
Second Or Subsequent years		Cutting→ (Top dressing)	Cutting→ (Top dressing)	Cutting→ (Top dressing)

Fig. 2.2.1.1 Flow chart of alfalfa cultivation.

2) Cultivation management

The point of alfalfa cultivation management is adequate water management and optimum time cutting. Especially irrigation is important when before sowing, before harvest, and after topdressing.

The points of concern in each items of alfalfa cultivation are shown in Table 2.2.1.3.

Table 2.2.1.3 Points of concern in each item of alfalfa cultivation.

Items	Contents	Work
Irrigation before sowing	• Sufficient irrigation before sowing is important. • In non-tillage seeding, irrigation is more important due to both moisturizing and softening of the soil. • Do not flow seeds away.	
Basal dressing	• Compost or livestock excrement: 1t / Mu • Urea: 10-15kg / Mu • Phosphoric acid: 20-25kg / Mu	
Sowing	• Sowing season: Between middle April to early May. • Sowing rate: 0.7-1.2kg / Mu • Sufficient yield can earn also non-tillage sowing.	
Irrigation	• Irrigate properly according to soil moisture content. • Standard irrigation interval is from 5 to 10 days. • Recommend to irrigate a few days before harvest.	
Cutting	• Cutting should be done at the optimum time. • Optimum time First cutting：50% of flowering Second and third cuttings：When plant height reach 50-60cm. • Cutting height: At 5cm above the ground	
Top dressing	• Apply chemical fertilizers is recommended after cutting. • Urea: 5-10kg / Mu • Phosphoric acid: 5-10kg / Mu	

Points of concern:

How to determine optimum cutting time

In order to contain high nutritive value in the herbage, harvest before flowering is recommended, because vegetative organ consumes a lot of nutrients when flowering. On the other hand, since the yield will be high as growth progresses, later harvesting can earn more dry matter yield. Therefore, in order to contain high nutritive value as much as possible, recommend to cut when 50% of plants in the field have flowered. When plants may not flower depending on climate at the second and third cutting, recommended to cut when the plant height reaches to 50-60cm.

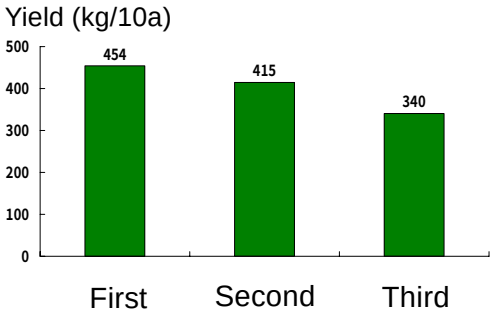
First cutting	Second and third cuttings
When 50% of plants in the field has flowered.	When the plant height reaches to 50-60cm.
	

Reference

Yield and nutritive contents in different cutting stages

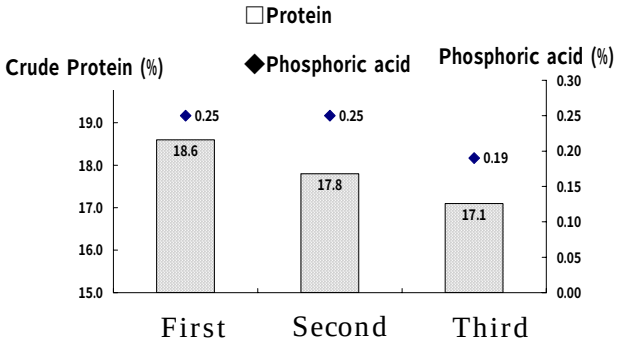
Yield, protein content, and phosphoric acid content of alfalfa in different cutting stages in Alahake town Altay city are shown in Fig. 2.2.1.2.

Alfalfa yield in different cutting stages



- Annual yield of alfalfa 800-1,000kg/10a (3 times cutting / year)
- The yield is highest when first cutting and decreased as cutting time goes on.

Protein and phosphoric acid content of alfalfa

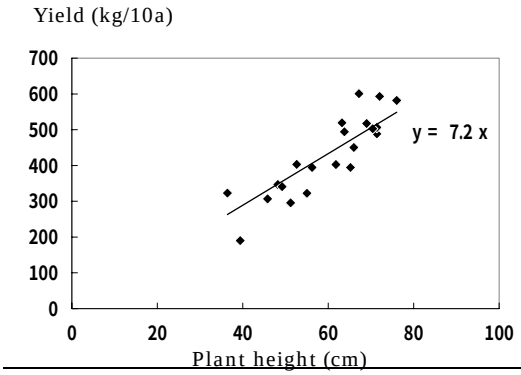


- Since the protein content is highest at the first cutting and decreased as cutting time goes on, efficient use of the first cutting is important.
- Since phosphoric acid content of the third cutting is lower than the first and the second cuttings, top dressing is recommended after the second cutting.

Fig. 2.2.1.2 Alfalfa yields in different cutting stages.

Relationship between plant height and yield

High correlation between herbage yield and its height has observed. Relationship between plant height and dry matter yield of alfalfa in Alahake town Altay city is shown in Fig. 2.2.1.3.



- Equation of plant height and dry matter yield.

  Dry matter yield (kg/10a)

  ＝Plant height (cm)×7.2

  (Correlation coefficient＝0.87)

- Example (Plant height)

  40cm：40×7.2＝288kg/10a

  70cm：70×7.2＝504kg/10a

Fig. 2.2.1.3 Relationship between plant height and dry matter yield of alfalfa.

2.2.2 Hay processing of herbage

(1) Objective

To ensure winter feed with high quality and palatability, it is necessary to carry out not only precise cultivation management of herbage but also precise hay processing. This section describes the specific procedure for processing alfalfa into hay.

(2) Procedure

The procedure of hay processing of alfalfa is shown in Fig. 2.2.2.1.

Mowing → Raking → Collecting → Storage

Fig. 2.2.2.1 Procedure of hay processing of alfalfa.

(3) Method

Alfalfa leaves tends to lose in the process of hay processing. To minimize this loss, maintenance of high quality is a key factor. Hay processing consists of mowing, raking, collecting, and storage.

1) Mowing Mowing is the first step of hay processing. To avoid difficulty in the following steps such as raking and bad influence on vegetation 5cm above ground should be conducted.	 Mower
2) Rake Raking is a process to promote drying with ventilating by loosing alfalfa block unraveling lump of cut alfalfa and reduce unevenness of up-and-down layer. In order to reduce loss of leaves in the work, it is important to weaken mechanical impulse force with selection of suitable machin e and moderate work speed	 Raking
3) Collecting Collecting is a work to pile alfalfa spread in the field for the efficient picking-up work to a truck. In piling collected alfalfa, less unevenness of the amount and arrangement in a line will lead to the increase in the efficiency of subsequent picking-up work.	 Collected alfalfa

4) Storage

Water content of stored alfalfa with stable quality is less than 15%. Since high temperature and moisture absorption during storage bring mold and heat and reduce nutritive value and palatability, the place with good ventilation without high temperature is optimal for storage.

Storage state of hay

Points of concern:

As criteria when judging the quality of alfalfa externally, there are mixing rate of foreign substance, purity and maturity of the herbage, color tone, proportion of leaves, etc.

If the herbage cut at the optimum time is fully dried for a short time, elastic hay will be made with many leaves in the color of bright yellowish green with fragrance. If it takes long time for drying alfalfa under rain, all leaves will abscise and only stems will remain, turning into brown color with a mold and perished smell. Since its nutritive value will also decrease sharply, it is not desirable.

Reference (Experimental data)

Changes in proportion of leaves and water content in stem and leaves during alfalfa hay processing examined in June 2005 are shown in Fig. 2.2.2.2.

In order to minimize loss of leaves, it is desirable to carry out raking and collecting at the same water content of stem and leaves to prevent abscission of leaves due to too much dry.

For this sake, works should be done in the evening or early in the morning when leaves have more water.

In calculating the required quantity of alfalfa hay as storage feed, it is necessary to take this loss of leaves into consideration.

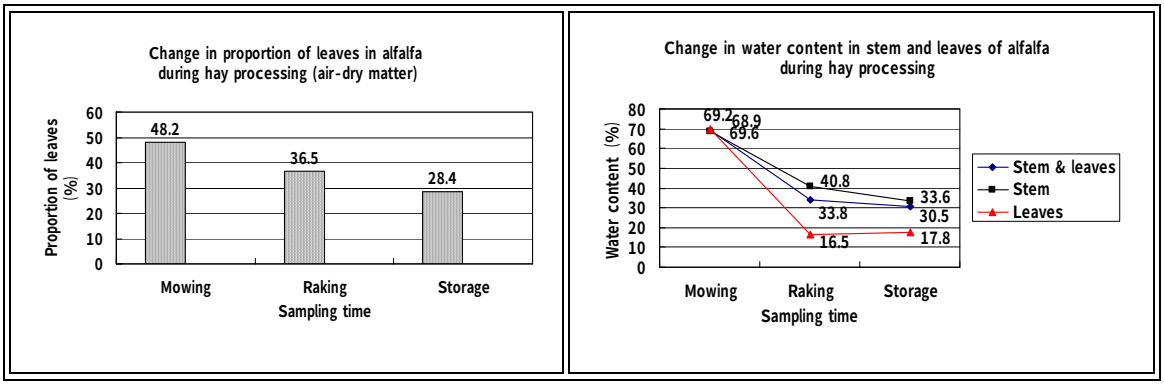


Fig. 2.2.2.2. Change in proportion of leaves in alfalfa during hay processing.

2.2.3 Efficient breeding barn technique

An animal shed provides a place for livestock to live and a workspace for the breeding farmer. A clean shed is healthy for livestock, and enables a farmer to work efficiently. Because sheep are sensitive to a humid environment, it is important to keep the shed ventilated and dry.

From a functional point of view, a simple structure is convenient to use. As shown in Fig. 2.2.2, for example, the interior of the shed should enable cages to be moved easily, so the area can be rearranged as the uses of the shed change with the seasons.

The basic size of an animal shed is 2-3m^2 a head. For lambing stock, however, the size should be at least 2.5m^2 because the sheep need more space (0.5m^2 a lamb) for nursing.

It also is necessary to prepare a play yard for holding sheep when changing litter and to provide enough exercise and exposure to sunlight.

Fig. 2.2.3 Efficient use of inside barn.

2.2.4 Off-season sheep breeding technique

(1) Objective

In the Altay Area, autumn mating and spring lambing is the most widespread sheep breeding technique. This pattern leads to overgrazing because lambing takes place on spring pastures when grass is still sparse, and creates conditions with a high rate of accidents including deaths of lambs during the early move to summer pastures so soon after birth. Off-season breeding is the one effective technique for addressing these issues. The technique includes artificial induction of estrus, but this manual describes early breeding (summer mating and winter lambing) as a specific technique.

(2) Procedure

The procedure of early breeding technique (summer mating and winter lambing) is shown in Fig. 2.2.4.1.

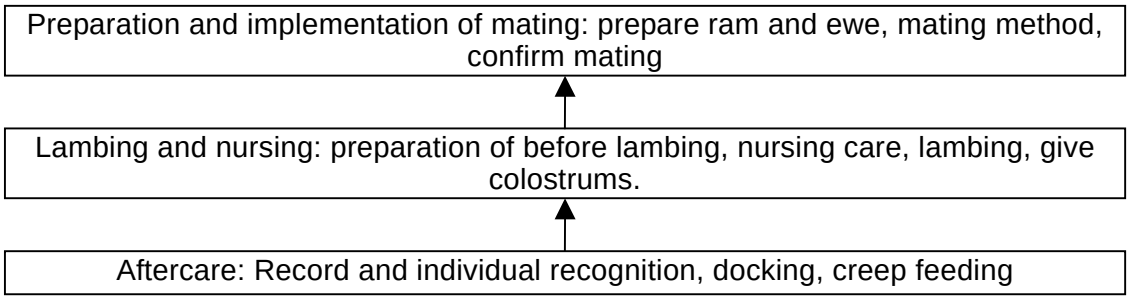


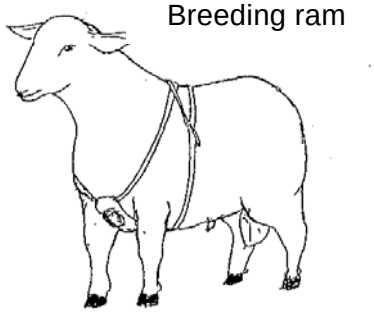
Fig. 2.2.4.1. Procedure of early breeding (summer mating and winter lambing).

(3) Method

1) Mating preparation and method

(a) Prepare breeding ram

Breeding ram should be check health condition one month before a mating and exterminate parasites. It treats completely when they have thrush. Especially, if breeding ram has thrush in hind foot, it cannot mount with hard pain, so breeding performance will be down. Inspect inflammation and stiff with palpation of testis.


Breeding ram

(b) Preparation of ewe

Breeding ewe is also inspected health condition, exterminate parasites and thrush as same as breeding ram. Also should be cleaned around genitalia with cutting dirty wool.

(c) Mating method

There are two mating methods such as artificial insemination and natural mating. While the mating by artificial insemination has an advantage which can use the semen of an excellent seed efficiently, it needs some equipment such as collect semen, inspection, dilution, store and injection, it better to do systematic tackling.

In Altay area, natural mating is more popular which place breeding ram in ewe group. It is possible 40～50 ewe per ram to mating. It is high conception rate and labor saving methods by mating suitable season. When mating period assume 40～50 days from the first of January, there are two or three times of mating opportunity a year.

(d) Check of mating

In order to check mating, fitting equipment on the chest of breeding ram can help easily. This equipment called Marking Harness (MH). When ram mount ewe, the crayon of MH gets ewe back. If it record everyday, it easy to confirm mating success or not individually and it can estimate the day of birth. It is two or three times of mating opportunity, it is easy to confirm mating by replacing the color of crayon, like red or blue, every two weeks.

MH and Crayon

Fitting MH

Crayon mark on back

2) Lambing and nursing

(a) Preparation before lambing

Pregnant ewe

When summer mating ewe becomes the last stage of pregnancy, a belly will be conspicuous and ewe will move slow. It needs sufficient attention when transfer and operate pregnant ewe to avoid intense action and strong stress around abdominal. To prepare lambing, cut off dirty wool around the breast and the genitals one month before lambing. This can help clean lambing and easy access to teat and taking milk by lamb. At the same time, it should be inspected the breast. Then after, keep the floor dry and clean by replacing dry new litter. And repair broken parts to shut from entering draft. Thereby, it can prevent humidity and the wind to protect bacterial infection and cold wind to the new lamb. Moreover, it better to provide ex-facility for the lamb group.

(b) Night watch at lambing nursing

When time coming of lambing, start night watch in the shed. Since an unexpected accident may occur with surprise, it starts a little early and the sheep which is not [at night] becoming tame is accustomed to a round at night. The lambing time is uncertain, therefore the lambing is at any time. For this reason, night watch should be done regularly. During night watch, observe silently and use eye and ear on the whole group. If the lambing is difficult, care it quickly.

(c) Lambing

Mother sheep usually lay down when she delivers the fetus (lamb) and after she will stand up. Mother sheep licks the mucus adhering to the body surface of a lamb briskly. The lamb try to stand up while being lick (knee stand). The mother sheep make the lamb stand by striking lightly with a front leg. When the lamb stands after some trial, the mother sheep will change the position that the lamb head turn to the direction of a breast with licking. After the lamb repeats trial and error, lamb can hold teat and suck milk (suckling). If lambing process dose not proceed normal, it is important to take necessary treat such as weak lamb care and adopt lamb as it needs.

Mother sheep and lamb

(d) Suckle of colostrum

Colostrum is a milk which different from the normal composition. After two or four days lambing, fat content of the colostrums is rather high than normal milk and it contain much immunoglobulin (Ig) which need to get disease-resistant of the lamb. But after two or four days from the birth, absorbing capacity of Ig in the intestine of lamb will be disappeared. It is necessary for energy and antibody intake to take enough colostrums to be lived of the newborn lamb.

Table 2.2.4.1 Difference of composition between colostrum and normal milk.

(Peat 1972, unit: %, kcal / 100g)

	Fat	Protein	Lactose	Ash	Total calories
Colostrum	10.60	5.98	4.57	0.78	144
Normal milk	6.95	5.36	4.98	0.80	110

3) Management after lambing

(a) Record and individual discernment.

When finish lambing, the mother sheep will be checked ear tag and measured the

lamb body weight, then be recorded on the ledge which noted breeding result. The lamb body weight will be recorded regularly until weaning and selling. Next, ear tag will be attached to the lamb and numbered individually. This individual discernment, measurement of body weight and management of breeding result are important to decision of feeding and selection of sheep group.

Check the ear tag.

Weight measurement of the lamb.

Table 2.2.4.2 Ledger of breeding results (an example).

Ewe			Lamb		Body weight(kg)								remarks
No.	Lambing day	Lambing difficulty	sex	No.	Time of birth	1-Jan.	1-Feb.	1-Mar.	1-Apr.	1-May	1-Jun	Selling date	
Average body weight	♂												
	♀												
	Average total												

(b) Docking

Docking of sheep will be done 1-2 weeks after the birth. However there is a sheep variety without a tail such as the Altay big sheep. The tail will be cut on the 2-3rd or 3-4th joint part with docking equipment. It is important to keep good sanitary condition.

(c) Creep feeding

A lamb starts to intake solid feed little by little from 10 days old. Then place the exclusive enclosure for the lamb at a bright warm place, and feed hay and concentrate

to the lamb. By feeding good quality solid feed, the rumen (1st and 2nd stomach) will grow well and efficiency of following body growth will be high. Place a little fence only for the lamb at the entrance of the pen. It needs enough litter to keep in the pen dry. The first amount of concentrate is enough as licking, then feed 200g a day at the 2 month old.

Mantelpiece for lamb

Creep feeding

Points of concern:

The points of concern in summer mating and winter lambing of sheep are shown below.

- Since mating is carried out in natural grassland, the activities should be introduced smoothly through planned feeding management of sheep based on the farming management and the annual schedule of grazing.
- Keep a daily watch on estrus of female sheep and calculate the estimated date of lambing for each of them.
- Since lambing is made in severe winter season, give the suitable amount of feed to the pregnant sheep according to their stage. Feeding amount should especially be suitable for the growth of fetus or the lactation after lambing in last stage of pregnancy or the first period of lactation.
- Perform appropriate feeding managements, such as installing a fireplace for lambs as a measure against cold.

Reference (example of feeding management)

Annual changes in weight of adult female sheep (model) and feeding management of sheep for summer mating and winter lambing (example) are shown in Fig. 2.2.4.2 and Table 2.2.4.3, respectively.

Average daily intake per head is 3.6kg as fresh matter (2.0kg as dry matter) at the beginning of gestation to the end of lactation. Dry matter to the average body weight (60kg) is about 3.3%.

When calculate necessary amount of alfalfa hay and silage as the winter reserve, it need to consider the intake of the periods of housing (winter).

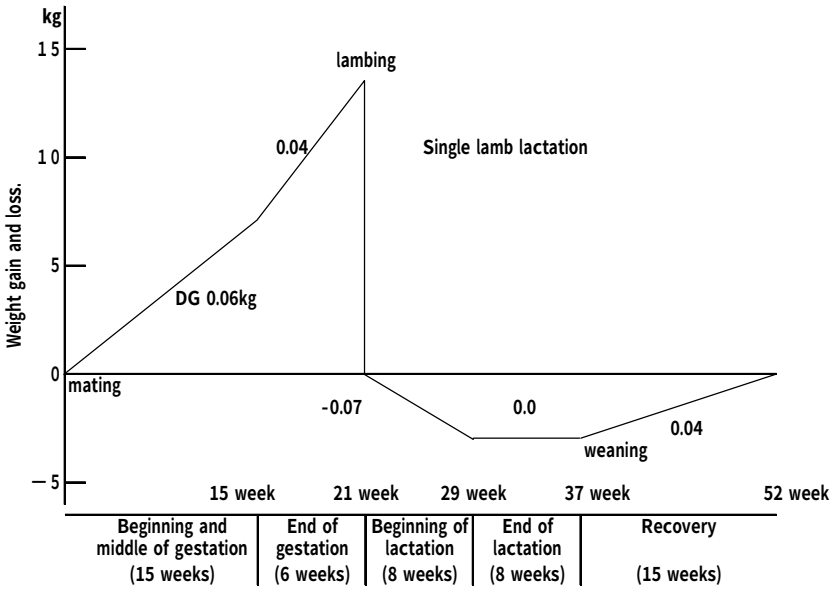


Fig. 2.2.4.2 Annual changes in weight of adult female sheep (a model).

Table 2.2.4.3 Feeding management of sheep for summer mating and winter lambing (an example).

ewe

	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
reproduction		mating					lambing				weaning	
stage	recovery		Beginning of gestation				End of gestation	Beginning of lactation		End of lactation		Dry off/recovery
feeding	grazing				housing							grazing
feeding quantity												
grazing	6～8kg											6～8kg
hay					2.0kg	1.8	1.7	1.8	2.0	2.0		
silage						1.8kg	1.7	1.7	2.1			
concentrate						0.1kg	0.2	0.2	0.3	0.2		

winter birth lamb

	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
stage							birth				weaning	Salling or raising
feeding							housing					grazing
feeding quantity												
grazing												1.4～1.8kg
hay							0.5kg	1.0	1.0	1.0	1.0	
silage								0.5kg				
concentrate							0.1kg	0.15	0.2	0.25	0.5	

2.3 Livestock farming type II

Livestock farming Type II is a farming pattern that aims at diversification of income by combining the breeding and sale of sheep with restraints on growth in the number of sheep through fattening of sheep or feeding of cows. For feed, this farming pattern introduces high-yield corn to process silage that is fed to livestock. This section explains the specific procedures concerning feed crop production, silage processing technique, sheep fattening technique and cow feeding technique.

2.3.1 Forage crop production

(1) Maize cultivation

1) Procedure

The flow chart of maize cultivation is shown in Fig. 2.3.1.1. Sowing date is decided in consideration of different growth period of each cultivar. Intertillage and top dressing are important work in order to obtain good maize growth.

	April-May	June-July	September
1st year	Irrigation→Tillage→Basal dressing→Sowing	Intertillage, Top dressing	Harvest

Fig. 2.3.1.1 Flow chart of maize cultivation.

2) Cultivation management

The points of maize cultivation are suitable water and fertilizer management.

Since aboveground biomass of maize is large, it requires larger amount of nutrients in soil than herbage. Nitrogen is especially important in maize growth since it is the material of protein that constitutes a plant.

Table 2.3.1.1 Points of concern in each item of maize cultivation.

Item	Procedure	Photo
Before sowing irrigation	・ Sufficient irrigation is needed before sowing.	
Plowing	・ Since maze is deep rooted crops, it needs to plow as deep as possible. ・ Plowing depth: 20-30cm	

Basal dressing	• Compost or animal feces: 1t/mu. • Urea: 5-10kg/mu. • Phosphoric acid is simultaneously applied at sowing. Urea is applied just before the first irrigation.	
Sowing	• Sowing season: The end of April to the first of May. (Sow April 24, harvest September 1st. When relative maturity 130 days) • Sowing rate: 2.0-3.0kg/mu.	
Irrigation	• Frequency of irrigation will be once at five or seven days as a standard, but suitable irrigation is needed as watching soil moisture condition.	
Intertillage	• Weeding and earth up is needed when mature leaf become 5-7 leaves (booting stage). • Take care not to hurt the root system.	
Top dressing	• Following fertilizer is needed when mature leaf become 5-7 leaves (booting stage). • Urea: 10-20 kg/mu.	
Harvest	• Harvest at the optimum time according to the purpose of use. • Optimum time is shown below. For silage: yellow-rip stage For soilage: dough stage	

Points of concern:

The time of topdressing and the optimum harvesting

Topdressing will be applied when booting stage of the mature leaf become 5-7 leaves. Booting stage is the period of change from vegetative stage to reproductive stage and the most needed period of nutrition for the plant. It is very important periods of irrigation and fertilizer.

Optimum harvesting time can be decided by the rate of maturity of the grain. The growth stage of the maize can be determined by checking of the milkline which marked between yellow part and white part of the grain.

Time of additional fertilizer	When mature leaf becomes 5-7 leaves (booting stage), weeding, earth up and additional fertilizer will be applied.	
Time of harvesting	• The growing stage of maize is shown below. • How to determine the yellow rip stage: When the milkline is half of the grain.	

Growth stage of maize

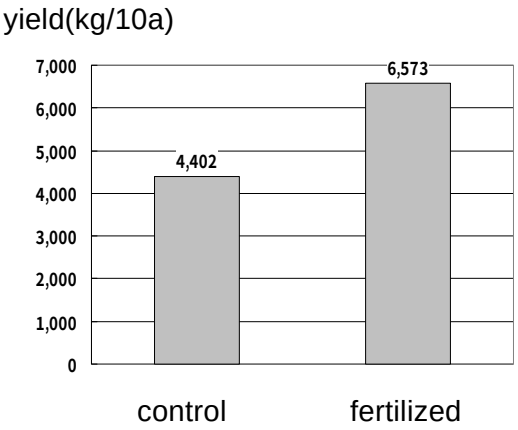
The growth stage of maize is shown in Table 2.3.1.2.

Table 2.3.1.2 Growth stage and its characteristics of maize.

Maturing stage	Characteristics
Booting stage	An ear begins to show from between ear rose.
Heading stage	An earing-up term ear comes out fully.
Blooming stage	Flowering period
Milk rip stage	Grain growing big.
Dough stage	Grain begins to become yellow
Yellow rip stage	The surface of grain begins to become depressed.
Full rip stage	Grains hard completely.

Reference

Yield of maize at Alahake of Altay city is shown in Fig. 2.3.1.2.



- Fertilized 12kg/mu of urea.
- The yield of maize is 6,500kg/10a at fertilized.
- Yield of fertilized is about 1.5 times of the control.

Fig.2.3.1.2 Yield of maize.

(2) Silage processing

1) Procedure

The procedure of making silage is shown in Fig. 2.3.1.3.

Prepare silo→prepare necessary materials→Maintenance of machines→Harvest→Load to the carrier→Transport→Unloading→Cutting→Compaction→Seal→Cover→Feed to the animal

Fig. 2.3.1.3 Procedure of silage processing.

2) Procedure

(a) Preparation of a silo

Trench silo (front view)

The size of silo is determined by considering the planting area, the number of over winter livestock and the quantity of feeding. The types of silo are above ground, half above ground, underground, but at the beginning, low cost trench silo is convenient. After farming stable, put the concrete block on the walls to improve airtightness.

To make trench silo, heap up center of the base at 10-15cm and make slope from center to the edge. Spread the plastic sheet into the silo which adjust size, and open some small holes at the edge of the base. To compact efficiently, make slope on the one side (part) in order to enter the tractor as shown in Fig. 2.3.1.4.

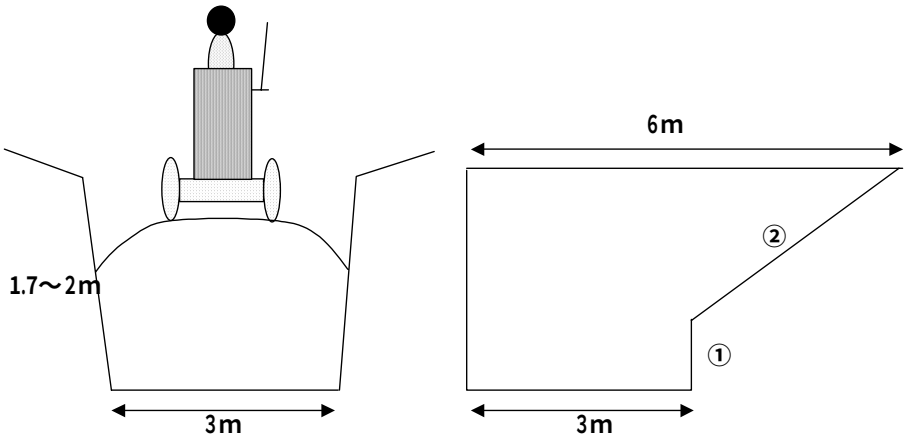


Fig. 2.3.1.4　Design of trench silo.

(b) Preparation of necessary materials

In order to improve airtightness of the trench silo, prepare plastic sheet and adjust the length and width as the size of silo. There are several thickness of plastic sheet, prepare thickly sheet (0.2mm thick) considering durability.

Plastic sheet

(c) Maintenance of machines.

In order to work smoothly, it is important to check and maintain the tractor and cutter. Check the quantity and quality of oil, degradation of a belt and wear of the blade of cutter. Replace and repair if it needs.

Tractor and Cutter

(d) Harvest

It is different by the harvesting time tat the yield, rate of grain mixture, feeding value and fermentative quality. The maize should be harvested at yellow rip stage. In order to determine maturity, it is not only check the milkline but also check the hardness of the grain by pushing the surface by nail.

Harvesting maize

- Milk rip stage: Milk like juice will come out.
- Dough stage: Like a fresh rice cake.
- Yellow rip stage: Barely depress.
- Full rip stage: Unable depress.

Moisture content of the materials is heavily effects silage quality. If the moisture too much, large quantity of juice which contain nutrition such as protein and carbohydrate will be spilled out. When content of the material moisture is too much, it needs to reduce up to 70% in the field after cutting. If the materials stay in the field a long time after cutting such as delay cutting or machine trouble, content of the material moisture will be disappeared. Take notice that the materials will not become too dry.

(e) Loading, transport and unloading

Load harvested materials onto the carrier and transport to the silo.

loading

transport

unloading

(f) Cutting

The materials will be cut as 5cm length to do easy compaction.

Cutting

(g) Compaction

After spread materials in silo, it is compacted by several humans or horses when heap every 50cm thick. If tractor can enter the silo, it is better to use tractor for compaction.

compaction by human

compaction by tractor

(h) Seal and cover

It should be finished packing materials by one or two days from cutting, and seal as fast as possible. When materials packed over ground level, it should be covered with plastic sheet by releasing air, then place some stones on the edge of sheet and after it will be covered by 20-30cm thick of soil.

seal

covered by soil

（i）Feed to the livestock

The silage fermentation is the following process.

Respiration will stop in about three days after sealing. After that a lot of juice will come out and start fermentation by lactic acid bacteria. When start fermentation, the pH will decrease and become good quality silage. It needs three or four weeks to ferment. The time of start feeding of silage to the livestock is after certain storage periods (45-60 days).

silage feeding

Before feeding, quality evaluation is needed. There are six items to evaluate quality.

Smell	Good silage has sweet smell like sour-sweet. If it has bad smell like ammonium, it cannot say good quality.
Taste	Sweet and acidity taste are sufficient (pH4.7 or less)
Color	Light cinnamon or light green are sufficient.
Feel	Moderate moisture and silky feeling are sufficient. Sticky feeling is not good.
Mixture rate of the grain	Mixed grain is sufficient.

Quality evaluation by expert.

Checking smell by farmer.

Points of concern:

When silage quality is not good, palatability of livestock is inferior, and it occur diarrhea and poor intake. When it feed long term, it will cause breeding disorder etc. Poor quality silage should be avoided or abandoned.

It is thought that the poor quality silage following basic mistakes.

1. Materials (early or delay harvesting, too much moisture)
2. Silo (air contamination, poor drainage)
3. Process (cutting length, low sugar content, high moisture content materials)

Reference (Data based on the experiment)

Silage was made on the end of September, 2004, and quality evaluation had done on the end of November (Fig.2.3.1.3).

After evaluate silage quality, it have feed to the sheep to execute reproduction and fattening examination. The result was that the palatability is same as alfalfa hay. The fermentation process is shown on table 2.3.1.5.

Table 2.3.1.3 Results of quality evaluation of silages.

	Silo No.1 Corn silage		Silo No.2 Sorghum silage		Silo No.3 Corn silage		Silo No.4 Corn+Sudangrass silage			
	score	remarks	score	remarks	score	remarks	score	remarks	pH	Score
smell	10	sweet	8	sweet-sour	10	sweet	8	sweet-sour	3.5～4.1	60
taste	10	sweet-sour	7	sour	10	sweet-sour	10	sweet-sour	4.2	55
color	10	light yellow	10	light yellow	5	yellowish brown	5	yellowish brown	4.3	40
feel	10	silky	10	silky	10	silky	10	silky	4.4	30
pH	30	4.4	0	4.8	30	4.4	0	4.9	4.5	23
total score	70		35		65		33		4.6	13
Japan standard	good (class 2)		passed(class 3)		good(class 2)		passed(class 3)		4.7	3
Chinese standard	90	excellent	80	good	85	ecxellent	80	good	4.8	0
palatability	good		good		good		good			

Referee C/P(Mr. Habdish)
Score and class 100～81 80～61 60～31 30～0
(class 1) (class 2) (class 3) (inferior)
excellent good passed bad
※ The score of silage was recorded from 80(good) to 90(excellent) by the C/P evaluation.

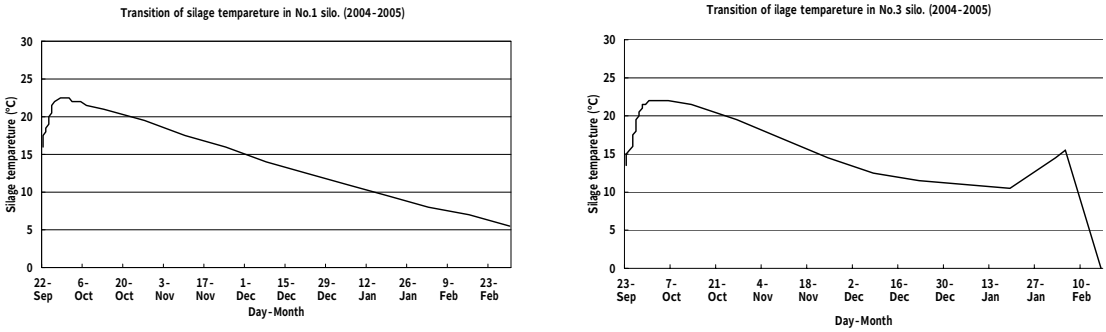


Fig. 2.3.1.5 Fermentation process of the silage (temperature change).

2.3.2 Sheep fattening technique

(1) Objective

Because most nomads depend on selling sheep for income, efficient management with fewer accidents is possible after settlement because winter feed can be produced and animal sheds built. By fattening sheep, agro-pastoralists can increase added value and adjust their selling periods based on or market trends. Sheep fattening is an extension the livestock techniques utilized until now, and this section describes the procedures making it comparatively easy to use.

(2) Procedure

The procedure of sheep fattening is shown in Fig. 2.3.2.1.

Production system: Market trend, fattening method, feed

↓

Selling system: Market, and cooperative-marketing

Fig. 2.3.2.1 Procedure of sheep fattening.

(3) Method

1) Production system

(a) Market research

To consider the profitable time, it need to research the consumption tendency and market retail price of the meet.

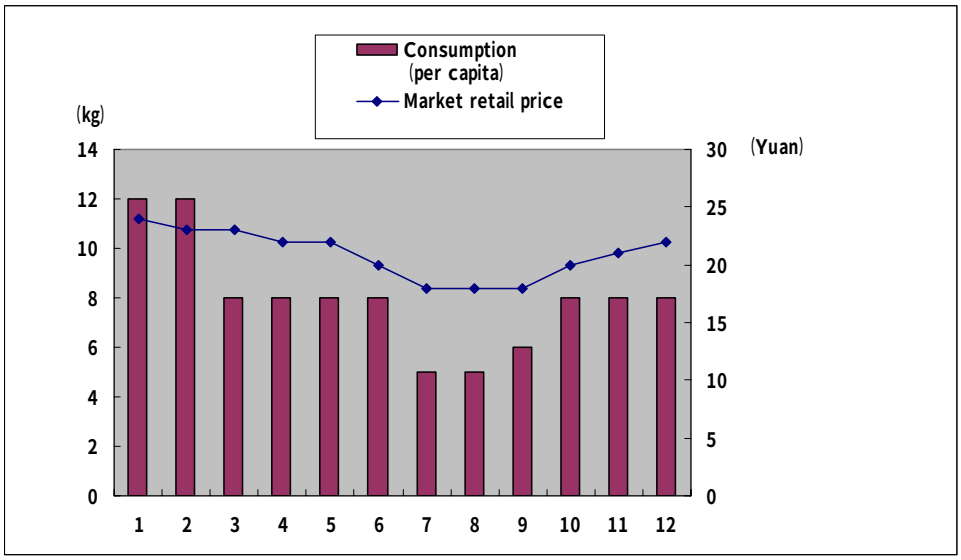


Fig. 2.3.2.2 Monthly transition of consumption trend and market retail price of lamb meat (2004).

(b) The fattening method

Fattening technique are shown on fig. 2.3.2.3. Considering the number of sheep, labor force and market trend, suitable method will be chosen.

Type A (housing method)

lambing	Nursing, fattening	→sale

Type B (grazing method)

Lambing	Nursing	Grazing	→sale

Type C (grazing and housing method)

Lambing	Nursing	Grazing	Fattening	→sale

Fig. 2.3.2.3 Fattening method of sheep.

a) Type A (housing method)

This method is that fattening of the winter delivered lamb (January or February

birth) by feeding hay and concentrate of creep feeding beside the mother sheep milk. Sell by 35-40kg of the five month old. Daily gain will be aimed 200-250g a day. Feed mainly good quality hay and silage and the concentrate will be used house made corn or market products as it needs. It takes notice the selling time on the end of March or June when the price of lamb should be high. This method can help reduce stress on natural pasture while lamb was feed in the settlement.

b) Type B (grazing method)

This fattening method is most popular in the Altay region, and it makes the best use of the herbivorous livestock. Daily gain should be aimed 150g a day in order to make the lamb body weight until 35kg at autumn while they are grazing on natural pasture. Because the selling time is autumn and it is the most supplying time of lamb, it is important to sell profitably by researching the market price.

c） Type C (grazing and housing method)

This fattening method is the selling system when sheep body weight not reached the target at the end of grazing, keep in shed for three month then shipping. Take notice feeding management, type of forage and feeding quantities because of winter feeding. Daily gain will be aimed at 150g. Feed mainly good quality hay and silage and the concentrate will be used house made corn or market products as it needs. Selling time will be targeted on the month when great demand for sheep such as Kurban festival or the lunar New Year.

Feeding to fattening sheep

2) Selling system

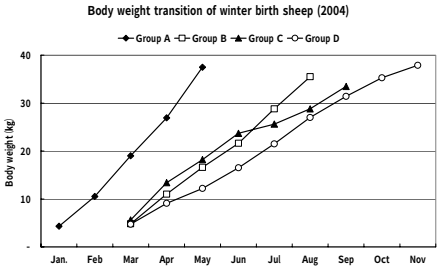
It is popular selling system in the Altay region that the face to face bargaining with farmer to merchant. It is very important that the market or sales method to cover the cost when carry out fattening sheep. Because it will be a high valued fattening system by planning a new feeding method, especially in type A and type C.

Points of concern:

Too much feed silage or concentration at the beginning of fattening will bring diarrhea and low intake then daily gain will slow. It is important the feeding quantity should be increased little by little. Quantity of the concentrates is necessary to change by the quality or intake of forage. Because of the sheep is ruminant same as the cow, the digestion system is also same. It is no problem to feed the forage for cow to the sheep. However, since the limit of copper poisoning is remarkably low compared with a cow and, as for the sheep, the danger that a copper intake will become superfluous and will cause copper poisoning becomes high about copper in diverting the object for cows to the sheep, it fully needs to be careful of the amount of demands, and a limit of poisoning.

Reference (Data based on examination)

Weight transition of winter birth lamb and its selling state (Fig. 2.3.2.4) in 2004 and sheep fattening result (Fig. 2.3.2.5) and feeding quantities (Table 2.3.2) are shown below.



Selling situation of winter birth lamb. (average)

unit: head, day, kg, RMP

	Number of sheep	Sex	Day old at selling,	Dairy gain	Selling price	Feeding type
Group A	25	male,female	136	0.24	330	housing
Group B	6	male	164	0.19	240	housing
Group C	25	male,female	185	0.15	280	housing → grazing
Group D	23	male,female	237	0.14	280	housing → grazing

Fig. 2.3.2.4 Weight transition and selling situation of winter born lamb.

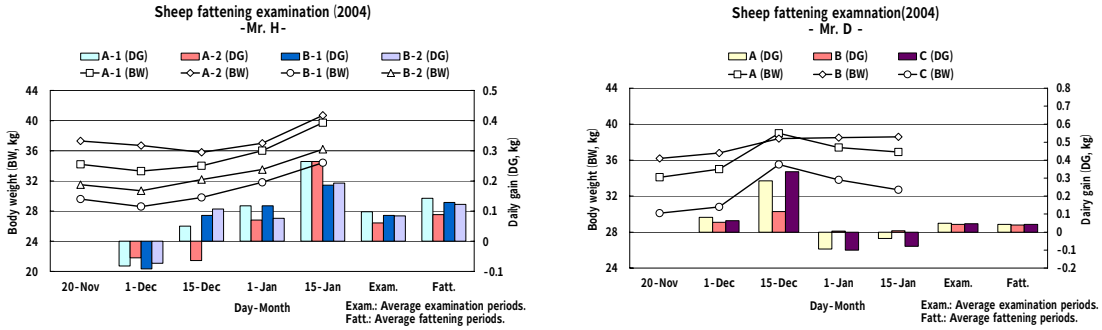


Fig. 2.3.2.5 Results of sheep fattening experiment.

Table 2.3.2 Amount of feed in sheep fattening experiment.

Unit: kg/head/day

	Feed	2004. 11/20～11/30	12/1～12/20	12/21～ 2005.1/15
Mr. H Group A-1 3 heads house-born lamb	Hay	2	2	2
	Sorghum silage	2	2	2
	Formula feed	0.5	0.8	1
Mr. H group A-2 3 heads house-born lamb	Hay	2	2	2
	Corn silage	2	2	2
	Formula feed	0.5	0.8	1
Mr. H group B-1 5 heads not house-born lamb	Hay	3	3	3
	Sorghum silage	2	2	3
Mr. H group B-2 5 heads not house-born lamb	Hay	3	3	3
	Corn silage	2	2	3
Mr. D group A 5 heads not house-born lamb	Hay	3	3	4
Mr. D group B 5 heads not house-born lamb	Hay	3	3	3
	Corn silage	2	2	3
Mr. D group C 5 heads not house-born lamb	Hay	2	2	2
	Silage (mixture)	2	2	2
	Formula feed	0.5	0.8	1

2.3.3 Feeding of cows

(1) Objective

Feeding of cows in the settlement, and selling the fresh milk consumed by farmers themselves in the past to a dairy factory, is an effective way to diversify income through livestock farming management. This section describes the procedures and other information for the production and sale of raw milk.

(2) Procedure

The procedure of production and selling of fresh milk is shown in Fig. 2.3.3.

preparation → milking → cooling and storage → collecting and inspection → selling

Fig.2.3.3 Procedure of production and selling of fresh milk.

(3) Method

1) Preparation of milking

(a) Put on the clothes for milking and disinfect your fingers. In order to make the effective disinfection, it is desirable to wear the glove made from rubber or plastic.

(b) Prepare the equipment for milking.

2) Milking

(a) Calm a cow, make it settle down, and carry out milking with the same procedure at the same time of day.

(b) Foremilk (first 4-5 times) should be throw into exclusive cup. Foremilk can help to find high count bacteria milk and find unusual milk (mastitis). And stimulating teat will induce hormone (oxytocine) which needs milking. Do not throw foremilk on the barn floor. Take notice not to infect mastitis from one cow to another.

foremilking

(c) Clean and dry the teat. It can remove stains and reduce bacteria count which sticking around teat. It is important to clean carefully not only the side but also the top of teat. And it can reduce more bacteria count around teat to wipe moisture and dry of tear.

Cleaning teat

(d) After clean and dry teat, start milking immediately. If it takes a time to start milking, secretion of oxytocine will be decrease and milking period will need more. Do not overmilk. It will damage teat if milking is carried out until the last one drop.

Milking

(e) Wipe the teat after milking in order to inhibit colonization and proliferation of bacteria on the teat orifice that is still opening for a while after milking. Wipe the teat well with the clean wrung cloth. Take notice, since it may cause mastitis without this.

3) Cooling and storage

After filtering with clean cloth etc., cool the fresh milk in a vessel covered with cold water, and store it in a dark cool place until transport to the collecting center. By lowering milk temperature to less than 10 degrees C within 1 - 2 hours after milking, it is possible to prevent a rapid multiplication of bacteria.

cooling fresh milk

store dark cool place

4) Collection and inspection

Transport stored fresh milk to the collecting center. The milk is inspected by the color, smell, specific gravity and existence of agglutination. Don't sell except for the normal milk.

Hydrometer

Agglutination inspection with alcohol

After passed inspection, the fresh milk should be measured and filtered, then keep it into the container for selling. The container should be kept in a dark cool place until sales.

5) Marketing (sale)

Transport stored fresh milk onto the truck coming from the daily factory. Check and record the selling quantity in order not to make a difference at the time of liquidation.

2.4 Diversified farming type

The diversified farming type model is characterized by the planting of cash crops other than feed production in the settlement fields and earning income from products other than livestock. Diversification of incomes leads to control on the increase in livestock, and as a result can limit the load on natural grasslands. It also is important to aim at sustainable recycling agriculture that makes the best use of the merits of livestock ownership.

2.4.1 Cash crop production

In contrast to food crops for self-consumption or feed crops, cash crops are planted for the purpose of selling them. They are characterized by the fact that producers earn more income as production is increased.

Cash crop production is divided roughly into three stages. These are (1) pre-planting, (2) planting and harvesting and (3) harvesting and sale. The work required at each stage is shown in the following table. It is important for agro-pastoralists themselves to know about these cultivation techniques and decision criteria for cash crop production.

Before Planting	Selection of crop kind, Determination of cropping season, Cultivar selection, Field preparation
Planting-Harvest	Determination of fertilizer amount, Determination of irrigation amount, Planting density determination, Cultivation management
Harvest-Sale	Decision of harvest time, Thresh, Processing, Sale

(1) Selection of crop kind

In case a cultivated crop is chosen as a cash crop, cultivation aptitude and marketing are important. The cultivation aptitude of each crop in Alahake town, Altay city is summarized in Table 2.4.1.1.

Table 2.4.1.1 Comparison of cultivation aptitude of crops and vegetables in Alahake

Item	More suitable	Less suitable	Evaluation criteria	Aptitude	Easiness in cultivation
Crop	Maize	Sunflower	Maturity	Earliness	Easy
Crop	Soybean	Wheat	Sowing season	Lateness	↑ |
Tuber and roots	Potato	Onion	Hypertrophy period	Shortness	| |
Root vegetable	Radish	Carrot	Hypertrophy start	Earliness	| |
Leaf vegetable	Cabbage	Chinese cabbage	Disease	Resistance	| |
Fruit vegetable	Eggplant	Cucumber	Water requirement	Little	| ↓
Fruit vegetable	Tomato	Hami melon	Water and fertilizer management	Easiness	Difficult

1) Maturity

In a high latitude area, since the temperature decline of autumn occurs sharply, late maturing crops will stop their growth before complete maturation. Therefore, early maturity is a favorable feature there. Comparing maize and sunflower with the same sowing date, for example, sunflower is considered less adaptable than maize because of its longer growth period.

2) Sowing season (Optimum sowing date)

If air temperature and soil temperature in spring do not rise, crops often do not emerge after sowing. The soil temperature required for emergence is about 5-10 degrees. In Alahake town, Altay city, soil temperature exceeds 5 degrees continuously for three days from late March to early April. In case of the crops whose optimum sowing date to obtain adequate growing periods is earlier than the time when soil temperature rises, the optimum sowing date will be missed. Therefore, if the optimum sowing date is late, it is a favorable feature there. Also described in “(2) Determination of cropping season”, the optimum sowing date of many vegetables is earlier than possible growth period, they are not suitable to open cultivation. Comparing soybean and wheat, for example, wheat is considered less adaptable than soybean because its optimum sowing date is earlier.

3) Hypertrophy period

In a high latitude area, since the cultivation period is restricted, crops requiring a long period for hypertrophy of tuber or roots will stop their growth before complete hypertrophy. Therefore, short hypertrophy period is a favorable feature there. Comparing potato and onion, for example, onion is considered less adaptable than potato because of its longer hypertrophy period.

4) Hypertrophy start

In a high latitude area, since the cultivation period, that is, the hypertrophy period, is restricted, when the enough length of a hypertrophy period is not obtained, the crops with a slow hypertrophy start will be harvested in small size. Therefore, early start of hypertrophy is a favorable feature there. Comparing carrot and radish, for example, carrot is considered less adaptable than radish because of its later start of hypertrophy.

5) Disease

Resistance to disease is a favorable feature there because of its cultivation ease. There is an example that only Chinese cabbage was damaged by disease with

cabbage cultivated in the same area. In such a case, Chinese cabbage is considered less adaptable than cabbage.

6) Water requirement

It is necessary to apply adequate irrigation to crops requiring much amount of water during the period from flowering to harvest. However, irrigation is often insufficient by inadequate interval or amount. Crops with a small decline of yield under such condition are easy to cultivate. Therefore, less water requirement is a favorable feature there. Comparing cucumber and eggplant, for example, cucumber is considered less adaptable than eggplant because of its larger water requirement.

7) Water and fertilizer management

Although there are crops requiring special water and fertilizer management for the increase in yield and improvement in quality, in contrast, it is easy to cultivate the crops with easy water and fertilizer management. Therefore, ease of water and fertilizer management is a favorable feature there. Comparing Hami melon and tomato, for example, Hami melon is considered less adaptable than tomato in an extensive cultivation system because of its requirement for special water and fertilizer management for the improvement in quality.

8) Ease of cultivation

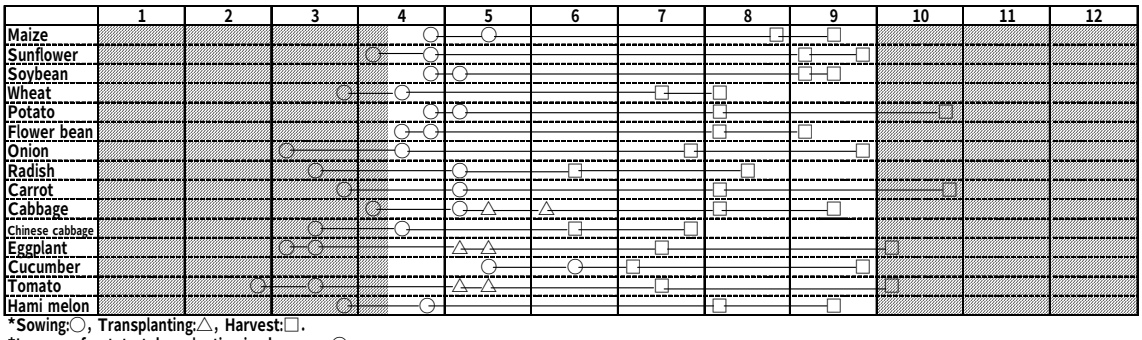
The evaluation criteria from 5 to 7 are related to the ease of cultivating. Comparing field crops with vegetables, generally field crops can be cultivated with more extensive management.

9) Marketing

In order to evaluate marketing, it is necessary to investigate what kinds of crops are currently planted around the settlement. Price investigation in a market is also important. It is also important to investigate whether there is a sure market. It is advantageous to plant the crops currently promoted regionally by the local government because of a sure market. However, intensive management is required when quality standard is requested.

(2) Determination of cropping season

Among climate conditions, temperature, solar radiation, day length, precipitation, soil temperature, and wind velocity are important items. The growth zero point of crops is usually 10 degrees, and a cropping season (possible growth period) is set up as a period when temperature exceeds 10 degrees. The cropping season tends to be restricted in a high latitude area.



*Sowing:○, Transplanting:△, Harvest:□.
*In case of potato tuber planting is shown as ○.

Fig. 2.4.1.1 Optimum sowing date and harvesting date of crops and vegetables grown in Altay area.

Points of concern:

Possible growth period

In Altay area, possible growth period is from around the middle April to late September, and it is important to select crops with cropping season in the period. The optimum sowing date of many vegetables is out of the range of possible growth period, the warmed seedling raising in a plastic house or indoor is needed.

1) Importance of early sowing

In the high latitude area, unless crops are sown in early season, their high production may not be expected in most case. For example of soybean in Altay area, as later it is sown, as lower its yield tends to be (Fig. 2.4.2.2).

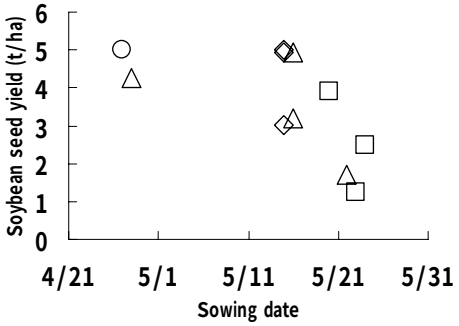


Fig. 2.4.1.2 Relationship between sowing date and seed yield in 2004.

(:Agropastoralists' field reclaimed in 2003 in Alahake town, Altay city, □: Agropastoralists' field reclaimed in 2004 in Alahake town, Altay city, :Field of Alahake town, Altay city (advanced), ○:Jiayilema town, Habahe county (advanced))

Strong wind in April, spring frost, and arrangements of the irrigation water, seeds and machines are the constraint for early sowing. It is necessary to consider labor shortage may occur by competition with livestock farming work at the beginning of spring.

If the low temperature of the beginning of spring or the beginning of autumn is a constraint for the cultivation, it may be possible to remove it by use of plastic house, plastic tunnel, or vinyl multi. However, since a large scale of them is difficult practically, it is good to limit to the use as a method for seedling raising of vegetables. The temperature in plastic house or plastic tunnel can be kept higher 3 - 5 degrees than that outside. However, a tunnel needs open and close, otherwise internal temperature can exceed 60 degrees, which should be cautioned.

2) Crop kinds grown in a short period

There are some kinds of vegetables that can grow for a short period. Radish and Japanese radish are the example of them.

(3) Preparation of a field

There are six points in land leveling. They are flatness, proper, fine, humid, straight line and light, smooth soil. It is required to fulfill these points for the appropriate emergence. Please refer to Chapter 3 about preparation of a field.

(4) Water and fertilizer management technology, and decision of planting density

In the land with the feature of the high solar radiation and low soil fertility in arid and semi-arid area, determination, in order to carry out cultivation with irrigation without much evaporation from land, the cultivation with relatively higher planting density is effective. The minimum irrigation amount suitable to it is needed. Since land has few organic matters in many cases, effective fertilizing method including topdressing is needed.

1) Water management technology

In the land cultivation is carried out with irrigation because of small precipitation, if irrigation amount is superfluous, much water will be used vainly. On the contrary, crop growth is inhibited when irrigation amount is insufficient. Therefore, it is required to acquire the information for adequate amount of irrigation to carry out efficient irrigation. Water management is adjusted by water amount of one irrigation and irrigation interval. It is desirable to adjust irrigation amount also according to the growth stage.

Points of concern:

Optimum amount of irrigation for maize and sunflower

The appropriate value of total amount of irrigation during growing period for maize and sunflower is 450mm (Altay area standard). If irrigation amount exceeds 450mm, growth of the aboveground part of the crop may be inhibited through the inhibition of root growth (Table 2.4.1.2, Table 2.4.1.3).

Table 2.4.1.2 Relationship between irrigation amount and growth and yield of maize (Alahake town, Altay city, 2004).

Irrigation amount（mm）	Plant height（cm）	Ear dry weight（mg/plant）	Total dry weight（mg/plant）	Root length（cm）
0	120	40.5	113.2	26.3
300	128	61.1	156.8	22.0
450	140	71.0	179.8	24.5
600	135	43.2	136.4	22.3

Table 2.4.1.3 Relationship between irrigation amount and sunflower growth (30 days after planting) (Alahake town, Altay city, 2005).

Irrigation amount（mm）	Plant height（cm）
0	14.7
300	15.9
450	17.2
600	14.8

Irrigation was applied proportionally based on the total amount.

2) Fertilizer management technology

In arid and semi-arid area with few organic matters in soil, considering fertilizer efficiency, topdressing will be required with its effective time and method for application. Since it is considered that the response to fertilizer varies with the crop species and varieties, it is important to grasp it. When the response of growth becomes blunt to the fertilizer above a certain level, it is necessary to care about that fertilizer beyond it is not used effectively.

a) Kind and characteristics of fertilizers

There are organic fertilizers and inorganic fertilizers (chemical fertilizers), the former are usually slow-released and the latter are usually readily available.

Although soil diagnosis is needed, potassium fertilizer application is usually unnecessary in the land like Altay area where much potassium is contained in the soil.

Urea usually has more fertilizer efficiency applied as topdressing than basal dressing. It is because development of root system is insufficient immediately after sowing and the rate of the urea not absorbed by crops is high. When early planting is

carried out in high latitude area, since temperature is usually low at the beginning, initial growth is slow and the rate of growth will become higher with the rise of temperature. In such case, fertilizer management is essential that utilizes phosphoric acid effect enough for root development in the initial growth, and does nitrogen effect in later growth after of temperature rise.

Organic fertilizers such as compost are not applied in the form of topdressing but usually applied to plow layer whole surface as basal dressing. It is because topdressing is required for readily availability.

The kind and the characteristics of typical fertilizers are shown in the following table.

Kind	Fertilizer efficiency	Effective application time	Effective application placement
Organic fertilizer (Manure, compost etc.)	Slow-released	Basal dressing (at plowing)	Whole surface, plow layer
Urea (nitrogen)	Readily available, Development of stem and leaves	Topdressing	Surface
Diammonium phosphate (phosphorus)	Readily available, Development of roots, flowers, and fruits	Basal dressing (at sowing)	Along the sowing line
Potassium sulfate (potassium)	Readily available, Root development	Basal dressing (at sowing)	Along the sowing line
Compound fertilizer	Readily available, Multiple	Basal dressing, Topdressing	Along the sowing line

b) Amount of fertilizer

Points of concern:

Different response to fertilizer between maize and sunflower

While maize can increase its yield in response to fertilizer increase above the standard in Altay area, sunflower has its maximum at the standard fertilizer level. (Table 2.4.1.4, Table 2.4.1.5).

Table 2.4.1.4 Relationship between fertilizer amount and growth and yield of maize (Alahake town, Altay city, 2004).

Fertilizer amount (Ratio to standard)	Plant height (cm)	Ear dry weight (mg/plant)	Total dry weight (mg/plant)
50%	137	20.2	78.6
Standard	125	26.8	83.7
150%	128	36.9	104.7

Table 2.4.1.5 Relationship between fertilizer amount and sunflower growth (at harvest) (Alahake town, Altay city, 2004).

Amount of fertilizer (Ratio to standard)	Plant height (cm)
50%	55.6
Standard	69.7
150%	67.3

c) Topdressing

Although urea is a nitrogen fertilizer readily available, its response does not usually continue for a long time. In such case, topdressing is effective. Flowering time is suitable to topdressing because most crops show rapid growth. In addition, when urea has not been applied as basal dressing, it is recommended to apply it as topdressing at the first irrigation.

Points of concern:

Method of topdressing

Topdressing should not be scattered from a top but be applied with trenching to prevent damage crop leaves.

Table 2.4.1.6 Effect of topdressing at flowering time on growth and yield of sunflower (Alahake town, Altay city, 2005).

Field No.	Plant height (cm)		Total fresh weight (kg/m^2)		Head fresh weight (kg/m^2)		Grain yield (kg/mu)	
	Without top dressing	With top dressing	Without top dressing	With top dressing	Without top dressing	With top dressing	Without top dressing	With top dressing
1	84	102	1.60	2.11	0.93	1.20	93	151
4	77	92	1.10	1.80	0.61	0.95	23	31
14	72	66	1.57	1.65	0.96	0.93	77	81
24	121	112	2.34	2.85	1.22	1.49	105	141

Topdressing is applied as urea at flowering time (two months after planting), at the rate of 10kg / Mu (150 kg/ha).

3) Planting density

Since individual plant growth is not so large in the land with low fertility, high density planting may be effective to obtain certain amount of growth per area. Moreover, high density planting is also effective to reduce evaporation from soil surface under high solar radiation conditions. Furthermore, high density planting is effective to control weeds.

Points of concern:

Optimum planting density of soybean

As higher planting density, as higher yield of soybean within the range of row space between 30cm to 60cm (Table 2.4.1.7). It is good to make row apace narrower than 45cm. 60cm is too large. There is a method of making rows with space of 30cm and 60cm alternately so that a tractor can enter conveniently in intertillage.

Table 2.4.1.7 Relationship between row space and soybean yield (Alahake town, Altay city, 2004).

Row space (cm)	Yield (t/ha)
30	3.08
45	2.69
60	2.33

Hill distance was 10cm in all treatment plots.

(5) Measures in case the optimal condition is not obtained

If crop cultivation is conducted under optimal condition, high yield will be expected, but the condition necessarily cannot be obtained. In such case, devising to a cultivation method may mitigate yield reduction.

1) In case optimum sowing time is missed

Since growth period becomes short, individual plant growth will become small. In this case, high density planting may be effective to obtain certain amount of growth per area. In addition, it is effective to select early varieties not to make harvest time too late. However, attention should be paid that if high planting density is excessive, risk for disease will increase.

2) In case chemical fertilizer is not purchased for required amount

Apply more livestock excrement and compost as basal dressing than the standard level. Since the varieties introduced from abroad may usually require more fertilizer and may exhibit inferior growth with a little fertilizer, it will be effective to select adequate local variety showing good growth with a little fertilizer.

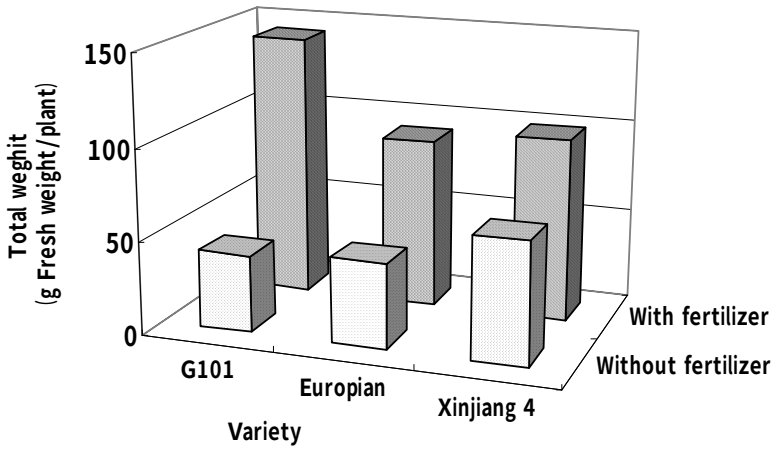


Fig. 2.4.1.3 Response of three varieties of oil sunflower to fertilizer (Jiayilema town, Habahe county, 2004).

Points of concern:

Varietal difference of response to fertilizer

While variety G101 from U.S. shows best growth with much fertilizer, local variety, Xinjiang 4 shows best growth with a little fertilizer among three sunflower varieties.

3) In case irrigation water cannot be obtained for required amount

Drought resistant crops that can grow with less water should be planted. Or crops with short growth period should be planted.

(6) Harvest, processing and sale

It is important to harvest at the optimum time. Drying can be carried out in the field using the dry climate. Processing is mainly drying and threshing. It is important to sell what with good quality. Conversely, it is important to meet with buyer's needs, and to feed back the opinion of buyer to cultivation.

(7) Method of cultivation of typical crops (soybean)

One of the typical cash crops in Altay area is soybean. Since soybean is insufficient on the whole in China, its demand is large there. If irrigation water is secured, Xinjang will be the best place to cultivate soybean because of high solar radiation and suitable climate. Although soybean is a crop relatively easy to cultivate, sowing date, planting density, and water management just after planting are important. The nitrogen fixation by rhizobium can be used besides a nitrogen fertilizer as nutrition for growth.

1) Procedure

Flow chart in soybean cultivation is shown in the following figure. Rhizobium inoculation is especially recommended for the cultivation in the first year after reclamation.

	April～May	June～July	September
First year	Irrigation→Tillage→Basal dressing→ Rhizobium inoculation→Sowing	Topdressing	Harvest
Second or subsequent year	Irrigation→Tillage→Basal dressing→Sowing	Weed control Pest control	Harvest

2) Cultivation management

The points of soybean cultivation are adequate management of water and fertilizer. Since high concentration protein is contained in seeds as products, nitrogen is very important as a material in soybean growth.

Item	Contents	Photo
Irrigation before sowing	• Irrigate sufficiently before sowing.	
Plowing	• It is desirable to plow enough so that root and root nodules may work efficient. • Plowing depth: 25-30cm.	
Basal dressing	• Compost or livestock excrement: 1-2t / Mu • Urea: 5-10kg / Mu • Phosphoric acid: 10-15kg / Mu • Phosphoric acid is simultaneously applied at sowing. Urea is applied just before the first irrigation.	
Sowing	• Sowing season: From late April to early May. • Sowing rate: 7-9kg / Mu • Row space: 30-45cm, Hill distance: 5-10cm • Planting density: 22000-26000 plants / Mu	
Irrigation	• Standard irrigation interval is 5 to 7 days. Irrigate properly according to the state of soil moisture.	
Topdressing	• Following chemical fertilizers are applied as topdressing at flowering period. Topdressing is essential especially when the leaf color is yellow. • Urea: 10-15kg / Mu • Phosphoric acid: 5kg / Mu	

Harvest	• Harvest at maturity. • Dry soybeans on the ground and pile them into stack. • Thresh is carried out by using a stick or a tool of bamboo, or running a tractor on the soybeans, or by using a power thresher.	

Points of concern:

Management at flowering period and optimum harvest time

Topdressing is applied at flowering period. Topdressing is essential especially when the leaf color is yellow. If rhizobium is inoculated, it is not usually necessary to apply topdressing. Irrigation and fertilizer management at this stage is very important.

The optimum harvest time is the time when almost all leaves become yellow or fall, and the color of the pod becomes brown more than half. If harvest is too late, there will be a risk of loss by pod shattering. After pods begin to change colors, irrigation must not be applied. (Harvest time will come in one - two weeks).

3) Role of rhizobium in soybean cultivation

Nitrogen fixation activity of rhizobium can be kept high in the land with high solar radiation when soil moisture content can be controlled by irrigation.

(a) Objective and method of rhizobium inoculation

In the land just after reclamation, density of rhizobium that is useful for nitrogen fixation in the soil is usually low. In such case, even if leguminous crops are cultivated, it is not expectable that nitrogen fixation increases immediately. Although there is a method of plowing land after mixing soil brought from soybean cultivated field, native rhizobium is not necessarily good at nitrogen fixation. In such case, it is effective to sow after inoculating rhizobium inoculants. In China, “Firster Nodule Bacterial Medicament of Leguminous Crops” made by “Qinhuangdao Leading Science & Technology Development Co., Ltd” can be obtained as rhizobium inoculants. There are three methods of inoculation as follows. Among these seed dressing has the highest effect. It is because inoculated rhizobium with high nitrogen fixation efficiency exists by high concentration near the seed and the rate of the root nodule formation by inoculated rhizobium increases.

	Method	Characteristics and points of concern
Application like fertilizer	After well mixed the inoculants with basal dressing, such as granular organic fertilizer and Diammonium phosphate, they are applied by machine together with seed sowing.	・Used by machine sowing. ・If contacted with nitrogen fertilizer, the effect will decrease.
Seed dressing	Proper quantity of water is applied to the inoculants, and then seeds are well mixed with the inoculants in order for surface of each seed to get the inoculants. Seeds are sown after drying in a shade for a while. Seeds can be wet first, then the inoculants may be mixed to seeds uniformly.	・Used by both machine sowing and hand sowing. ・If machine sowing is carried out before fully seed drying, seeds will not drop well, which will cause reduction in sowing rate.
Hole application Line application	The inoculants is well mixed with 10kg of wet fine fertile soil. Seeds are sown after applying the same quantity of inoculants as other methods into holes or slots.	・Same effect as “Application like fertilizer”. ・It is possible to apply as topdressing.

Points of concern:

Effect of rhizobium inoculation

Rhizobium inoculation brings yield increase in most cases, though it may sometimes reduce plant number per unit area by reduction in amount of sown seeds.

Table 2.4.1.8 Effect of Rhizobium inoculation on soybean yield (Alahake town, Altay city, 2005).

Field number	No. of plants (/m^2)		No. of pod per plant		No. of pod per area (/m^2)		Seed yield (kg/Mu)	
	Without inocu-lation	With inocu-lation	Without inocu-lation	With inocu-lation	Without inocu-lation	With inocu-lation	Without inocu-lation	With inocu-lation
1	50	35	14	22	707	756	199	219
12	48	45	14	16	671	687	148	169
13	50	68	8	9	418	595	128	174
14	44	48	14	15	594	710	151	174
24		61		8		495		127
New 4	49	37	17	26	822	954	156	187
New 18	56	29	13	24	754	636	221	169

There is no plot without inoculation in No. 24 field. Cultivation was started in 2004 in New 4 and New 18 field and in 2003 in the rest. 1ha=15 Mu. Seed yield is adjusted by 15% of seed moisture content.

(8) Method of cultivation of typical crops (oil sunflower)

Another typical cash crop is oil sunflower there. Oil sunflower has long growth period. Using very early variety with high density is the best production method in the short high latitude area because possible growing period is short. Since renewal of a variety is difficult in a short term, cultivation method using the common variety at present is explained below.

1) Procedure

The flow chart of oil sunflower cultivation is shown in the following figure.

	April	June-July	September
Every year	Irrigation→Tillage→Basal dressing→Sowing	Weed control, Pest control, Topdressing	Harvest

2) Cultivation management

The points of oil sunflower cultivation are adequate management of water and fertilizer. Since sunflower shows rapid growth in flowering period, management of water and fertilizer is especially important in the period.

Item	Contents	Photo
Irrigation before sowing	• Irrigate sufficiently before sowing.	
Plowing	• Plowing depth: 25-30cm.	
Basal dressing	• Compost or livestock excrement: 1-2t / Mu • Urea: 5-15kg / Mu • Phosphoric acid: 10-20kg / Mu • Phosphoric acid is simultaneously applied at sowing. Urea is applied just before the first irrigation.	

Sowing	• Sowing season: From early April to late April. • Sowing rate: 0.6-1.0kg / Mu • Row space: 40-70cm, Hill distance: 10-20cm	
Irrigation	• Standard irrigation interval is 5 to 7 days. Irrigate properly according to the state of soil moisture.	
Topdressing	• Following chemical fertilizers are applied as topdressing during the period from flower bud formation to flowering. • Urea: 10-20kg / Mu	
Harvest	• Harvest at maturity. • 40 - 50 days after flowering, when surface of flower stipule shows dark yellow.	

Points of concern:

Management during the period from flower bud formation to flowering and optimum harvest time

Topdressing is applied during the period from flower bud formation to flowering. Since sunflower shows rapid growth in this period, irrigation and fertilization management in this period is very important.

Optimum harvest time is 40 - 50 days after flowering, when surface of flower stipule shows dark yellow. After flower heads begin to turn to downward, irrigation must not be applied.

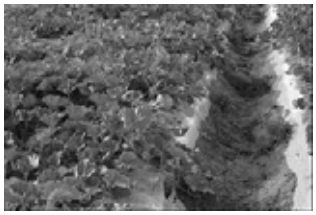
(9) Method of cultivation of typical vegetables (Hami melon)

Hami melon is a typical vegetable successful as a cash crop in the Altay area. Its profitability is high if product has a good quality. Because it has a demand from China whole country as a specialty of Xinjiang. Since buyers usually come from large consumer area, such as a city, products should have a certain amount to sell. Seeing from the side of ease of cultivation, it may be difficult at first, but improvement in productivity and profitability is expected with improvement in technology.

1) Cultivation management

The points of oil Hami melon cultivation are adequate management of water and fertilizer. Water and fertilizer management in flowering period is especially important. Since the fruits sugar content that occupies a part of product value is influenced by water and fertilizer management, and is influenced by ascertaining of harvest time, the skill to them is required for it.

Item	Contents	Photo
Irrigation before sowing	• Irrigate sufficiently before sowing.	
Plowing Ridging Mulching	• Plowing depth: 25-30cm. • Ridging: (Ridge width: 2m, hill distance: 40-50 cm). • Mulch with vinyl sheet.	
Basal dressing	• Compost or livestock excrement: 1-2t / Mu • Urea: 20kg / Mu • Phosphoric acid: 10-20kg / Mu • Phosphoric acid is simultaneously applied at sowing. Urea is applied just before the first irrigation. • SACF (16N-16P-8K): 25kg / Mu can be applied instead of urea and phosphoric acid.	
Sowing	• Sowing season: From early May to early June. • Sowing rate: 2 seeds / hole, 80-120g / Mu	

Irrigation	• Standard irrigation interval is 5 to 7 days. Irrigate properly according to the state of soil moisture. • Irrigate as much as whole ridge surface gets wet.	
Topdressing	• Following chemical fertilizers are applied as topdressing during the period from flower bud formation to flowering. • Urea: 10-20kg / Mu • Phosphoric acid: 5kg / Mu • SACF (20N-10P-10K): 15kg / Mu can be applied instead of urea and phosphoric acid.	
Harvest	• Harvest at half maturity. • When fruit weight reaches standard level. • When sugar content of fruit exceeds 13%. • When fruit surface is covered 70% in nets.	

Points of concern:

Water and fertilizer management in budding, flowering, and harvest time

Topdressing is applied during the period from flower bud formation to flowering. Irrigation and fertilization management in this time is very important.

Since harvest season continues one month or more, attention should be paid about lack of water and fertilizer.

Measure against noxious organisms

Since it is easy to suffer from powdery mildew, pesticide should be applied if needed.

Since a bird is easy to aim at the fruits before harvest, measures against birds should be taken if needed.

(10) Extension method of cash crop production technologies

1) Guidance by extension staff

Agricultural technology extension staff is present closest to agropastoralists who carry out crop production, and can be often asked for advice from them about selection and decision in cultivation. It is important for both to keep communication closely.

2) Utilization of technical books

The knowledge of crop cultivation is acquired from the cultivation manual and books published by the organization in charge of agricultural technology extension. Referring to them with sowing time and so on is important. However, it is important to utilize in consideration of the following things about the amount of fertilizer. (1) Soils often contain only a few organic matters just after reclamation. (2) Materials that can be input with agropastoralist's economic conditions are restricted. In such case, for example, increasing the rate of the organic fertilizer of livestock excrement origin etc., it is effective to devise the kind and quantity of fertilizers.

3) Exchange with a person acquiring technology

When an agropastoralist does not know what to cultivate or how to cultivate just after settlement, it is effective to look for cooperation of person who has an experience. It is also effective to conduct agricultural work together and to study cultivation technologies.

2.4.2 Measures against noxious organisms

At the time herbage, crops or vegetable production is started on a settlement, few noxious organisms that can seriously damage plants immediately will exist on land that was not arable land before settlement. Especially in arid and semi-arid areas, pests are very rare. Nevertheless, measures against organisms that can negatively affect production need to be prepared before damage occurs, because it may be too late once damage has spread. On fields where production has started, weeds and pests frequently will increase with the start of irrigation because the ecosystem and microclimate will shift towards a wetter environment.

(1) Weed control

In crop cultivation on large-scale, it can be usually permitted that weeds grow partially. However, since crop growth might be influenced if weeds become high-density or exceed the height of crops, it is important to prevent weeds from spreading wider.

1) Objective of weed control

The objective of weed control is to certify growth and yield of crops. Suitable weed control is effective also in lowering the weeds density in the following year.

2) Method of weed control

There are a method of using herbicide (chemical control), a method of using intertillage, etc. (physical control), a method of using allelopathy, etc. (biotic control) in weed control. Another method of controlling weeds by improving crop growth (ecological control) is considered more practical and effective. Main methods are to make high planting density and to make crop growth exceed weeds growth by appropriate irrigation.

3) Time of weed control

There is a method of mixing a detergent that inhibits weed growth with soil before planting. When four or five main leaves have emerged, weed control should be carried out if there are many weeds emerged in the field. There are a method of spraying herbicide and a method of weeding using a simple machine, a hoe, and a hand. Crops growth usually exceeds weeds after it. In using herbicide, it is important to select one that does not affect crop growth but has a high effect on weeds, with careful attention to the selectivity of herbicide.

4) Crops and weeds

In soybean cultivation, intertillage and weeding work is easy in early growth stage, and shading in a canopy increases by the growth of stem and leaves in middle to late growth stage. Therefore, cropping system including soybean is considered to generate less weeds. However, if adequate weed control is not carried out, since plant height is lower compared with sunflower and maize, there will be a risk of weed expansion on the contrary. In alfalfa cultivation, cuttings carried out three times per year. This means weeding is carried out before weeds come to maturity to have seeds, and it is effective in lowering the weed density.

Points of concern:

Weed in levee

Weed control is necessary not only in the field but also in levee or canal. If weed control is neglected, levee will be a hotbed of weeds, will spread their seeds, and will increase the weed density in the field in the following year.

5) Japanese dodder

Japanese dodder is annual herbaceous parasitic plant that coils a plant or a low tree. In Altay area, it is a typical weed that reduces the productivity of alfalfa field greatly.

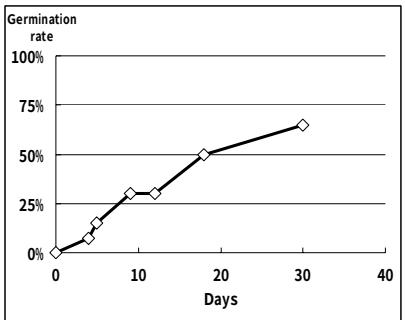


Fig.2.4.2.1 Germination rate of Japanese dodder with moisture.

If it coils around host, parasitic roots will develop and moisture and nutritive substance will be absorbed from host. After developing parasitic roots, main root disappears and the plant separates from the ground.

The seed of Japanese dodder germinates easily by supply of moisture. When there is no supply of moisture, a seed may live in the ground for more than 20 years.

Cuttings are the most effective and labor-less control method. The most effective time of cutting is the period when it coils around host with developing parasitic roots and its main root leaves the ground. When it cannot control by cutting, there is also a method of using herbicide.

Alfalfa with coiled Japanese dodder

The parasitic root of Japanese dodder (that looks notched)

(2) Pest control

Since pathogens (fungi, bacteria, virus, etc.) like moisture in general, their occurrence and spread are restricted in the environment of high solar radiation and few rain in arid and semi-arid area. Although nematodes exist widely in Altay area by a survey, serious damage has not come out yet.

1) Objective of pest control

In the cultivation environment where amount of irrigation and fertilizer can be controlled, pest has the largest influence on production. When damage is serious, nothing may be harvested. Therefore, it is important to limit pest within the permissible range.

2) Method of pest control

Even if control by pesticide is also possible after occurrence, it is better to think a preclusive measure as important for sustainable agriculture. Seed disinfection is also one of the preclusive measures, and has a great effect is especially in the soil born disease. If occurrence of pest is recognized, it is also required to investigate whether there are disease resistance and insect resistant varieties and to cultivate them.

3) Method using pesticide

Once occurrence of pest is recognized, the pesticide against it should be sprayed. In order to prevent pesticides remaining so much in products, too much spraying and spraying of the time beyond proper spraying time should be avoided.

Points of concern:

Prevention of soil transmission of pest

In order to prevent soil transmission of pest in cropping, a slot made between different kinds of crops may be effective. Farm ditch can also be used for this purpose. Crop cultivation of the following year should be taken into consideration based on pest occurrence. When damage is excessive, it is required not to consider a profit but to cultivate a cleaning crop.

(3) Noxious animal control

Since vegetable seedlings tend to receive the damage from rat when they are small just after transplanting, attention should be paid. Wheat also tends to be damaged by rat. When cultivation area is small-scale, the influence of damage is serious, but when large-scale, influence can almost be usually disregarded. In carrying out a kitchen garden, it is necessary to care about that a vegetable seedling receives the damage of

rat. Furthermore, vegetable seedlings have to be protected also from livestock. Soybean tends to receive the damage from birds, such as domestic pigeon, at the time of emergence. Furthermore, seedlings tend to receive the damage from hare at the early growth stage.

1) Objective of noxious animal control

Since existence of a noxious animal reduces crop yield same as weeds and pests, its density should be kept within the permissible range.

2) Measures against rat

Since damage by rat is common, measures against rat are described. Especially the measures in the kitchen garden with a small cultivation scale and serious damage are described. Measures are roughly classified into three types, (1) rodenticide system, (2) rattrap system, and (3) rat repellent system.

In using (1), it is necessary to recognize the danger to a child, livestock, hen, etc. (2) Rattrap system is effective in indoor, but not so effective in outdoors. Although the smell of (3) continues only about one month, (3) is considered more effective compared with (1) or (2).

3) Rat repellent

Substances a rat dislikes are as follows. Pyroligneous acid (wood vinegar), naphthalene, peppermint (Penny Royal Mint, peppermint crystal, dry peppermint, natural mentha oil), a Japanese iris, *Sasa veitchii*, Juniper bush, clove, Tansy, Colchicum, a Japanese horseradish. Among these, naphthalene and peppermint are easy to obtain. An effect is expectable, if a thing like an envelope containing naphthalene or peppermint crystal is put or hung in the kitchen garden.

2.4.3 Sustainable recycling agriculture

When forage production and cash crop production are begun after settlement, one advantageous point compared with simple agricultural management is that livestock manure from livestock farming can be used. Management that uses products and by-products from both agriculture and livestock farming efficiently – i.e., a system that combines livestock farming and agriculture – is resource recycling agriculture. Resource recycling agriculture also is useful for achieving sustainability and stabilizing management. This section describes techniques useful for maintaining the production environment for such crops, rather than the crops or vegetable themselves. They are broadly classified into application of organic matter and cropping systems. Furthermore, although different from cultivation in fields, the kitchen garden method is described as a miniature form of resource recycling agriculture.

(1) Application of organic matters

Application of organic matters has the following effects in general. Since there are generally few organic matters and much sandy soil in the land just after reclamation, holding capacity of nutrient and water is low. Indirect effect is more important in such a place.

Direct effect	Indirect effect
Supply of inorganic nutrients contained in organic matters.	Improvement in physical property of soil.
Absorption of organic matters and effects on the physiological functions.	Increase in nutrient supply capacity.
Promotion of micronutrients absorption through chelate formation.	Effects on soil microbe condition (property).

Points of concern:

Use of organic matters

For efficient use of the organic matter resources, it is necessary to consider the source of acquisition, transport cost, labor work, etc. At this point, if livestock farming is carried out, it is easy to obtain livestock excrements. Moreover, it will take ten years or more to increase soil productivity under low cost management, even if maximum use of the organic matters, such as plant residues in the field is carried out.

(2) Compost production

It is necessary to apply organic matters from the exterior into soil with few organic

matters just after reclamation. When livestock excrements are applied directly into the field, there will be problems such as, (1) mixing of weeds seeds, such as Japanese dodder, and (2) the influence of toxic substances. Therefore, in order to use livestock excrements effectively, completely fermented compost is produced with the purpose of killing seeds and changing toxic substances. It is necessary to consider time and materials in compost production.

1) Procedure of compost production

Acquisition of materials→Piling→Trampling→Mixing upside down→Fermentation

2) Method of compost production

(a) Season

It is easy to produce in spring and in autumn considering the ease of material acquisition.

(b) Materials

Plant residues	Wheat straw, Maize stem, Sunflower stem, Sorghum
Livestock excrements	Cow dung, Sheep dung, Chicken droppings
Water	Irrigation water

Points of concern:

Acquisition and mixture of plant residues and livestock excrement

- Plant residues are easy to obtain in autumn, and livestock excrement is easy to obtain in spring.
- Adjust the proportion of plant residues and livestock excrement. C/N ratio after mixture should be around 30.
- Adjust the water content to 60% after mixture of plant residues and livestock excrements by adding water. (Trampling on the mixture, sounds of water can be heard.)

(c) Method

There are underground method and aboveground one in compost production. Although underground method has a purpose of wind prevention, aboveground method is better if fermentation progress and ease of work are taken into consideration.

Underground

Abovegraound

Plant materials and livestock excrement are piled in layers by turns, and are trampled. It is required to mixing upside down after 1 or 2 weeks to make fermentation uniformly. Mixing upside down is carried out further several times.

(d) Temperature change during fermentation

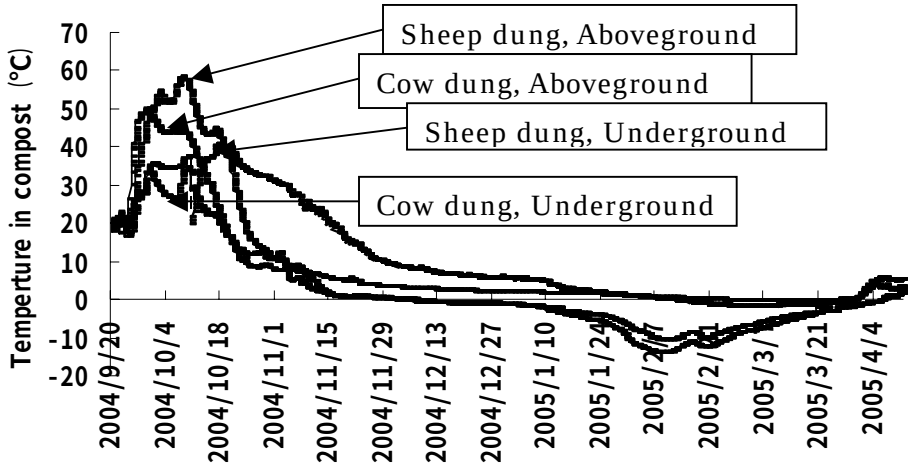


Fig. 2.4.3.1 Difference in temperature changes during fermentation in different materials and methods (Alahake town, Altay city, autumn 2004).

Points of concern:

Difference in temperature change during fermentation in different materials and methods

Temperature rises more rapidly with sheep dung than with cow dung, and high temperature state continues for a longer time (Fig. 2.4.3.1). Temperature rises more rapidly in aboveground method than in underground method. These temperature rises relate to the activity of aerobic fermentation. Temperature rise progresses in aboveground where more oxygen is easy to obtain with sheep dung of higher nitrogen content.

3) Corrugated paper box compost

In case compost is produced on a small scale, put livestock excrements into corrugated paper box with plant residues and water to ferment. Contents should be well mixed by a shovel etc. weekly. When the livestock excrement of barn is mixed with straw, plant residues are not necessary.

(3) Cultivation of green manure crops

1) Objective

Arid and semiarid areas are generally deficient in vegetation, and their organic matter content in soil is very low. In order to carry out crop cultivation in such soil condition, improvement in soil is essential. Green manure crops are the crops grown in order to improve soil. The objectives of green manure crop cultivation are classified into four, (1) improvement in physical property of soil, (2) improvement in chemical property of soil, (3) improvement in biological property of soil, and (4) conservation of environment. The contents are shown in the following table.

Objective	Contents
Improvement in physical property of soil	Aggregation of soil, Improvement in drainage capacity
Improvement in chemical property of soil	Improvement in fertilizer holding capacity, Atmospheric nitrogen fixation, Absorption of soil salts
Improvement in biological property of soil	Formation of the soil biota, Mitigation of soil disease, Control of nematode
Conservation of environment	Landscape beautification, Topsoil protection

The most important thing is restoration of the organic matters to soil in green manure crop cultivation. Restoration of organic matters brings the effects, such as soil aggregation and improvement in fertilizer holding capacity. Cultivation of huge gramineous crops such as maize and sorghum is especially effective for restoration of

organic matters. Since absorption capacity of sorghum is especially high, effects such as absorption of excessive salt by the plant can also be expected.

2) Kind of green manure crops

Kind and main effects of typical green manure are shown below.

Crop	Main effects
Alfalfa	Physical Soil aggregation, Chemical Nitrogen fixation
Sunflower	Chemical Absorption of soil salts, Improvement in fertilizer holding capacity, Conservation of environment Landscape beautification, Topsoil protection
Maize	Physical Improvement in drainage capacity, Chemical Absorption of soil salts, Conservation of environment Topsoil protection
Sorghum	Chemical Absorption of soil salts, Conservation of environment Topsoil protection

Points of concern:

Use of green manure

When organic matters originated from plant increase in the soil, C/N ratio may become high and nitrogen starvation may happen. Take care that the time of plowing in is not just before planting. In case of the crop that is a host of a specific noxious organism, it is necessary to select crops that do not affect succeeding crops.

(4) Crop rotation

Continuous cropping of single crop often reduces productivity. Reasons are the increasing damage by specific pest, deficiency of specific nutrients, and change of physical property of soil worse. In order to prevent them, crop rotation is effective. It is necessary to make a possible crop rotation system including herbages, forage crops, and cash crops, on the basis of feed reservation. When the land just after reclamation contains high concentration of salts, it is effective to make a crop rotation system of cultivating salt absorbing crops, such as sorghum and sunflower as cleaning crops at first.

1) Examples of the effects of crop rotation

It is said that sunflower has an effect to make succeeding crops easy to absorb phosphorus. There is an example that soybean yield in the field following Hami melon cultivation was higher than the others, which is considered that because soybean

absorbed fertilizer ingredient that had not been absorbed by Hami melon.

Points of concern:

Pests

When crop rotation is carried out with including some crops that are the common host of a specific pest, damage may easily spread.

2) Example of crops effective to crop rotation

While cultivating cash crops, by changing the kind of crops an effective crop rotation system is constructed. If leguminous crops, gramineous crops, root vegetables, and others are incorporated with good balance, each characteristic can be efficiently employed.

Crop	Classification	Use of residue	Effect of crops as rotation
Sunflower	Cash crop	Stem and leaves: Fuel, Green manure	Promotion of phosphorus absorption by succeeding crops, Salt absorption
Sugar beet	Cash crop	Stem and leaves: Feed, Green manure	Improvement in physical property of soil, Salt absorption
Soybean	Cash crop		Weed control
Hami melon	Cash crop		Residual effect of fertilizer to succeeding crops
Alfalfa	Herbage		Improvement in physical property of soil, Green manure, Weed control
Sorghum	Forage crop		Green manure、Salt absorption
Maize	Forage crop		Improvement in physical property of soil, Green manure

Points of concern:

Seed spread

In cultivating crops with easy spread seeds in the crop rotation system including tall herbages or crops, take care not to spread seeds so that the succeeding cropping may not be affected. After many seeds have spread to the field, it is necessary to control their germination or to plant tall crops in the following year.

(5) Kitchen garden

Kitchen garden is a small garden using the land in the house to grow vegetables mainly for self-consumption. Since the scale is small, its cultivation management can be more intensive compared with field cultivation. Cooperation of women is easy to be obtained in terms of labor force. In addition, this experience of cultivating vegetables can be applied to the field cultivation in the future. Use of livestock excrement is easy

because barn is close to house. That is, a kitchen garden can be a miniature model of recycling agriculture. Although the concrete cultivation method differs in each vegetable, here is described mainly how to prepare the production environment as a kitchen garden.

1) Objective of kitchen garden

Kitchen garden has a purpose of cultivation of vegetables for self-consumption, and it makes living environment in the settlement comfortable and brings an improvement in a status of women.

2) Procedure of kitchen garden

Land preparation→Water preparation→Selection of crop kind→Seed preparation→Seedling preparation→Sowing→Compost making→Seedling raising→Thinning→Planting bed preparation→Transplanting→Irrigation→Cultivation management→Harvest

3) Necessary tools (what are prepared) for a kitchen garden

Tool	Use
Watering pot	Irrigation
Water tank	Drawing and keep of water
Shovel	Land preparation
Prop	Training and fixation of stem of tomato, eggplant, etc.
Seedling raising pot	Seedling raising from a seed
Corrugated paper box	Making small-scale compost
Fence	Prevention from damage by livestock
Scissors	Harvest

4) Method of a kitchen garden

Land for kitchen garden	Choose a sunny place in the area of house. Approximately 2mx3m area is suitable for a small kitchen garden.
Water for kitchen garden	Checking that water is obtained from a well, a canal, a river, etc. or not before cultivation. Required amount of water is approximately 15 liters per m^2 per day at maximum.
Selection of crop kind	Refer to 2.4.1 Cash crop production（1）Selection of crop kind (p.39)
Vegetable seeds for kitchen garden	Since the seeds produced by own sometimes may not germinate, it is safer to purchase ones in a seed store. Pay attention its production date and validity. When there are too many seeds in a bag for one house, seeds shall be distributed to a group in the neighborhood or be used next year. However, germination rate will decline as it becomes old.
Seedling for kitchen garden	Seedlings raised by yourself from the seed and those raised by the farmer (vegetable village) can be used.
Sowing	Root vegetables and leaf vegetables are suitable to sow directly. Fruit vegetables are suitable to raise seedlings. 
Compost making	Refer to 2.4.3（2）Compost production 5）Corrugated paper box compost (p. 67).
Seedling raising	Seedling is raised in a pot in a sunny place. Indoors is suitable in the season with low temperature. Approximately for 30 to 60 days. 
Thinning	Seedling with inferior growth should be thinned one by one, finally to be one seedling a pot.

Planting bed	Mix the compost well with soil and make the soil as soft as a hole can be made by hand. Make a ridge.	
Transplanting	Make a hole in the ridge, and transplant a potted seedling with pot soil.	
Irrigation	Irrigate to the base of plants every morning or every evening using watering pot.	
Mulch	Mulch given to the base of plants with plant residues is effective to reduce evaporation from soil surface. However, notice that pests can grow easier by mulching. Vinyl film can be used as mulch.	
Cultivation management	Pay attention to irrigation, weed control, and pest control.	
Fence	Especially when livestock is in the barn at cultivation period, fence for livestock should be made. Net, wood, wire net, block, brick, etc. can be used as a material.	
Harvest	Harvest at the optimal time.	

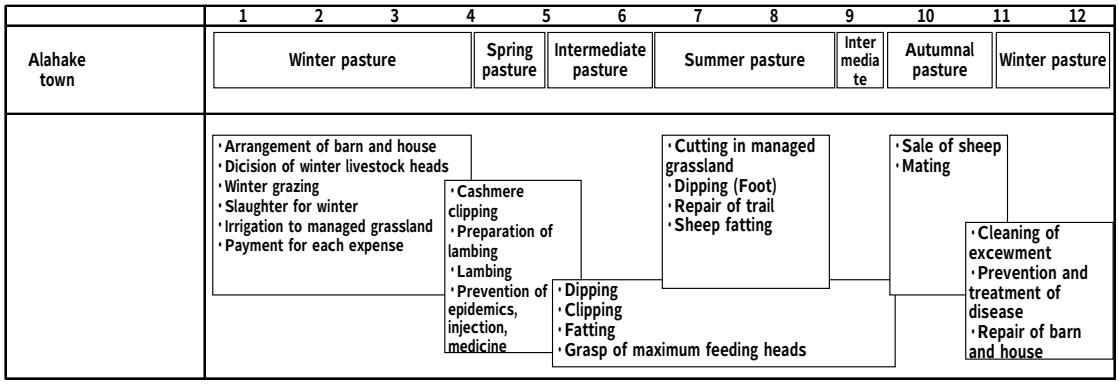
5) Difference between kitchen garden and field cultivation

	Kitchen garden	Field cultivation
Soil condition, Preparation for cultivation	Since it is not suitable for cultivation, apply much of manure and compost.	Suitable for cultivation to some extent by reclamation.
Water	Use well water, canal water, and river water (tap water use is restricted).	Use irrigation facilities.
Works	Much use of human power.	Much use of machines.
Management	Intensive management.	Extensive management.
Livestock excrement	Easy to obtain from barn near the house.	Need to carry by a tractor.
Seedling raising during low temperature season	Use an indoor sunny place (place by the window).	Use a plastic house.

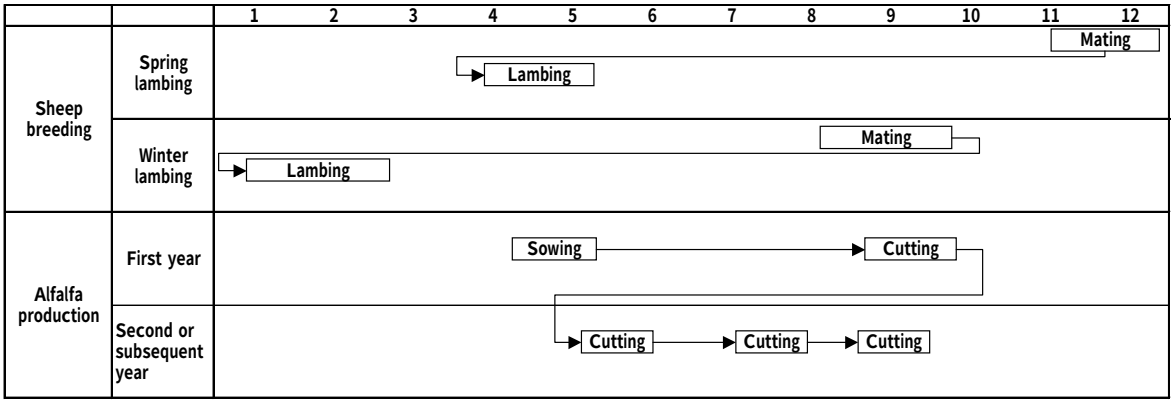
2.5 Sustainable agriculture and livestock farming calendar

Under the diversified farming type, agricultural work and livestock farming frequently overlap. Skillful arrangement of the work schedule is required. Although lambing is usually performed from April to May, this period is also the best time for crop planting. September is the best time for crop harvesting, but also the time for moving from summer pasture (intermediate pasture) to autumnal pasture. If possible, a cropping plan that enables harvesting to be carried out in early September should be prepared.

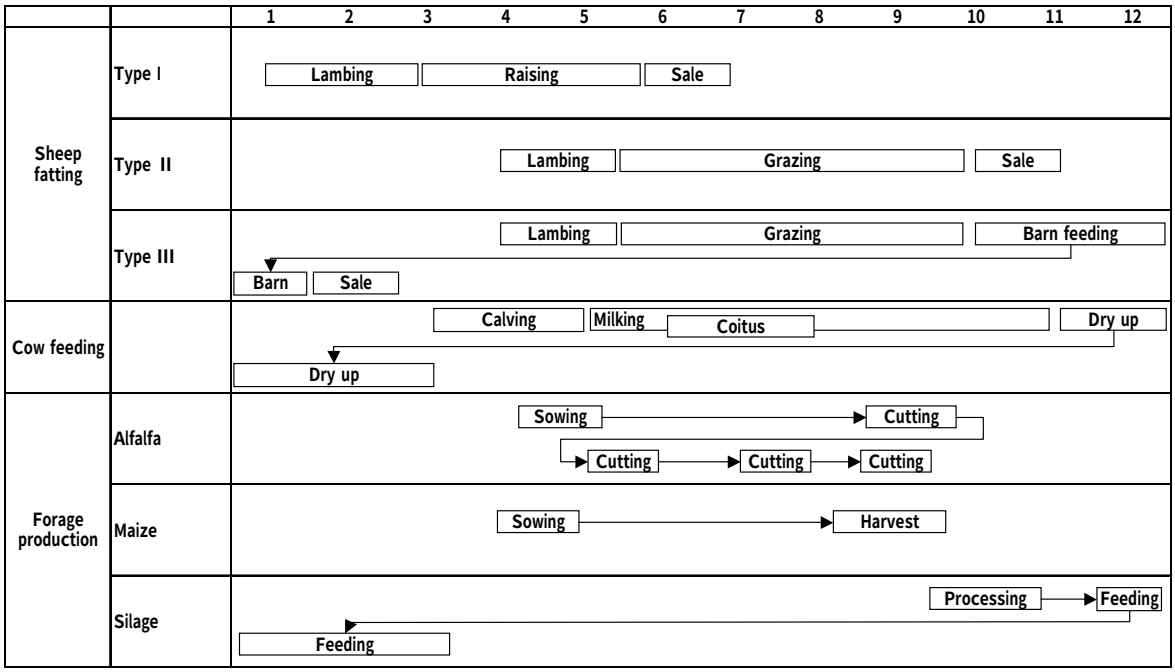
Nomadism calendar



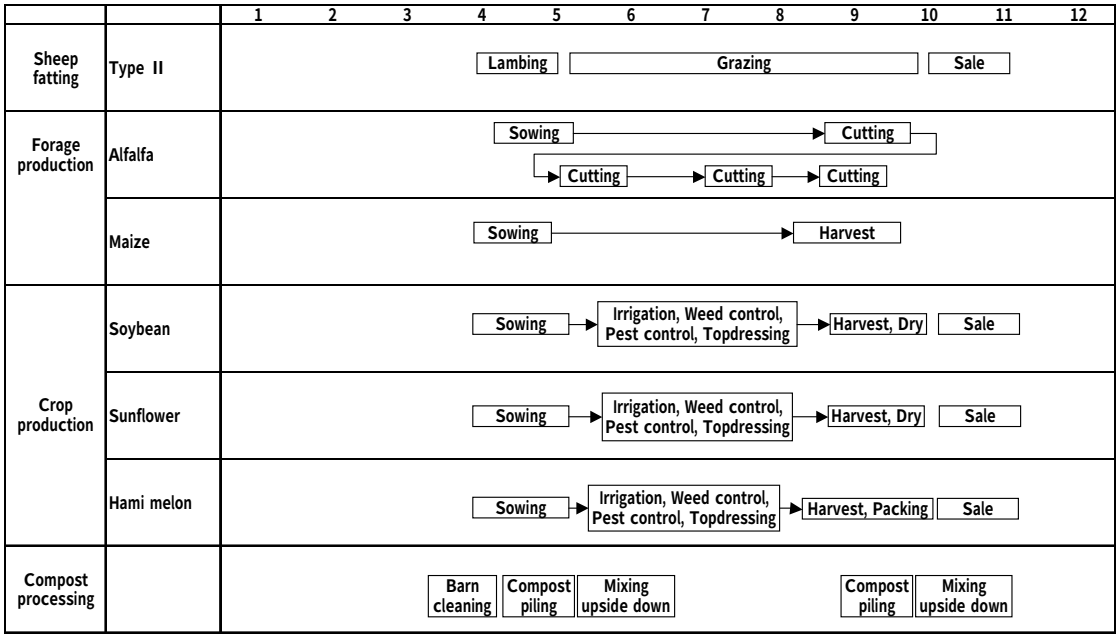
Livestock farming type I



Livestock farming type II



Diversified farming type



Chapter 3 Field Management Techniques

The preceding chapter described the production techniques for feed and cash crops and a farming pattern that will enable agro-pastoralists to develop stable production activities in the settlement.

In this chapter, the points to note for development before farmland reclamation, water use for maintenance and improvement of crop production, and creation of windbreak forest belts for farmland conservation are described as field management techniques that form the base for crop production.

This chapter can be utilized in guidance and extension activities, to ensure agro-pastoralists can utilize these techniques correctly.

3.1 Matters to consider for reclamation of fields on degraded lands

When implementing reclamation of fields on degraded lands in arid and semi-arid areas, especially land with sand hills, careful attention must be given to the method and time of reclamation, because sand storms from fixed or semi-fixed hills, resulting in secondary damage to surrounding land, could occur if errors are made in the manner or time of reclamation. This chapter looks at the example of measures taken for farmland in Habahe County, Altay Area as a model field in the Study on Prevention of Desertification in Arid and Semi-arid Areas in Asia.

3.1.1 Outline

The area called Kerdala where the verification field was reclaimed in Habahe county, Altay region is dotted with various sizes of sand hills and is windy all the year round.

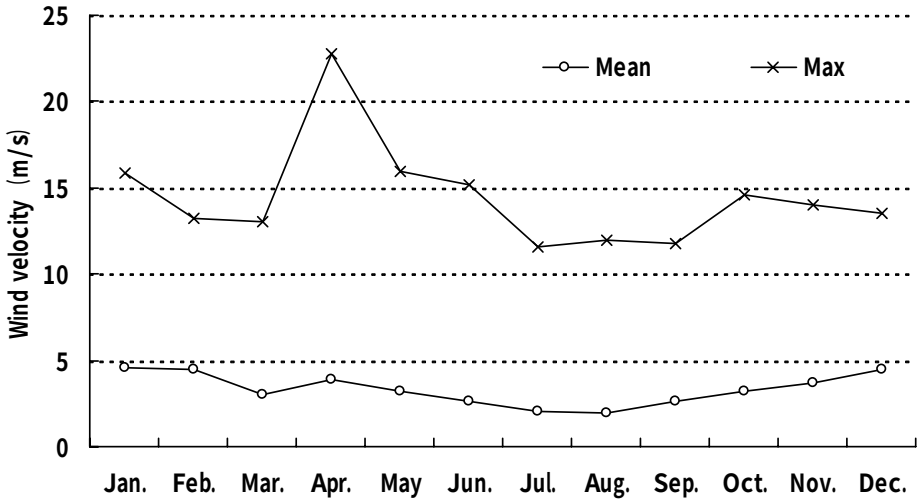


Fig. 3.1.1.1 Monthly mean wind velocity in Habahe county, Altay region (statistical data, 1998 - 2000).

Since *Agriophyllum squarrosum* is grown, the sand hill is in the state of being fixed at present. In the Study on prevention of desertification in arid and semi-arid areas in Asia, irrigation facilities, such as main canal and a branch canal, were built and about 670 ha of farmland were developed in this Kerdala area as a verification field for the settled agropasoralists to begin farming.

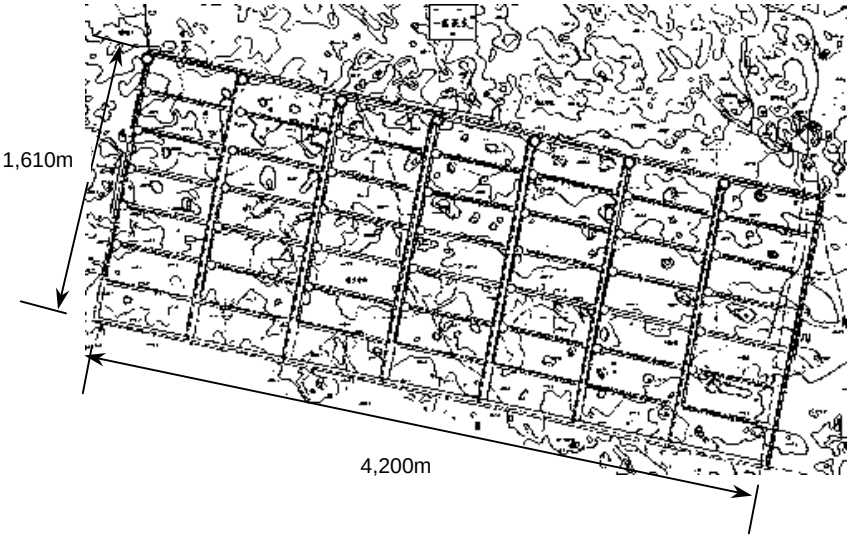
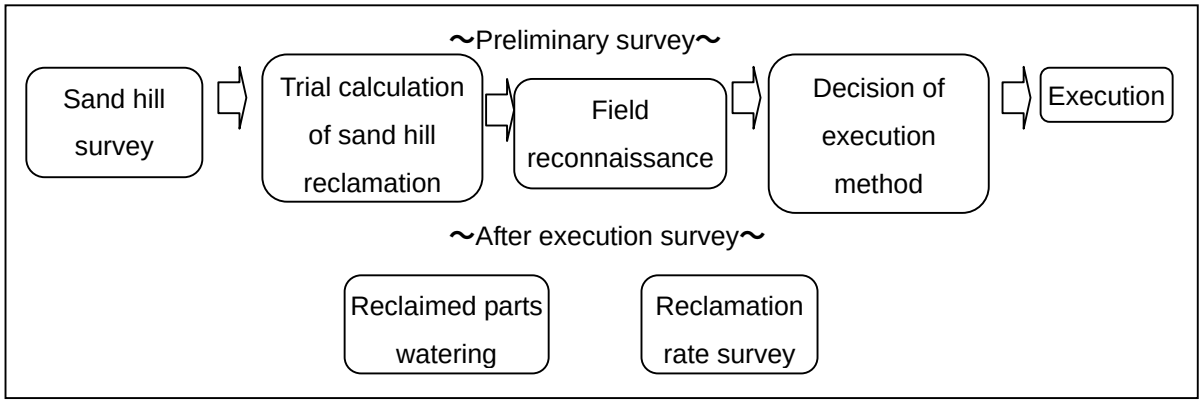


Fig. 3.1.1.2 Plan of Kerdala verification field in Habahe county, Altay region.

A simple preliminary survey and subsequent land grading and leveling by bulldozer is not sufficient for reclamation of sand hill parts. That is because land leveling of sand hill that have been fixed will produce wind draft in response to the influence of a strong wind. Therefore, it is necessary to adopt a construction method that does not produce wind draft as much as possible.

In the farmland reclamation in denuded land, a sand construction method for hill reclamation with less wind draft has been devised. Here, each work process is explained.



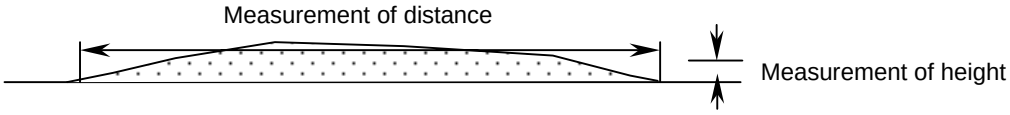
3.1.2 Preliminary survey

(1) Sand hill survey

In advance of reclamation, it is necessary to grasp the present condition of sand hills being dotted. For this purpose, the result of survey is arranged as a sand hill survey plan. The procedure is shown below.

1) Measurement

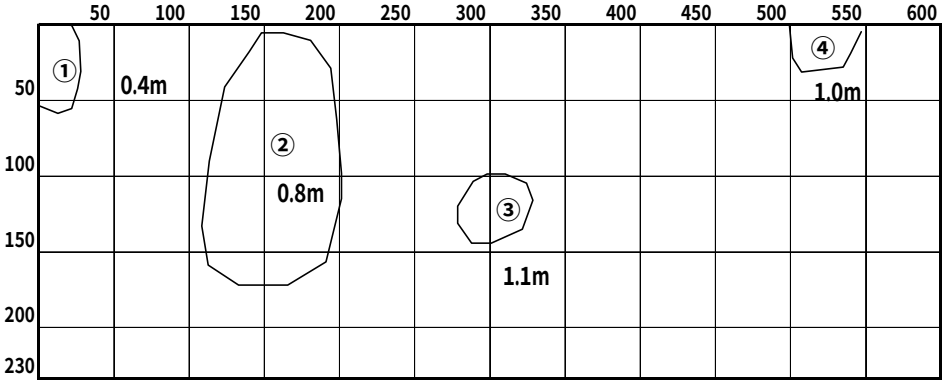
Measure the distance of the both ends of a sand hill. Measure the average height of a sand hill. Then write measured lines in the record paper with the pencil etc. It is good to write a distance line in the record paper beforehand.



2) Treatment of measured results

Calculate the area of each sand hill drawn on the record paper. In that case, if you use an area measuring instrument, planimeter, it is convenient, but without it the area can be obtained by the additive integration of triangular areas. The volume of a sand hill is calculated by the multiplication of area and mean height.

The following figure is an illustration.



Number	Area（m^2）	Mean height（m）	Volume（m^3）
(1)	1,300	0.4	520.0
(2)	11,889	0.8	9,511.2
(3)	1,520	1.1	1,672.0
(4)	975	1.0	975.0
Total	15,684		12,678.2

(2) Trial calculation of sand hill reclamation

It is necessary to level a sand hill as much as possible within the limits of a budget at the time of development. It is good to set estimation in trial calculation of a sand hill, as shown in the following table.

Reclamation rate shows the rate how much the present sand hills should be reclaimed with percentage. After determining the reclamation rate, calculate the reclamation amount.

Reclamation rate	Explanation
100%	100% of sand hills are reclaimed. Applicable to small-scale and convex sand hills.
50%	50% of sand hills are reclaimed. Applicable to small- and middle-scale sand hills.
20%	20% of sand hills are reclaimed. Applicable to middle-scale sand hills.

(3) Field reconnaissance

Since the reclamation rate of each sand hill calculated prior may differ from actual condition of the sand hill, field reconnaissance should be carried out. If there becomes a difference, correct a reclamation rate suitably. The following table is an example of desktop trial calculation prior field reconnaissance and correction after field reconnaissance. The following table shows that field reconnaissance enabled 20% of reclamation of sand hill number 2.

Number	Sand hill volume (m^3)	Desktop trial calculation prior field reconnaissance		Correction after field reconnaissance	
		Reclamation rate (%)	Reclamation amount (m^3)	Reclamation rate (%)	Reclamation amount (m^3)
(1)	520	100	520	100	520
(2)	9,511	0	0	20	1,902
(3)	1,672	50	836	50	836
(4)	975	100	975	100	975
Total	12,678		2,331		4,233

* Reclamation amount (m^3) = Sand hill volume (m^3) x Reclamation rate (%).

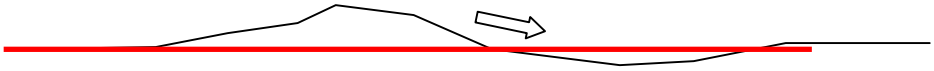
(4) Decision of execution method

Classify sand hills into the ones for land leveling (small scale sand hill) and the ones (small-middle scale sand hill) for push up according to the results of field

reconnaissance, and determine the execution method. Sand hills with 100% of reclamation rate are for land leveling, and the others are for push up. The points of concern in decision of execution method are as follows.

1) Sand hill suitable for land leveling（Small scale sand hill）

(a) Sand hill with a place for land leveling around it.



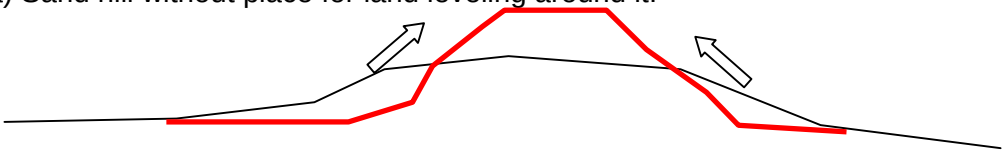
(b) Small scale sand hill less than 1,500 m^3.

(c) Sand hill more than 1,500 m^3 with height of less than 1 m suitable for land leveling. (Sand hill along an irrigation canal).

However, it is better not to conduct land leveling for a sand hill located at the end of field even if the size is less than 1,500 m^3, since it has little value to be utilized.

2) Sand hill suitable for push up（Small-middle scale sand hill）

(a) Sand hill without place for land leveling around it.



(b) Sand hill with height of less than 1.5m.

(c) Single sand hill. In addition, it is better not to reclaim a large scale sand hill or sand hill rows because it is difficult to do.

This construction method has a merit to cut down construction cost through reduction of volume of earthwork movement by bulldozer. It has another merit to increase the effect of wind-draft prevention through sand hill push up, and by afforestation or planting grass on the sand hill surface.

(5) Execution

Execution is carried out based on the results determined by the above. It is desirable to start execution at the time when temperature declines to 4 to 5 degree below freezing point and surface soil has frozen.

Reclamation by bulldozer

After reclamation (middle scale)

3.1.3 After execution survey

(1) Reclaimed parts watering

After reclamation is completed, watering is necessary to the area to contain water in the surface. Without this work, wind-draft will be produced under the influence of a strong wind at the beginning of spring. This is evident from the results of the study, and therefore it is especially an important work after reclamation.

However, even if water is contained in the surface soil, wind-draft cannot necessarily be prevented completely. Since the surface soil may dried by a strong wind and wind-draft may occur as a result, it is desirable not to leave the reclaimed land for a long time, but to plant of crops as soon as possible.

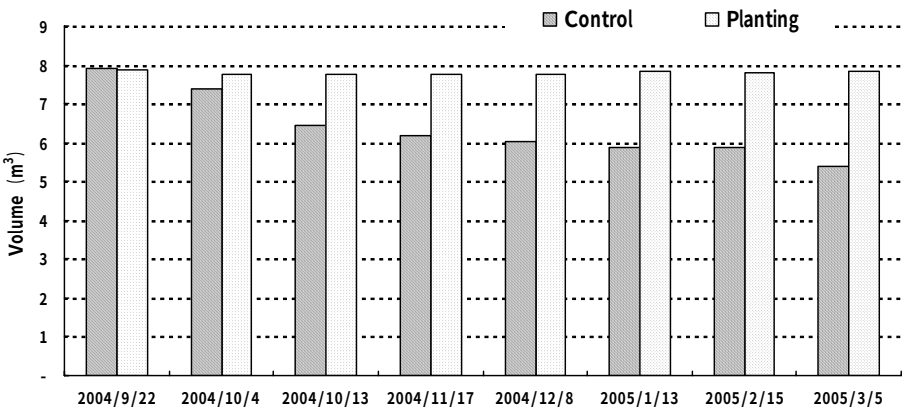


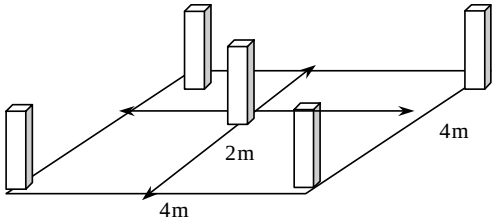
Fig. 3.1.3 Wind-draft situation after sand hill reclamation (Fixed point observation).

* The graph above shows the results of wind-draft observation in the fixed point comparing the plot left without water after reclamation (control) with the plot planted after reclamation. In the control, 32% of sand has been lost by wind-draft in about five months. On the other hand, in the plot of planting, wind-draft has not been produced very much. This shows the importance of watering and planting after reclamation.

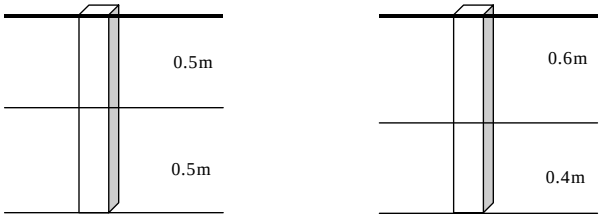
[Reference]

Method of wind-draft survey

a) Five 100cm of wooden stakes are embedded to a depth of 50cm in a 4mx4m square. (Stake number (1-5) is marked on the top, 50cm line is marked on the sides, sand volume is 4mx4mx0.5m=8m^3)



b) Observation record method is to measure the distance from the base line (the upper end of the stake, shown as thick line) to the sand surface by ruler. (Example is as follows)



Reading: 50cm after about 30 days→ Reading:60cm

* It means that wind-draft occurred in this case. If reverse, it means that wind-draft accumulated.

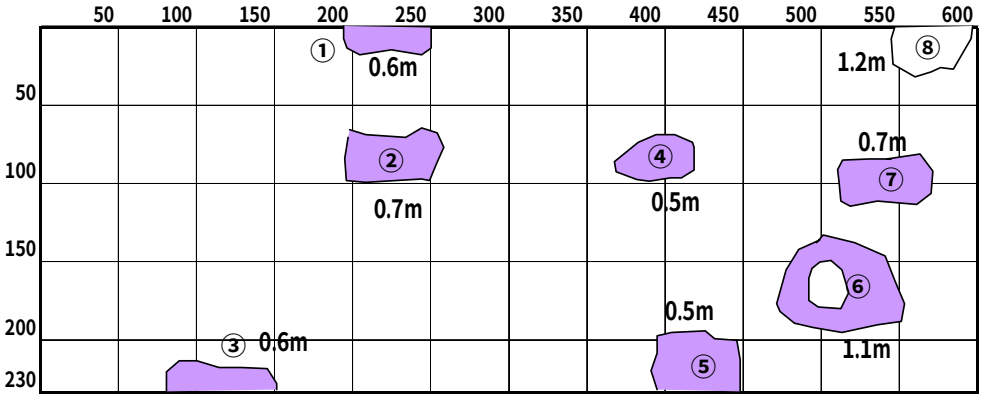
c) Record paper (example)

Observation place: Plot without water after reclamation

Observation date	Observation time	Weather	Reading of the stake length (cm, stake numbers)					Snowfall (cm)	Volume (m^3)
			1	2	3	4	5		
9/22	12:08	Cloudy	50.3	50.6	50.8	50.6	50.3	-	7.92

(2) Reclamation rate survey

Reclamation rate survey is carried out in the reclaimed field in order to grasp the quantitative area available as farmland. It is a sand hill survey with the same procedure after reclamation. An example of the results of reclamation rate survey carried out in Kerdala is shown below.



（Unit：m^2）

Sand hill number	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	Total
Before reclamation	750	2,000	1,600	1,500	1,800	3,750	1,750	1,250	14,400
After reclamation	0	0	0	0	0	840	0	1,250	12,090
Difference	-750	-2,000	-1,600	-1,500	-1,800	-2,910	-1,750	0	-12,310

3.2 Water supplies for maintenance and improvement in production

It is difficult to carry out farm management without irrigation in arid and semi-arid areas, because evaporation exceeds year-round precipitation. Agro-pastoralists have little experience with irrigation technology, however, and frequently irrigate extensively in the beginning.

For effective use of limited water resources, agro-pastoralists themselves should efficiently carry out the irrigation work. Improvement in yield of forage crops for winter feed or cash crops can be expected as a result.

This section introduces the improvements to water management in the fields in Alahake Town, Altay City that were made to enable agro-pastoralists to perform irrigation work efficiently.

3.2.1 Improvement in field water management

Irrigation refers to supplying water to a field artificially, and is classified into upland irrigation and lowland irrigation depending on the crops. Upland irrigation is the principle of supplying water intermittently, utilizing the water retention capacity of the effective soil layer.

This section gives an outline of the irrigation system in upland fields. Because the irrigation method is closely related to the water supply at the farm level, and affects the cost for water canal facilities and maintenance, the most suitable irrigation method for an area should be decided by examining the location, farming conditions and water supply situation.

Table 3.2.1.1 Irrigation method and outline.

Irrigation method	Outline
Sprinkler irrigation	It is a method to inject pressure water from a nozzle, like raindrops or mist. It can be suitable to the different purpose for water supplies and crop kinds, if the form of sprinkler, application water pressure, and height of the riser are changed. There are few restrictions by geographical feature or soil.
Perforated pipe irrigation	It is a method to water linearly along perforated pipe or perforated hose with pressure. Watering distance is shorter although application water pressure is lower than sprinkler irrigation.
Drip irrigation	It is a method to supply waterdrop gently to limited positions, such as just around crops, from dropping holes with a special structure punched at emitters or dropping pipes attached in the dropping pipe at the fixed interval. Application water pressure is quite lower than sprinkler irrigation.
Furrow irrigation	It is a method to flow water from the upper side end to the lower side end of the furrow and to infiltrate in the furrow. Since it takes time for water arrival to the lower side end of the furrow, unevenness of infiltration depth of water along the furrow is unavoidable. There are restrictions by geographical feature or soil.
Border irrigation	It is a method to infiltrate water with thin-layered flow for whole surface from upper side end of the divided strips in flat or gently inclined field. Although it is suitable for the crops with high density by broadcast sowing, land leveling of the field is required.
Contour ditch irrigation	It is a method to infiltrate water by shielding of the branch canal along a contour line to overflow water to the lower side of inclination in sharply inclined field. Branch canal perpendicular to the contour line is shielded to overflow water in gently inclined field. A distribution of overflow water is infinite form water application efficiency is low.
Basin irrigation	It is a method to infiltrate water by flooding in a division enclosed with ridges. Ridges are made to enclose whole field or for an example area around a fruit tree partially.

Application condition and its range of each irrigation method are shown in the following table.

In developing countries, furrow irrigation and border irrigation are often applied as surface irrigation because of the ease of irrigation technology. However, these irrigation methods have low water application efficiency (rate of irrigation water stored in the soil in effective soil layer) as low as 55% - 75%, less than 60% especially several years after

reclamation. Furthermore, since water resources in arid and semi-arid area limited, they must be used efficiently.

Table 3.2.1.2 Application range of each irrigation method.

Irrigation method	Inclination of field	Soil and basic intake rate	Applicable crops, others
Sprinkler irrigation	There are few restrictions.	Almost all soils. Ib＞5mm/hr	It is applicable for all crops and fruit trees. However, to some leafy vegetables and fruit vegetables, disease may occur frequently.
Perforated pipe irrigation	There are few restrictions.	All soils except extreme clay. Ib＞15mm/hr	Applicable crops are the same as sprinkler irrigation. Since watering intensity is high and watering distribution are in rectangle, there is little necessity of overlapping watering area.
Drip irrigation	There are few restrictions.	All soils	Applicable to all crops. Since nozzle hole is fine, it is easily closed by dust, and the protection measure against it is required.
Furrow irrigation	Less than 5% Less than 27% in Contour furrow irrigation	Clay, loam with low water permeability Ib＜75mm/hr	It is applicable to ridge culture crops and fruit trees. However, in high water permeability soil, water application efficiency is low, and it is not practical.
Border irrigation	Less than 5%	Clay, loam with low water permeability Ib＜75mm/hr	It is suitable for broadcasted crops such as herbage. It requires uniform inclination of land, land leveling in the perpendicular direction of water flow, and large flux.
Contour ditch irrigation	14～50%	No restrictions	It is applicable to crops with high density such as herbage. However, water application efficiency is remarkably low. If irrigation efficiency is neglected, it can be applied to land with complicated geographical feature.
Basin irrigation	0.2%	Clay Ib＜75mm/hr	It is applicable to fruit trees and grass in paddy field. It is suitable for flat land and low water permeability soil.

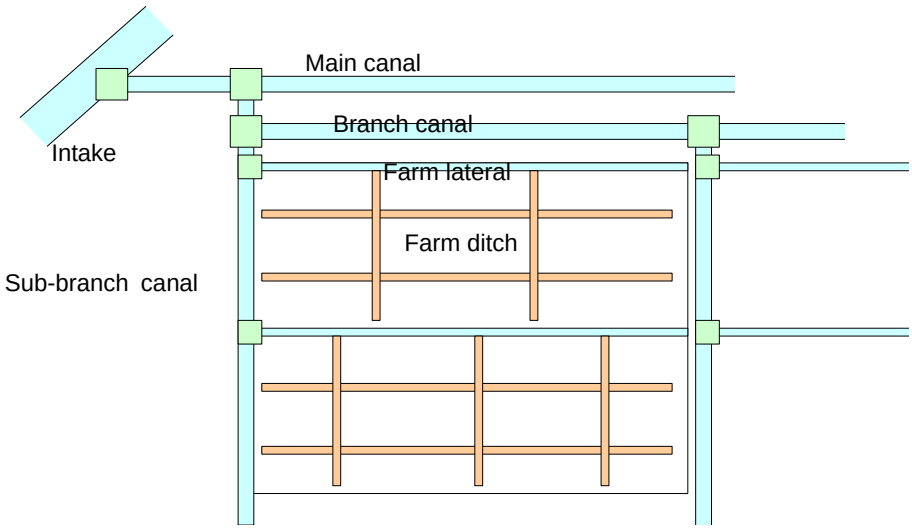
* Intake rate: It is infiltrated amount of irrigation water or rain water from soil surface in unit time. It is an index of water permeablity in unsaturated soil, and is an important factor of the determination of irrigation method and optimum irrigation intensity in upland irrigation.

Furrow irrigation

Border irrigation

Contour ditch irrigation

Generally, irrigation water is distributed from main canal through sub-branch canal and farm lateral (earth canal) to the field as shown in the following figure. In the field, irrigation is carried out according to crops through farm ditch.



Improving the water supply in the field will lead to improvement of crop yield. High yield and water management technology have a close relation. However, in case of agropastoralists unfamiliar to irrigation, there are many problems such as over irrigation or not reaching of irrigation water to the end.

Following is an explanation what works for agropastoralists to do for adequate water use and for improvement of crop yield.

(1) Preparation before sowing

1) Objective

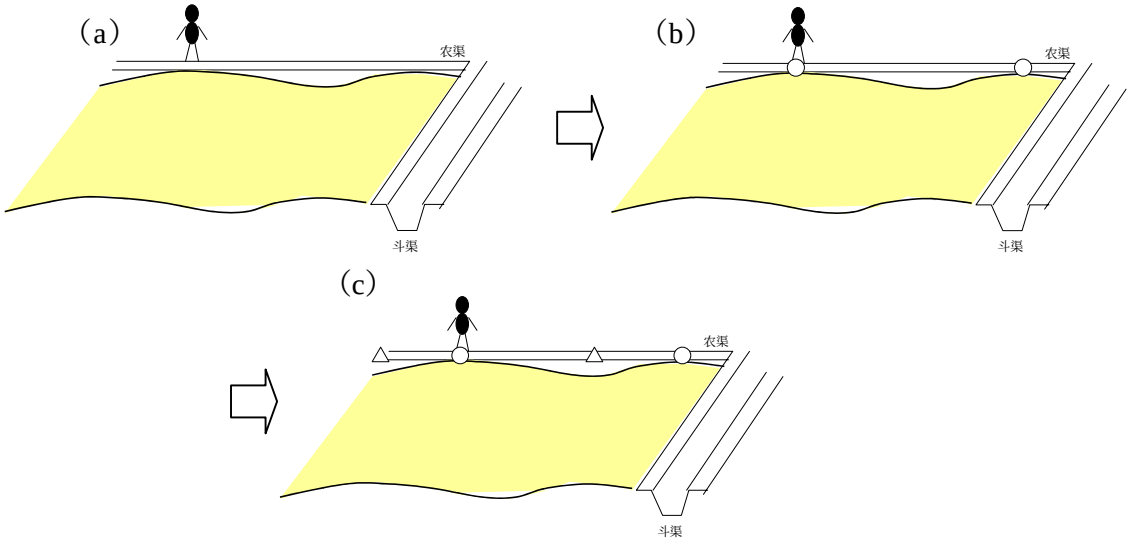
Reclaimed land from denuded land often leaves original relief parts because complete leveling is impossible. In order to dismiss this, there is a method of leveling by bulldozer, but it is expensive. A technical solution method to this problem is to construct a farm ditch that enables to irrigate whole field. Here is described mainly how to construct farm ditch in a relief land as preparation before sowing. These contents are described also in the “handbook for agropastoralist” for agropastoralists to carry out by themselves.

2) Method

(a) Grasp the relief situation of the land by walking along a farm lateral and overlooking the whole field.

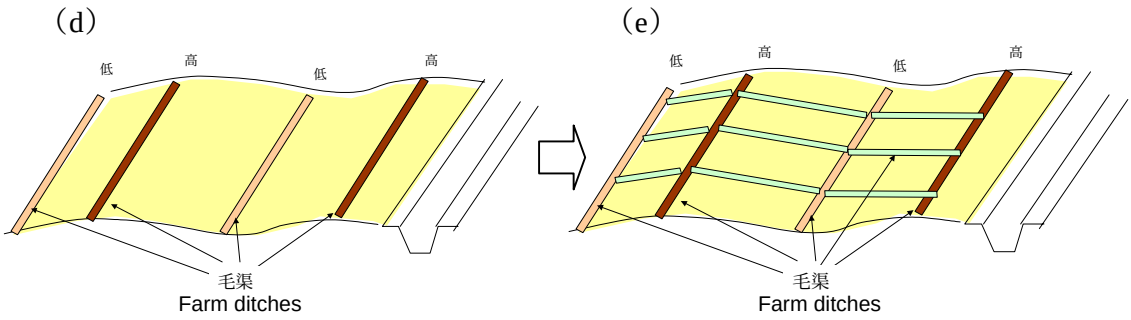
(b) Decide the turnout position of a farm ditch at the higher place of the relief. Turnout positions are shown as O in the following figure. It is good to put a mark by a stone, timber pile, etc.

(c) Decide the turnout position of farm ditch in the lower place of the relief. This has a role of drainage. Turnout positions are shown as in the following figure. The appropriate interval is less than 50m in a relief land and less than 100m in a flat land.

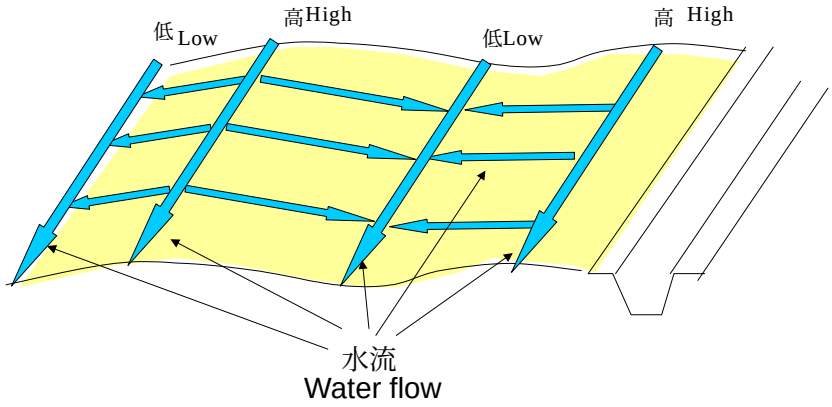


(d) After turnout positions are determined, construct farm ditches at a right angle to the farm lateral.

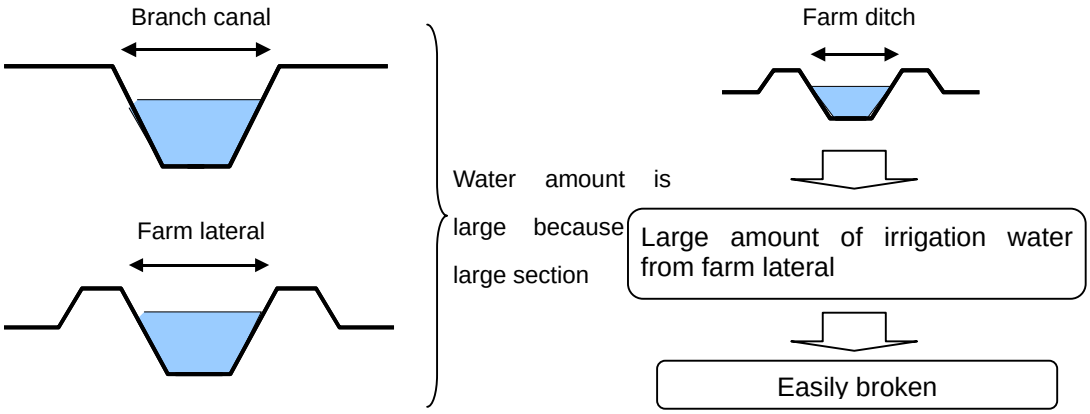
(e) Then construct farm ditches also in a parallel direction to the farm lateral.



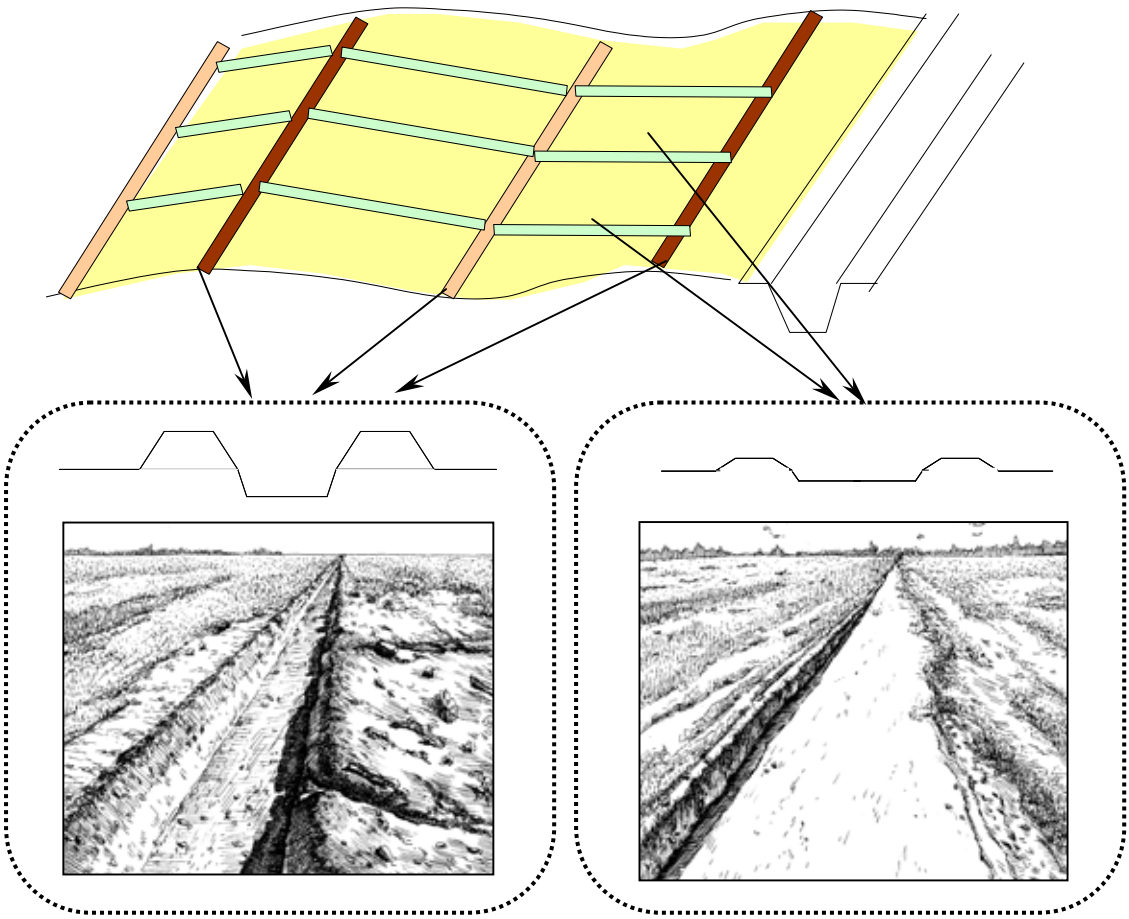
(f) By constructing these farm ditches, water flows as shown in the following figure, which will supply irrigation water to the whole field.



(g) Then, the section of farm ditches is explained. Irrigation canals located close to the field are a branch canal, a farm lateral, and a farm ditch. Since a branch canal and a farm lateral have relatively larger section, they have much amount of water. However, since the section of farm ditch is small, when water is directly taken from farm lateral, since farm ditch receives a lot of water, it may be broken easily.



Therefore, in case of the direction perpendicular to a contour line, since a lot of water flows into the field, firm ditch should be firmly constructed with deep section. In case of the direction parallel to a contour line, since there is small quantity of water in it, the farm ditch with a small section is sufficient. Thus, if a section is made properly according to the geographical feature, a farm ditch will become hard to break.



Points of concern:

Since farm ditch is an earth canal, it is often broken by autumn when irrigation stops. Therefore, it requires repairing in the following year before irrigation at the beginning of spring.

With experiences agropastoralists will get used to these works, however, it is desirable to guide agropastoralists just after settlement by training at the beginning of spring.

(2) In Beginning irrigation - Efficient irrigation in the field block -

1) Objective

Irrigation work in the field is very difficult for agropastoralists. Here is introduced very easy irrigation work method for turnout and shielding to the field (1) with less labor force, (2) with less time, and (3) convenient.

2) Method

There are mainly four types of intake from farm lateral to farm ditch as follows.

(1) Cutting and banking of farm lateral

(2) With accumulated stones

(3) With concrete board

(4) With pipe

Comparison of these four types from easiness and cost is shown in the following table.

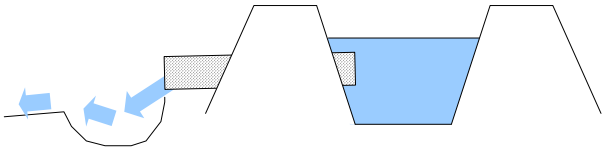
Classification	Easy making	Maintenance and durability	Cost	Easy receiving
(1)Cutting and banking	△	×	○	○
(2)Small stones	○	△	○	○
(3)Concrete boards	×	○	×	×
(4)Pipes	○	○	×	×

○：good △：not so good ×：bad

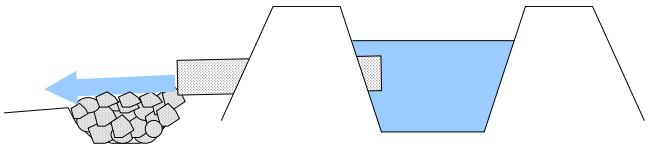
Note in case of using concrete boards or pipes: it is recommended to fill up a hole with small stones or sandbags, when erosion has occurred by the power of water and a hole has opened (Figure: Before repair), by using of concrete boards or pipes.

This work should be repeated several times until small stones are firmly contacted to the soil (Figure: After repair).

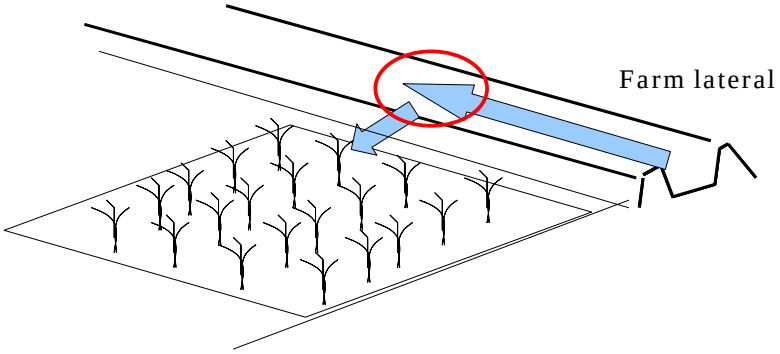
Before repair



After repair



As shown in the following figure, when irrigation is only required in a plot, it is necessary to shield water so that water may not go to the other unnecessary plots (O mark). The most efficient method in the shielding ones is to shield with a sheet covered on a timber stick with the length of the cross sectional width of a farm lateral. The merit of this method is to require much less labor force comparing with the method of banking for shielding. However, there is a demerit not to shield completely. The shielding method by a sheet is easily carried out as the following photographs.



Points of concern:

It is desirable to use pipes for intake. Because,

(1) Cutting and banking require a lot of labor force.

(2) Cutting is easy to break.

(3) Since the section of pipe is smaller than that of concrete board or cutting, it can be shielded by covering with familiar materials, when unnecessary.

(4) It does not take time and effort for maintenance.

However, when material, such as pipes or concrete boards, is hard to obtain, it is necessary to use small stones easy to obtain instead of them. Furthermore, since pipes are easy to be stolen, it is desirable to fix them with concrete around them.

Method with efficient and easy work has a merit acceptable to agropastoralistsits in extension.

(3) Water management after sowing - Water consumption and farm ditch -

1) Objective

When upland irrigation is implemented, the most fundamental values are field capacity, allowable soil water depletion, effective soil layer, and consumptive use of water. These are called irrigation water requirements. However, it is very hard to obtain the known values of irrigation water requirements for the reasons of financial or technical constraint in developing countries. Therefore, “FAO (Food and Agriculture Organization) irrigation and drainge paper 56” is usually used.

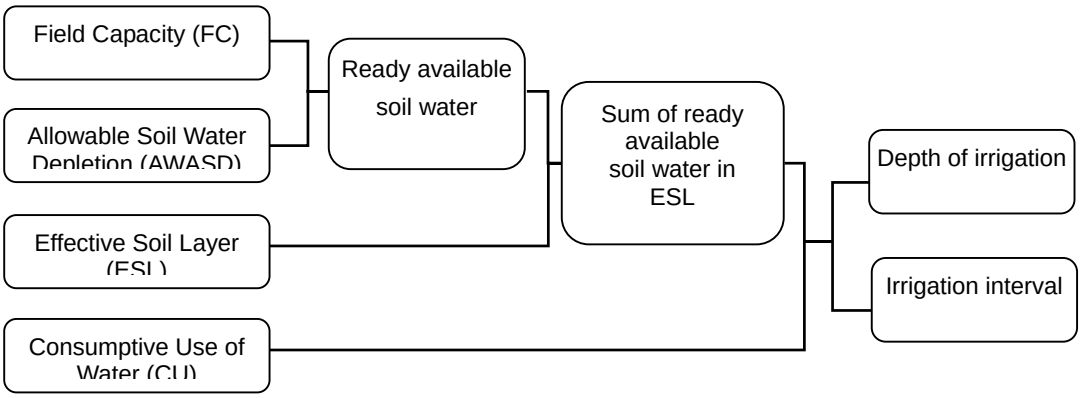


Fig. 3.2.1.1 Procedure of irrigation planning.

Hereafter, water supplies in the field, especially points of concern in the irrigation in relief areas are explained, based on the general concept of irrigation water requirements and experimental results by application of the soil moisture depletion method in the verification field of “Study on prevention of desertification in arid and semi-arid areas in Asia” in Altay city, Altay area.

2) Definition of irrigation water requirements

Irrigation water requirements are explained with a model that considers soil as a moisture reservoir.

After the moisture supplied by irrigation or rain is stored in soils to the upper storage limit of a soil moisture reservoir, it is slowly consumed by evapo-transpiration. When the water level of a soil moisture reservoir reaches the lower storage limit after several days, it becomes impossible to consume water any more. The next irrigation is required at that time. The required irrigation amount of water at that time is equal to the capacity of a reservoir. Values necessary for planning and management of irrigation are " when (irrigation interval) and how much (depth of irrigation) to irrigate”. The fundamental values that determine them are the capacity of the soil moisture reservoir and consumptive use of water.

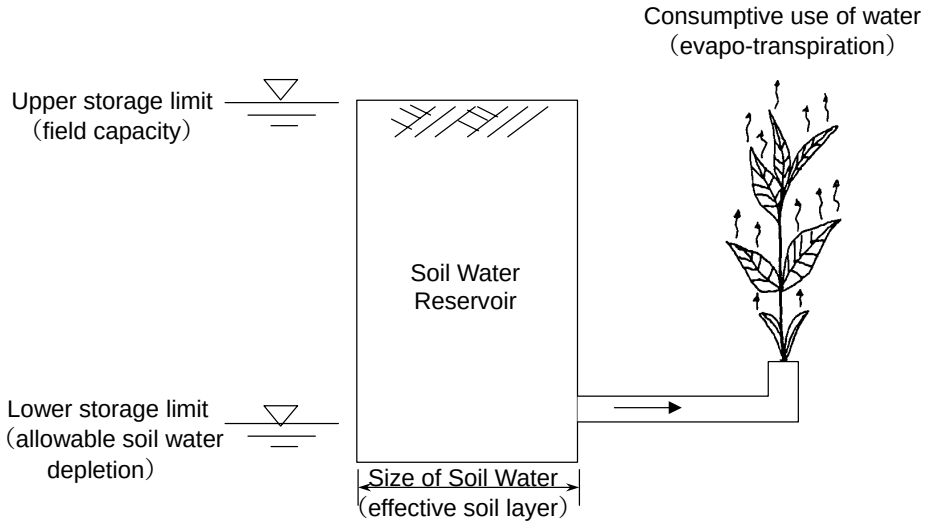


Fig.3.2.1.2　Schematic illustration of soil water reservoir and irrigation water requirements.

The capacity of a reservoir is determined by the upper and lower storage limit of the reservoir, and size of soil water.

Therefore, the most fundamental values are the upper and lower storage limit of the reservoir, size of soil water, and consumption use of water. They correspond to field capacity, allowable soil water depletion, effective soil layer, and evapo-transpiration, respectively.

[Terminological description]

(a) Field capacity:

Field capacity is the moisture content of the steady state that the drainage speed from soil layer becomes as small as evapo-transpiration rate in the soil layer without influence of groundwater level after a lot of rain or irrigation. It means the upper limit of soil moisture in the soil layer crops can use.

(b) Allowable soil water depletion:

Allowable soil water depletion is the soil moisture content that shows water deficient state inhibiting normal growth of crops, and is different with soils or crops. Allowable soil water depletion is usually used for the irrigation starting point.

(c) Effective soil layer:

Effective soil layer is the soil layer in a range of water consumption by soil surface evaporation, water absorption of crop roots, and capillary action during continuous sunny days prolonging about irrigation interval.

(d) Consumptive use of water:

Consumptive use of water is depletion of water in effective soil layer during the period starting from field capacity state until restricted soil layer reaches a allowable soil

water depletion.

3) Method

Soil moisture depletion method is one of the actual measurements of consumptive use of water. It is a method that determines amount of soil moisture lost by evapo-transpiration through measurement of moisture depletion in each layer divided in the vertical direction. Measurement with soil moisture depletion method in Japan is shown below as a reference.

[Reference]

1) Actual measurement starts when all soil layers reach the water holding capacity after 24 hours. The sites for measurement should have absorptive roots distributed uniformly, and 10cm from a stump.
2) Soil moisture is measured in principle at the depth of 5, 15, 25, 35, 50 and 70cm. If soil layer observation shows the effective soil layer to be thin, the measurement of soil moisture at deeper layer can be omitted.
3) Measurement is applied to all the field for irrigation. At the same time, rainfall and pan evaporation are measured. The measurement time is around 9 a.m. every day.
4) Daily consumptive use of water Σ*en* is calculated from daily measured soil moisture at the effective soil layer using the following formula.

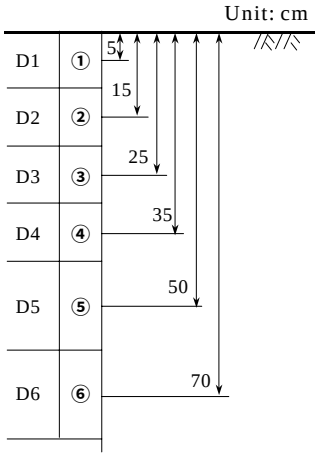
$$\sum en = e1 + e2 + \cdots\cdots\cdots + en$$

$$e1 = \frac{1}{10} \times \left(M_1 - M_1'\right) \times D1$$

$$e2 = \frac{1}{10} \times \left(M_2 - M_2'\right) \times D2$$

$$\cdots\cdots\cdots\cdots\cdots\cdots$$

$$en = \frac{1}{10} \times \left(M_n - M_n'\right) \times Dn$$



*D*1、*D*2・・・・*Dn*：Thickness of each layer (cm)
*M*1、*M*2・・・・*Mn*：Measured soil moisture of the day at each layer (volume%)
*M*1’、*M*2’・・・・*Mn*’：Measured soil moisture of the next day at each layer (volume%)
*e*1、*e*2・・・・*en*：Soil moisture consumption at each layer (cm)

Theory and measuring method of irrigation water requirements have been shown above. Hereafter, actual irrigation in the field, especially water supplies in the relief areas are explained, based on the experimental results in the verification field of “Study on prevention of desertification in arid and semi-arid areas in Asia”.

(a) Irrigation interval

a) Present condition

The calculation results of monthly averaged consumptive use of water measured by soil moisture depletion method in Alahake field in Altay city are shown in the following table. In the first year of the experiment, irrigation interval was left to agropastralists in order to grasp their irrigation situation at that moment. Material was maize, a forage crop.

Table 3.2.1.3 Calculation results of monthly averaged consumptive use of water (maize, 2004).

Month	Calculating conditions				ZFP	CU/d	SMEP (%)					CU/Epan
	Days	Cycles	Epan/d	pF Range	(cm)		1	2	3	4	5	
May	6	1	9.3	2.18-2.27	21	0.8	30	25	17	19	9	0.08
June	13	3	13.1	2.06-2.23	46	2.2	30	21	19	21	9	0.17
July	6	2	10.6	2.02-2.33	40	3.2	26	23	24	20	7	0.30
Aug	20	4	9.6	2.00-2.40	45	3.0	30	20	22	19	9	0.32
Sep	7	2	8.7	2.02-2.25	45	2.4	20	17	28	25	10	0.27

Notes)

(1) When rainy days with more than 5 mm/d were included in a cycle, they were removed from calculation of consumptive use of water because it was judged that evaporation conditions were disturbed.

(2) When the sum of days during the calculation period in one month was less than five days, monthly average was not calculated because it was judged that the number of basic data was insufficient.

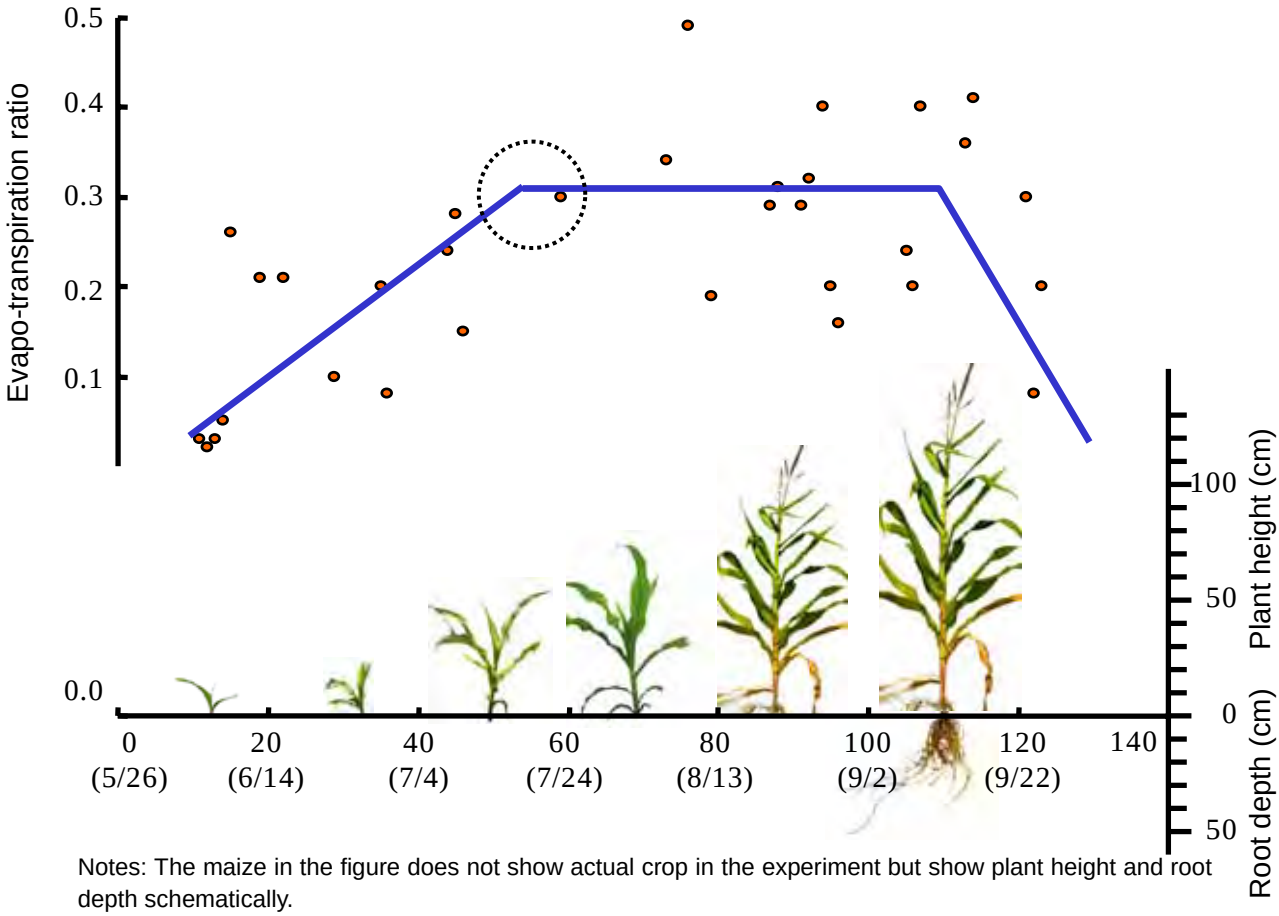
(3) Since the depth that root zone developed most greatly was 15cm, this depth was set as the standard depth, and pF at 15cm depth was measured.

(4) ZFP (zero flux plane) is the border plane of water between upward region by evapo-transpiration and downward region by gravity drainage. Soil layer from earth surface to this ZFP was used for effective soil layer.

(5) Soil moisture extraction pattern (SMEP) shows proportion of moisture extraction by each soil layer.

(6) CU/Epan shows a ratio of monthly average consumptive use of water to monthly average pan evaporation. Monthly average pan evaporation was calculated from the pan evaporation during the period for calculation of consumptive use of water.

Relationship between growth atage and evapo-transpiration ratio is shown in the following figure.



Notes: The maize in the figure does not show actual crop in the experiment but show plant height and root depth schematically.

Fig. 3.2.1.3 Relationship between growth stage and evapo-transpiration ratio (maize, 2004).

As shown by the dotted circle in the above figure, evapo-transpiration ratio reached maximum on 60 days after sowing. That was around the booting stage and thereafter the crop required largest water. However, by middle September, evapo-transpiration ratio declined. It was because crops usually stop their growth in the later growth stage with decline of consumptive use of water.

b) Corrective strategy

Based on the results obtained in the first year, irrigation interval was set to 4 days in the experiment in the second year (irrigation every 5 days), and was maintained until middle September. Irrigation interval was also set to 4 days before emergence.

As a result, calculation of consumptive use of water, relationship between growth stage and evapo-transpiration ratio were as follows, respectively, and the growth state was obviously better than that in the first year. Yield was 534 kg/a that can be the proper amount for storage as winter feed. Yield was determined as fresh weight (stem and leaves + ears) in this case on 118 days after sowing. (While target yield was 150 kg/a in dry weight, results of the experiment was 534 kg/a (fresh weight) x0.25 (general

conversion coefficient) =134 kg/a.)

Therefore, by maintaining irrigation frequency every 5 days, consumptive use of water will increase and obtain high yield.

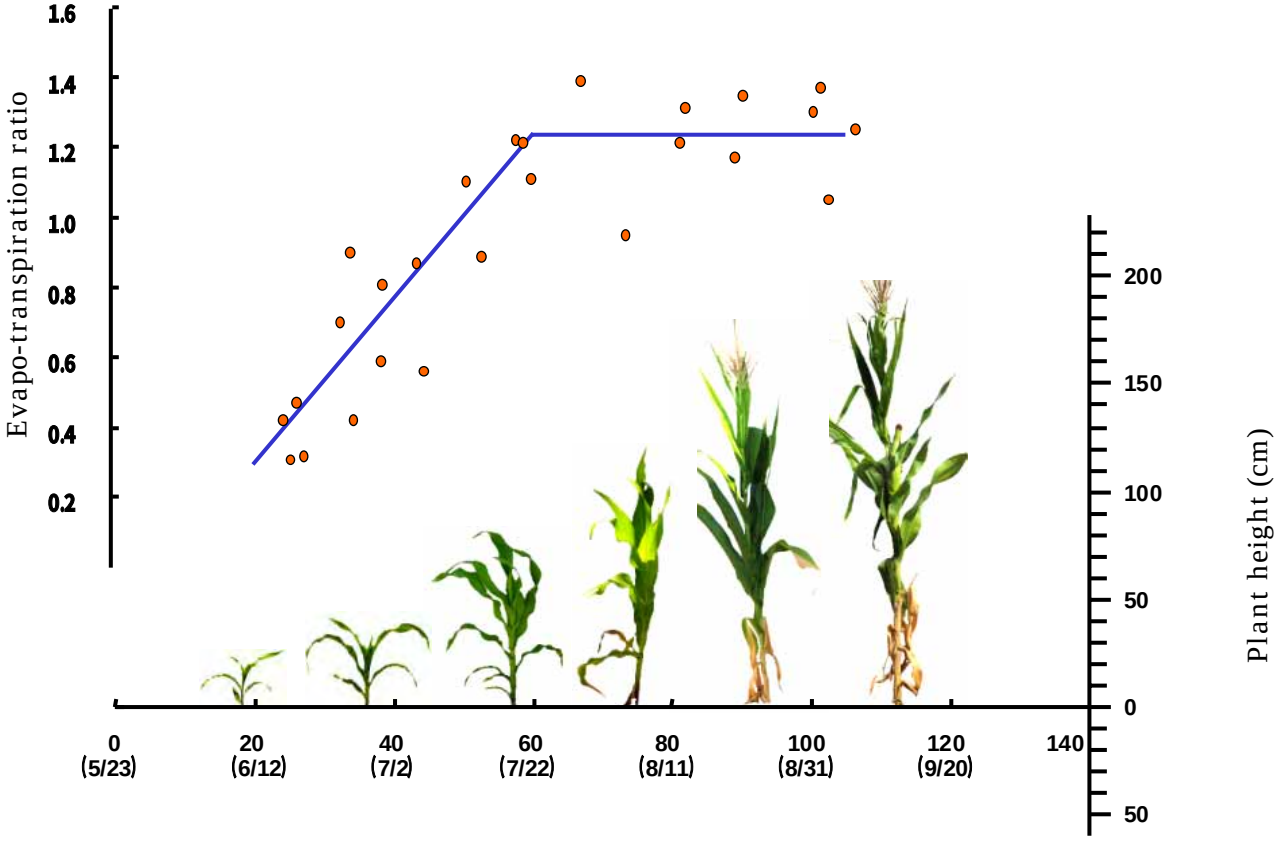


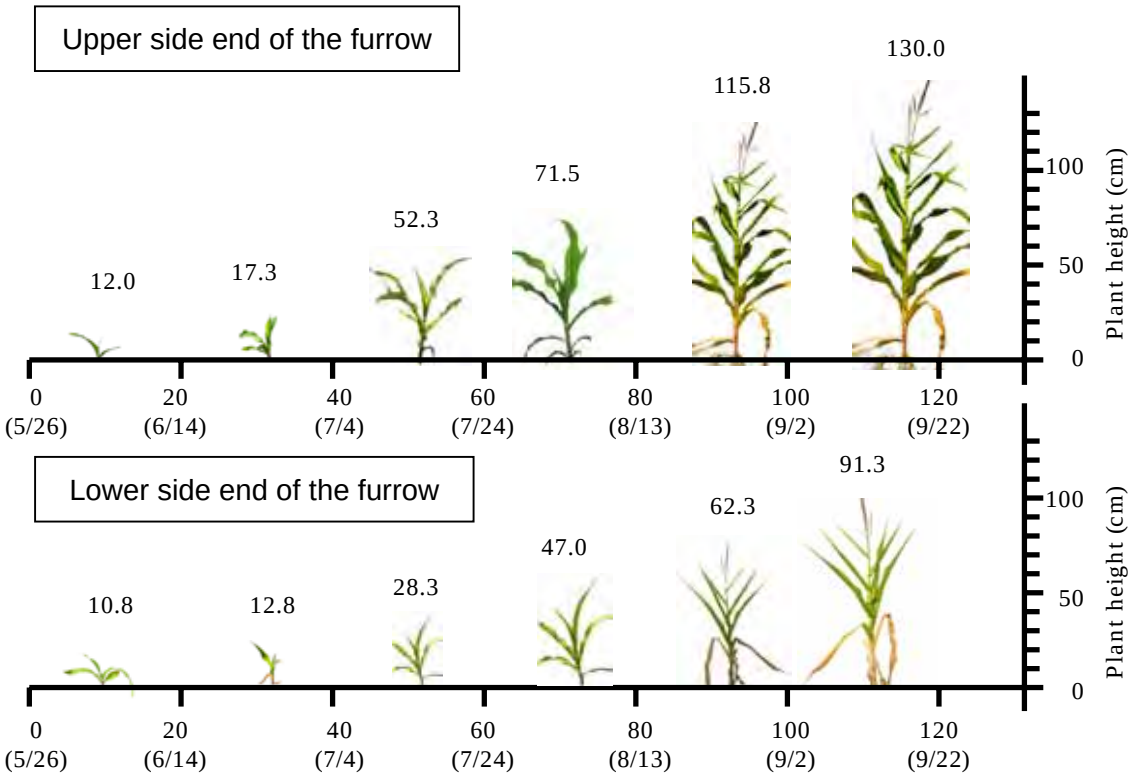
Fig. 3.2.1.4 Relationship between growth stage and Evapo-transpiration ratio (maize, 2005).

(b) Water supplies in the relief area

a) Present condition

It is necessary to construct farm ditches in the relief area to supply water to the whole field. However, target yield is not necessarily obtained even if farm ditches are constructed in the adequate position. It is because agropastoralists unfamiliar to irrigation work do not irrigate crops evenly.

In furrow irrigation since there is a difference in arrival time of water between upper side and lower side, it is not avoidable that irrigation becomes unequal. Especially when furrow length is long, imbalance will become large. In such case, if over irrigation is avoided at the upper side end of the furrow, water deficit will occur at the lower side end of the furrow. As a result, growth will be influenced as shown in the following figure.

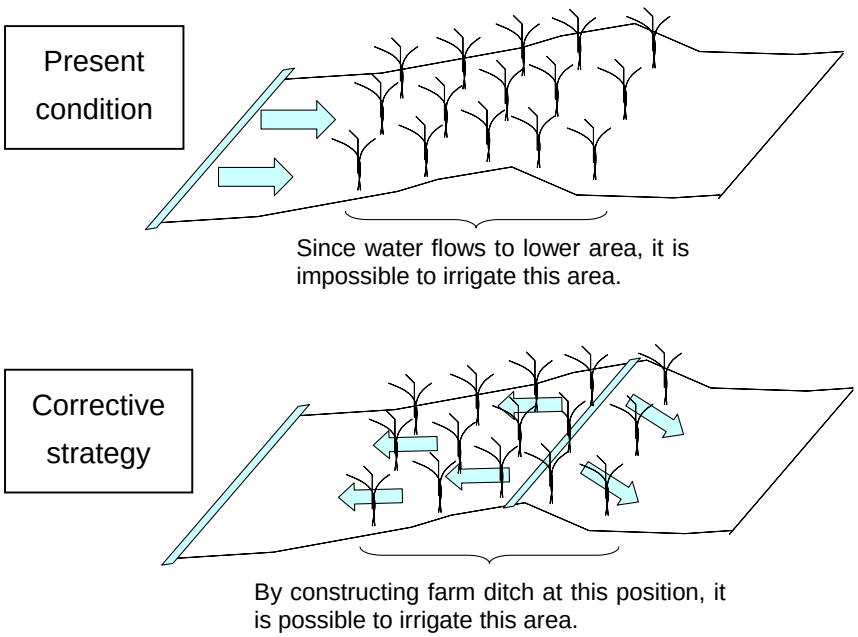


Notes: The maize in the figure does not show actual crop in the experiment but show plant height and root depth schematically.

Fig. 3.2.1.5 Comparison of plant height of maize in upper and lower side end of the furrow (2004).

b) Corrective strategy

By constructing a farm ditch as shown in the following figure, area for irrigation to reach can be reduced. By this, irrigation will reach evenly to whole plot, and excess and deficit of irrigation water will become hard to occur. It is necessary to irrigate so that water may be guided along with the furrow.



It is impossible to irrigate whole field by sitting and just watching.

It is necessary to irrigate evenly so that water may be guided along with the furrow.

Points of concern:

Although measurement of consumptive amount of water was carried out only with maize, a forage crop, the basic view is the same also in cash crops, such as soybean and sunflower.

In the climate condition specific to arid area with small rain and large evaporation, depending on the physical property of soil, soil surface often hardens by a remarkable amount of evaporation after irrigation. Therefore, agropastoralists have a custom not to irrigate until emergence because they fear no emergence by soil hardening.

However, for the crops, since the amounts of initial moisture are absolutely insufficient, it is desirable to irrigate even small amount of water after sowing.

As a result, the soil surface did not harden and target yield was obtained.

In water supply in the field, practice rather than theory is important. Technical visit to advanced area to see farmers' irrigation method has enough effect.

3.2.2 Reclamation and management of salt-affected soils

In arid areas, alluvial lands contiguous to a river frequently are used as farmland because irrigation water is obtained easily. Because the water permeability of soil on these lands generally is low and the topography flat, however, natural drainage is poor, which results in a rise of the groundwater level and causes waterlogging. This not only inhibits the normal growth of crop roots but also carries the salts contained in the groundwater into the root zone, promoting gradual salinization of the soil.

Although salt accumulation was not observed during the period of the Study on Prevention of Desertification in Arid and Semi-arid Areas in Asia, the occurrence of salt accumulation and improvement measures generally taken against it are explained here because salt accumulation can easily occur when irrigation is used in arid areas.

(1) Outline

In arid areas, land is used for pasture, rain-fed agriculture, and irrigated farmland. There are some problems as follows.

Pasture	Over grazing, Wind erosion, Sand hill re-activity
Rain dependent area (Rain-fed agriculture)	Over cultivation
Irrigated farmland	Salt accumulation

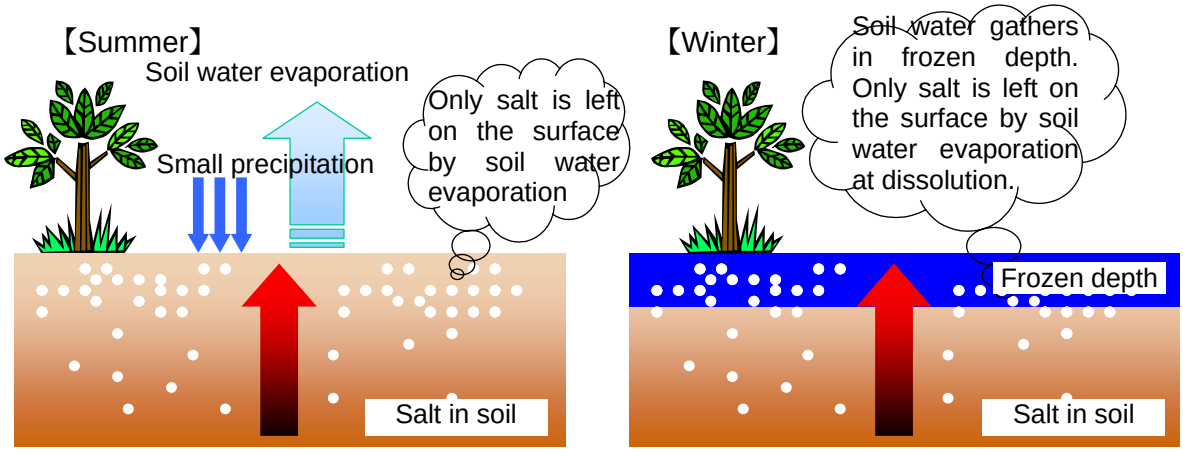
Saline soil is a kind of deteriorated soil. Although the distribution area cannot be correctly summed, it is mainly distributed over the farmland in arid and semi-arid area. Although about one third of land area in the world is arid and semi-arid area, it is just about 5% that is extremely dry like a desert. Most of the area is in the environment where productivity is expectable with abundant solar radiation, if there is water. Most of wheat, soybean, and maize, are produced in arid and semi-arid area.

However, saline soil in arid and semi-arid area is generated in the area that evapo-transpiration exceeds precipitation. Since there is much amount of supply of the bases such as sodium, potassium, calcium, and magnesium, saline soil area is increasing rapidly.

(2) Mechanism of salt accumulation

In summer in arid area, there is seldom rain and evapo-transpiration of soil moisture is remarkable. If irrigation is applied excessively, groundwater level will rise and the salt in the soil will dissolve and appear in the surface. If the farmland is left without cultivation, it will become impossible to use. On the other hand, in winter, moisture in soil rises up on the surface and freezes. Since the salt in soil rises similarly with water in

the process, the salt in the soil will appear in the surface at the time of dissolution. That is, movement of soil moisture and salt is the same in the process of freezing and dissolution, and the process of evapo-transpiration.



Soil water and salt rise by capillary movement

Soil water and salt rise by freezing and dissolution of soil

Fig. 3.2.2.1 Movement of soil moisture and occurrence of salt accumulation in cold and arid area.

(3) Cause of salt accumulation

There are roughly two causes for salt accumulation as shown below.

(1) It is based on the salts contained in irrigation water. When a lot of soluble salts are accumulated in root zone of crops, salt concentration in soil water will increase and osmotic potential of soil water will decrease, which will make water absorption by crops difficult. When Na^+ is contained in irrigation water more than other cations, by increase of exchangeable Na^+ content in soil, (by alkalization of soil) degradation of physical property of soil such as poor permeability of water and air in the soil will occur, which will bring a bad influence on crop growth.

(2) It is based on existence of groundwater with high salt concentration. While irrigation water passes along a river, bases are dissolved in. After irrigation it reaches to underground with only water being taken by evapo-transpiration, which will make the concentration of the contained base high in the groundwater. The groundwater level rises because of poor drainage. Groundwater with high salt concentration causes waterlogging. The rise of the groundwater level not only inhibits normal growth of the root of crops but also carries salts contained in groundwater into root zone, which will promote salinization of soil increasingly.

In addition, ponding in inadequate flat land (dam in flat land raises the groundwater level and expands salinization around), canal with inundation and leakage, and cultivated land of unevenness with a little covering are the causes.

(4) Salt injury control

In the arid area, measures for preventing the rise in the groundwater level or lowering the groundwater level are essential to prevent salt injury. Water management including leaching for reducing salt injury and avoiding excessive irrigation by presumption of consumptive use of crops correctly is important in the field.

1) Control of groundwater level

As mentioned above, in order to prevent waterlogging and salt injury, it is necessary to control groundwater level within the tolerance range. There are several methods for this, such as level drainage by the surface drainage by open channel, horizontal drainage by underdrain, and well drainage by tube well.

Well drainage has the following merits and demerit compared with gravity drainage such as underdrain. Merits include (1) It is a flexible system, and the water level can be controlled at any levels, (2) If water quality is good, it will play a auxiliary role for the existing irrigation system, (3) It can be constructed regardless of geographical feature, and (4) Pumping from the leaky aquifer reduces the pressure on confined aquifer, and promotes water movement from the upper layer to the lower layer. Demerits include (1) Pumping from the aquifer containing salt water increases the salt load on the irrigation system, as a result needing another drainage treatment facility, (2) It is technically complicated compared with gravity drainage, and (3) Material is inferior in durability compared with underdrain. When both systems are technically possible, cost will be the determinant. Cost of gravity drainage are generally expensive for initial investment and annual maintenance. Comparing the cost among well, underdrain, and open channel, initial cost of well is 1 / 7 - 1/12 of the others, and annual cost of well is 1 / 2 - 1/6 of the others.

The result of groundwater level observation in the verification field in Kerdala, Habahe county, Altay area is shown below as an example.

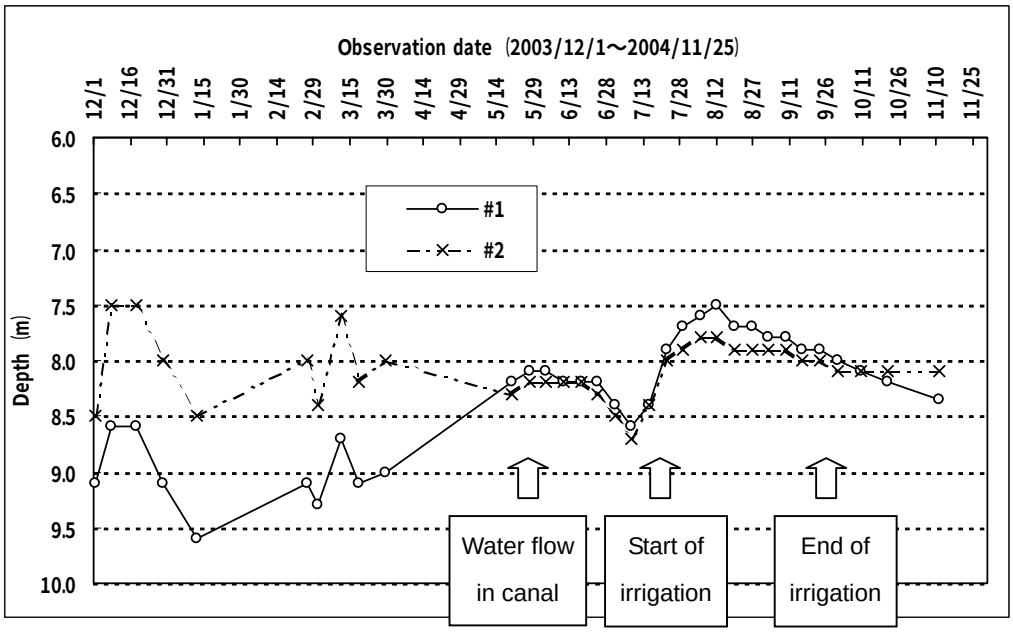


Fig. 3.2.2.2 Results of groundwater level observation in the verification field in Kerdala.

The field was not irrigated from December, 2003 of observation start until the end of April, 2004, and the groundwater level was around 8m in the upper side (#1) and around 9m in the lower side (#2). However, in May water was flowed in order to flush the sedimentary soil and sand in branch canal and sub- branch canal. By this, the groundwater level of 1 and 2 became same, and after that showed the similar trend till the end of November.

Irrigation was restarted from middle July. Although the groundwater level rose to 7.5m temporarily, it did not continue to rise any more and tended to fall gradually.

That is, since root depth is usually 15cm in the verification field in Kerdala, groundwater cannot reach root zone in case of capillary rise, showing that there is no risk of salt injury to the extent of the above figure.

2) Presumption of consumptive use of water

In arid and semi-arid area, while introduction of irrigation increases the productivity of farmland and brings agricultural stability, danger of reduction of the productivity and denudation of the farmland by waterlogging and the salinization of soil always accompanies. Water management in the field concerning with the perpetuity of the farmland is important. It is important to presume exactly consumptive use of water in order to determine irrigation water requirement in relation to it.

Since there is a limit of exact water management in earth canal and surface irrigation even if irrigation water requirement is determined by exact presumption of consumptive use of water, the effect of presumption of consumptive use of water on salt injury control will be considerably restricted in actual condition.

3) Water quality of irrigation water

Salt concentration in irrigation water is expressed in two manners. One is total dissolved solids (TDS), that is expressed as the mass per unit volume of the solution (mg/l), from calculation of evaporation residual of a certain amount of solution. The other is the electrical conductivity (EC, S/m) of irrigation water. Since EC value of solution changes according to not only the amount but also the form of salt, relationship between EC and TDS is not determined strictly. However, if EC expressed with dS/m is multiplied by 640, it will become the approximate value of TDS (mg/l). EC is widely used as an index of growth inhibition of crops caused by salt in soil water because of its easy measurement, and the sodium adsorption ratio (SAR) shown below is used as an index of alkali damage. Here, as for the unit of each ion concentration, me/l is used.

$$SAR = \frac{Na^{+}}{\left\{\left(Ca^{2+} + Mg^{2+}\right)/2\right\}^{1/2}}$$

Guidelines for interpretations of water quality for irrigation are as follows.

Table 3.2.2.1 Guidelines for interpretations of water quality for irrigation.

Potential irrigation Problem		Degree of restriction on use		
		None	Slight to moderate	Severe
Salinity				
ECw（dS/m）		＜0.7	0.7 - 3.0	＞3.0
TDS（mg/l）		＜450	450 - 2,000	＞2,000
Infiltration				
SAR=	0 - 3	ECw= ＞0.7	0.7 - 0.2	＜0.2
	3 - 6	＞1.2	1.2 - 0.3	＜0.3
	6 - 12	＞1.9	1.9 - 0.5	＜0.5
	12 - 20	＞2.9	2.9 - 1.3	＜1.3
	20 - 40	＞5.0	5.0 - 2.9	＜2.9

Source: Ayers and Westcot, 1985

(5) Crop tolerance to salinity

All plants do not respond to salinity in a similar manner; some crops can produce acceptable yields at much greater soil salinity than others. This is because some are better able to make the needed osmotic adjustments enabling them to extract more water from a saline soil. The ability of the crop to adjust to salinity is extremely useful. In some areas where a build-up of soil salinity cannot be controlled at an acceptable concentration for the crop being grown, an alternative crop can be selected that is both

more tolerant of the expected soil salinity and can produce economically yields.

Crop tolerance and yield potential are given in Table3.2.2.2 by FAO.

Where insufficient data exist to give numerical values for tolerance, a relative rating has been assigned to the crop, based on filed experience, limited data or observations.

Table 3.2.2.2 Crop tolerance and yield potential.

（Unit：ECe（mS/cm））

Yield / Crop	100%	90%	75%	50%	0%
Maize (sweet corn)	1.7	2.5	3.8	5.9	10
Soybean	5.0	5.5	6.2	7.5	10
Wheat	6.0	7.4	9.5	13.0	20
Alfalfa	2.0	3.4	5.4	8.8	16
Maize (forage)	1.8	3.2	5.2	8.6	16

Source: FAO irrigation and drainge paper 56 (extract)

(6) Soil management practices

1) Sequence of successful reclamation program

Soil management requires the following investigations,

a) investigation of soil salinity as to type, concentration, vertical and horizontal distribution
b) structure and permeability of the different soil layers
c) depth, quality, dynamics and fluctuation of water table
d) irrigation water available, as to quantity, quality and cost
e) geomorphology, relief and drainage outlets
f) climatic conditions including evaporation, rainfall, temperature
g) detailed topographic maps

On the basis of the above mentioned data a decision can be made as to:

a) reduction of salt content in the root zone to a level tolerable of most crops
b) reduction of exchangeable sodium below a value less than 10%
c) lowering of the water table below the minimum level for the condition in question (less than 2m in general)
d) demineralization of the groundwater to a minimum concentration

2) Reclamation of Saline Soil

(a) Steps to be followed

After collecting the basic information about the soil, groundwater, relief, and climate, the following steps are to be taken in most cases:

a) rough leveling
b) main canals and drains to be dug
c) secondary leveling
d) secondary drains and irrigation ditches to be dug
e) field drains and irrigation ditches to be dug, if required
f) fine leveling

The fine leveling should be done to within not more than 5cm difference. This permits uniform water distribution and effective leaching.

a) plowing and leaching
b) examination of soil and drainage water for salinity
c) cropping with salt tolerant crops as soon as salinity of the soil permits
d) normal cropping soils and guard against resalinization with special management practices

(b) Drainage

The methods of drainage vary according to the specific local conditions but namely two types of drainage, namely surface and subsurface are in vogue. Subsurface drainage comprises of horizontal-open drains of closed tile drains, and vertical, mainly through pumping.

Drainage should be adequate to cope with the amount of leached water during the early stages of reclamation. In addition, in order to prevent the accumulation of salts, adequate permeability of the depth or spacing of the conduit and open channel must be considered and decided upon. In areas of high salt accumulation, open channel method rather than conduit method as preferred. This is because large amount of leaching are necessary.

Basically, the open channel is used during the first stages of reclamation, during periods of stable channels the production costs will be economized, and because it lowers maintenance costs, the change to conduit is best. Generally the drains required are of two kinds; shallow and narrowly spaced field drains for quick leaching (depth about 0.9-1.25m, spacing10-100m) and deep, widely spaced main drains (depth 2.5-3m, spacing 300-1,000m) for lowering groundwater table of the area.

Drainage depth should ensure a groundwater depth that prevents resalinization of both sides. The controlled permissible depth should be decided by taking the following into consideration.

a) evaporation rate
b) salinity and dynamics of groundwater
c) water conducting properties of the soil
d) irrigation regime
e) cropping system

(c) Leaching

Leaching water should be added in quantities to dissolve soluble salts and remove them into the drainage system. Two methods are generally followed in leaching: continuous and intermittent. In continuous leaching, water is added to the soil and maintained at a depth of about 10cm by frequent additions of water to replace amounts lost by evaporation or drainage. The method ensures quick removal of salts and thus permits early cropping of the soil. Continuous leaching is permitted if only recommended under the following conditions:

a) good permeability of the soil
b) high, saline water level
c) high evaporation rate

In intermittent leaching water is first added in quantities sufficient to dissolve soluble (depth about 10cm) followed by about 20cm to leach the salts out. This is repeated at intervals, sufficient to prevent resalinization of topsoil.

3.3 Windbreak forest belts for land conservation

3.3.1 Construction of windbreak forest belts

Windbreak forest belts demonstrate a number of effects, such as preventing erosion of fields from sand storms, promoting crop growth by weakening wind strength and preventing surface soil flow caused by wind. Therefore to implement agricultural and rural development in arid and semi-arid areas, setting up windbreak forest belts is effective for protecting fields and houses from dryness and strong winds.

Windbreak forest belts for protecting local rural development should be created by the local government and local inhabitants together. In the past, however, local governments usually have been responsible only for location planning and distribution of seedlings, and subsequent management has been left entirely to local inhabitants. As a result, many windbreak forest belts suffer from insufficient management.

To produce healthy windbreak forest belts that are carefully managed, it is necessary to combine proper guidance by the government, proper awareness concerning the roles of windbreak forests and voluntary management by agro-pastoralists. If the local government and local inhabitants work together to build a windbreak forest belt development system, encompassing every phase from windbreak forest belt construction planning to seedling production, seedling planting, and windbreak forest belt management, the functions of windbreak forest belts will be exhibited and maintained continuously.

3.3.2 Construction plan

(1) Selection of planting tree species

In construct of a windbreak forest, tree species with high windbreak effect should be selected. Although introduced tall tree species, such as black poplar (*Populus nigra*) and white willow (*Salix alba*), are mainly used for the windbreak at present, native species which are adapted for the environment are also desirable to be used in arid and semi-arid areas. Although native species such as oleaster (*Elaeagnus angustifolia*) and saxaul (*Haloxylon ammodendron*), usually have the features of low height and slow growth, they also have some advantages of drought resistance and resistance to strong wind. Use of thorn trees is also effective in the area where livestock are grazed in order to prevent damage from livestock.

Table 3.3.2.1 Main tree species used for afforestation.

Specie	Scientific name
Black poplar	*Populus nigra*
White poplar	*Populua alba*
White willow	*Salix alba*
Oleaster	*Elaeagnus angustifolia*
Saxaul	*Haloxylon*

Points of concern:

Tree species used for a windbreak forest should be selected synthetically by productivity of a seedling and by duration for growth to exhibits the windbreak function. Fruit trees or timber trees have not only the function as a windbreak but the profitability to the future.

Reference: Study on the growth characteristics of the seedling as the selection criteria was carried out in the Study on combating desertification in arid and semi-arid areas in Asia. The results are described below.

Xylem sap flow rate, an index of the water status of a plant, was measured for black poplar (*Populus nigra*), *Salix pyrolifolia*, oleaster (*Elaeagnus angustifolia*), and *Populus euphratica*. The rates were compared by the value per unit leaf area.

The rate was higher in order of *E. angustifolia* > *S. pyrolifolia* > *P. nigra* > *P. euphratica*. As higher xylem sap flow rate the plant had, as more active transpiration and photosynthesis were consider to be performed by it. Native medium-low height tree species, *E. angustifolia* and *S. pyrolifolia* were active with small leaf area of a plant, and had the characteristic to maintain stomata opening not to decrease transpiration in dry condition. A tall tree specie, *P. nigra* showed lower xylem sap flow rate compared with the two above-mentioned species despite higher soil moisture content. Stomatal closure was considered to occur in response to low humidity. It is suitable for a windbreak forest because of its height and high growth rate, however, it is only suitable for the water available situation, since its large leaf area per plant needs a lot of water for growth.

P. euphratica showed lowest xylem sap flow rate. This is a characteristic that reduces the transpiration and keeps water inside found in plants that can grow in extreme-arid area. It is not suitable for prevention forest with sufficient irrigation. However, it is considered suitable for tree planting in drier condition outside of field hard to irrigate.

Thus different species have various characteristics. Therefore, it is important to select tree species according to the local climate, irrigation condition, and their usage.

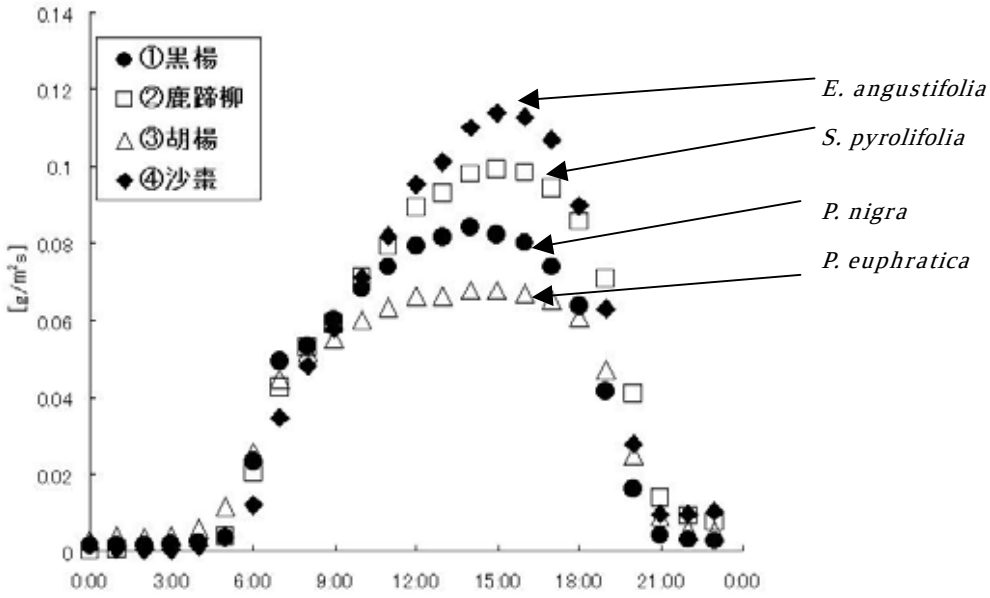


Fig. 3.3.2.1 Rate of xylem sap flow per unit leaf area of a tree.

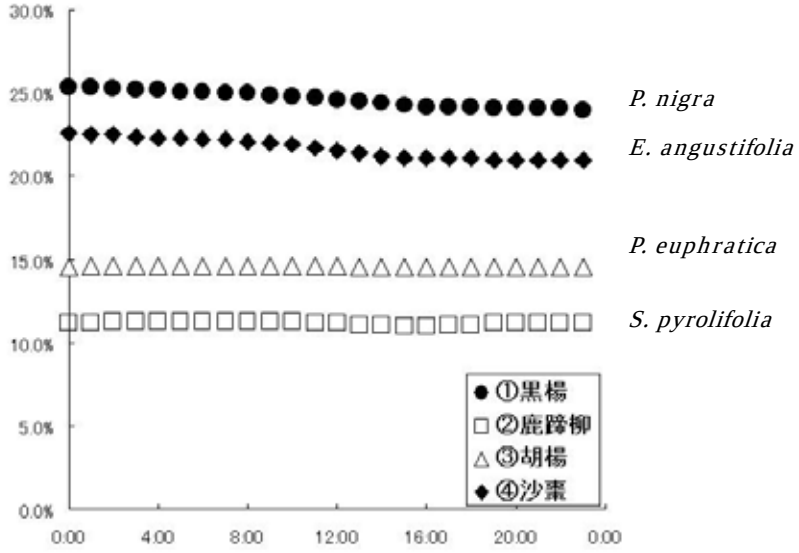


Fig. 3.3.2.2 Diurnal changes of soil moisture.

(2) Design of windbreak forest belt

1) Elements of windbreak effect

Tree height and planting density are important elements of a windbreak forest. The effect range of windbreak forest is about 5 to 10 times and 20 to 30 of tree height in the windward and leeward side, respectively.

Points of concern:

The higher windbreak effect is obtained with higher tree height, however, since planting of tall tree requires a lot of water for growth, its influence on water resources will be large. Grown windbreak forest with high density will become like a wall by the tree crown closure. Since the wind overcoming windbreak zone descends immediately and generates a whirl area, the range of windbreak effect will narrow. If trees are planted at optimum density, the wind will be divided into the one overcoming the windbreak forest and one passing through the inside of the forest, which will make the wind weaker. Moreover, since the latter disturbs the whirl area generated by the former, the windbreak range will spread wide. Tree species and windbreak width are determined according to the conditions of location and the scale of farmland.

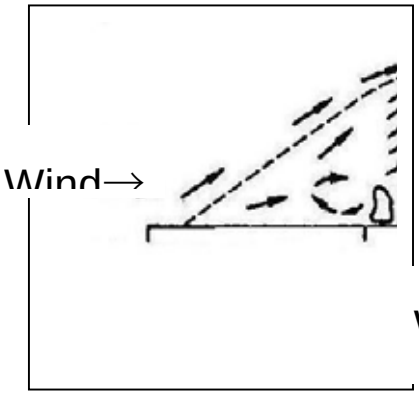


Fig. 3.3.2.3 Effect ranges of windbreak forest (overcrowded state).

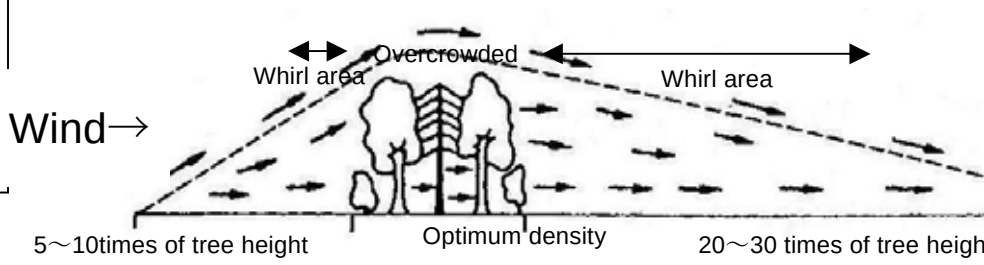


Fig. 3.3.2.4 Effect ranges of windbreak forest (optimum density).

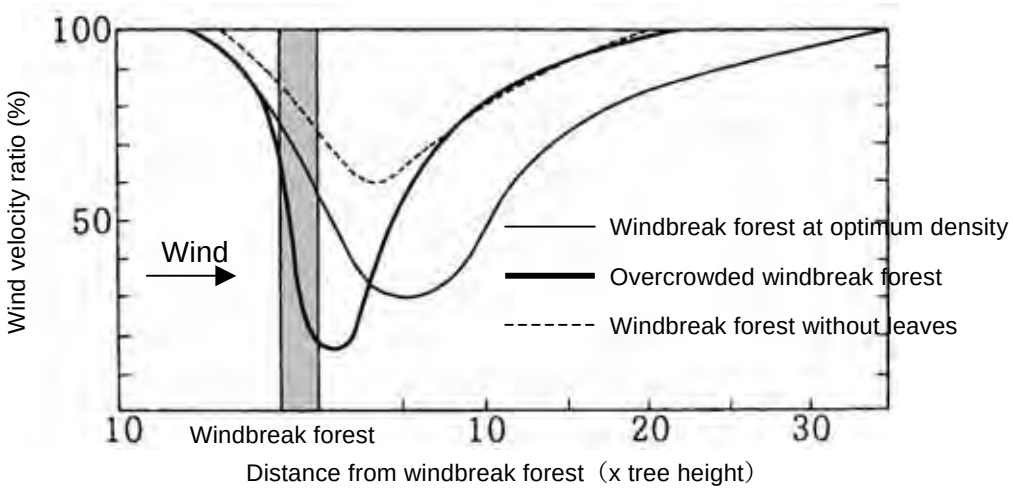


Fig. 3.3.2.5 Wind velocity reduction effect of windbreak forest.

2) Composition of windbreak forest belt

A mixed forest with a few tree species is more desirable for windbreak forest than a single-storied forest with single one. A mixed forest with different height trees strengthens the windbreak effect by the layered structure of the tree crown. When the form of tree crown in the upper layer becomes less uniform, the energy of the wind passing along the upper part of the windbreak forest will be weakened, which is the higher windbreak effect than by a windbreak with uniform tree height (Fig. 3.3.2.6, Fig. 3.3.2.7). As the lower layer prevents exposure of surface of the land, it is effective in preventing erosion of the topsoil caused by a wind.

A more functional windbreak forest can be constructed with a combination of high tree species and tree species with sandbreak effect by thin branches and narrow leaves such as tamarisk or thorn trees without damage from livestock such as oleaster.

Reference: In “Study on combating desertification in arid and semi-arid areas in Asia”, construction of single-storied forest was not included but the composition such as black poplar＋oleaster, black poplar＋white willow＋oleaster, white elm＋oleaster, *Salix pyrolifolia*＋oleaster, that is, high trees + low trees, and introduced species + native species.

Points of concern:

A swarm of long-horned beetle occurred in the shelterbelt project in the northeast, north and northwest of China (China's Green Great Wall) in recent years brought a great havoc to single-storied poplar forest, however, there was a little damage in the forest consisted of two or more tree species. There is a risk of suffering the serious damage in single-storied forest when such insect damage or weather damage occurs, however, there is a possibility to reduce risk by constructing a mixed forest.

* The shelterbelt project in the northeast, north and northwest of China (China's Green Great Wall) – Prevention forest belt being constructed in 13 provinces, cities, and autonomous regions in the north, northeast and northwest areas in China. Construction started in 1978 and will end in 2050. Planned afforestation area is about 360,000km^2.

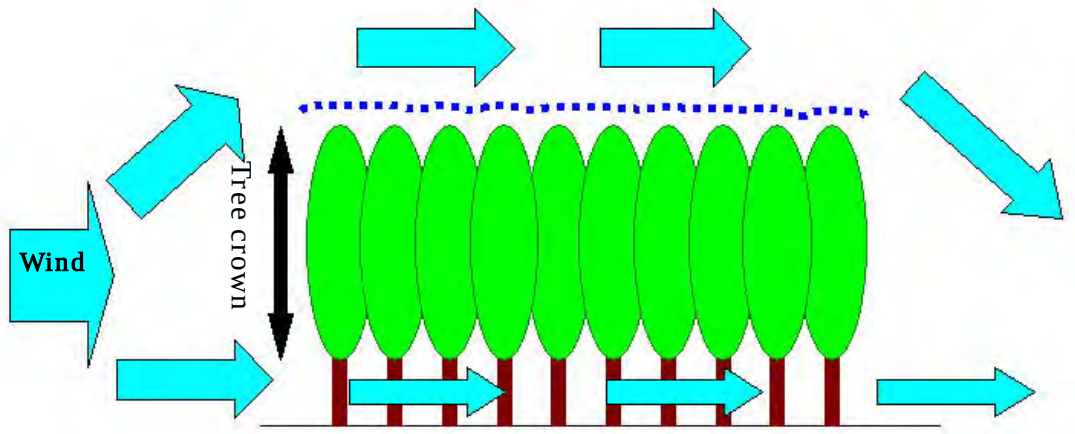


Fig. 3.3.2.6 Effect of single-storied forest on wind reduction.

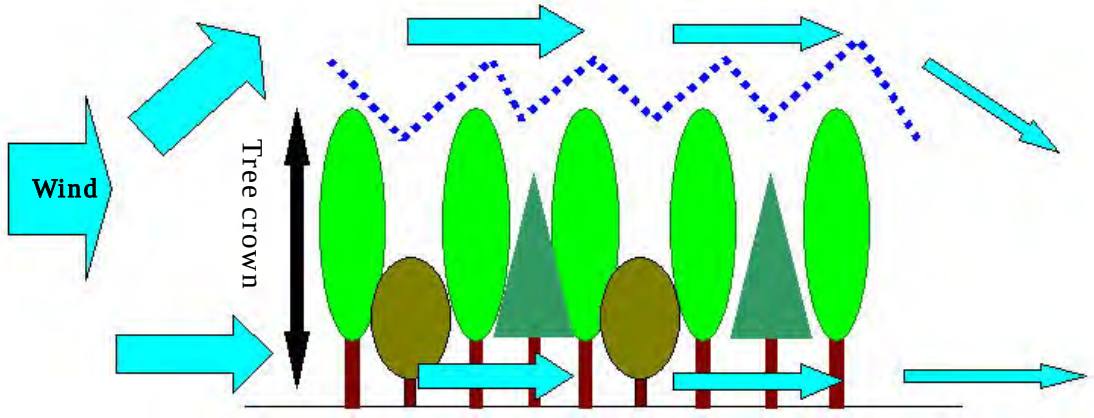
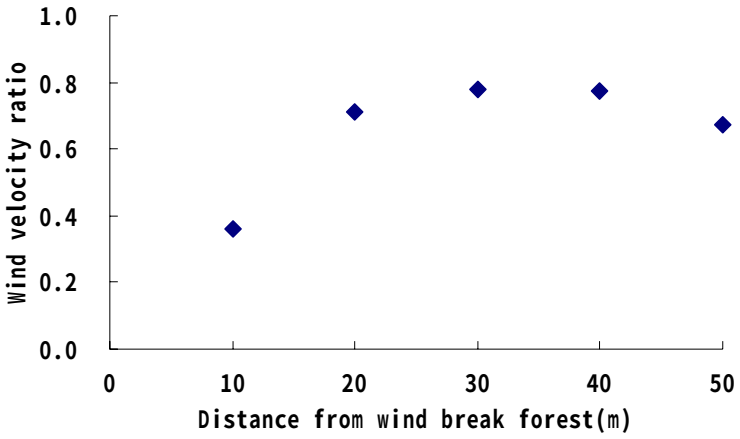


Fig. 3.3.2.7 Effect of mixed forest on wind reduction.

3) Direction of windbreak forest

When the direction of a windbreak forest is right-angled to a wind, windbreak effect will be maximized. By grasping the main winds direction in the area, direction of the windbreak forest is determined in consideration of geographical feature and the form of farmland to protect.

Wind velocity measurement was conducted in Alahake field. The forest was consisted of black popular planted in2003 with hill distance of 1.5m and row space of 2m. The present tree height was 4-5m. Mean wind velocity on the day was 6.2m/s with a main direction of southwest.



The windbreak effect was observed within the range of 10 times of tree height. Although a great effect is obtained in the twice of tree height at present, it is expected that the distance will become longer with such a great effect as windbreak forest grows in the future.

The width of this field is 150m to the direction of the wind. Since the windbreak effect is considered the range of 20 to 30 times of tree height in the leeward side, Windbreak function can be obtained in this field not by tall tree species like black popular but by middle-height tree species with about 10m of height.

It is important to consider the form and scale of farmland and the difficulty of irrigation. If tall tree species are planted in a farmland, windbreak effect will be obtained earlier. However, in the farmland with a difficulty in irrigation, if a windbreak forest is constructed with not tall tree species that require much amount of water, but constructed in combination with middle-height tree species and low-height tree species, water resources will be saved.

(3) Required number of planting trees

By the determination of the scale of the windbreak forest to construct and the hill distance, required number of planting trees is integrated. Although there are a square, a rectangle, equilateral triangle planting, etc. as a form of planting, equilateral triangle planting with the maximum planting number per area is generally performed.

Table 3.3.2.2 Relationship between hill distance and number of planting trees (equilateral triangle planting).

Hill distance (m)	Row space (m)	Occupied Area (㎡)	Tree number (/ha)	Tree number (/mu)
1.0	0.87	0.87	11,547	771
1.5	1.30	1.95	5,132	343
2.0	1.73	3.46	2,887	193

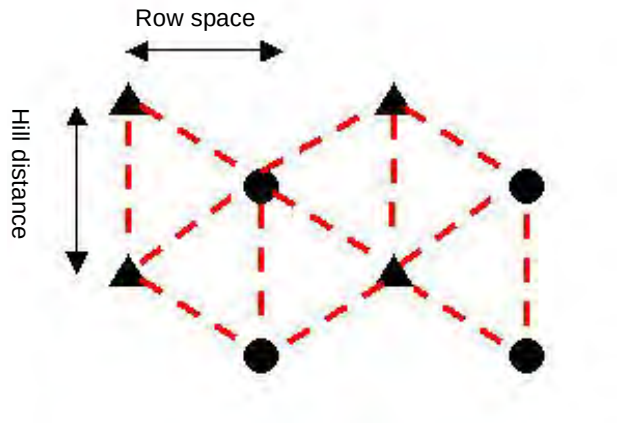
a：Hill distance（m） b：Row space（m） S：Occupied Area（㎡） A：Planting area（㎡） N：Planting number of trees

$b=0.866a \quad S=a\times b \quad N=A/0.866a^2=1.1547\times A/a^2$

Number in the case of planting in area of 1 Mu by hill distance of 1.5m.

N= 1.1547x667 / 1.52= 342.3 = 343(trees)

Space of planting



●▲＝Planted tree

(4) Legal system

The legal system about afforestation varies with a country. In China, there are “The law for preservation of forests” which is the fundamental law of forest and forestry including conservation and raising of forest resources, rational use, and penalties, “The law for preservation of seeds” and “The law for management of permission for tree seed production management” that regulate the seedling production and management, "The ordinance for returning farm land to forest or grassland and covering hills with afforested trees” whose purpose is to restrict agricultural production and use of mountainous and to return land to forest.

After the legal system of the country where the program is implemented is checked, the plan should be made with a consideration of selection of tree species, production of seedlings, and the future utilization of the planting trees.

(5) Overall planning and annual planning

After integrating the total construction area of windbreak forest and the total number of required seedlings, construction area and seedling numbers are calculated for the each year. When seedlings cannot be purchased, personnel expenses required for construction and management of nursery, and planting expense, etc. should be also calculated.

3.3.3 Seedling production

(1) Objective

When tree planting is implemented in arid and semi-arid areas, seedlings should be raised at the planting site because of the effects of dryness on seedlings during transport from a nursery to the planting site. Furthermore, raising young trees at the site is useful not only for creation of windbreaks but for subsequent supplementary planting or generational renewal as well.

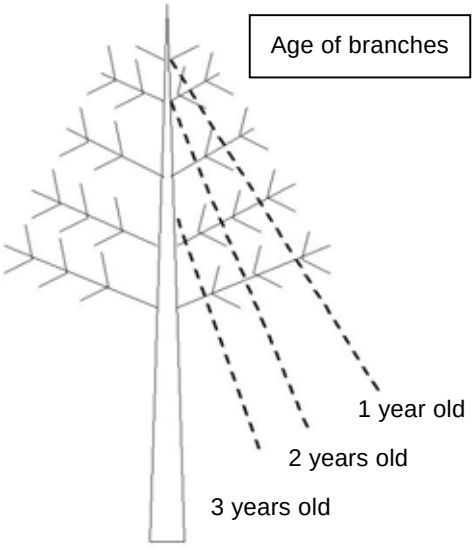
(2) Collecting of seeds and cutting seedlings

1) Seeds

Seeds should be collected the time when they are at maturity. Since the same tree species grown at the same place do not necessarily have healthy seeds similarly, a tree with a good shape and characteristics with many seeds should be chosen as a mother tree.

Collected seeds are dried in the shade for a few days after removing worm-eaten seed etc. Then seeds are selected by soaking into the water. Since the seeds floating on water are not good in quality, they are removed. The rest seeds are dried, and then stored in a cool place with constant temperature with sufficient ventilation.

2) Cutting seedling



Rooted cutting is made by a branch cut from a mother tree (cuttings), and is planted in nursery to grow to seedling. A tree with a good shape and characteristics should be chosen as a mother tree for cuttings the same as for collection of seeds. Age of branch varies from one to three years. Although rooting is good in branch of 1 year old, since its cut end is perishable, some portions of branch of 2 years old will be added for use. Lower part of a mother tree is the best position for cutting, and branches in shade side have higher capacity of rooting than those in sunny side. Cut by the length of 20-30cm, cuttings are immediately soaked in water. If duration from cutting to planting is long, rooting rate will decrease. Therefore, planting should be carried out to the nursery in one week from cutting

(3) Construction of nursery

Plowing (more than 20cm) and land leveling are carried out for root growth. Squares are divided by ridges so that the water from the canal spreads one by one.

Reclamation of nursery

Nursery (just after reclamation)

(4) Seedling raising method

1) Sowing

Seeds are sown to lines and covered with soils to invisible. In case of irrigating by border irrigation, since there is a possibility that seeds may flow away by water, seeds should be sown in depth of 2-3cm.

2) Cutting seedling

After cutting from a mother tree, seedlings should be planted in nursery as soon as possible. The depth of planting is 30 - 40% of full length of cutting seedling.

3) Irrigation and nursery management

At the beginning immediately after sowing and rooted cutting, irrigation should be carried out every two days. After rooting, irrigation should be carried out every five to seven days, checking the seedling state and drying condition of soil. Irrigation should be carried out gradually to fill up water in a square so that seeds may not flow with water. When nursery is placed near a field, crop seeds and weeds are easy to enter from the field in addition to water. Since weed control influences seedling growth, weeding should be carried out frequently.

(5) Seedling raising in Alahake town, Altay city

Seedling raising experiment was conducted in the nursery, in Alahake town, Altay city, and the results of cutting seedling are reported below as a reference. The planting density was in the range of 15-50 trees per square meter.

Table 3.3.3 Survival rate of tree species after rooted cutting.

Tree specie	Scientific name	Survival rate
Black popular	*Populus nigra*	29
White popular	*Populua alba*	38
Tamarisk	*Tamarix ramosissima*	36

It is said that popular species and willow species are easy to carry out production by rooted cutting. This result supports it. In this study survival rate of seedlings decreased gradually from April until June, and no change of the rate was observed after July. From this result, if attention is paid to irrigation and weed control for two - three months after planting, production rate will increase further.

3.3.4 Implementation of planting

(1) Time of planting

Planting should be carried out at the time when the climate condition and the physiology conditions of a young tree are ready. Since the period suitable to the planting is short in arid area, in case planting is not carried out in the optimum time, survival rate after planting will be greatly affected. For this reason, fully preparation is required in advance.

In China, spring planting (from late March to late April) and autumn planting (from late September to middle October) are usually carried out. The frozen soil dissolves with a rise of temperature at the time of spring planting, which will become suitable for planting. Time of autumn planting is not the time for seedling growth, and soils are caking from dryness. It is necessary to irrigate before planting in order to make soil soft, however, seedlings planted in autumn sprout earlier in the following spring and have resistance to dryness at the beginning of spring.

(2) Implementation of planting

1) Land preparation and ridging

Since irrigation water will flow partially concentrated if there is unevenness on the surface, land leveling should be carried out as much as possible.

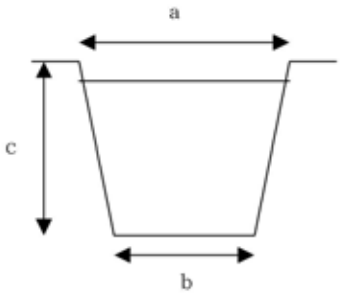
In order to carry out furrow irrigation or border irrigation, it is necessary to make a ridge in the windbreak forest. A ridge with width of about 50cm and height of 20-30cm is made and squares are made every 10-20m.

A ridge of windbreak forest

2) Planting hole

Although the size changes with tree species, a hole is dug with upper diameter of 30-50cm, bottom diameter of 20-40cm, and depth of 30-50cm. Using a stick with the length of the planting space and putting marks with a strict interval will make the planting efficient.

Form of planting hole



a=diameter (upper)
b=Diameter (bottom)
c=depth

3) Selection and transport of a seedling

Handling of seedlings during the time from dug in nursery until planting affects survival rate and the growth after planting. It is important to maintain seedlings at a healthy state.

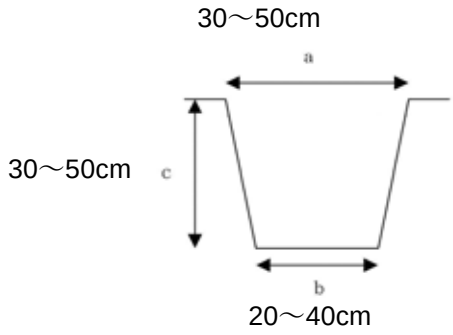
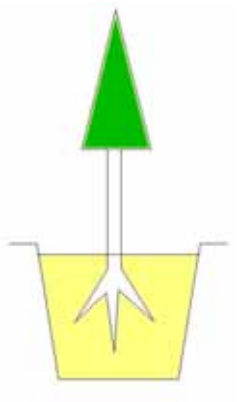
(a) Selection of a seedling

Considering of growth after planting, seedlings with large diameter of root base have resistance to severe environment such as arid area rather than seedlings with height. There is a difference in growth among the seedlings produced in nursery. Since possibility of withering and dying is high after planting, the seedlings with poor growth should be discarded.

(b) Transport

In carrying seedlings, a certain amount of soil should be kept around the roots in digging from nursery. It is effective to prevent drying and physical damage of root in transport. In transport with a track, potted seedlings should be fixed firmly to prevent soil overflow from the pots. In case of bare-root seedling, the whole loading platform should be covered with rush mat or plastic sheeting to prevent drying of seedlings.

4) Planting procedure

(1) Dig a planting hole. (The size changes by tree species.)	
(2) Extend the roots of a seedling and cover soil and step on the ground to contact the roots to the soil by shaking a seedling.	
(3) Lower the soil level a little so that water may gather.	
(4) Cover the base of the seedling with grass or stones (mulch) to prevent drying.	

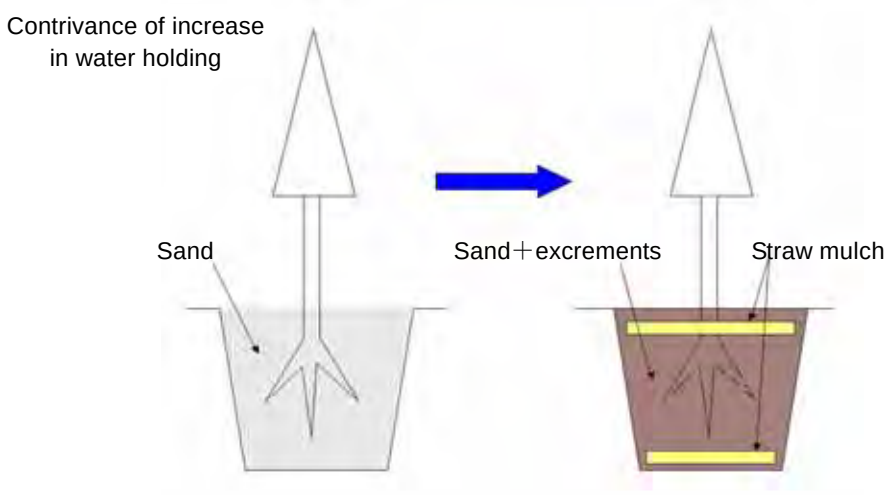
Points of concern:

Planting should be carried out smoothly from digging planting holes until seedling planting. Especially, if duration from transport of seedlings to planting is long or root is dried, rooting will be greatly influenced. In order to promote root growth, it is required to extend the roots and to contact them to the soil well. Planting with stuffing rounded root into planting hole will give bad effect on rooting.

Root growth is also inhibited when soils are strongly pressed by foot beyond necessity. A certain amount of pore space is needed for root growth. Especially for tree species such as oleaster (*Elaeagnus angustifolia*) that have root nodule to fix nitrogen, the performance of the effect will be inhibited.

5) Contrivance for using water effectively

In arid area, effective use of available water resources and contrivance for increasing water holding capacity of soil will increase the survival rate of planting trees. For an example, if straws are placed at the bottom of planting hole and on the surface of the soil at planting, they will increase water holding capacity of soil, will reduce evaporation, and will be manure. Use of collected rain and use of surplus irrigation water of autumn to afforestation are already tried also in China.



(3) Organization responsible for implementation of afforestation

Construction of a windbreak forest of a field in the settlement is generally carried out by duty labor of staffs of local government and hospital or students in spring or autumn. In spite of being responsible for management of a field, agropastoralists usually do not carry out construction of a windbreak forest. However, it is desirable for agropastoralists themselves to plant trees for healthy raising of a windbreak forest that protects a field, because they are beneficiaries and responsible for management of a windbreak forest. In order to raise a windbreak forest in an area, not only management of each agropastoralist but also organized management is necessary.

Reference: Although tree planting in a windbreak forest had been carried out by duty labor in Alahake town, Altay city, in the “Study on combating desertification in arid and semi-arid areas in Asia” it was decided that tree planting in the study site was carried out by agropastoralists themselves.

Then, tree planting in the windbreak of a field in Alahake town became to be carried out entirely by agropastoralists themselves. Government of Alahake town has made a contract with agropastoralists concerning about the management of a windbreak forest. It defines that all responsibility for management of a windbreak forest lies in agropastoralist.

3.3.5 Windbreak forest belt management

(1) Objective

To raise healthy windbreak forest belts after planting, proper management must be implemented. Follow up activities including regular irrigation, branch pruning, thinning to manage the number of trees and construction of fences to protect planted trees from livestock. For proper management, a common awareness of windbreak forest belts among agro-pastoralists in the area is important, and to achieve this voluntary management by agro-pastoralists is required. Planting fruit trees in windbreak forest belts, and creating economic value by means such as the sale of thinned trees, can provide incentives for windbreak forest belt management.

Furthermore, management by individual agro-pastoralists is insufficient for developing area-wide management, and organized management by an association is needed. Even when a windbreak forest belt association does not exist, organized activity is possible in cooperation with the water users association.

(2) Management

1) Irrigation method

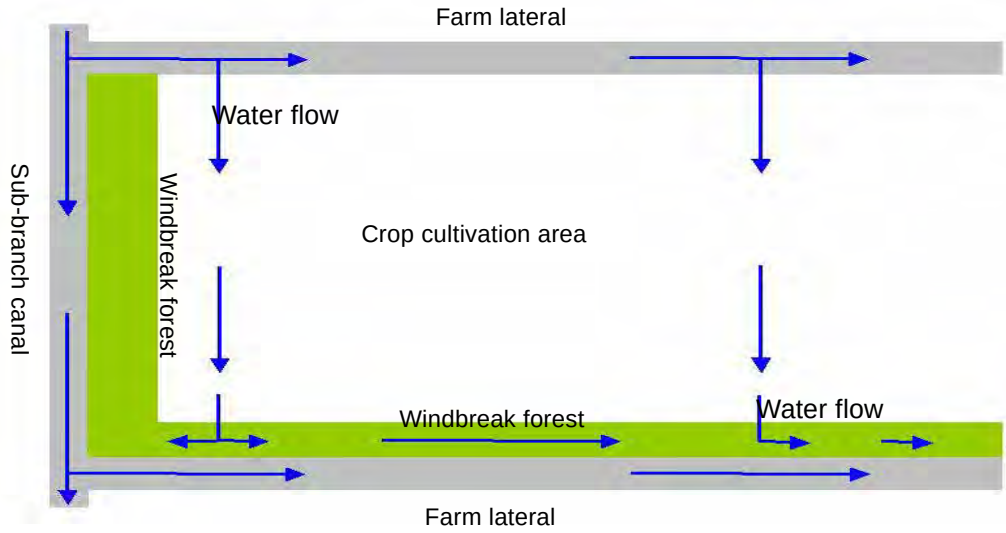
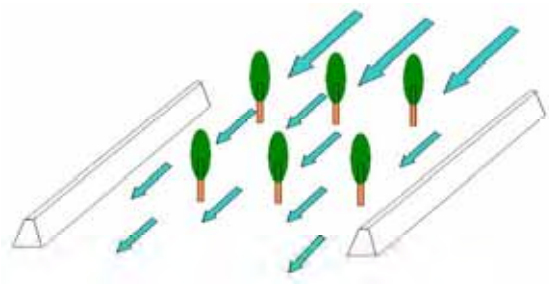


Fig. 3.3.5.1 Position of windbreak forest in Alahake town, Altay city.

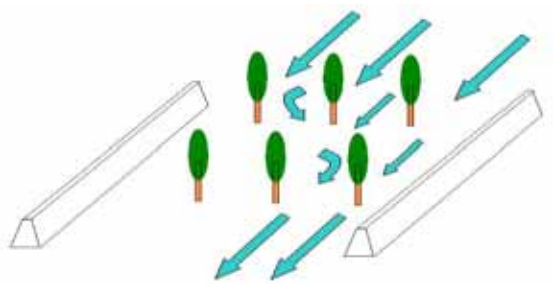
The management after planting is important for a windbreak forest. If initial irrigation for especially two - three months after planting is appropriately carried out at intervals of five - seven days in order to make planting tree survive certainly, then windbreak forest will grow healthy.

Irrigation to windbreak forest should not be partial water flow, but water spread round the whole windbreak.

Good

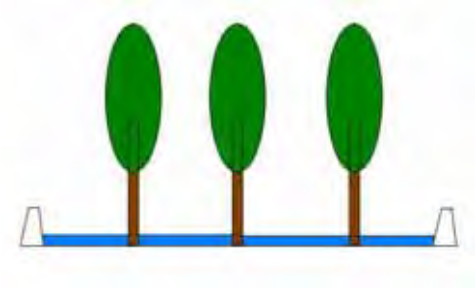


Bad

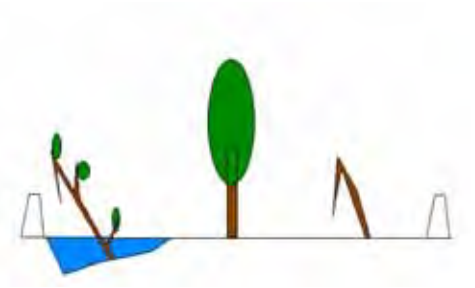


Even if irrigation is spread to the whole area of windbreak forest at first, ridge may break or water way may cause erosion after repeated irrigation. It is necessary to conduct periodical check and repair.

Good



Bad



2) Irrigation to windbreak forest along sub-branch canal

Since surplus water flows in the windbreak forest along farm lateral at the time of irrigation to crops, irrigation is easy. However, since apart from the cropping field, irrigation to the windbreak forest along sub-branch canal should be carried out with special consciousness.

(a) Turnout position

If a turnout position is constructed near along sub-branch canal, since water flow will become violent, irrigation will not reach all the corners of windbreak forest. Furthermore, water flow may cause erosion on the soil surface and the subsequent irrigation may become difficult. Therefore, a turnout position is constructed 10-20m away from the windbreak forest. It is desirable to irrigate to windbreak forest slowly same as crop irrigation.

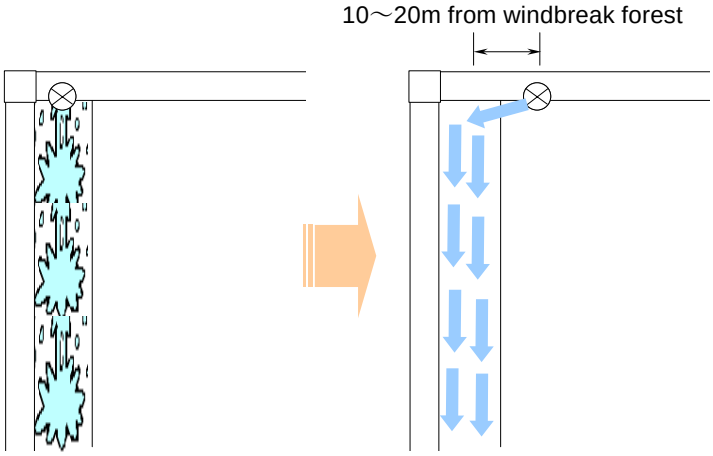
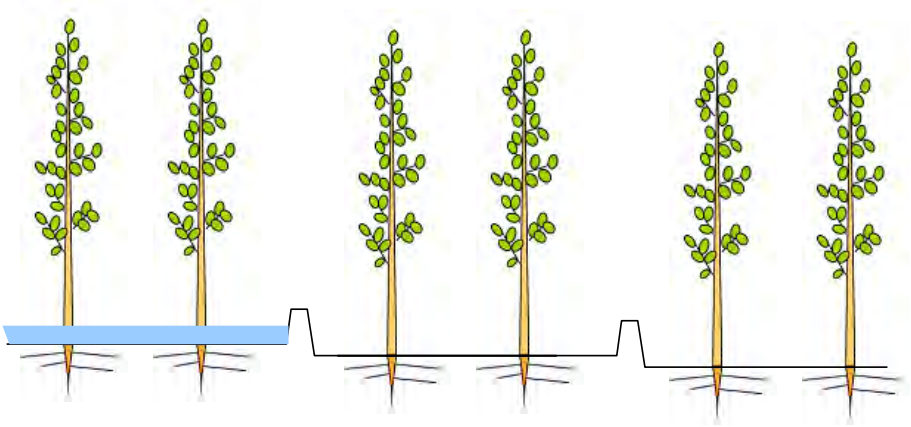


Fig. 3.3.5.2 Spatial relationship between windbreak forest and turnout position.

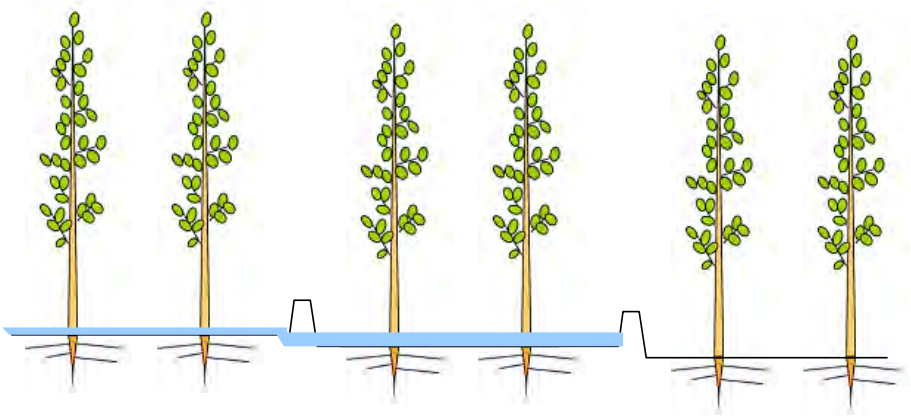
(b) Irrigation procedure

Irrigate 1st square to the sufficient level, and cut a part of ridge to irrigate 2nd square. Repeat it one by one. The highest part of the ridge should be cut.

1st square



2nd square and subsequent ones



(c) Irrigation interval

Since it is efficient to perform irrigation to crops and a windbreak simultaneously, it is appropriate to irrigate at intervals of five to seven days.

(3) Diagnosis of the growth state of a planting tree

1) Objective

In order to raise a windbreak forest healthy, the growth state of a planting tree should be judged. In addition, it is necessary to catch the state of the whole windbreak forest and to judge the quality of the present management.

By investigating the growth state of each planting tree, a simple drawing showing the survival rate of whole windbreak forest is created. By comparing with the geographical feature of the field, area where water is easy to spread or not can be distinguished. By judging synthetically from the present management in addition to it, make a windbreak forest always maintains a healthy state.

2) Diagnosis of the growth state of a tree

The growth state of a planting tree can mainly be judged into four classifications.

Table 3.3.5.1 Classification of growth state.

Classification	Growth state
(1) Normal	Leaves are attached from base to the tip of a planting tree.
(2) Shoot blight	Upper part of main shoot of a planting tree is dead (more than 50cm of lower parts of trunk alive).
(3) Sprout	The main trunk of a planting tree is almost dead, and there are sprouts from the root base.
(4) Death	Completely dead.
*Damage by livestock	Bark is peeled-off around the trunk. Branches receive a torn damage.

If management of a windbreak forest is inadequate, a planting tree will gradually change into the state of (4) from the state of (1). When it is in the state of (3), subsequent healthy growth of a planting tree cannot be expected, and supplementary planting is needed. The state of a windbreak forest should be always watched to maintain the state of (1) or (2).

Points of concern:

When there is a broken part of dead trees in a windbreak forest, crop growth will be affected by wind and sand entering from the broken part. Therefore, supplementary planting should be promptly carried out to the broken part. However, when supplementary planting is carried out to the windbreak forest passing more than five years after planting, planted seedlings may be confined by the preceding planting trees. Therefore, implementation of supplementary planting should be judged by the situation of the field.

Since it is impossible to prevent damage from livestock by each agropastoralist' management, not only agropastoralists but also local government should implement measures, such as an agreement of prohibition of livestock into a field or construction of protection fence as the measures of whole local community.

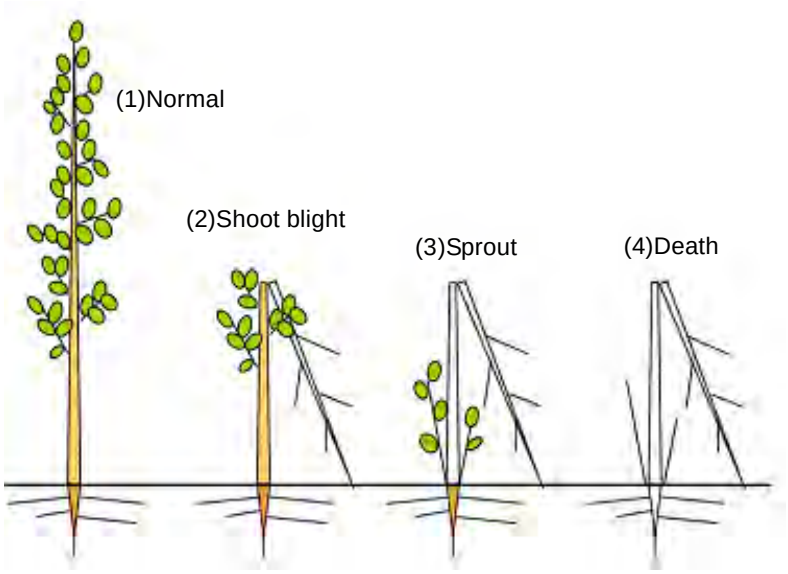


Fig. 3.3.5.3 Growth state of a planting tree.

3) Diagnosis of a windbreak forest

A windbreak forest is divided into plots by every 20-30m. Planting trees are judged in above-mentioned growth state from (1) to (4), and each rate is recorded for every plot. Investigation of survival rate in the "Study on combating desertification in arid and semi-arid areas in Asia" is described as an example.

Fifteen divided plots were made in a field. Regarding from (1) to (3) as survival, and (4) as death, each plot is shown with changing patterns according to the survival rate. Carrying out at the whole field, results were 72.3% of survival (normal 58.8%, shoot blight 7.5%, sprout 6.0%), and 27.7% of death. Based on this number, survival rate of whole field in Alahake is shown in a figure.

Growth tendency of a windbreak forest can be judged by classifying a drawing by color according to the survival rate. Judging from this drawing, there are some fields showing low survival rate of windbreak forests along the sub-branch canal. Therefore those who guide management should carry out interview the problem of geographical feature and the management method up to the present from the person responsible for management in order to examine measures and improvement strategy of the whole windbreak forest.

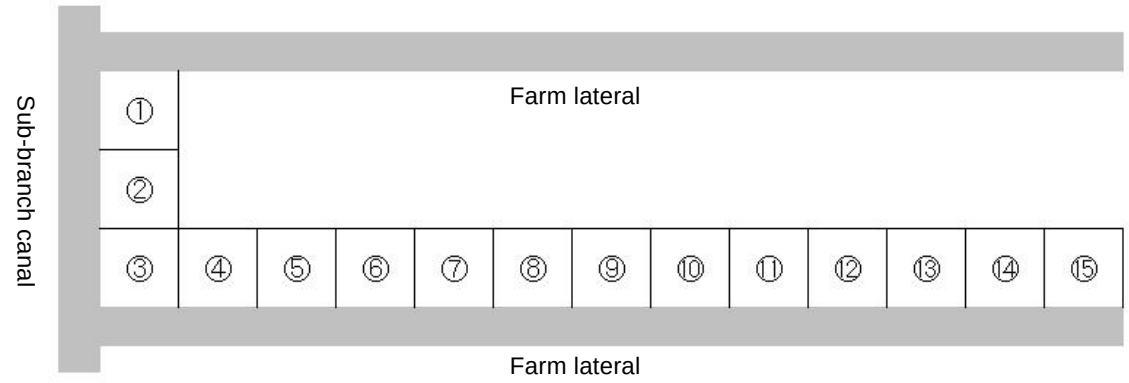


Fig. 3.3.5.4 Divided plots of windbreak forest.

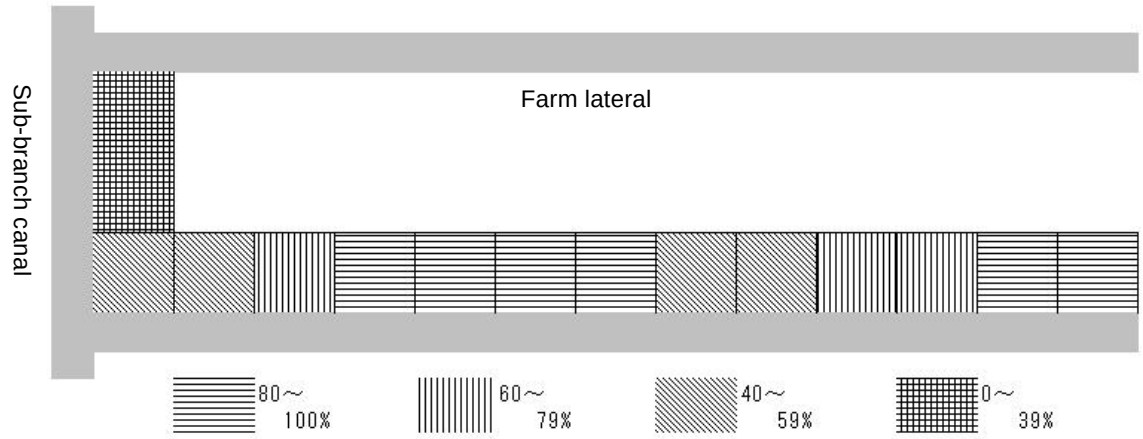


Fig. 3.3.5.5 Survival rate of planted trees in each plot.

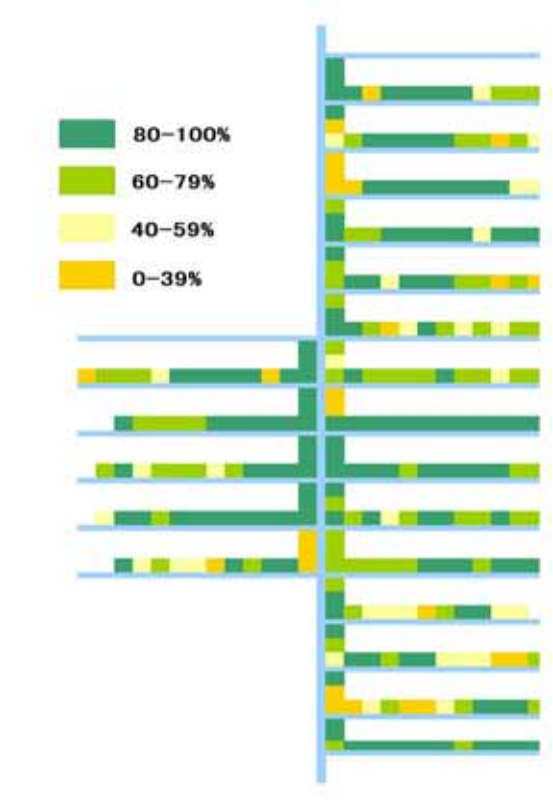


Fig. 3.3.5.6 Survival rates of planted trees in the whole field of Alahake.

4) Thinning

As the windbreak grows, planting trees comes to compete each other. If the number of trees does not change from the planting, height and tree crown can grow but the growth of trunk comes to small. As a result, gap of the tree crown will decrease and the windbreak forest will be like a wall. Although the windbreak effect seems to be high from the outside, reverse effects, such as narrowing of the range of the windbreak effect will occur.

Moreover, in planting with mixture of tall trees and middle trees, or tall trees and low trees, after growing at the same density as planting, middle trees or low trees will be confined by tall trees and will show poor growth. By adjusting the planting density through cutting a part of tall trees that have been confining middle trees and low trees, competition can be alleviated and windbreak function can be improved.

For tall tree species, such as black popular, planting density should be adjusted about 1,500 / ha (hill distance of 2.5-3m) at the time of tree height of 15m.

5) Measure against livestock

In afforestation in arid area, cautions for damage from grazing or nomadism are required as well as cautions for withering to death by dryness. Peeling-off of bark by sheep and goat especially causes serious damage. In China, when livestock moves, damage will occur.

Although construction of protection fence and repellent are the measures, it is difficult to carry out in all windbreak forests. Prohibition of grazing in the whole field, using thorn trees as planting trees, and consciousness enlightenment to agropastoralist on damage of trees are the measures that agropastoralists and local government need to conduct together.

Damaged tree

Damaged windbreak forest

(4) Incentive to the management

1) Objective

Adequate management is required for growing of a windbreak forest. However, according to the forest law, windbreak forest is in a category of prevention forest not for the purpose of profit different from commercial forest. Therefore, it seems that the management consciousness of agropastoralists for the windbreak forest is less compared with for field crops. In order to facilitate their spontaneous management, it is effective to give an economical merit to a windbreak forest.

2) Use of thinned timber

While cutting down all trees of a windbreak is forbidden, thinning as a management business is accepted in China. As above-mentioned, thinning is a necessary management for healthy growth of a planting tree, and thinned trees are used for firewood and protection fence. If thinned trees are popular or willow species, they can be used also as timber pulp or timber for furniture.

If thinning is carried out by organized group through association, timber can be collected more than by each agropastoralist. Attention should be paid to stand density so that it may not be over lumbering.

3) Agroforestry

It is possible to plant a windbreak forest and crops in the same area. It will produce food and forage in addition to windbreak effect. Moreover, agroforestry system can reduce the outflow of topsoil, or can use water resources effectively through transpiration control. There is an example in Alahake town, Altay city that Hami melon is planted in a windbreak forest with an effective use of water.

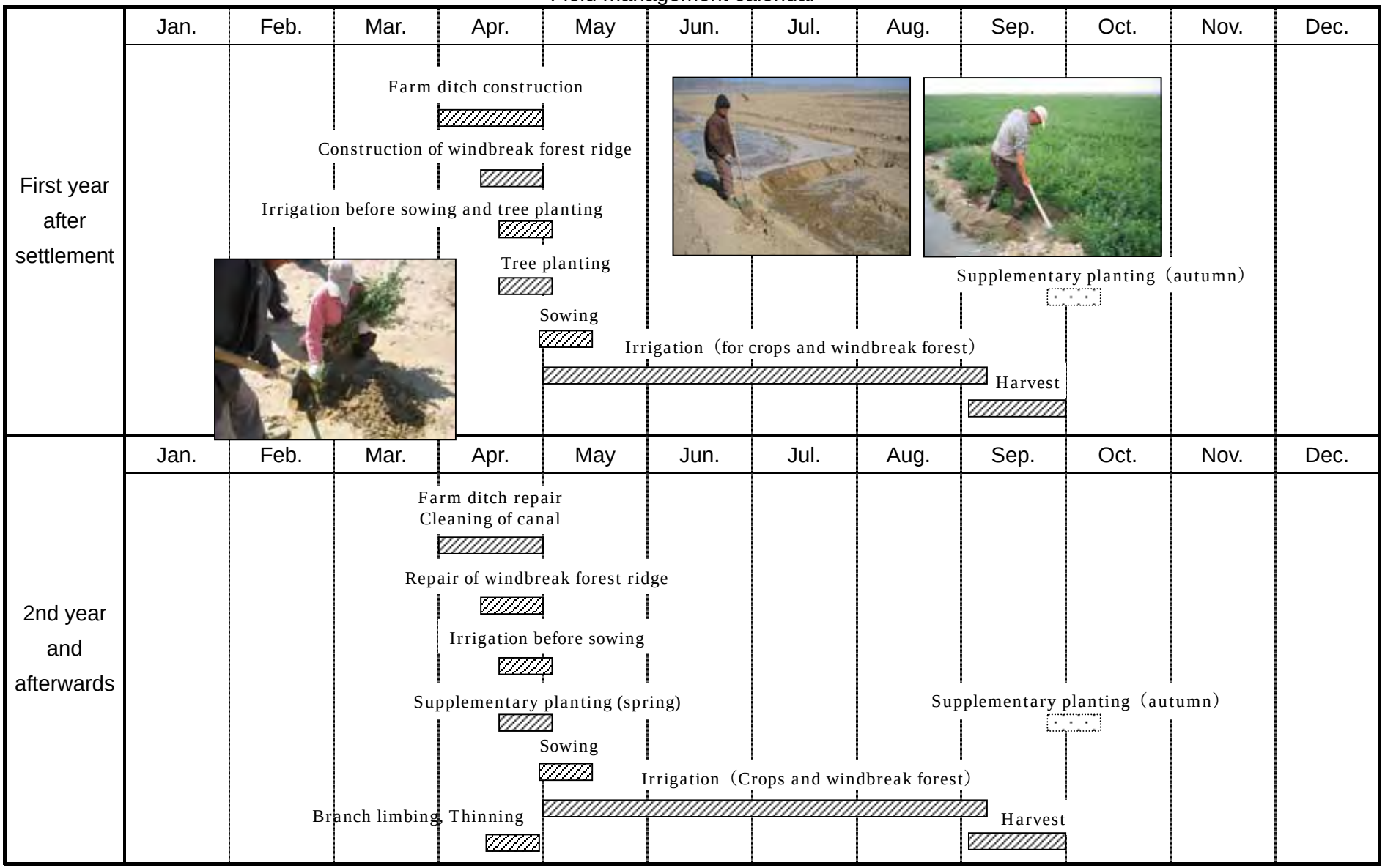
In the study site, alfalfa was planted in a windbreak forest, resulting in improvement in consciousness of initial irrigation compared with the field without alfalfa planting, and in improvement in a survival rate to 75% from 64% which is the mean value of results in the last year.

Alfalfa in a windbreak forest

3.4 Field management calendar

Annual flow chart for agropastoralists is shown in the next page as a field management calendar.

Field management calendar



Chapter 4 Organized Activities

For agro-pastoralists to implement sustainable agriculture and livestock farming, they not only must acquire farming techniques but also must be able to improve their lives and reform their awareness of the environment. The local government usually plays a major role in agro-pastoralists' acquisition of such techniques. In many cases, however, local governments cannot respond sufficiently because of their weak financial condition and limited number of technicians to provide guidance and extension activities.

Therefore the agro-pastoralist who are the recipients of techniques always need to act to mutually improve each other's techniques, and not remain passive. Exchange of mutual opinions becomes easier especially when many agro-pastoralists gather and live in a settlement,. Furthermore, if organized activities are conducted by grouping, improvements in techniques will be carried out more effectively and efficiently.

This chapter describes the efforts to provide technical guidance and promote agro-pastoralists' organized activities carried out in the study by the local government of Alahake Town, Altay City.

4.1 Farming guidance

4.1.1 Objective

Farming guidance is provided by the local government or the most advanced farmers in the area, in order for agro-pastoralist to master farming techniques, engage in sustainable agriculture and livestock farming management and live better lives in the settlements, and to reform awareness of appropriate uses of natural grasslands.

4.1.2 Method of farming guidance

As the method of farming guidance, technical visit to an advanced area, training by a lecture, on-the-job training, and opinion exchange in a workshop are usually employed. Each method is selected according to the situation of guides and participants.

In this case, since the objective of farming guidance is to extend technologies widely, it will be effective and efficient to be carried out with as many participants as possible. A workshop is also useful for the guides, because the participants can identify the problems and awareness of them. Here, the special feature of each farming guidance is described.

(1) Technical visit to an advanced area

Technical visit to an advanced area is very effective, because it has a merit that the

participants can feel advanced technologies for themselves. Considering the expense and avoiding being a pleasure trip, it is desirable to collect participants who are interested in the target technologies. The theme of one technical visit is desirable to be limited to two or three for its efficiency.

(2) Training seminar

Training seminar is the most general method for the agropastoralists who are unfamiliar to learn technologies. In this case, many participants may have experiential knowledge because they have already carried out agriculture and livestock farming. Therefore, it is important to explain agricultural works theoretically to such participants. Never treat them as people without knowledge. Showing numerical data as much as possible and using a visual explanatory material such as PowerPoint if possible will increase participants' interest.

(3) Workshop

Even if similar crop cultivation and similar livestock feeding are carried out, the farming environment of each area differs greatly. It is because the problems that occur from different natural environment and different financial situation will differ even in a neighboring area.

The local government of such an area is considered to understand the problems in the area well. However, if its financial source is limited, importance is attached only to understanding such problems, and the measure for problem solving is usually not made. As a method for solving such a situation, a workshop is one of the effective methods. When the participate members are in various positions, a workshop can discover a new problem out of the discussion based on the stagnant situation, and can produce a method of problem solving.

However, in this case, it is necessary to take participant number and member composition into consideration enough in order to keep the discussion from being diffused.

(4) Seminar

If target persons are not agropastoralists but engineers of the area, it is effective to transfer technology by a seminar in addition to a workshop. The theme of the seminar should be focused on the contents verified there, and introduction of some advanced technologies should be made. If the counterparts with an experience of the activities give presentation on the verified contents, not only the presenters but also the participants will be able to recognize the problems familiar.

It is important to invite senior government officers who do not attend to the ordinary

seminars to the special seminar in order to renew their recognition of the area.

(5) Questionnaire study

It is effective to carry out a questionnaire for participating agropstoralists at the end of the training seminar. A questionnaire can be the precious information for the guides, since the degree of fixing technologies and the intention to future farming can be grasped from a large number of people.

The result should be analyzed enough to produce the theme of the activity that will be needed thereafter.

When carrying out a questionnaire, questionnaire items should be as concrete as possible. If an unknown point is asked, explanation should be made to the participants enough to make them participate to the next training seminar.

4.2 Organized activities

When conducting sustainable agriculture and livestock farming in settlements, organized activities rather than farming activities carried out by each individual agro-pastoralist may be a more effective means for achieving activity results.

In addition to the acquisition of techniques and knowledge, a variety of effects can be expected particularly in the case of new farming activities and new lives in a new settlement, such as provision of labor force through cooperative action, cost-cutting through the cooperative use of machinery, more efficient water management operations for irrigation and cultivation of a cooperative consciousness.

4.2.1 Measures for promoting organized activities

It is extremely difficult for residents to carry out organized activities uniformly because of the many factors involved, such as the traditions, culture, and customs of the area. Therefore organized activities should be conducted through the local government in the area, or a responsible person well versed with local circumstances, after first comprehending factors such as the social relationships and political situation in the area and with adequate consideration to the cultural background.

Moreover, to implement such activities smoothly, the transfer of information is very important. Especially when communication tools are not sufficiently widespread, a responsible person such as the head of the village frequently will take on the role of communication, but creating a communications system using a bulletin board, circular notice or similar means to promote local activities also is effective.

4.2.2 Promotion of women’s organized activities based on kitchen gardens

It is clear from the results of questionnaires that many herders in this area wish to

settle because of problems such as health and education. The effects of settlement are especially significant for women, because settlement eases anxieties concerning children's illnesses and education and releases women heavy labor. Furthermore, the changes to lives in collective settlements create possibilities for lives to become better than under family units in the traditional nomadic lifestyle, by taking advantage of living as a group. Implementing certain activities by organizing groups can be effective for making settlers' lives proceed smoothly.

Many women in particularly hope to effectively use the land around their house and the surplus time provided through settlement to create a kitchen garden.

Based on such circumstances, kitchen garden activities will stimulate grouping and promote group living.

In the settlement at Alahake Town, Altay City, a female committee had been organized but actually carried out few organized activity, and during the study group activities were carried out through kitchen garden efforts.

Points of concern:

- Utilize the organization, such as the female committee of the area.
- Make a responsible female person intervene from the local government of the area.
- Although it is honest, limit to an activity with a sure effect.
- Expense should be charged so that it may not become an activity like Food for work.
- Since it is the activity by volunteers, it is not necessary to establish regulation. However, when a large number participates, grouping should be carried out to determine a representative.

Food for work is to supply food as the countervalue, when people (ussually the target residents of a project) are engaged in a certain labor in a certain project. It is the method often utilized in case disaster has occurred in an area and emergency assistance project is carried out.

4.2.3 Cooperative use of machinery

(1) Objective

Use of agricultural machinery is indispensable for performing agricultural work effectively and efficiently on fields. In this situation, cooperative use of machine is very effective for preventing surplus investment by individuals. On the other hand, when using machinery cooperatively it is important to begin by determining rules and reaching an agreement concerning the use of the equipment, because agricultural work should be carried out within a limited period and the number of machines will be limited.

In addition, as s means to control investment in machinery, alternatives such as leasing the machinery or contract plowing should be utilized. This section introduces points to note based on the example of cooperative machinery use in Alahake Town, Altay City by agro-pastoralists who wanted to process silage as storage feed.

(2) Grasp of machine use at present

By grasping situations, such as machine possession, lease of machines, and tenant farming of agropastoralists in the area, consider an effective method to cooperate target machine operation. For an example in Altay, most of settled agropastoralists have a flexible small tractor, and use it for the work, such as cutting, raking, collecting, and transport of alfalfa. However they lease machines, such as sowing machine used only once in a year, from neighboring people or from town.

(3) Grasp of work procedure and required machines

In cooperative use of machine, a series of processes of operation is checked to decide which work can be cooperated. Corn silage processing in the area is usually carried out with trench silo underground, and the work and the machine shown in the following table are necessary. Necessary machines are only tractor and cutter. Among them, the machine set as the cooperative use was the cutter, and for power each tractor of own was used.

	Harvesting	Loading	Transport	Cutting • Spread	Compaction
Power	Tractor (human power)		Tractor	Tractor	Tractor (horse)
Work machine				Cutter	
Others		Human power	Human power	Human power	Human power

Points of concern:

・In cooperative use of machine, it is important to define the agreement about cooperative use of machine concerning the place to keep machine, responsible person for management, range of users, using methods, and maintenance management.

・In case of the work requiring a lot of labor force, such as silage processing, cooperative work by members of the groups is mainly implemented, through which technologies will be improved.

<Reference> Cooperative use of agricultural machine in Altay

In the Alahake town, cooperative use of cutter for silage processing has started. Four organizations for cooperative use of machine by three agropastoralists have been founded.

The agreement concerning cooperative use of cutter for silage processing is as follows (A-C is substituted for a name).

The agreement concerning cooperative use of agricultural machine

(Objective)

Article 1 This agreement shall define a required matter in order to aim at proper and smooth management of the agricultural machine which Mr. A, Mr. B, and Mr. C posses and use cooperatively.

(Machine)

Article 2 The machine is one cutter for silage processing.

(Place to keep machine)

Article 3 The place to keep machine is Mr. A's house.

(Person responsible for management)

Article 4 The person responsible for management is Mr. A.

(Range of users)

Article 5 The users of the machine are Mr. A, Mr. B, and Mr. C (henceforth "cooperative user"). Users other than cooperative users shall be passed through deliberations of cooperative users.

(Using methods)

Article 6 Using methods are determined upon deliberation of cooperative users for their smooth use.

2 The cooperative user shall always use the machine with greatest cautions.

3 If any trouble occurs during use of the machine, the cooperative user shall report to Mr. A immediately, and shall follow his directions.

4 The repair charge for machine trouble shall be paid by proportional division of cooperative users according to their use situation. When trouble occurs according to on purpose or serious negligence of a cooperative user, he shall restore it to the original form.

5 Those who use the machine have to clarify the contents of use, and have to report them to Mr. A.

(Miscellaneous rules)

Article 7 Deliberations of cooperative users shall determine the matter that is not in this agreement.

Additional rule This agreement is enforced from September 12, 2005.

4.2.4 Cooperative marketing of products

(1) Objective

In many cases, producers sell their livestock products through intermediaries. Prices, however, are based on decisions by merchants, the buyers. When the market is of a certain size, or the distribution infrastructure is in place, one means for producers to overcome such disadvantageous conditions is the cooperative marketing approach. Cooperative marketing of agricultural and livestock products has been adopted by individuals who have same thoughts and strategies on sales, who form a group for the purpose of raising income. Because in this case the goal was simply unification of sales, a broad approach on cooperation encompassing production and feed management was considered. For such an effort, it was necessary to formulate a realistic plan, taking into consideration the level of cooperative marketing experience in the area. Moreover, when taking this approach it also is important to pursue the plan while obtaining support from the government as needed.

This section introduces points to note based on the example of cooperative marketing of sheep by agro-pastoralists who are fattening sheep in Alahake Town, Altay City.

(2) The present condition of cooperative marketing

The cooperative marketing is effective when there is a product with a certain scale in an area. However, even in such an area, agropastoralists are usually based on the farming by family management, and cooperative marketing is usually carried out after a surrounding economic condition and marketing system are developed to some extent. Therefore, asking for assistance of the local government of an area is effective to grasp such a situation and information.

Points of concern:

(1) In cooperative marketing, examine fully the possibility whether advantage is certainly secured or not in consideration of various risks.
(2) Grasp the market trend concerning about retail price of the target products and quality of them that market requires.
(3) Those who implement cooperative marketing should try to equalize the technical level by fully grasping the present technical level of farming in the group.
(4) Those who implement cooperative marketing should continue examination not only about improvement in feeding technology but also about the marketing strategy.

<Reference> Cooperative marketing of the sheep in Altay.

Sheep weight(kg)	Actual price (yuan/kg)	Common price (yuan/kg)	Difference in price (yuan/head)	Loading capacity per vehicle (head)	Profit by cooperative marketing (yuan)
35	7.6	7.4	7	100	700

4.2.5 Communication tools

Even in the collective housing in settlements, in many cases there are few close relationships among settled agro-pastoralists. This reflects the tradition of nomadism based on life in an extended family system, and may not change soon. Once agro-pastoralists have settled, however, relationships with neighbors naturally will become closer than before.

Because differences in living conditions will become more evident, particularly depending on differences in farming results, interest in technical improvements will increase. Meetings among settled residents with the aim of improving their lives, including technical training, will become even more necessary in the future. As a communication tools in such instances, publicity using bulletin boards or circular notices can be effective when the diffusion rate of cellular phones is not very high.

4.3 Foundation and management of a water users' association

Water use facilities are utilized cooperatively and require a certain amount of costs for operation, maintenance and management, which the users must pay. For this reason, establishment of a water users' association composed of the agro-pastoralists who are the users is required for the purpose of maintaining and managing such facilities.

Normally, the government formulates the system for water use and control methods. This system must be explained to agro-pastoralists and widely publicized so it is well understood. Detailed rules for water use and management should be adjusted according to actual conditions after actual application has begun, based on discussions with the agro-pastoralists.

The following figure shows the water management system for the model fields in Alahake in the Altay Area. A water users association should be operated by being positioned between the on-site water control station and the agro-pastoralists.

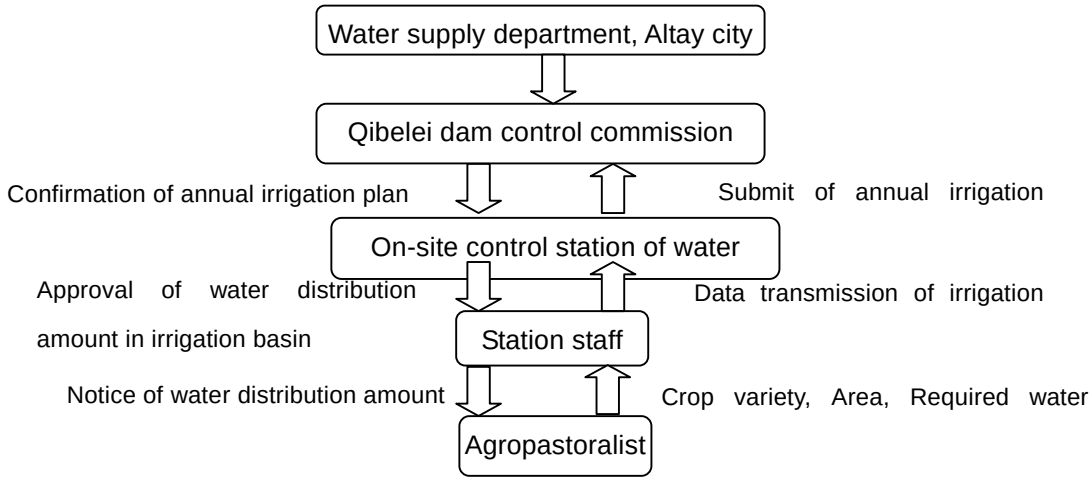


Fig. 4.3 Water management system diagram in Alahake.

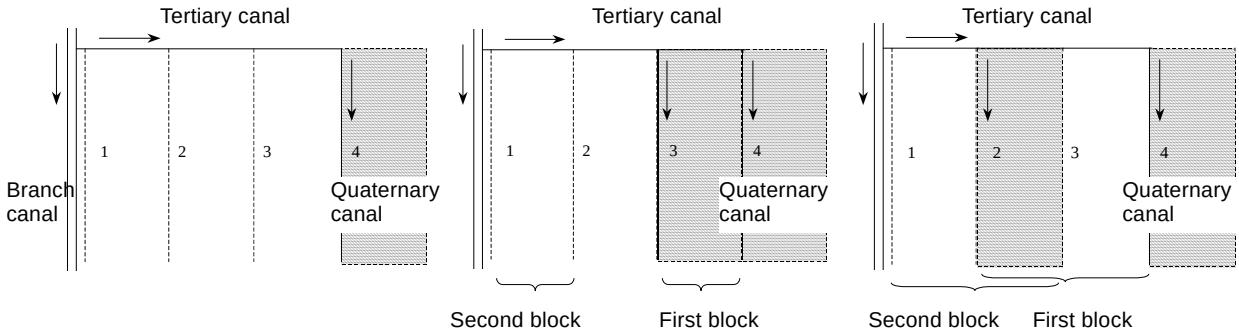
4.3.1 Rotation irrigation

(1) Objective

An irrigation basin is divided into several blocks, and the water distribution procedure to supply water irrigation to each block in turn is referred to as rotation irrigation. With an irrigation area covering several hundred ha, without an agreement on rotation irrigation at the branch canal level disputes frequently will arise because the downstream areas are in a disadvantageous position for water distribution compared with the upstream areas. For this reason, a water users' association must determine the irrigation water supply procedure.

(2) Method

There are three systems in rotation irrigation as shown in the following figures.



(a) Concentrated rotation irrigation (b) Grouping rotation irrigation (c) Grouping alternate rotation irrigation

(a) Concentrated rotation irrigation

Concentrated rotation irrigation is to distribute water in the way that the canal discharge of one class is concentrated on one canal of lower class. In carrying out rotation irrigation between quaternary canals, canal discharge of tertiary canal is concentrated on one quaternary canal, and after finishing it, water is supplied to the next quaternary canal. When the capability to drain of the quaternary canal is small to receive the canal discharge of tertiary canal, the following grouping rotation irrigation should be considered to apply.

(b) Grouping rotation irrigation

Grouping rotation irrigation is to distribute water in the way that the canal discharge of one class is supplied to one group of its lower class. By this system, the adjacent quaternary canals are divided into some groups, and water is supplied to each group according to the appointed order. This system is often adopted when the canal discharge of upper class is relatively large.

(c) Grouping alternate rotation irrigation

In some case, a water distribution method is used to supply canal discharge of tertiary canal to the group of quaternary canals made every other. This system is adopted in order to guarantee the equity of benefit for all water using units of each class of canals.

Here is introduced, an example of irrigation block of rotation irrigation in the Alahake verification field in Altay city. Also explained in the clause of crop consumptive use of water, it is necessary to plan the rotation irrigation to be carried out within the limits of five - seven days, since adequate irrigation interval is once every five days.

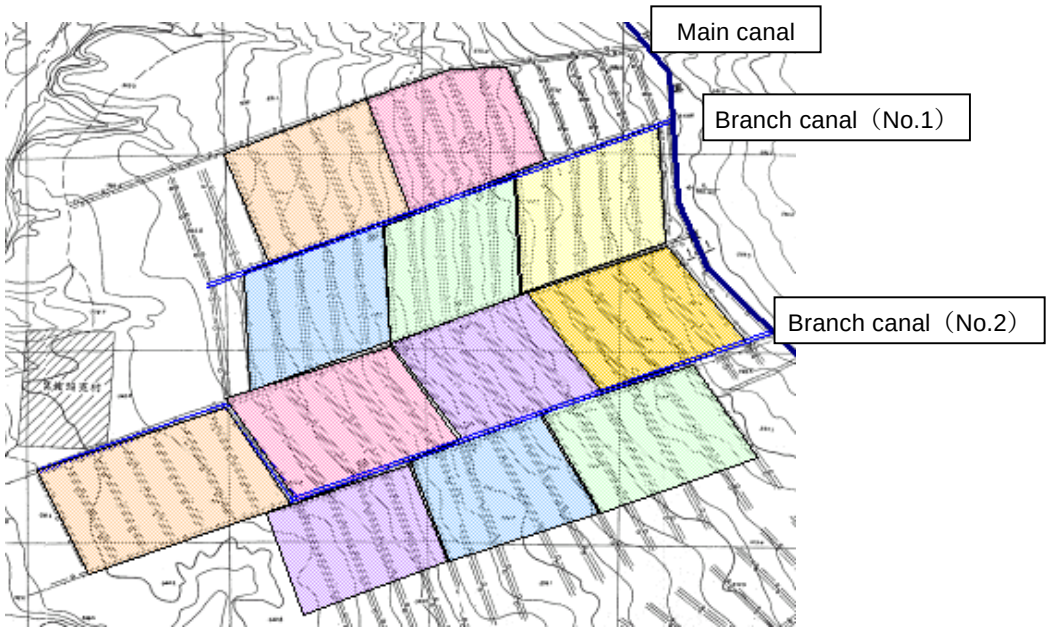


Fig. 4.3.1.1 Rotation irrigation blocks in Alahake verification field, Altay city.

As shown in the above figure, the field of five to seven divisions was set as one group, and 5-7groups were set under one branch canal. The area of one division is about 6.7 ha. It takes 24 hours to irrigate to one group.

It is emphasized here to agree the rule concerning the supply and management of water planned by the on-site control station of water finally through discussion in the training seminar of agropastoralists.

Moreover, it is desirable to elect a leader from these groups. The leader has to notice people, when water comes to their irrigation block next time.

There are methods of using a bulletin board and a circular notice as an example of the notice method to the agropastoralists.

It is desirable for the operation of water distribution from branch canal to farm lateral by the gate offtake regulator to be carried out by staffs of on-site control station of water in the early stage. However, after this rotation irrigation method are well-known or after agropastoralist master operation of water distribution by the gate offtake regulator, each agropastoralist may carry out opening and closing of the gate offtake regulator by himself.

Points of concern:

Positive reservation of water resource is required for the irrigation in arid and semi-arid area, however, when water shortage has occurred unavoidably, every agropastoralist should reduce irrigation area for the year in response to it. The burden of a water shortage lies on each agropastoralist. Even in such a case, the amount of water to distribute to the terminal field lots should be secured.

Moreover, operation of water distribution of gate offtake regulator is difficult without skillful technology. When water comes to the canal in the first year of water distribution, it may not often be distributed to all the corners of the field because of an insufficient water level. In order to prevent such a situation, measures are required to secure a certain water level in the terminal field lots and to distribute water to the field with a special large difference of water level, while operation is unskilled.

4.3.2 Water use facilities maintenance and management

(1) Objective

Adequate water use facilities maintenance and management extends the life of the facilities and reduces costs. This involves full-time monitoring, periodic observation, inspections, repairs, emergency measures for flood prevention during flooding periods, annual maintenance and removal of sediment during normal periods when water flow is halted and renewal of the facilities.

To implement adequate maintenance and management by a water users' association, easy-to-understand visual instructions for the daily checkpoints should be prepared for each facility. An example of facilities maintenance and management conducted in the Study on Prevention of Desertification in Arid and Semi-arid Areas in Asia is provided.

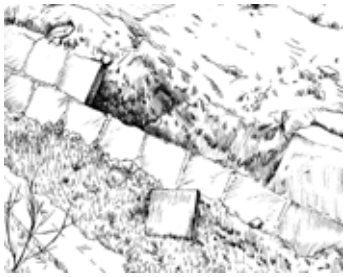
(2) Method

In the repair work of irrigation facilities, the role should be shared between local government and agropastoralists beforehand. For an example, since repair of the lining canal is difficult economically and technically for agropastoralists by themselves to carry out, local government (on-site control station of water) should repair it. Weeds and sediment in the canal can be removed by agropastoralist with burning. It is desirable to make the agreement like that.

Classification	Lining canal		Farm lateral		Farm ditch	
	Collapse	Such as weeds	Collapse	Such as weeds	Collapse	Such as weeds
On-site control station of water	○	×	×	×	×	×
Agropastoralist	×	○	○	○	○	○

Notes) O: Responsible, X: Not responsible.

Weed removal by agropastoralist



Repair by on-site control station

Irrigation facilities may break with progress of time. It is desirable to let agropastoralists know well to present a check sheet made as follows with a sketch of the situation of the broken canal to the on-site control station if they discover a broken part.

Check-sheet (an example)

Date:	Person of entry:
Place:	Sketch:

Points of concern:

Irrespective of the maintenance and management of the facilities, the local government has to guide agropastoralists with initiative at an early stage until management of a water users association sets on way. Training seminar should be periodically held as a guiding method, and the purpose must be exactly told to the agropastoralists so that it is well known to all.

In some cases, it is necessary to consider gathering agropastoralist for regular and irregular repair of weir, or maintenance, management, and cleaning of canals.

4.3.3 Cost management

(1) Objective

If the costs related to water supply facilities operation are not covered by the earnings produced by use of the facilities, the facilities will not result in sustainable production activity. The fee the water bureau receives from water users based on a specified method is called a water charge. The purpose of water charge collection is to promote rational use and conservation of water resources, and to secure the funds for repair, maintenance and management of irrigation facilities. The funds required for large-scale facilities construction or repairs are set aside to maintain simple restoration or large-scale restoration of irrigation facilities. In this chapter, the water charge collection system in the Xinjiang Uygur Autonomous Region is described as an example.

(2) Method

In the Xinjiang Uygur Autonomous Region water supply agency (District water supply agency), document proclamation is carried out concerning with the "Water supply to house" system in the irrigation division in February, 2001. This system is to develop and use water resources rationally, to promote water use and water saving intentionally, to stop the phenomena of collecting money indiscriminately by taking the opportunity of water cost collection, to make a standard of collection, and to make water management transparent.

Furthermore, it is the system that the facilities upper than branch canal are managed by on-site control station of water and facilities lower than branch canal are managed by agropastoralists democratically. It is to calculate irrigation amount, to improve irrigation service, to make collection of water charge transparent, to realize "water distribution, water measurement, record, and collection of water charge are all carried out by farmhouse", to reduce unreasonable burden, and to empower and promote consciousness of water saving.

By this system, the calculation method of water charge has changed from calculation per area into water amount calculation.

Although the farmland area given to each agropastoralist is the same, if there is a place where water cannot reach easily to the end due to the relief of land, cultivation will be restricted there. Even if farmland area is uniform, it will be a problem to collect water charge uniformly. Water amount calculation method has above mentioned background, and has a purpose to cancel those and to improve the consciousness of water saving of agropastoralists

It is necessary to construct water measurement facilities on the gate offtake regulator in order to calculate irrigation amount with measuring irrigation time. The scale is painted on gate offtake regulator as shown in the right photo. Since the scale may disappear if it is exposed to a rainstorm, it is necessary to carry out periodical check and repaint periodically (once every two weeks).

Measurement of irrigation time is carried out and recorded by the staff of 0n-site control station of water at the early stage, but gradually should be transferred to agropastoralists with training seminars and explanation meetings.

The table of the following page is a use detailed card of the irrigation water actually used in the Alahake field. Irrigation is made at proper time with proper quantity according to the water requirement of the field crops there.

Moreover, "Irrigation license" and a "Irrigation card" are to be used in the "Water supply to house" system. "Irrigation license" and a "Irrigation card" are printed and distributed to each district, an autonomous state (city), or each county (city). Every farmhouse keeps one "Irrigation license". Staffs of on-site control station of water keep "Irrigation card" and use them corresponding to Irrigation license. They have to proclaim a water distribution book at each time or every month, to proclaim amount of water, water charge, and a collection real frame certainly to farmhouse, and to supervise them whole-heartedly.

Points of concern:

The greatest reason for agropastoralists' not paying water charge is that water does not actually come as expected. In a wide range there seems to be a contractual concept that water charge will be paid if water comes and will not be paid if water does not come.

Moreover, agropastoralists just after settlement are not good at irrigation work. For this reason, it is desirable to collect water charge with a stepwise increase, for example, 30% in the first year, 50% in the second year, and 100% in the third year.

Use detailed card of irrigation water in agropastoral district of Altay city

Water use unit ： Oimake village Irrigation division No.1 Branch canal No.1 Group No.1

Name / Date		Cultivation area (mu) / Irrigation area (mu)										Flow rate m^3/s	Duration of irrigation (h)			Amount of water (m^3)		Unit price 0.024 yuan/m^3	Water charge (yuan)			Name of water distributor	Name of water user
		Wheat	Maize	Legume	Sunflower	Beet	Squash	Leaf Vegetable	Alfalfa	Pasture	Others		start	end	duration	Prediction (m^3)	Actual (m^3)		Charge	Paid	Not yet		
Year, month, day																							

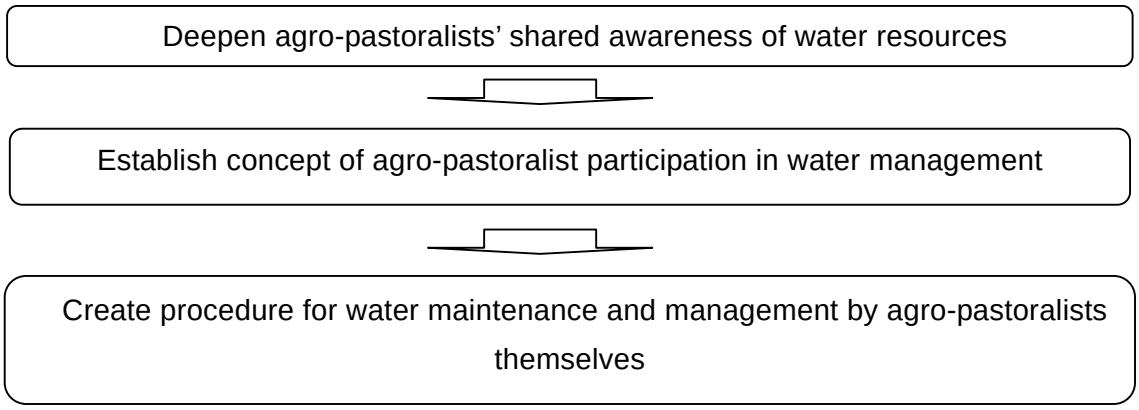
4.3.4 Water management education and dissemination activities

An extension staff at the on-site water control station frequently is the individual who is in daily direct contact with agro-pastoralists concerning water management. The abilities of the person positioned at the lowest level of the local government also are critical. Locating the most suitable individual is often is difficult, however. A young person with limited experience who is unacceptable to the agro-pastoralists may be given this responsibility. When deciding to organize agro-pastoralists in a rural village, it is necessary to select a suitable person from the settlement to become an instructor and provide the training so that individual will become an expert.

4.3.5 Water use based on the local community

Active participation by agro-pastoralists in the maintenance and management of agricultural water use facilities is important for efficient use of irrigation water and effective use of limited water resources. Agricultural water use projects in developing countries usually are considered to be a national project, however, and currently agro-pastoralists do not sufficiently understand that they should perform maintenance and management work themselves. Furthermore, both economic development through irrigation and environmental protection of an area are important, and this means the formation of a new concept that includes agro-pastoralists must be considered.

One tentative plan for a procedure is shown below.



Rural villages are found in various forms throughout the world. Each village exists on the basis of conditions such as the village's own history, traditional lifestyle and social and economic environment, as well as natural conditions such as climate, natural features, soil, and geographical features. As a result, the creation of water management procedures involves complicated problems that cannot be resolved simply by understanding of water supply technology. The application of sociological

techniques is also essential to handle these problems.