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WPSR No. 44

Developing Production of a
Non-Traditional Crop in
Southeast Asia:
Wheat in Thailand

J.G. Connell



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Acronyms

ARTC	Agricultural Research and Training Center
ATT	Agriculture Transfer of Technology Project
CMU	Chiang Mai University
DOA	Department of Agriculture
DOAE	Department of Agriculture Extension
FSR	Farming Systems Research
FSR/E	Farming Systems Research and Extension
GTZ	Gesellschaft für Technische Zusammenarbeit (German Agency for Technical Development)
HDP	Highland Development Project
ICARDA	International Center for Agricultural Research in the Dry Areas
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDRC	International Development Research Center (Canada)
KKU	Khon Kaen University
KU	Kasetsart University
MAC	Ministry of Agriculture and Cooperatives
MCC	Mennonite Central Committee
MC-WSP	Mae Chaem Watershed Project
MOA	Ministry of Agriculture
MOI	Ministry of Interior
NESDP	National Economic and Social Development Plan
OFR	On-farm research
R-HDP	Royal Highland Development Project
RRI	Rice Research Institute (in the Department of Agriculture, Thailand)
TA-HASD	Thai Australian Highland Agriculture and Social Development Project
TA-WLD	Thai Australian - World Bank Land Development (Project)
TG-HDP	Thai German Highland Development Project
TN-HDP	Thai Norway Highland Development Project
UNHAMP	United Nations Highland Agricultural Marketing and Production Project
UNHCR	United Nations High Commission on Refugees

Units

Bt	Baht, Thai monetary unit (in 1988-93, the exchange rate was approximately 25 Baht = US\$1)
Rai	Thai unit of area; 1 rai = 0.16 ha; 1 ha = 6.25 rai

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Preface

This Wheat Special Report relates the accomplishments of nearly a decade of work in Thailand by John G. Connell, former CIMMYT associate scientist. It describes the development of wheat production in Thailand over the past decade and focuses on the processes and dynamics of the crop's introduction and expansion, the underlying constraints and imperatives that have operated, and the roles of and interactions between the various cooperating institutions.

Why worry at all about wheat production in a warm, non-traditional country like Thailand? Urbanization has led to increasing wheat imports in many such countries. Globally, Southeast Asia has had the most rapid increase in wheat consumption. Thailand—as well as some of its neighbors in the region such as Indonesia, the Philippines, Laos, and Vietnam—has investigated the feasibility of initiating or increasing domestic wheat production to supplement grain imports. Throughout the 1980s and into the early 1990s, CIMMYT—with support from the United Nations Development Program (UNDP)—cooperated in this effort.

We focus on Thailand because it has been the most advanced in its development of wheat production. After nearly one decade, there is now a solid, problem-oriented and consultative research program among the Thai Department of Agriculture and a wide range of institutions. The Thai Department of Agricultural Extension's (DOAE) Crop Promotion Campaign has succeeded in establishing "production centers" for wheat in most provinces in the northern reaches of the country. Local grain merchants have begun to purchase the crop at these centers and ship it south to the mills in Bangkok.

Since 1987, the area sown to wheat in Thailand has expanded to about 5500 rai (880 hectares). During the same period, annual wheat imports have risen from 170,000 tons to an estimated 400,000 tons. Domestic wheat production in Thailand will probably never make a serious impact on reducing grain imports. However, due to the crop's low water requirements during the winter growing season, it is still likely to play a useful role in increasing productivity and farm incomes in disadvantaged areas.

We see this report as being of interest to a wider range of people than those involved only in wheat production. There are aspects that should interest specialists working in the areas of nutrition and changing food habits, expansion of a non-traditional crop, farming systems research, extension methodologies, and farmer participation.

Sanjaya Rajaram
Director
CIMMYT Wheat Program

Foreword

Biologically speaking, wheat production is feasible in Thailand. Anybody who visits fields in the north of Thailand will come to that conclusion. Then what is hindering wheat's rapid spread in the country?

There are external reasons, such as world market prices of wheat, competing crops, substitute crops and fertilizers. They can be countered by government intervention at a social cost (and we have to admit that each government in the world makes these value judgments irrespective of any strictly economic assessment). Such subsidies may depend on the interests of the government, or the pressure on it by lobbyists. Wheat does not have a strong lobby in Thailand. The small import tax serves more to assure rice consumption than to protect local wheat production. Under the current world market price, government regulations, and production technologies, wheat is just about economic for those farmers who grow it. Then why has it not spread more rapidly?

The answer lies in a myriad of interacting local factors; each of them can stop production in a whole village if not adequately dealt with. Some of the more frequent scenarios that hinder wheat production include the following:

- ◆ In a new crop, extensionists and farmers can easily make management mistakes, e.g., wheat being researched by the Rice Research Institute of the Department of Agriculture becomes yellow in poorly drained rice paddies. Since rice becomes yellow if it is short of water, this must be the case for wheat as well. So, the wheat crop is given more water and it promptly dies.
- ◆ Landholdings of wheat farmers are 5 ha or less (with a few exceptions). They have no means of taking their harvest to a distant buying point. If a courageous farmer has harvested 200 kg of wheat, but the bags sit unsold in front of his house for weeks or months, none of his neighbors will consider growing the crop next season.

- ◆ Suppliers of inputs and buyers of farm products are local merchants in rural towns. If they are not aware of a fixed price at the mill in Bangkok and confident that they will receive the money soon after delivery, they will not buy from the farmer.
- ◆ In parts of Thailand, land is inherited maternally, so many cropping decisions are often decided by farmers' wives. It is important for extension to target them, but this does not happen as a rule.

In short: Somebody has to recognize problems that nobody seems to be responsible for, take them to the right group of people for solution, and help implement the improvements. If not, all increases in productivity of resources cannot be put to work.

Specialists from many institutions in Thailand worked on various components of this wheat production campaign aimed at small farmers. All of them, however, had to continue to perform their regular duties as pathologists, professors, breeders, merchants, millers or extension agents working on other issues and crops. In hindsight, it appears correct that CIMMYT provided a good deal of integrating services where it had a comparative advantage to do so. CIMMYT staff had no vested personal or institutional interest except to establish production itself. It provided continuity where national staff could not put too much time and effort into a not yet fully commercial crop; it tapped international sources of professional knowledge, which could not have evolved at the national level. The author of this Wheat Special Report executed most of CIMMYT's contribution to the integration of locally existing components of wheat production. This, I think, gives the views and experiences presented here their heavy weight.

From 1982 to 1992, John Connell was employed by the CIMMYT Regional Wheat Program for Southeast Asia (there was a 15-month interruption in 1989-90 when he

freelanced as an extension consultant mostly working with wheat). During these 10-plus years, Chiang Mai University provided him with an office as a base for his work. The regional CIMMYT office was far away in the Department of Agriculture in Bangkok and was limited in the assistance it could provide. Mostly he had to find his own way to achieve what he was asked to do—promote wheat production by removing obstacles for the farmers, be they marketing, diagnosis of management problems, or lack of knowledge or inputs. He did this in his own unique manner—by way of quietly listening to all sides, bringing the right people together at the right time across institutional boundaries, tactfully pointing out weaknesses, providing hands-on training, visiting fields frequently enough to correct shortcomings before total losses occurred, never in a hurry when it came to talking wheat or spending the night in a village, putting activities in perspective to clear the minds, and (more recently) conducting research about appropriate extension methods for a crop in a new environment to which it is only marginally adapted and in which neither researchers nor extensionists nor farmers have experience. An economist would have difficulty quantifying his contribution in communicating with many socially diverse people and spreading technical knowledge, especially given the lack of a proven strategy on how to reach the goal. But whatever his share in the success, it is surely underrated in this report.

Wheat production in farmers' fields in Thailand has come a long way. Farmers, government departments, universities, non-government organizations, international institutions, millers, and other private sector companies put great efforts and dedication to make it go. The general openness to listen, which prevails in this hospitable country, made it possible to integrate knowledge and initiate cooperation to achieve the goals described here.

Today, wheat production in Thailand has reached a crossroads: it is profitable, but just barely so; the market is huge, but the marketing structure for small farmers is still not responsive to the small amounts produced. Under the existing program, which supplies free inputs to farmers, there is a limit to the number of new wheat farmers that will be served. If the area is to expand substantially, new avenues must be opened, e.g., further cost saving management practices acceptable to small farmers have to be sought and introduced, and input supply has to move to local private people such as farmers storing their own seed through the rainy season and fertilizer being bought on the local market.

I am sure this report will contribute to choosing appropriate solutions by looking into the past and by considering suggestions for the future. It may also help others who are trying to introduce wheat—or another crop—into new countries by describing experiences and ideas that they can then adapt and modify.

Christoph E. Mann
Former Wheat Breeder
CIMMYT Southeast Asia Program

Executive Summary

Introduction

Urbanization has led to increased wheat imports by non-traditional, wheat producing countries. Globally, Southeast Asia has had the most rapid increase in wheat consumption. Over the past decade, Thailand, Indonesia, the Philippines, Laos, and Vietnam have attempted to assess the feasibility of initiating domestic wheat production to substitute or supplement their imports of wheat.

All of these countries have areas suitable for wheat production, but no production experience, indigenous consumption, or marketing structures for wheat to provide a base for expansion. Despite the appeal of developing domestic wheat production, it must be considered essentially an experimental venture. Thus while it has been possible to gain the enthusiasm of technical people, it may not necessarily rate high on the list of government priorities.

The main difficulties of developing wheat in Thailand have surprisingly not been technical issues, such as poor plant development, pests, and diseases. Instead, the unfamiliarity of the crop amongst scientists, extension workers, and farmers has been the key constraint. Functionally this has resulted in a number of problems in unexpected areas;

- ◆ Identifying the areas where wheat would have a comparative advantage over other crops was not clear for some time. As a result, early extension efforts were scattered and shifted from area to area.
- ◆ The recommended technology for planting wheat was too intensive and liable to misinterpretation by farmers, which led to repeated crop failures in the early years of the program. Easily adopted technologies that allowed reliable crop establishment by farmers took some time to evolve.
- ◆ Local grain merchants had no knowledge of wheat and were not prepared to purchase small volumes from isolated groups of farmers. This created a lack of confidence in the crop among farmers and extension workers.

These issues were recognized as being significant once the production program was in the progress and they had to be dealt with as they were encountered.

The program in Thailand is notable in that it has not been structured as a pilot project with a specific pilot area for production; special fund allocations; or any program to buy back the crop from farmers. Instead, the program has been implemented within existing planning, budgeting, and operating procedures of the various government institutions involved. This has had inherent difficulties, but has also led to some innovative initiatives. In the long run, these have given the program greater strength and sustainability:

- ◆ The difficulty of marketing small quantities of the crop was initially addressed by attempting to promote local use of the crop.
- ◆ The Department of Agricultural Extension (DOAE) has begun to develop a market structure for wheat based on local independent grain merchants. This should expand dynamically with a minimal input of government funds.
- ◆ A wide range of institutions has been involved in the program, which gave the program access to inspiration and initiatives from different directions. This has helped maintain momentum to a greater degree than if only one institution were involved.
- ◆ Finally, the problem of developing appropriate production technologies for a diverse production environment, was solved through a process of cross-fertilization between researchers' on-farm trials, and farmers' informal trials. This interaction between research and extension evolved through a "participatory extension" approach that engaged farmers in the process of fine-tuning the technologies to their particular situation.

Most of the major crops that have been introduced to Thailand since World War II (i.e., maize, cassava, soybean, and tobacco) have been export-driven, with the private sector playing an active role in supplying farmers with inputs, production technologies, and a waiting market. Wheat, on the

other hand, is competing with efficiently produced imports, with all stages of the program for developing production; technology development, seed supply, and marketing, being led by the government sector. This offers a unique opportunity to draw useful lessons. At this point, the technical viability of wheat production has been established. Dynamic expansion of the crop has yet to occur and will depend on the program's successful transition from being government-sponsored to the private sector. Final establishment of the crop will also depend on factors outside of the program's control, such as world prices for wheat.

This Report focuses on the processes and dynamics of wheat's introduction and its expansion, the underlying constraints and imperatives, and the roles and interactions of the various cooperating institutions. The three chapters covering these topics are briefly summarized below.

Chapter I. Promoting "Local Use" of Wheat as a Strategy for Developing Crop Production

Extension efforts to introduce wheat to small farmers in northern Thailand began in the early 1980s. The program was immediately faced with the problem of disposing of the small output being generated by scattered groups of farmers. To escape this problem, local use of the wheat was promoted as a substitute for selling it. This was intended to allow farmers time to begin to obtain reasonable yields so that it would be economic for them to produce and permit production volume to increase sufficiently so that local grain merchants could purchase and ship the harvest to the flour mills in Bangkok.

Local use was promoted on two levels: direct consumption within farm families to supplement their staple diet of rice, and sale of locally milled whole-wheat flour to food vendors. Whole-wheat flour was selected due to the simple grinding process involved and the feasibility of blending it with commercial white flour.

The program developed several ways of preparing food that allowed wheat to be included in the food habits of local Thai farmers and the ethnic hilltribe people. These dishes were readily accepted on the basis of taste, but the long

preparation and/or cooking time prohibited their ready adoption into the farm family diet. However, there are some indications that ethnic hilltribe people could fit the more basic preparations into their diets and daily routines.

There was a consistent interest among farmers' housewives to use wheat for various types of snacks. A number of small bakeries started using methods of milling and baking, based on locally available technologies and materials. In the end, the main obstacle to widespread replication of such enterprises was not poor market acceptance or the lack of appropriate technologies, but the lack of middlemen who would maintain a stock of wheat in the village. Without material readily available, there was little opportunity for potential entrepreneurs to begin trial operations.

Overall, the local use effort was not successful in its main objective of generating home consumption in the place of selling the crop. However, there were indications that local use of wheat could develop in certain situations once production became more commonplace. While unsuccessful in this primary goal, the effort did help to popularize the new crop among women farmers. The interest and cooperation that the program engendered was significant. Therefore, when trying to stimulate interest in a new crop, the local use concept should not be rejected out of hand.

Chapter II. Developing Production: Initiatives and Constraints

The current program to establish wheat production is the latest attempt to do so over the past 50 years. The Department of Agricultural Extension (DOAE) initiated the program with a series of multilocation trials, beginning in the 1983/84 cool season. A widespread wheat promotion campaign began four years later (1987/88 cool season). As a key element of the campaign, the DOAE has provided free seed and fertilizer. Where substantial production areas developed, mobile threshers were made available free of charge.

Production has been promoted in both rainfed and irrigated environments. A rough estimate of the area in these two production domains is 110,000 and 55,000 ha, respectively.

Extension efforts have alternately targeted rainfed and irrigated environments as the expectation of success in the two domains changed. By 1990/91 season, "production centers" of wheat had been established in six of Thailand's eight provinces. The production area in 1995/96 had reached a modest 742 ha and 720 ha for rainfed and irrigated areas, respectively, with a total of about 1500 ha.

Early extension efforts were plagued by consistent crop failure due to farmers' unfamiliarity with the crop. In irrigated areas, farmers consistently over-irrigated, over-seeded, or left seed uncovered. Rainfed areas had similar problems of over-seeding and poor seed-cover. In rainfed production the seeding date has to coincide with the last storms of the wet season. As the pattern of these late storms changes from year to year, this has necessarily prolonged the learning curve for rainfed farmers. Thus the yields for rainfed production have been slower to rise. Such a set of management errors is typical for any extension program introducing a new crop. But in the case of wheat, the technology extended to farmers played a major role in their consistent crop failures. It was not until more appropriate technologies were developed that extension began to achieve any success.

The severity of these management errors has been reduced (but not eliminated) so that the average yields for the 1996 harvest were approximately 1 t/ha and 0.64 t/ha for irrigated and rainfed areas, respectively. This is still below the calculated "break-even" point of 1.2 and 0.82 t/ha for irrigated and rainfed areas, respectively. However, farmers with a number of years experience growing the crop are achieving double these yields.

Marketing has been a major issue for wheat. The DOAE made a concerted effort to develop a market structure based on independent local grain merchants. They acted at two levels. In Bangkok, guaranteed prices of 7.4 Bt/kg (0.30 US\$/kg) at the mill door and procedures for handling the crop were established with mill representatives. At the local level, extension workers selected local grain merchants and introduced them to farmers.

The two groups held yearly marketing meetings before crop harvest. The system has some rough spots, but the network of local grain merchants purchasing the crop is increasing each season. This structure should expand dynamically as production expands without continued coordination by government institutions. This attempt to engage the private sector, should it prove effective, will have been achieved with minimal government expenditure.

The crop is at its "watershed" in Thailand. There are expanding centers of production in both rainfed and irrigated areas, appropriate technologies are available, and marketing links with flour mills in Bangkok have been established. However, dynamic expansion is yet to occur.

Government support of free seed has reached the limit of its usefulness now and is beginning to inhibit dynamic expansion. Average yields are still depressed by the typical management errors noted in the early years of extension, and by market links, which are not yet responsive. All of these problems can be managed. However, the overall constraint is the lack of any real drive from the mills as the end users. The government sector has succeeded in establishing the basis for wheat production in northern Thailand. Its job is more or less done. At some point the private sector will need to become a driving force. When the program began in early 1980s, wheat prices were low, but they have risen substantially since, so that domestic wheat should now be cheaper than imported wheat.

Chapter III. Developing Appropriate Technologies in a Diverse Production Environment

The initial research effort was confined to experiment stations where scientists themselves had to become familiar with the crop's characteristics. The original recommended technology was time- and labor-intensive, and was open to misinterpretation by traditional rice farmers. It is unlikely that any extension program based on this technology would have been successful.

Most of the more appropriate technologies that are now being adopted were identified through fairly informal on-farm trials. The research program has changed considerably over the last 12 years. Research is now strictly oriented towards production problems and has a strong on-farm component. In addition, scientists are beginning to examine the focus of the research program in the context of the diversity of the production environments.

Since the beginning of widespread promotion of the crop to farmers in the 1987/88 season, there have been dramatic shifts in the preferred technology used. Perhaps as few as 10% of the farmers are still using the originally recommended technology. Broadcasting instead of row seeding, minimum tillage instead of soil preparation, and the use of mulch to alter the micro-climate of the crop are some of the changes that promise to increase yields and/or reduce inputs. There have been several stages in the evolution of appropriate production technologies, and the specific technology preferred at a particular site varies according to local conditions.

Farmers themselves have played an active role in adapting and innovating appropriate technologies. This is perhaps to be expected with a new crop. An extension approach in which farmers are presented with a number of alternative technologies appears to be effective in engaging them to evaluate and adapt the technologies.

Because there is a definite contributing role for the farmers with this extension approach, it is called "participatory." This participatory approach could offer a way around the impasse that farming systems research (FSR) faces; in diverse production environments where any technology developed will be necessarily site specific, the need for repeated trials for each environment places a load on institutionalized FSR that it will never be able to meet. Participatory extension prompts the farmers to fine-tune the technologies themselves and should allow FSR to focus on issues that are beyond farmers' resources to deal with. The viability of institutional adoption of participatory extension was investigated through an action research program funded by Canada's International Development Research Center (IDRC) within the existing Thai Wheat Program.

Chapter I.

Promoting “Local Use” of Wheat as a Strategy for Developing Crop Production

Introduction

During the early part of CIMMYT's support for the Thai Wheat Program, a significant effort was made to promote wheat consumption in the production areas. This was both a strategy to absorb production from scattered groups of small farmers until production and market links developed, and to supplement the local diet. The idea for this somewhat unconventional approach came from several small projects established before the CIMMYT program began.

Two models were construed for “local use” of wheat. The program first attempted to do this by developing small businesses to sell wheat products (the “local market” model). As the limitations of this approach became apparent, the program began to focus on the opportunity for direct consumption by the farmer's family (the “home consumption” model). A range of specific food preparations and appropriate processing technologies were developed for both these models. In the case of home consumption, this included preparations using wheat as whole grain and cracked grain, in order to fit local food habits. For the local market model, efforts focused on developing appropriate technologies for grinding flour, baking, and noodle making.

Extension approaches were developed to implement these two models. Home consumption of wheat was introduced to farmers' wives through village food demonstrations linked to crop extension programs. Commercial utilization of wheat at the village and district level was introduced by providing local merchants with whole-wheat flour on trial. A range of

organizations, including the DOAE, Women's Groups, bi-lateral projects, and NGOs, were enlisted in these activities to broaden the reach of the program.

Exploratory Activities (1981-82)

The initial rationale for encouraging villagers to consume wheat was that it was an off-season crop that could be grown during the dry season in areas where production of other crops was unreliable due to limited water availability. Thus it gave farmers the opportunity of growing an additional food crop, without necessarily competing or displacing rice, the staple grain.

This initial work was carried out before CIMMYT's Southeast Asian wheat program was established within three aid programs (1981-82). It provided an interesting background for developing ideas that were later incorporated into the program.

Bakeries as an income-generating activity

Refugee camp bakery. The refugee camps along the Thai-Lao border¹ accommodated a range of Lao and hilltribe minority peoples (Hmong, Yao and Htin), who had fled the war in Laos. The people in these camps, unlike the Khemer camps along the southern stretch of Thailand's eastern border, had arrived with their basic communities still intact. Even in the camps they had been able to construct their housing according to their traditional designs from bamboo and thatch supplied by the United Nations High Commission for Refugees (UN-HCR).

¹ Sob Tuang Camp, Mae Charim District, and Nam Yao Camp, Pua District, Nan Province.

The refugees were well provided with the basic needs of food, shelter, and medical services. The refugees were confined to the camps, where life was monotonous and with little opportunity to be active or plan for the future. Various programs in the camps provided the refugees with activities to occupy time and energy, and to provide a small income. The bakeries set up in these camps were an attempt to provide work for small groups of men, which would require planning and decision making on a daily basis. Bread baking was well suited to this goal, as each day it required an assessment of the market and quantity to be baked; judgment and skill were needed as well to adjust the dough preparation and to fire the oven according to the expected market and the weather on each day.

The bakeries were established using materials and equipment that were locally available, so that the enterprise could be repeated by other groups. In both the refugee camps, the ovens were built from clay packed onto a bamboo frame (Plate 1). The bread was baked using a 50:50 mixture of whole-wheat flour and commercial white flour. The wheat grain for the whole-wheat flour was obtained from the opium crop replacement project, and ground in the bakeries using a large hand driven stone mill. These mills exist in all Hmong hilltribe villages to grind maize for feeding pigs.

The bread was sold as small buns (70-80 g wet dough weight) for 1 Baht (Bt) each. At the Nam Yao Camp, whose population fluctuated between 7,000 and 11,000 persons, a group of six men earned a reasonable income by baking and selling up to 600 buns daily. A measure of the success of this venture can be gauged from the fact that, when the camps closed and the refugees relocated in the Ban Vinai camp in Loei Province, the bakers from the Nam Yao camp built a new clay oven and started a new bakery there.

Vocational school bakery. The school, operated by a Seventh Day Adventist Mission, was located in rural Mae Dtang District, about 40 km north of Chiang Mai. The 200 children and young adults who attended the school studied either the normal school curriculum or an

adult education curriculum. Most of the students were from poor backgrounds and earned their keep by working part-time in running the school.

Bread baking was introduced to the students as an income-generating activity. A bakery similar to those in the refugee camps was established. Unlike the refugees in the camps, the students had many options to purchase snacks. They could not be considered a captive market, and their purchase of the whole-wheat buns represented a real choice. The bakery operated every other day, and the students soon adapted the basic 50% whole-wheat preparation to include different jams to make sweet rolls selling for 1 Bt each.

The school had upland and paddy areas on which the students cultivated a proportion of the food needs of the boarding students. Following the establishment of the bakery, wheat production as a rainfed crop on the school's fields was introduced. The output of this was then ground into whole-wheat flour using a small electric grinder.

The bakery continued operating for about three years—each generation of students teaching the next how to bake—until the teacher responsible moved to another post.

The opium crop replacement program

The UN Highland Agriculture Marketing and Production Program (UN-HAMP) took a different line from the refugee camps, by attempting to introduce consumption of wheat directly to the farmers cultivating it as an opium replacement crop.

Opium is normally planted in mid-October following a wet-season crop of maize, at elevations above 800 m. The UN-HAMP project had introduced a large number of field and tree crops to the hilltribe farmers. Some of these, such as coffee, have brought a greater return than opium. Although not a high-value crop, wheat does directly replace opium in the upland fields during the cool season. The hilltribe villages were rice-deficient, although not necessarily poor, due to their opium

production. Bread was the way wheat was introduced to the villagers for preparation and consumption. Individual households used a small coffee grinder to grind the wheat and kerosene tins were made into small ovens (Plate 2). These isolated villages (reached after a 3- to 4-hour walk) had small shops that sold essential items and dried yeast could have easily become an item for sale in these if home bread baking had been accepted. While bread made in demonstrations (from 100% whole wheat flour) was readily consumed, it quickly became clear that the whole process of preparation was too long and complex to be accepted by the hilltribe housewives.

Impact of exploratory activities

No sustained local consumption of wheat resulted from this work, although the small bakeries in the refugee camps and the school did continue for some years until other events overtook them and they ceased operation.

These initial experiences did, however, serve to demonstrate that it was technically possible to grind whole wheat flour and to bake bread using simple technologies available in rural areas. More importantly, this early period of work showed that bread, and, possibly, other snacks, could appeal to local tastes and compete in local markets, even when baked with a whole-wheat flour content of up to 50%. The bread baked in the camps and the school were not sold to captive markets. The brown bread had to compete with a host of other products. So the argument often presented that brown bread was not acceptable has been shown not to be valid, as long as the bread was sweet.

The link of this early work with CIMMYT's new Southeast Asian Wheat Program stemmed from an article in one of Thailand's English language newspapers, the Bangkok Post, "Confessions of a hilltribe baker" (Connell 1982). The article ended by describing the potential for whole-wheat flour in local markets. This attracted the attention of CIMMYT's Bangkok-based liaison officer, who foresaw that scattered groups of small farmers would not be able to sell their small production to large commercial mills. As an alternative, the proposed "local markets" for wheat

might absorb the small output long enough for farmers to gain experience with the crop, and until production became substantial enough to allow market links with the Bangkok mills to be established.

Evolution and Implementation of "Local Use" of Wheat in the Thai Wheat Program

Programs to change local food habits are rife with failure. Yet there are notable examples where populations have radically changed their food habits due to the increased productivity offered by the introduction of a new crop; i.e. maize in Africa; potatoes in Ireland, and, more recently, wheat in Bangladesh (Meisner 1992). The adoption of consumption in these cases was spontaneous, rather than the result of any specific program.

There are examples of small programs where the promotion of consumption of a new crop played a stimulating role in developing production. In Bangladesh the Mennonite Central Committee was successful in developing soybean production essentially to improve food self-sufficiency and nutrition. Recipes using soybean in local food preparations were developed and promoted to farmers as an integral part of the crop extension program (Horlings and Martens 1985). In Thailand, a similar type of program had initial success in stimulating production of cowpea in Khon Kaen through promoting simple preparations and vendor use (Ngarmsak 1982). Thus this type of approach is not without some basis.

In the case of the Thai Wheat Program, the acceptance of the bakeries in the refugee camps and the vocational school had already shown that both local Thai and hilltribes would accept wheat-based foods. The inclusion of "local use" of wheat as part of CIMMYT's support to the Thai Wheat Program was begun on an experimental basis. The expected impact and the implementation were only loosely formulated. The general objectives of the program were to help dispose of the wheat harvest until the production volume increased and a market structure

was developed, and to stimulate farmers' interest in the new crop.

Several times throughout the local use program, the focus or "entry point" shifted. The first entry point was for food vendors in local markets to use wheat in the form of flour to make known preparations for sale. As the program progressed, home consumption by farmers' families was recognized as a possible entry point. Attempts to develop appropriate food items and preparation methods shifted with this change in entry points.

Efforts to find preparations for local markets initially turned to common western-style preparations, such as bread and noodles. This type of preparation uses wheat in the form of flour and usually requires special equipment, such as grinders, ovens, and cutters. Thus while looking at the recipe composition, this work devoted a significant effort to the appropriate processing technologies. As the possibility for direct consumption by farm families became evident, effort gradually shifted to finding ways to include wheat in traditional foods prepared by housewives. For these preparations, wheat is used in forms, such as whole or cracked grains, which eliminate the need to grind.

Adaptation of western-style foods for local use

Grinding. All western foods use wheat in the form of flour. Various types of grinders are used locally for grinding rice flour and other products, including hand "coffee" grinders, small electric grinders for wet-grinding soybean milk, larger commercial grinders for wet-grinding rice for noodles (Plate 3), and larger pin mills. These have all been used depending on the size of the operation. However, they all produce whole-wheat flour only.

White flour can be produced at the local level using Chinese-made roller mills designed for village use. These have a single stand of grooved rolls and can produce approximately 80 kg/h of 60% recovery white flour. The retail price in Thailand is Bt 40,000-50,000 (US\$ 1,600-2,000) per unit. Machines of this type were

installed with three of the cooperating institutions; the Food Science and Technology Department at Chiang Mai University, the Faculty of Technology at Khon Kaen University, and the Phrae Rice Research Center.

Baking ovens. The ovens used at different sites were all innovated on the spot. Commercial ovens in the refugee camp and school bakeries were based on the "Dutch oven" design used in most domestic ovens. The baking chamber is located above the firing compartment, with the two chambers separated by a partial barrier (against radiation) so that the hot gases can rise into the baking compartment. Because the smoke will enter the baking chamber, only charcoal—not wood—should be used as fuel.

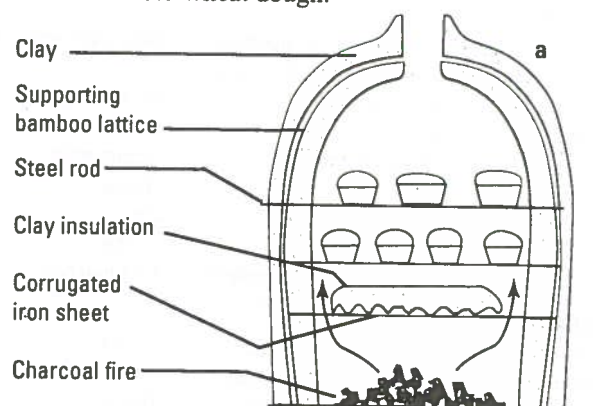
The ovens themselves were constructed from a clay/rice husk mixture (to reduce shrinkage of the clay as it dries) packed onto a green bamboo frame (Plate 1 and Figure 1.1a). The ovens were dried over a period of three days by a low fire. The temperature of these ovens was easily adjusted and controlled by an experienced baker. The oven in the Nam Yao Refugee Camp was used daily for more than a year. The construction of these clay ovens was difficult and would have hindered broader use.

An alternative oven made from 200-liter drums was easier to construct and could burn timber as fuel without the smoke damaging the bread (Figure 1.1b). The baking compartment was one intact drum, mounted with shelves and a door. A second drum was split and wrapped around the baking compartment. The fire under these drums is directed in the space between these two drums and through a chimney at the top. The whole assembly was mounted and covered with clay or bricks for insulation.

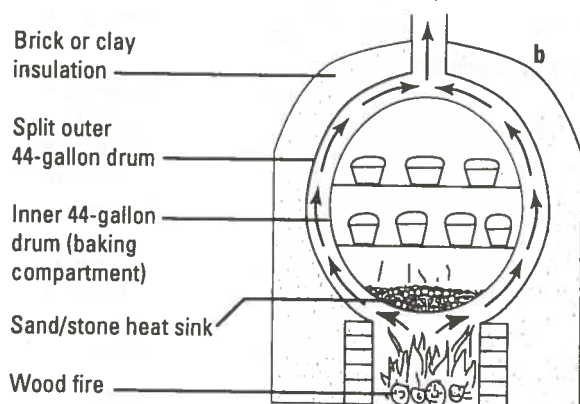
A kerosene tin oven has been the most popular design for domestic use. It is cut from used 20-liter kerosene tins; the top half is insulated with thick cardboard (Plate 2). The oven is placed on top of a small charcoal brazier or even a gas ring. This oven was used in most village demonstrations and its construction taught to many DOAE home economics officers.

Methods for bread baking and noodle making. Bread was prepared in village demonstrations as small buns and other sweet breads. Introduction of bread as a dietary supplement was hampered by the concept of bread in Thailand as a desert. The Thai word for bread, *kanom pung* (*kanom* meaning a dessert of some sort), reinforces this image of bread as being soft and sweet. The idea of eating bread as a staple is therefore a contradiction to its name in Thai.

In village demonstrations, the typical recipe used a 50:50 mixture of whole-wheat flour (unsifted) and commercial white flour. This gave the bread a reasonably soft texture, while still making significant use of the local whole-wheat flour. Dried yeast was readily available in provincial towns. Experiments were even tried using sourdough in the highland areas, where yeast would not be available. Chinese steamed bread was also made using this 50:50 whole-wheat dough.



Note: Gases (but not smoke) from charcoal fire enter the baking compartment.



Note: Gases and smoke from wood fire do not enter baking compartment.

Figure 1.1. Clay and metal drum ovens used for baking local wheat products.

Wheat noodles are commonly found in markets and road-side vendors' stalls. These can be made from sifted whole-wheat flour with an acceptable texture. In villages, the method demonstrated for making noodles used a straight sided bottle as a rolling pin to form a thin sheet of dough. Noodles strips were simply cut using a knife. Italian made hand-operated noodle making machines were also introduced for local food vendors.

Local-style foods

Adaptation of local preparations. As the focus turned to direct consumption of wheat by farm families, food preparations that fitted into the local food habits were developed. Two points were kept in mind: the preparations should use the same techniques and equipment that are normally used in preparing daily meals. Boiling, frying, and steaming are the most common cooking techniques used by the Thai village housewife. Also, the food should be presented for eating in a familiar form. For example, the staple rice and most side dishes have no regular form; a slice of bread by contrast has an unfamiliar regular shape. Local-style foods were developed to a large extent from village food demonstrations, which were very interactive. Comments by village women often generated new ideas for including wheat in traditional foods.

A typical process of recipe adaptation is illustrated by the evolution of *khao dom*. Sieving whole-wheat flour for making noodles left a coarse flour of a semolina texture as well as bran. Rather than discard this, ways were sought to use it to make another dish by boiling to make a fine gruel. Sugar and cow's milk were then added to make a tasty dessert. Village housewives quickly substituted coconut milk for the cow's milk, to make a common dessert called *kanom biak*. This treat became so popular that, instead of using leftover by-products, wheat grain was cracked on purpose to make it. A further adaptation of the initial recipe came when an extension worker decided to use the cracked wheat to make *khao dom*, a savory gruel, by adding chicken broth and some chopped vegetables.

Until 1986, the author played the main role in this recipe development process, although the recipes themselves came mostly from village housewives and colleagues. In 1986, funds were obtained for the Agriculture Transfer of Technology (ATT) Project. This engaged food scientists from the participating institutions to take the leading role in developing new preparations that included wheat in local-style foods. These were published at the end of the project by the Phrae Rice Research Center as an illustrated recipe book, *Delight and Fun with Thai Wheat* (Department of Agriculture 1989).

Niches for local-style foods made from wheat. A wide range of local-style food preparations were developed. It is germane to classify food preparations used in the program (Table 1.1a-c) according to the form of wheat used, i.e., whole grain, cracked grain, and whole-wheat flour; the way it is eaten, i.e., as a snack, a confection, or as a side dish to rice; and whether the food is consumed in the home or sold at the local market.

Foods prepared from whole grain and cracked grain were simple to prepare and resembled local dishes, and so were suitable for home consumption (Plates 4 and 5). Most preparations made from flour were considered more appropriate for local food vendors to make and sell because of the time and skill needed to make them. Various adaptations of these basic preparations were made according to personal tastes, district, and/or ethnic group. For instance, *khao dom* prepared for lowland villagers as a between meals filler is fairly watery, whereas hilltribe people would include it in main meals and so preferred it with a much heavier texture. Some of the basic preparations open a broad range of opportunities for use, e.g., adding the whole grain to curries or the cracked grain to the large number of chili pastes that normally accompany rice in the North.

Models for introducing local use of wheat
The introduction of these food preparations and technologies followed two models. The models defined the entry point for the adoption of local use of wheat, and the strategies for introducing its use to the target group.

Both models had the eventual aim of providing a means for absorbing the crop until the volume of wheat produced could be shipped to the flour mills in Bangkok.

The "local market" model. Given the success of the bakeries established in the refugee camps and vocational school, the first model was based on the use of locally ground whole-wheat flour by small food vendors. Many types of sweet breads and other snack foods made from wheat flour were readily available for sale in small-goods shops throughout the rural areas. Thus there was an established market for wheat products.

Table 1.1. Food preparation using wheat in various forms.

Preparation name	Description	Use niche
a) Whole grain		
Lao Khao	Distilled liquor	Home, commercial (illegal)
Khao Kua	Roasted: eaten whole ^a or pounded and added as a thickener to curries ^b	Home/commercial Home
Khao Kua	Boiled: + sugar + coconut ^a + rice + vegetables/fried ^b + veg + meat/curry ^b In many types of confection ^a	Commercial Home Home Home Commercial
b) Cracked grain		
Khao dom	Gruel + chicken broth ^a	Home
Kanom biak	Coconut sweet porridge ^a	Home/commercial
Yum	"Tabooli"-type salad ^a	Home
Chili pastes	Soaked grain pounded with herbs, spices ^b	Home
Sausage	As above for filling ^a	Commercial
c) Whole wheat flour		
Bread (various)	40-80% + white flour ^a	Commercial
Noodles	40% + white flour ^a	Commercial
Salapow	Chinese steamed bread ^a	Commercial
Cookies	40% + white flour ^a	Commercial
Doughnut	40% + white flour ^a	Commercial
Krop kem	Dough sheet fried and covered in syrup ^a	Commercial Commercial
Nieu nagm	Fried dough stick ^a	Commercial
Chinese roti	Dough + oil, salt, and herbs, pan baked ^a	Home
Kanom tien	Paste steamed in banana leaf ^a	Home
Cat's ear noodle	Dough strip added to a broth ^a	Home

^a Eaten as a snack.

^b Eaten with rice as a main dish.

The main driving force for the local market model was expected to be the lower price of locally ground flour compared to commercial white flour. Locally ground flour had to be whole-wheat as the simple grinders which were locally available could not produce white flour. Since the use of 50% whole-wheat flour had not proved an obstacle in the earlier aid projects, it was not expected to be an obstacle, now in the context of crop promotion. Whole-wheat flour had no established price, but was expected to be approximately half that of the commercial white flour. Thus there was a substantial profit margin to allow for grinding and to still undercut the price of commercial white flour.

The model was designed to proceed in two stages: 1) use of whole-wheat flour by local food vendors in the towns and villages to provide a wheat market for a small group of farmers; and 2) sale of the crop to encourage new farmers to increase the area cultivated. Once the volume of wheat produced became substantial, local grain merchants would begin to purchase it for shipment to the flour mills in Bangkok.

It was also expected that once farmers became aware that their new crop was being consumed in nearby towns, they would become interested in retaining some of the grain for their own consumption. In this way, wheat would gradually begin to supplement the family diet.

The initial work focused on finding appropriate bread recipes to suit the tastes of up-country villagers and simple methods of baking. Other preparations, such as noodles and *salapow* (Chinese steamed bread), were also made from whole-wheat flour.

During the period that this model was applied, the DOAE had not yet begun its promotion of wheat production in the north of Thailand. To gain access to villages, various projects with income-generating activities were invited to include the use of locally ground whole-wheat flour for making food products as a component of their program. The wheat program provided assistance with training and village demonstrations.

Constraints to this model became evident within the first year. The flavor of whole-wheat flour was generally acceptable, but its darker color and texture did reduce its attractiveness; however, this was expected to be overcome with familiarity. It was expected that consumer acceptance would increase with exposure. The main problem for implementation of the "local market" model was the difficulty of simultaneously developing production, balanced with the demand from local food vendors, who at the same time were trying to gain acceptance of a new product. Secondly, the model envisaged the village bakery as a self-sufficient unit, which would purchase and stock a year's supply of grain for milling and baking. In reality small food vendors did not normally have the resources necessary to purchase a year's stock of grain, nor did they want the additional labor of milling the flour themselves. They simply wanted access to enough raw material to make a product for sale each day.

As these difficulties surfaced, opportunities to use wheat in simpler forms became apparent. Preparations using whole or cracked grain were included to fill in time during baking demonstrations. It soon became clear that while people were fascinated by the process of baking bread and enjoyed its flavor, they were far less self-conscious when eating these simple preparations which resembled local food preparations! This suggested the possibility that wheat could be consumed directly by farm households as a supplement to the diet. While the effort to promote local markets was not abandoned altogether, there was a gradual shift in the focus of the program to consumption of wheat within farm households.

The "home consumption" model. An extension model based on direct consumption by farm households was far simpler than developing a local market. Links to a local market and the step of grinding flour were eliminated. Any number of farmers could begin growing small areas of wheat, depending only on what they thought their family would want to eat. This allowed a broader base of farmers with experience growing the crop and sped the development of production. The success of the home

consumption model hinged on farm families' acceptance of local-style foods. It had three stages: 1) a small number of farmers plant small areas of wheat according to their intention to consume the crop; 2) additional farmers follow their example, growing a small area for consumption, thus expanding the number of farmers gaining experience with the crop; and 3) as production area and efficiency increase, the output becomes great enough for local merchants to purchase the crop to ship to the mills in Bangkok.

The most common tool for promoting local use of wheat was through village food demonstrations, where the primary goal was to give villagers a sense of acceptance of the taste and a sense of familiarity for wheat.

Demonstrations were held at various times to achieve a different impact: before the planting season, to interest villagers in planting the crop; before harvest, to encourage housewives to keep some grain for home consumption; and following harvest, to ensure that preparation methods were understood.

Demonstrations worked best in the morning so that the foods prepared could make up the midday meal. Since most preparations were local-style foods, participating housewives could be directly involved in the their preparation (Plate 6). This ensured that by handling wheat themselves, they gained some sense of familiarity with it. Also, the food was prepared to the right saltiness, sweetness, etc., according to local tastes. As the villagers had prepared the food themselves, they had no reservations about consuming it once it was finished.

The actual dynamics of village food demonstrations varied according on the type of village. In lowland Thai villages, it is common for women to jointly prepare various dishes for temple festivals, weddings, or other social occasions. The food demonstration or "food party" fitted well in this pattern, so that lowland Thai women participated in food preparation without hesitation. In hilltribe villages, the dynamics were somewhat different. Communal food preparation is not common. On important days, special foods are made by each family and then exchanged with other households. Thus, party

demonstrations had little parallel in hilltribe village life. As a result, hilltribe women were hesitant at first to take part in food preparation. But with a little patience, the barriers dropped and the demonstrations generated as much interest as with the lowland Thai housewives (Plate 7).

The shift to the home consumption effort occurred at the same time as the DOAE began its first phase of introducing wheat to farmers through a series of multi-location trials in 1983 (Ch. II, p. 16). Since the DOAE had made no provisions for purchasing the harvest from these trial plots, it was expected that the wheat would be consumed in the farm households.

Until then "local wheat use" had no institutional home. As part of including wheat in the DOAE program, a group of DOAE home economics staff were trained in preparing food using wheat, which they then demonstrated to village women. During the 1986-89 period, the Agriculture Transfer of Technology Project also employed this strategy and further reinforced official recognition of the "local use" approach for introducing wheat to farmers. With funds available from this project, all of the institutions² involved in the Thai Wheat Program began their own initiatives in the development and promotion of wheat-based foods.

Despite this official support and the increase of organizations working to promote wheat consumption, food demonstrations were often poorly conducted. Timing of the demonstrations was counterproductive. Typically they were conducted after harvest, by which time farmers had already sold their crop. Even if the villagers had liked the foods demonstrated, they no longer had grain left to adopt them. The style of the demonstrations tended to be from the lecture and classroom, which did not fit the village atmosphere and worked against the village women gaining a sense of familiarity with the new grain.

² Chiang Mai University, Kasetsart University, Khon Kaen University, the Agricultural Research and Training Center, the DOA, and the DOAE.

The DOAE and other organizations actively promoted home consumption of wheat for about six years. In the lowlands, where there is a wide food choice, only isolated examples of wheat consumption by farmers occurred. Even if wheat becomes commonplace, it is never likely to be more than a novelty food for lowland Thai farmers. However, in the highlands, where rice deficits are common, home consumption could be accepted as a supplement to the diet by hilltribe farmers. The main constraint to acceptance during the period of the program was not taste, but rather the inconvenience of cooking wheat, which took so much longer than rice. If quicker and simpler cooking preparations had been available, this model may well have had an impact.

Acceptance of Local Wheat Consumption

Wheat was never intended to replace rice in Thai diets, but it was expected to become an occasional supplement (100-200 kg kept in stock) where villagers experienced regular rice deficits, particularly in the highlands.

At the same time, an increasing number of products were appearing in village shops as snack foods: cakes, biscuits, instant noodles, etc. It was hoped that these could be replaced by similar products using locally ground wheat to a substantial degree, mainly in the more isolated areas.

Lowland Thai farm families

The local style of food preparations were readily consumed by low-land Thai villagers. They spontaneously described the preparations as being *hom* (i.e. "having a good aroma") and enthusiastically ate the preparations during demonstration lunches. The two favorite preparations were boiled wheat grain with sugar and shredded coconut, and the spicy Thai-style tabooli salad. Village women participating in the demonstration were impressed enough to carry left-overs home to share with the rest of their families.

Yet over the whole program, adoption was minimal, with only a few families in any village keeping any of their

harvest for home consumption, usually no more than a 20-liter kerosene tin (16 kg). The lack of more significant acceptance of wheat for home consumption was not due to unacceptable taste. *The limiting constraint was the long time required for wheat preparations.* Boiling wheat grain takes 90 min, compared to 20 min for rice. Cooking time can be shortened by using cracked grain. But there is no equipment in the rural Thai household which can do this conveniently.

Quicker and more convenient preparations might have facilitated more widespread wheat adoption, for example, roasted wheat, where the grains are simply dry-roasted in a hot pan for five minutes until they have popped. They can then be eaten as a snack or pounded into a powder to add to curries as a thickening agent. Another convenient food is bulghur wheat, where the grain is boiled until tender and sun dried, and then cracked and stored. To prepare for a meal, it is simply soaked in water until it swells. It can then be added to many types of dishes. A constraint with this product is the long pre-boiling time for sun drying and cracking. These two preparations were not identified until the end of the program and therefore not included in any demonstration.

Hilltribe farm families

In contrast to the lowlands, some consistent use of wheat in the home did begin to develop among hilltribe farmers. Wheat was stored for consumption by the majority of families in some villages. Hilltribe farmers kept somewhat more wheat than lowland Thai farmers (10-50 kg) within the first or second year of production. Food demonstrations in hilltribe villages featured more basic foods than in the lowlands. These were prepared using, for example, whole grain boiled with sugar added (the most popular dish), boiled wheat mixed with rice (used by Lahu and Yao farmers), or roasted wheat as a snack, or ground and used to thicken curry (Karen farmers). Other foods such as *Khao dom* (chicken gruel eaten by Karen farmers) called for cracked wheat or whole-wheat flour, as in roti, chapati, and *kanom tian* (a steamed cake).

This easier acceptance by the hilltribe farmers was probably because there is a greater need for an additional grain diet supplement, as rice deficits are common. The isolation of the hilltribe villages encourages them to fill this deficit themselves, rather than by purchasing and carrying additional rice. Also, the hilltribes are not so interested in the subtleties of food preparation as the Thai (e.g., the “chewy” boiled wheat does not face such strong objections).

Acceptance of wheat products in local markets

While lowland villagers did not take to consuming wheat as part of their household diets, village women consistently showed an interest in preparing food items they could sell in local markets (Plate 8). This was particularly so in well established villages with good market opportunities, i.e., school lunch stalls, food stalls, and dry-goods shops.

During the ATT project, white flour from the Chinese roller mills located at the project centers was used to demonstrate various snack foods. These had an impressive response, and where possible, the project supplied white flour @ 12 Bt/kg (cf. 15 Bt/kg for commercial white flour) to the village women for income generating activities. There are a number of examples where village women were successful in establishing small enterprises that used locally produced wheat to make different types of preparations to sell at temple fairs or in schools.

This interest in food vending was due to the cheaper flour price and the stimulation and skills transfer that the ATT project provided. These successful enterprises demonstrated that village women could form a local market for wheat, and that food demonstrations could promote such enterprises.

Unfortunately, all these enterprises, except the Farm Women’s Group at Pai, have stopped their activities. It is not possible for villagers to produce white flour using the Chinese roller mill, and the price at which it was supplied by the project is too cheap for a real commercial venture. By comparison, whole-wheat flour

can be ground on a small soybean grinder, and so the Pai District Farm Women’s Group enterprise has continued.

At least four enterprises, all catering to the tourist market, developed by 1990, based on the use of whole-wheat flour: Phisan’s Bakery, Chiang Mai town; Yai Bakery, Pai district; Tatum Bakery, Pai district; and Cave Lodge Guest House, Pang Ma Pha district. Several stages of support were provided to enable them to experiment without making large initial commitments: a) whole-wheat flour was first supplied (at a realistic price of 12 Bt/kg) to allow vendors to test the market, and b) once the enterprises were confident of the market for whole-wheat bread, they were lent a small grinder and supplied grain at the farm-gate price (Bt 6/kg) to allow them to experiment milling their own flour. This provided an additional profit margin.

By 1992, Phisan’s Bakery was purchasing and milling about 10 tons of wheat per year. The bakeries in Mae Hongson use about 2 tons between them each year, to supply a mainly tourist market.

Acceptance of whole-wheat flour

Considerable effort was put into the development and promotion of preparations using some proportion of whole-wheat flour because: a) the technology to produce whole-wheat flour was locally available, cheap, and easy to operate, and b) almost 100% of the grain is recovered as flour, giving it greater profitability.

This path was taken despite repeated warnings that Thai consumers preferred white bread. While this is true, it became clear that they could accept brown bread and, in some cases, even find it more tasty than white bread. This was demonstrated again and again in the bakeries that were set up in the refugee camps, the school, and during numerous village demonstrations. ARTC operated a mobile bakery during the annual fair of the Department of Technical Education held in Bangkok and it could not keep up with the demand for 50% whole-wheat bread.

Since the late 1980s, two specific markets for brown bread have developed in Thailand: among foreign tourists, in fairly isolated districts such as Pai, that have become

popular with backpackers, and among urban middle-class Thai, who are becoming more health conscious.

Based on these markets, a rough estimate of the market for whole-wheat flour in Chiang Mai is between 50 and 100 t/year. This may appear small, but is not insignificant when compared with the total volume of grain delivered to the Bangkok mills in the initial production phase (106 t in 1991). Given moderate promotion, it could be easily increased further.

When Chinese roller mills were introduced during the ATT project, interest switched from whole-wheat flour to the promotion of white flour coming from these mills. A rough estimation of the unit cost of production of this flour, Bt 11.3/kg at 60% recovery, indicates that commercial production of white flour in competition of the already available commercial white flour would not be profitable for local entrepreneurs. Local milling of white flour would also face serious problems maintaining a consistent high baking quality in comparison with the commercial white flour. Whole-wheat flour is seldom used without mixing in some proportion with white flour which buffers the variation in the whole-wheat component.

Another possible type of flour, which could potentially have greater acceptance is an improved 90% extraction white flour promoted in Mysore, India (Shurpalekar *et al.* 1983). This is produced by first polishing the grain (10% loss in weight) and then milling it in simple mills used for whole-wheat flour. This could be carried out on a village level and may have a place for up-country markets. This system was never investigated by the program.

It is still worthwhile investigating the processes for milling whole-wheat flour. The market for whole-wheat flour is likely to expand well beyond 100 t/year in the 1990s. Local milling in centers such as Chiang Mai and Chiang Rai could provide a visible market for wheat and help to stimulate production. Use in these large centers could eventually popularize whole-wheat flour so that its

acceptance and use might spread to district and village consumers.

If programs were to attempt to develop local milling and use of whole-wheat flour, they would need to support this by first providing supplies of whole-wheat flour to vendors wishing to experiment with its acceptance, and secondly providing stockpiles of grain to supply local entrepreneurs to mill flour on a trial basis without having to commit themselves to purchasing a large quantity before they are ready. These enterprises may still develop spontaneously in Chiang Mai as wheat production expands.

Impact of the "Local Use" Wheat Program on the Development of Crop Production

Direct impact on crop production

As we have seen, the "local use" wheat program was not able to support or stimulate extensive wheat production. Despite the interest and active involvement of many organizations, the process of introducing it to local markets was too delicate a process, and for family consumption, there was no real food deficits in the lowlands for it to fill any role other than an incidental one. Even should local use of wheat use continue to develop, this will no longer affect production as a network of merchants has already begun to purchase the crop and will be the driving force in stimulating expansion of production (see Ch. II, p. 39).

Gaining access to women farmers

Women throughout Southeast Asia form the backbone of the labor force in the fields. In northern Thailand, it is often the women who control the fields during the cool season, particularly for minor crops (Shinawatra and Connell 1991). Thus, while a new crop like wheat is still not a significant income producer for the family, the interest and involvement of women can be very useful. Food demonstrations place wheat in an area of interest for local women and did in fact help to enlist new wheat farmers, for example in Fang and Pai, two districts which have become production centers for wheat.

Indirect impact on crop production

The promotion of local use of wheat enabled several Thai institutions to obtain funds for research and extension of wheat as a dietary supplement. Two projects were funded by the United States Agency for International Development (USAID) totaling more than US\$700,000.

The major grant supported the Agriculture Transfer of Technology (ATT) Project, which covered a critical gap in Thai government funding for extension of wheat, and was extremely formative in bringing scientists into farmers' fields. It also provided a *de facto* core fund and the most consistent opportunities for national research and extension institutions to come together as a loose consortium to plan and work together (see Ch. II, p. 32).

Chapter II.

Developing Production: Initiatives and Constraints

Introduction

This chapter focuses on an effort launched by the Ministry of Agriculture in 1981. The program has to date succeeded in establishing the feasibility of wheat production; a number of production centers exist, and marketing links with commercial mills in Bangkok are functioning. This chapter examines the dynamics of production area expansion, i.e., shifts in targeting between rainfed and irrigated production domains; the constraints of inexperienced extension workers and farmers dealing with the crop; the role of free inputs (seed and fertilizer), and farmers' yield levels and profitability.

The chapter then examines the effect of policy on the operation of the Thai Wheat Program, as well as the role of the technical sector in the absence of a strong policy directive and strong market demand. The vigor of the program has come from an informal consortium of educational institutions, bilateral development projects and NGOs, led by the national agricultural research and extension institutions. This consortium was pivotal in providing a "multiple source of innovation" and a resilience against budget and policy fluctuations over the last decade.

The Thai Wheat Program has been notable for the absence of any marketing component. Instead, the program has relied on developing a free market structure based on local grain merchants. While the basis for the crop has been established, sustainable establishment of the crop will, however, depend on policy.

Early Introductions of Wheat into Thailand

Cross-border migrations (1700-1950)

The earliest wheat production in Thailand probably came from scattered rainfed plots grown by hilltribe minorities. These people migrated to the highlands of northern Thailand from Laos, southern China, and Myanmar (Burma) in two waves, 200 and 50 years ago. Then wheat probably served as a supplementary subsistence crop. Today it is still possible in northern Thailand to meet older hilltribe villagers who—either they or their parents—had grown wheat in Yunnan and then carried wheat seed with them into Thailand (i.e., Hmong in Nan and Chiang Mai Provinces and Lisu in Mae Hongson and Chiang Rai Provinces). The hilltribes use the word *mer dzer* for wheat, from the Yunnanese dialect.

Subsistence production of wheat in Thailand by the hilltribes may have persisted to as late as the 1960s, just 30-odd years ago. Possible reasons for wheat's disappearance from the hilltribe farming systems could include better rice yields in the then still virgin upland areas of northern Thailand, or poorer yields from wheat varieties brought from China. But these reasons do not appear to be the entire answer.

Opium was also introduced to the highlands of Thailand by migrating hilltribes. Both wheat and opium are planted as rainfed crops on the hill slopes, immediately following the harvest of maize to utilize the last rains of the wet season. During the 1960s, opium from Thailand gained access to the international heroin markets (McKoy 1972). With the increase in income from opium, the need for a supplementary subsistence crop declined. Thus the expansion of opium production is the more

likely reason for the disappearance of wheat from the hilltribe farming system.

Over the last 15 years, there has been increased suppression of opium production, concurrent with various crop replacement programs. Opium production has declined from an estimated 145 t/yr during the 60s to less than 30 t/yr in the early 90s. It is somewhat ironic then that wheat has been reintroduced as one of the crops to replace opium (Ch. I, p. 2).

This initial entry of wheat into Thailand has had no implications for the present production program. Perhaps unfortunately so. The traditional varieties introduced by the hilltribe people and grown over successive years, should have undergone a process of adaptation for the environment in northern Thailand. Such material, while perhaps not high yielding, may well have developed worthwhile characteristics for the current program (i.e., early heat tolerance, resistance to spot blotch). The opportunity to obtain such material in Thailand was missed by a mere 20 years or so. Similar material may still be available from areas with hilltribe populations in Laos, northern Vietnam, and southern China.

Production support project for wheat: Ministry of the Interior (1962-69)

While it was known that there was isolated wheat production in the North, it was not until 1933 that there was official interest in the crop. Dr. Ariyan Manjkul of the DOA began experiments with the crop in Phrae Province, not far from the present Phrae Rice Research Center, with two varieties, one from Australia and one from India. Further experiments using varieties from Japan and Myanmar were carried out during the period of the Second World War, mostly at the Fang Horticulture Experiment Station.

Thailand imported all its wheat as flour until 1967, when the first flour mill was established in Bangkok. The beginning of milling within the country provided a rationale for domestic production. Thus, with creditable foresight, a program to develop wheat production was begun in 1962. The production support project for wheat

was initiated by the Ministry of Interior (MOI) through its local officials at each district office. (At this time, the Department of Agriculture Extension was yet to be formed. All activities, including agriculture fell under the District Governor's office.)

While the project did achieve a significant area of wheat (just over 900 ha by 1967), the overall yields achieved were quite poor, only 200-400 kg/ha (Table 2.1). At least Bt 20 million were spent on wheat trials and promotion in 1962-69. Support and interest in the project gradually waned, and it was scaled down from 1969 on (Titapiwatanakun *et al.* 1982). While the project failed to establish wheat production, it did leave a legacy of a dozen or so farmers who continued to grow about 150 ha/yr of rainfed wheat, with average yields of about 1 t/ha. These farmers in Mae Sai, the northernmost district of Thailand, grew extensive areas of the crop by broadcast seeding. They hired labor and farm machinery for land preparation, seeding, and threshing.

These farmers were large enough to establish their own links, not with the flour mills, but with a specialist market in the northern province of Lampang, which used wheat for malting into a glucose syrup (*be sae*). This market favored locally produced wheat for its better germination, and paid prices that were significantly higher (Bt 9-11/kg) than what they would have received from the mills (approximately 4-5 Bt).

**Table 2.1. Early wheat production in Thailand, 1965-1980.
Period of Ministry of Interior's production support project for wheat.**

Year	Area planted		Production (kg)	Yield	
	(rai)	(ha)		(kg/ha)	(kg/rai)
1965	4,895	783	176,894	36	226
1966	5,312	850	329,770	62	388
1967	5,694	911	306,119	54	336
1968	3,567	571	188,156	53	330
1969	4,925	788	215,430	44	273
1970	3,331	533	446,334	134	837
1971-77	na	na	na	na	na
1978	800	128	100,000	125	781
1979	670	107	123,950	185	1,158
1980	950	152	156,750	165	1,031

Source: Titapiwatanakun *et al.* (1982).

While this sole pocket of extensively grown wheat has continued up to the present time, it has *not* served as a springboard or nucleus for expanding production during the current program. The *be sae* factories provided only a limited market for wheat. As a result, established wheat farmers tended to guard their market from new farmers. Thus, the experience from this area of established production did not spread into the target areas of the new extension campaign.

As the volume of production has increased, the *be sae* factories lowered their prices to Bt 6-7/kg (Table 2.13). The mechanized rainfed producers in Mae Sai began to find wheat profitable only in years of good rainfall, and this pocket of production started to shrink.

While the large production fields in Mae Sai district have not played a direct role in developing the current production, they did have an important indirect role in demonstrating viable wheat production each season. For the first 3 or 4 years of extension, farmers' plots were disappointingly poor. Visits to these Mae Sai fields were always included in field trips each season. They showed that the crop could in fact be grown and served to boost spirits. The value of the moral support this Mae Sai production provided to the Thai Wheat Program should not be underestimated!

Development of the Current Thai Wheat Program

The current introduction of wheat production to Thailand developed from DOA's renewed research efforts, with support from CIMMYT's Southeast Asian Wheat Program. CIMMYT set up a regional office in Bangkok in 1981 and began to support networking of scientists who had been working independently on wheat. A mid-term adjustment to the 5th National Economic and Social Development Plan (NESDP) directed the DOAE to look at the feasibility of wheat production. This was done through a series of multi-location trials, and wheat was then included in the 6th NESDP (1987-1991). The DOA and the DOAE have provided the main impetus and structure for the development of wheat production since then.

The DOAE was formed in 1967. Extension activities are based on the "training and visit" system, with extension workers located in each subdistrict. Offices are located at the district and provincial levels, and report to Bangkok. Subject matter specialists based in the provincial office are responsible for coordinating special projects, such as the wheat program. Each district office has a number of extension workers who work directly with farmers and a home-economist who works with women's groups, mainly on income-generating activities. The mandate of the DOAE is for the lowland areas only. Agriculture extension for the highlands has been left to other government agencies and special projects.

While the DOA and DOAE provided the main impetus and the structure for the current program, a large number of institutions and organizations have been involved in carrying out Thai Wheat Program research and promoting it to farmers. These include institutions such as the Ministry of Agricultural Cooperatives (MAC), the Department of Agriculture (DOA), the Department of Agricultural Extension (DOAE), and Hui Si Ton Small Farm Pilot Project (HST), as well as Kasetsart University (KU), Chiang Mai University (CMU), Khon Kaen University (KKU), and Agricultural Research and Training Center Lampang (ARTC). Also involved were other agencies such as bi-laterally funded development projects and non-government organizations.

These institutions and organizations formed a loosely organized network. Interaction between the government institutions was through exchange of information and joint planning of a number of activities for which they shared funds but yet implemented independently (Ch. II, p. 34). Official committees were few. The Thai Wheat Program has one central body to set priorities and coordinate research and extension accompanied by a marketing program to purchase the crop from farmers. This loose consortium of institutions and organizations has given the program resiliency to ride through changes in priorities, budgets, and personnel that have occurred within each institution over the last decade. Had the project relied on a single institution, this would probably have resulted in efforts being abandoned.

Phase I: Multi-Location Trials (1983-86)

During the first four years, the DOAE conducted a series of multi-location wheat trials of five varieties: SMG 1, SMG 2, Fang 60, Phrae 60, and #1510.³ These had all performed well on the DOA's Samoeng experiment station, and the multi-location trials were expected to confirm the on-station results, and to serve as promotion to farmers.

In preparation for the multi-location trials, a group of extension workers together with farmers from nine subdistricts were trained by research staff at the Samoeng experiment station. The technology presented was that which was used for planting trials on-station (i.e., full soil preparation and row seeding). Seed and fertilizer were supplied to the farmers⁴ with the extension workers supervising the planting. Scientists were not involved in the implementation and made only two scheduled visits to inspect results in farmers' fields.

The crop stands which farmers achieved in these trials were generally poor. Many plots appeared to have been implemented without much serious effort or intent; token yields of a quarter to half a ton per ha were recorded for many sites. Average yields under irrigation did gradually improve to about 1.25 t/ha. There were a few encouraging plots which yielded as high as 3.75 t/ha. However, the overwhelming message the trials provided was that wheat was too sensitive a crop for local farmers to manage in this environment. The technical reasons for crop failures were poor site selection (e.g., heavy paddy soils), over-irrigation (in paddy fields), over-seeding, inefficient land use, late or no fertilizer application, shallow seeding, and late seeding (mainly in rainfed areas). These management problems will be discussed in detail later in this chapter (see p. 28).

³ Samoeng 1 = Inia 66; Samoeng 2 = Sonora 64; #1015 = Bulbul.

⁴ Seed @ 100 kg/ha and compound fertilizer 15-15-15 @ 300 kg/ha. This level of fertilizer supplied for the multi-location trials was considerably higher than what was later supplied during the crop promotion phase: 125 kg/ha.

Due to the failure of the crop and lack of back-up from scientists, farmers and extension workers were unwilling to attempt growing the crop a second season. Thus each year, the trials had to be moved to a new subdistrict. This prevented both farmers and extension workers from accumulating experience with the crop.

Impact of the multi-location phase

Very few lessons were learnt from this period. When site visits were made by research staff, management errors were discussed and farmers advised at the site, but no attempt was made to collate these observations into an overall pattern, or to examine the underlying causes of certain management errors.

One of main factors for this lack of analysis was that multi-location trials were normally used to simply evaluate varietal material. Cultivation practices were rarely in question. However, it was the recommended technology which was problematic. As a result, a convenient consensus was reached, that poor crop establishment was due to lack of farmer experience and poor extension.

In hindsight, grave deficiencies in this first effort to introduce wheat to Thai farmers are evident; first, the technologies recommended came directly from experiment stations to farmers' fields with no field assessment by research staff; second, there was little cooperation between research and the extension sectors for implementation or evaluation of the multi-location trials.

DOA scientists should have conducted on-farm trials for at least two seasons before the DOAE led multi-location trials. This would have demonstrated to the research staff the difficulties of using on-station technology under field conditions and at the same time would have provided the opportunity to adjust recommendations for farmers' conditions. Such field exposure would also have impressed upon the scientists the key points to emphasize when training farmers and extension workers. This station orientation of the researchers, and lack of

cooperation between research and extension, did improve dramatically as the program progressed, but at this early stage of the program, each institution was still working very much within its traditional mandate. As a result, very little was gained from the first four years of the program which contributed to the establishment of the crop with farmers.

A few gains from the multi-location trials

Some benefits were gained from this initial period. Superimposed on the DOAE multi-location trials, CIMMYT instituted two seasons of un-replicated observation trials in farmers' fields. During the 1984-85 season, a fertilizer pack was distributed to farmers to determine the crops response to different elements. from direct field observation, nitrogen was the only element that consistently produced a response (Saunders 1990). Notably this has not affected fertilizer recommendations.

During the 1985/86 season, a variety pack of five varieties was distributed to farmers. This contained two varieties already registered; Samoeng 1 and Samoeng 2 and three candidates for release (#1015, #1510, and UP 262). Earlier experiment station trials had shown #1510 to have higher yields and it was favored over #1015 for release as a new variety.

The second trial had a decisive effect for the program as it clearly showed that the germination and seedling establishment of #1510 was unreliable in farmers' fields. As a result, #1510 was dropped and #1015 was released under the local name of Fang 60. Following initial doubts by the mills due to its poor quality for bread baking, this variety has continued to perform well in both rainfed and irrigated areas.

The 1985/86 observation trial in farmers' fields also changed established views on the performance of two released varieties. On station, Samoeng 1 had yielded higher and had better quality than Samoeng 2. As a result Samoeng 1 was given priority for both seed multiplication and extension to farmers. The observation trials showed that Samoeng 2 was more tolerant to

drought and poor management. In subsequent years the emphasis switched to the multiplication and distribution of Samoeng 2. As nearly all future production centers which developed were based on Samoeng 2, this observation trial was of crucial significance for the program as a whole.

Phase II: Crop Promotion Campaign (1987-)

Context of the DOAE's crop promotion campaign

A program for promoting wheat production was included in the 6th National Economic and Social Development Plan (NESDP). At that time, there was little reason for confidence in wheat, due to the experience of the previous four years of trials in farmers' fields. There had been only a few sites where farmers had achieved good stands, and there was little reason to expect that another five years of extension would produce results that would be any better!

The DOAE's projected production areas and yields specified in the 6th NESDP were ambitious, reaching 40,000 ha within the five-year plan (Table 2.2). Such impressive figures were needed to ensure the plan would receive serious consideration and funding. But as the program progressed, the high figures meant that each year the DOAE failed to meet the objectives. In 1989 a mid-term adjustment resulted in a more realistic plan with the goal of 2400 ha wheat cultivated in five years (Table 2.3).

The target for wheat during the period of the multi-location trials had been the rainfed areas, following the example of the only existing production area at Mae Sai,

Table 2.2. Wheat production plans under the Sixth National Economic and Social Development Plan (1987-92).

	Planting year				
	1987	1988	1989	1990	1991
Area (ha)	320	1,129	8,000	24,000	40,000
Production (t)	460	1,600	12,500	39,000	67,000
Average yield (kg/ha)	1,438	1,500	1,563	1,625	1,688

Source: Wunnapee (1985).

Table 2.3. Adjusted wheat production plans: mid-term adjustment of the Sixth National Economic and Social Development Plan.

	Planting year				
	1989	1990	1991	1992	1993
Area (ha)	960	1,280	1,600	1,920	2,400
Production (t)	1,200	1,640	2,100	2,687	3,300
Average yield (kg/ha)	1,250	1,281	1,313	1,344	1,750

Source: Policy and Guidelines for the Development of Wheat Production in Thailand, MAC, 1989.

and the conditions at the Samoeng experiment station. However, the only good stands of wheat during the trials had been in paddy areas. Thus the extension target for wheat shifted to paddy areas. Concurrent with this change, within the DOAE, the responsibility for wheat shifted from the Field Crop to the Rice Division. This administrative change in effect raised the status of wheat, and allowed it to gain a far greater focus within the DAOE than previously.

The inclusion of wheat in the 6th NESDP gave the crop a significant budget, which allowed distribution of free seed and fertilizer (125 kg/ha of seed and 125-155 kg/ha of compound fertilizer, 15-15-15) to farmers to encourage interest. The seed rate had been increased to compensate for poor tillering. The fertilizer rate remained low; although this sacrificed some yield, it avoided raising production costs. A number of grain merchants up country were nominated to purchase the crop.

Even with policy and budget support for wheat in place, DOAE commitment to promoting the crop among farmers was still somewhat fragile. At the field level, rank and file extension workers retained a negative attitude towards wheat. They had already concluded from the experience of the earlier years that wheat was a "difficult and delicate" crop for farmers. Even more of a disincentive was that, due to the poor market structure for wheat, extension workers not only had to advise farmers on how to grow the crop, but also were responsible for its sale. Extension workers disliked having to be involved in this role.

The negative attitude was further encouraged by the competing promotion of barley by one of Thailand's largest brewers. The brewery was closely involved with the DOA research program and was also supplied with ICARDA/CIMMYT barley nurseries. Doing very poorly in its own extension attempts, the brewery set up links with the DOAE to promote barley as well as wheat. Most of the material inputs (seed, fertilizer, etc.) and technical back-up were supplied by the company. This link with the DOAE gave barley more status and leverage in extension than if the company had promoted the crop independently. The brewery set a local price for barley of Bt 8/kg, almost double the world market price at the time. Extension workers were courted by the company with assurances of high yields and through lavish training sessions. As a result, most of the local extension personnel were initially more favorably disposed to work with barley than with wheat.

Potential production domains

Northern Thailand has an extremely diverse environment. The topography is hilly, with 60% of the land area higher than 600 masl. The area is crossed by three major river valleys running north-south. Only 13.5% of the land is arable and, of this, only 31% receives reliable irrigation; the remainder is sloping land fed by seasonal streams (Siam Studies Inst. 1988).

Rainfed production. The production of wheat in upland rainfed areas during the cool season follows maize or early soybean. Wheat is seeded in mid-October when temperatures are beginning to fall, but the soil profile is still saturated. One or two final storms can still be expected at the end of the wet season to establish the crop, with one further substantial rain in late November. There is an additional substantial rain in late December or early January about once in every four years (Figure 2.1).

This production system is possible in upland areas of the eight provinces of the Upper North depending on elevation and latitude. A rough estimate of the potential wheat area of this production domain, based on the area of maize planted during the wet season, is about 112,000

ha. Apart from a limited amount of mungbean, cotton, and second-crop maize, there are no crops that have significant production in upland rainfed areas during the cool season. With a basal application of fertilizer (156 kg/ha of 16-20-0 compound fertilizer), farmers have achieved yields of 0.95 - 1.7 t/ha (Plate 9).

At some highland sites above 700 masl (Mae Sarieng and Mae Chai Districts), farmers have achieved yields of more than 2.5 t/ha. These highland areas are usually on steep slopes and so cannot represent an extensive or long term production area.

Irrigated production. The main rice crop is harvested from mid-November to late December. The period from mid-November to mid-December is the optimum time for sowing wheat (Saunders 1990). Due to crop turn-around time, this optimum date is rarely achieved. With fertilizer application similar to the rainfed production, farmers have been obtaining yields of 1.25-2.50 kg/ha (Plate 10). Again at higher elevations, and with

additional fertilizer, farmers have obtained yields of 4.6-5.0 t/ha (Omkoi and Pua Districts).

Where water is available, a wide variety of crops is planted in paddies during the cool season, including: second-crop rice, soybeans, peanuts, tobacco, garlic, onions, and various fresh vegetable crops. Some are highly sensitive to water deficit towards the end of their cycle; soybean commonly suffers 80% yield reduction where irrigation is lost after seed-set (Rerkasem and Shinawatra 1988). Under the same conditions wheat would suffer only a 15 - 25 % yield loss (Rerkasem and Rerkasem 1984). Throughout Thailand, water for irrigation is beginning to face a critical situation and water availability for dry season cropping is likely to continue to decline in the future. Wheat's greater drought tolerance will give it an increasing advantage in areas so affected.

It is difficult to estimate the size of the potential area for irrigated wheat. The total areas of soybeans and peanuts grown in the Upper North are approximately 64,000 and 48,000 ha, respectively. Wheat could certainly take over soybean and peanut in areas with uncertain late irrigation, and in areas where these crops have not been established. Use of mulches could further reduce irrigation requirements and give the wheat crop even greater potential.

Development of the production area

Extension strategies and implementation. The DOAE campaign to interest farmers in wheat production was based on providing farmers with free inputs and informing them of yields and prices. Technical recommendations were provided to those farmers interested in growing the crop. The main responsibility for this fell on extension workers at the Tambon, or subdistrict level, with occasional back-up from the S.M.S. in the provincial DOAE office.

There were few training aids for the extension workers. Farmers were instructed in wheat production according to the style of the individual extension worker, which varied from quick farmer meeting, to field

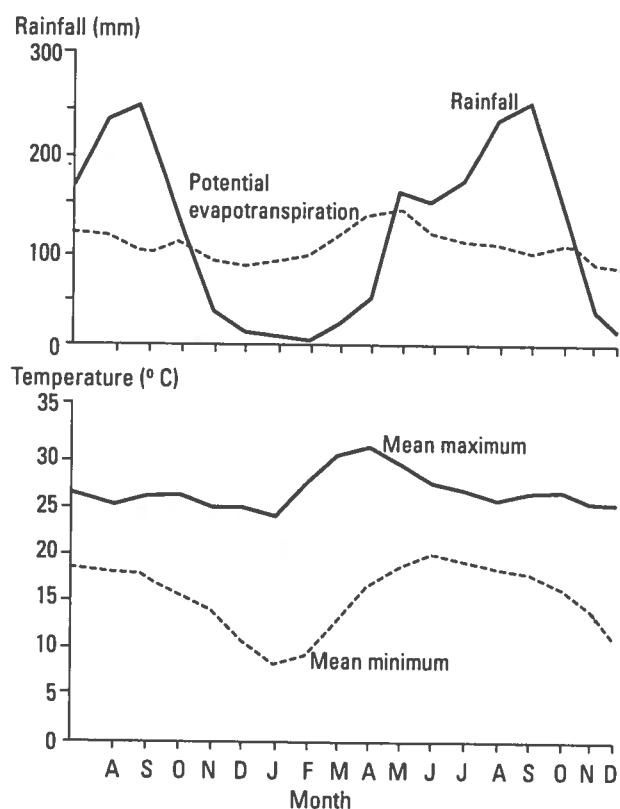


Figure 2.1. Average temperature and rainfall data for Chiang Mai Province.

demonstrations, to assistance planting the crop. During the early stage of this campaign, the Seed Multiplication Division of the DOAE played a key role by purchasing the whole crop, thus resolving the problem of marketing.

Production area increased consistently from 1987 to 1993 (Table 2.4) and remained static at 1500 ha for the last three seasons (Ch. II, p. 40). Targeting of production has swung a number of times, according to results in the field and to accommodate policy of the day.

Shifts in targeting the extension effort: Rainfed vs. irrigated. The DOAE's targeting has shifted back and forth between rainfed and irrigated areas a number of times since the beginning of the program. Both production domains have niches within them where wheat production has a comparative advantage.

The first sites for the multi-location trials (1983/84) were all rainfed. As some of the multi-location trials crept into irrigated paddy fields and began achieving higher yields than rainfed plots, the DOAE dropped rainfed areas from its objective altogether. Thus, at the beginning of the crop promotion campaign in Phase II, the local extension workers were directed to include *only* irrigated areas in their production area quotas.

Table 2.4. Development of wheat production under the current Thai Wheat Program.

Year	Distribution of sites			Farmers (#)	Average yields	
	Area (ha)	Sub-dist. (#)	Provinces (#)		Irrig. (t/ha)	RF (t/ha)
<i>Phase I - Multi-location trials</i>						
1983/84	4					
1984/85	23					
1985/86	33					
1986/87	29					
<i>Phase II - Crop promotion</i>						
1987/88	84	na	na	na	na	na
1988/89	272	37	8	396	0.64	0.90
1989/90	504	90	8	~750	0.84	0.61
1990/91	761	40	7	~800	0.93	0.47
1991/92	867	na	7	852	na	na
1992/93	850	38	7	1155	0.82	0.73
1993/94	1542	45	7	2334	0.77	0.30
1994/95	1535	32	7	1693	0.79	0.56
1995/96	1462	na	6	1535	0.99	0.64

Source: Department of Agricultural Extension, mimeo reports.

Interest in rainfed production returned after some of the ATT project areas at Fang, under CMU direction (Ch. II, p. 34), demonstrated the potential of this production system if the crop was planted correctly. At the same time that rainfed production was being vindicated (1998), extension of wheat in paddy areas began to receive criticism from various sectors within the DOAE. The reason behind this was that it seemingly conflicted with the push to promote soybeans as a second crop in paddy areas. As the increase in soybean production had become one of DOAE's success stories, the Wheat Program retreated and re-identified its target areas to be: "where other crops cannot be successfully grown." This brought rainfed production into focus once again.

During the 1989 to 1993 planting seasons, rainfed production of wheat increased at a faster rate than irrigated production (Figure 2.2). Wheat was recognized by farmers to be a more reliable performer in rainfed areas during the cool season than any other crop. As its drought tolerance was recognized for rainfed areas, this attribute began to point to a similar advantage for paddy where water was limited in the cool season. At the same time, soybean prices dropped and its promotion began to taper off, once again leaving an opportunity for wheat promotion in paddy areas. With this rapid increase in rainfed farmers, the overall production and average

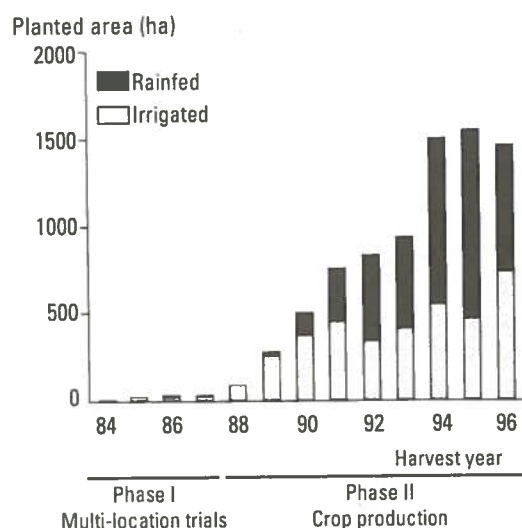


Figure 2.2. Expansion of production area for irrigated and rainfed wheat under the current extension campaign of the DOAE.

yields dropped to quite low levels. In an attempt to improve these, the DOAE began in 1995/96 season to restrict seed distribution to rainfed areas in preference to irrigated areas, and thus there has been a third shift between the two production domains.

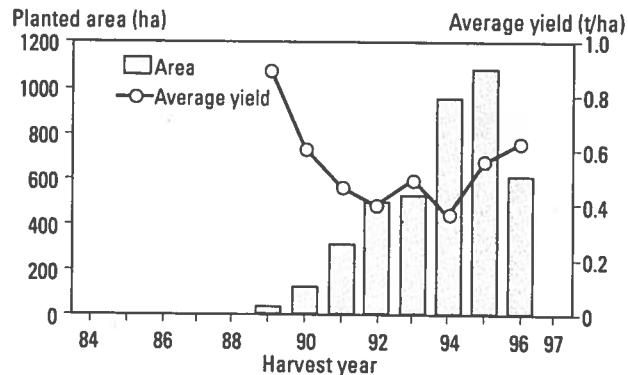
Perhaps the production niche for wheat was not well defined from the start. Or perhaps wheat could fill so many niches, that it was difficult initially for DOAE to focus on a target area. As a result, these shifts represents attempts by the DOAE to find not only the niche where the crop has the best comparative advantage, but also to fit the program to the various policy requirements of the times. Because of their distribution of free inputs, the DOAE has been able to determine where production could develop. Thus it is still not completely clear which area will be the predominant production domain for wheat, if and when it is established.

Trends in farmers' crop yields. The demands of wheat production have been different in a number of ways from other crops with which farmers and extension workers had experience. Thus the early years of the crop promotion campaign provided a learning experience for extension workers, as well as farmers. The recommended technology had several problems which led to constant misinterpretation by farmers (Ch.II, p. 28). Eventually there has been a complete shift away from the initially recommend technology. Both these factors have had an influence on farmers' yields, but perhaps the most important factor has been the number of new farmers who each year obtain low yields due to their lack of experience with the crop.

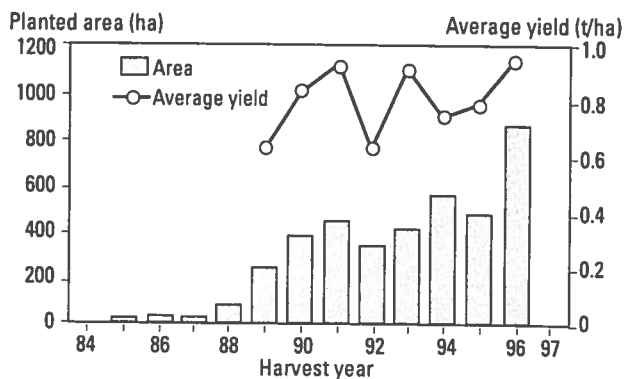
The first year of the crop promotion campaign, **rainfed production** was based on a small group of experienced farmers; the average yield was 0.90 t/ha, higher than that for irrigated areas. But with each step in the expansion of production area, the average yields dropped. This was most noticeable in the 1994 harvest when the area of rainfed production almost doubled (Figure 2.3). Rainfed production has a particularly difficult learning curve, as farmers need not only to adjust their methods of crop establishment, but also need to match the planting date

with the last rains of the season. As the rain pattern changes each year, the optimum planting date cannot be predicted from the previous year's experience. Since 1993/94, seed distribution to rainfed areas was restricted to experienced farmers and, as result, average yields have begun to increase.

The average yield for the 1996 rainfed harvest (0.64 t/ha) is still not impressive. The maximum yields collected from farmers in the first years of the crop promotion campaign indicate what could be obtained. **Maximum rainfed yields**, recorded over three seasons (1988-89 to 1990-91), ranged from 1.7 to 2.0 t/ha. These were obtained by farmers in Fang district of Chiang Mai (± 400 masl) using Fang 60 variety and applying additional fertilizer to the free input supplied by DOAE. Under optimum conditions, at 1000 masl, with cool temperatures and higher rainfall, farmers obtained over 2.5 t/ha. But, as stated earlier, this favorable environment cannot be considered as a potential extensive or sustainable production domain.



(a) Rainfed production area



(b) Irrigated production area

Figure 2.3. Changes in production area and average yields.

Average yields for **irrigated production** show a more positive trend overall despite some severe fluctuations (Figure 2.3). This trend has been due to the increasing experience of DOAE extension workers and to extension workers beginning to provide farmers with simpler production technologies. The average yield is close to 1.0 t/ha, but in villages with a number of years experience, average yields of 1.6 t/ha are obtained (Mann 1994). The **maximum irrigated yields** recorded over three seasons (1988-89 to 1990-91) were 3.1 to 5.3 t/ha and obtained under cooler than average growing conditions (500-700 masl) and where fertilizer rates are 2 or 3 times above the level of the DOAE-supplied inputs. In a more typical environment in Pua, the better farmers were obtaining just over 2.2 t/ha with an application of an additional 125 kg/ha of fertilizer (16-20-00) over the DOAE supplied inputs.

Overall, irrigated yields are higher than those of rainfed areas. This is as expected, as the crop with its later planting date has the advantage of cooler temperatures and is not water-stressed. These advantages are clearly evident in a comparison of maximum yields, but not

nearly as evident in a comparison of average yields. Despite having the advantage of irrigation, farmers in this domain have had their own set of production errors and not performed much better than rainfed wheat farmers. Common management errors (Ch. II, p. 28) of over-irrigation, over-seeding and poor seed cover are still occurring. There are major improvements to be obtained by focusing more attention on improving farmers' practices.

Emergence of "production centers." The first three years of wheat promotion followed a shot-gun approach, with promotion to farmers in 90 subdistricts during the 1989/90 season (Table 2.4). From this large number of extension sites, a number of production centers for wheat began to emerge, i.e., where the wheat area increased steadily and a significant number of farmers were achieving economic yields. The extension effort then began to consolidate and concentrate on these areas, and were reduced to 40 subdistricts by 1990/91. By 1991 six of the eight northern provinces had one or more wheat production center (Table 2.5).

These production centers are spread over a wide range of physical environments (Figure 2.4); however, all the sites can be considered disadvantaged in one way or another, i.e., limited water, poor soil quality, poor access to markets. Some sites, like those in Ngao and Omkoi Districts, while having adequate dry season irrigation, are isolated with few opportunities. The range of these sites indicates first, that wheat is reasonably well adapted to northern Thailand as a whole, and second, that it need not be relegated to one agricultural niche; also, that wheat can provide a fairly reliable crop for farmers in marginal areas.

The most important factor leading to the establishment of production centers has been the commitment of DOAE personnel. At each site, there has been at least one extension officer who has taken wheat on as a personal responsibility. They have implemented extension activities (e.g., farmers' meetings and seed distribution) conscientiously and in a timely fashion. They have also visited farmers plots to monitor progress of the crop. Any

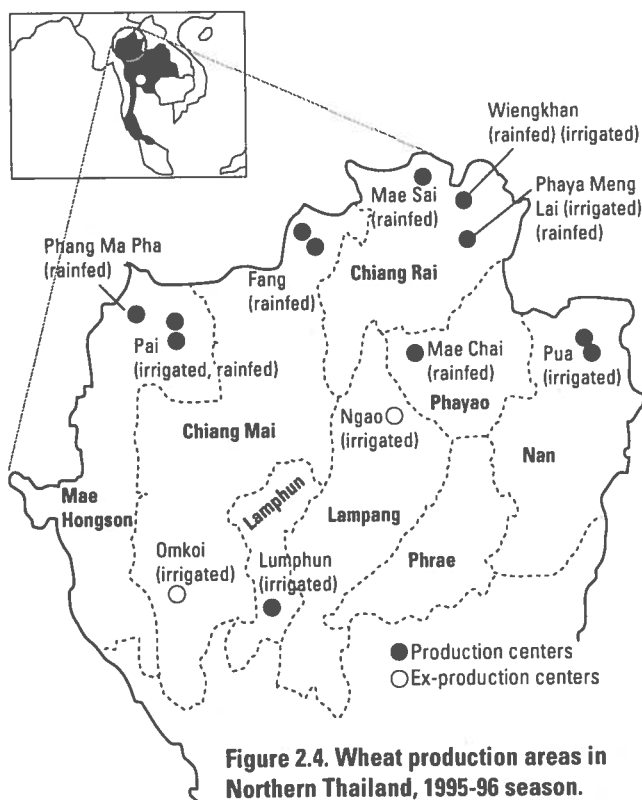


Figure 2.4. Wheat production areas in Northern Thailand, 1995-96 season.

Table 2.5. Emergence of production centers for wheat in Northern Thailand.

		1989 - 90		1994 -95	
Province/ district	Production domain	Area (ha)	Av. yield (kg/ha)	Area (ha)	Av. yield (kg/ha)
CHIANG MAI					
- Fang	rainfed	40	675	312	381
- Omkoi	irrigated	32	1250	-	-
CHIANG RAI					
- Mae Sai	rainfed	19	1125	25	718
- Phaya Meng Rai	rainfed	-	-	-67	656
	irrigated			16	581
- Wiengkan	rainfed	-	-	88	593
	irrigated	-	-	24	750
PHAYAO					
- Maechai	rainfed	44	713	200	625
NAN					
- Pua	irrigated	26	669	131	531
LAMPANG					
- Ngao	irrigated	27	1300	-	-
MAE HONGSON					
- Pai	rainfed	13	614	184	330
	irrigated	14	1119	92	1125
- Phang Ma Pha	rainfed	-	-	40	380
LAMPHUN					
- Tung Hua Chang	irrigated	-	-	72	850

problems they encountered they saw as being a normal part of the process of introducing a new crop, and not necessarily as an obstacle, or proof that the crop could not be grown.

In many sites, extension workers attempted to fulfill their "extension quota" and introduced the new crop (which they were unfamiliar with) to large numbers of farmers who planted significant areas of wheat in their first attempt. In none of the sites which eventually developed into production centers was this the dynamic. In each of these sites there was a three- or four-year gestation period, where a small number of farmers planted areas as small as 0.04-0.16 ha. As these farmers learned about the crop and established production, additional farmers began to attempt it. This pattern of development has been typical in both rainfed and irrigated areas (Table 2.6).

During this period, both farmers and extension workers gained experience and confidence in the crop. Management errors were made, but since farmers had cultivated only small areas, losses were small and did not disappoint the farmers. Local extension workers identified and (sometimes) corrected these errors. In some areas, the production technology also went through

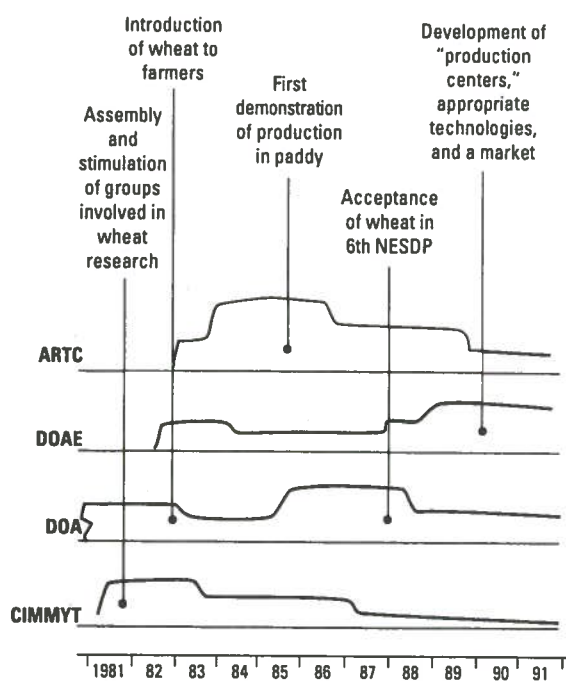


Figure 2.5. A subjective presentation of the relative contribution of various institutions to innovation and progress of the Thai Wheat Program.

Table 2.6. Pattern of initial establishment and expansion of wheat production for three production centers.

Production center characteristics	Production year					
	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91
Pua District:						
<i>Irrigated</i>						
Area (ha)	0.04	2	8	25	96	
Number of farmers	1	26	36	127	236	
Area/farmer (ha)	0.04	0.08	0.22	0.20	0.40	
Pai District:						
<i>Irrigated + Rainfed</i>						
Area (ha)	0.04	0.12	3	2	28	60
Number of farmers	1	3	15	16	92	150
Area/farmer (ha)	0.04	0.40	0.18	0.12	0.30	0.40
Fang District:						
<i>Rainfed</i>						
Area (ha)	-	4	7	8	40	69
Number of farmers	-	demo	30	36	89	93
Area/farmer (ha)	-		0.24	0.22	0.45	0.74

Sources: Mimeo reports of SMS officers presented at annual DOAE wheat workshops 1989-90 and 1990-91, ATT project reports, and DOAE district office records.

extensive modification. This further helped to improve stand establishment and adoption of the crop by farmers (see Ch. III, pp. 46, 48). Many poor plots often had patches of well developed plants, e.g., high spots that escaped waterlogging (Plate 11), which provided lessons for improvement in the following season.

The initial slow expansion of the production area failed to fulfill normal departmental directives. Each district was given a wheat production quota. In Pai, for example, by the fourth season the quota for growing wheat in the district was 30 ha, but they achieved only 2 ha. While the development of the crop might have seemed to be progressing satisfactorily at the field level, reporting such low figures made it difficult for local extension workers to justify continued involvement with the crop at the provincial level.

With more appropriate production technologies now available, the next generation of wheat farmers and extension workers should not have to go through the same learning curve, and the build-up of production should be more rapid.

Profitability and farmers' attitude towards wheat.

Profitability of wheat will largely determine whether wheat will be accepted by farmers and established as a crop in any area. Profitability of real production is still difficult to determine as wheat is such a new crop to the area. Wheat is grown in both rainfed and irrigated conditions with a large number of technologies in each domain. These technologies are still evolving and should improve production efficiency (Ch. III, p. 46).

A joint study by CIMMYT and Kasetsart University examined the profitability of wheat production under these dynamic conditions (Tiravattanasert *et al.* 1992). The study calculated the budgets for the most commonly used production technologies and estimated break-even yields (on the basis of the current farm-gate price of 6 Bt/kg).

The technology that is currently most widely applied by farmers in both rainfed and irrigated areas is *full land preparation with broadcast seeding and harrowing*. The

private full cost budgets calculated in the study for the two production domains are as follows:

Rainfed areas (from Table 2.7a):

Private full cost budget	- 4923 Bt/ha (\$189/ha)
Break-even yield	- 0.82 t/ha

Average wheat yields in rainfed environments (0.64 t/ha) are still below this (Table 2.4). But farmers planting within the favorable period (Oct. 10-20; Ch. II, p. 30) are consistently able to achieve yields of 1.125 - 1.250 t/ha, and under favorable conditions, up to 1.7 kg/ha.

Table 2.7a. Private full cost budget for wheat production in rainfed areas: tillage and broadcast seeding.

Item	Amount	Unit	Value (Bt/unit)	Total (Bt/ha)
Labor				
land preparation ^a				938
seeding	1.1	days/ha	40	43
fertilizer application	0.8	days/ha	40	30
weed control	1.6	days/ha	40	63
harvesting, collecting	1250	kg	0.58	725
threshing, cleaning ^b	1250	kg	0.55	688
transport				188
Material Costs				
seed ^b	125	kg/ha	10	1250
fertilizer 15-15-15 ^b	125	kg/ha	6.5	813
herbicide	0			0
Other Variable Costs				
Interest on working capital ^c			6%	188
Fixed Costs				
land ^d	1	ha	na	0
Total Variable Costs				4923
Total Cost per Ha				4923
Total Cost per Kg of Wheat (Bt/kg)				3.94
Wheat Yield (kg/ha)				1250
Price Received by Farmers (B/kg)				6.00
Gross Benefits (B/ha)				7500
Returns to Land + Management (B/ha)				2577
ROR to Land + Management				52%
Total Non-Harvest labor days/ha ^e				3
Break-even yield (kg/ha)				821

^a Hired machinery including labor. All machinery costs (interest, fuel, repairs depreciation) paid by owner.

^b Provided free by DOAE, but charged as cost in this budget.

^c Working capital charges for 4 months for all variable costs except for interest on machinery and harvest related expenses. Annual real interest rate set at 12%.

^d Not included, as budget is designed to estimate returns to land and equipment.

^e Area planted appears to depend partly on labor availability during sowing time.

Source: Tiravattanasert *et al.* 1992.

Thus small farmers, using family labor, should not risk a loss, even in years of poor follow-up rains. Larger farmers employing hired labor, such as at Mae Sai, would experience losses in some years. Farmers' profit expectations in upland areas in the off-season are quite low. A return of Bt 3000/ha at low risk would be enough to encourage wheat planting. No other crop would offer this opportunity to farmers at present.

Irrigated areas (from Table 2.7b):

Private full cost budget	- 6932 Bt/ha (\$267/ha)
Break-even yield	- 1.155 t/ha

Table 2.7b. Private full cost budget for wheat production in irrigated areas: tillage and broadcast seeding.

Item	Amount	Unit	Value (Bt/unit)	Total (Bt/ha)
Labor				
land preparation ^a				2188
seeding	1.9	days/ha	40	75
fertilizer application	1.0	days/ha	40	40
water management	2.0	days/ha	40	80
weed control	0.5	days/ha	40	20
harvesting, collecting	1563	kg	0.58	906
threshing, cleaning ^b	1563	kg	0.55	859
transport				234
Material Costs				
seed ^b	125	kg/ha	10	1250
fertilizer 15-15-15 ^b	125	kg/ha	6.5	813
fertilizer 21-0-0 ^b	62.5	kg/ha	3	188
herbicide	0			0
Other Variable Costs				
Interest on working capital ^c			6%	279
Fixed Costs				
land ^d	1	ha	na	0
Total Variable Costs				6932
Total Cost per ha				6932
Total Cost per kg of Wheat (Bt/kg)				4.44
Wheat Yield (kg/ha)				1563
Price Received by Farmers (B/kg)				6.00
Gross Benefits (B/ha)				9375
Returns to Land + Management (B/ha)				2443
ROR to Land + Management				35%
Total Non-Harvest labor days/ha^e				5
Break-even yield (kg/ha)				1155

^a Hired machinery including labor. All machinery costs (interest, fuel, repairs depreciation) paid by owner.

^b Provided free by DOAE, but charged as cost in this budget.

^c Working capital charges for 4 months on all variable costs except interest on machinery and harvest expenses. Annual real interest rate set at 12%.

^d Not included, as budget is designed to estimate returns to land and equipment.

^e Area planted appears to depend partly on labor availability during sowing time.

Source: Tiravattanprasert *et al.* 1992.

Average yields achieved for irrigated wheat (0.99 t/ha) are just below this (Table 2.4).

According to experienced farmers, obtaining yields of 1.6 t/ha, in excess of the break-even yield, should be possible. Farmers producing irrigated wheat, even when employing labor, are not risking losses, due to better water control and more reliable productivity.

Wheat grown as second crop in paddy does face a wide variety of competing crops. It need not be compared to various horticultural crops grown under favorable conditions, but with limited markets. Soybean is the main extensively grown field crop which competes with wheat for the same production domain.

The 1992 CIMMYT-Kasetsart study found that wheat would not compete with soybean under favorable conditions. It also concluded that wheat can be both profitable for farmers and socially profitable to the national economy if management errors are eliminated, expected yields are achieved, and lower cost broadcast seeding technologies are used in both rainfed and irrigated areas; however, this does not hold in areas favorable for soybean production.

New production technologies for irrigated areas, such as zero tillage and mulching, are continuing to reduce production costs and turn-around time. The estimated cost of this technology is down to 5673 Bt/ha (\$218/ha), with a break-even yield of only 0.95 t/ha. Farmers in the Pua district who have begun using this technology are achieving over 2 t/ha. Thus though the final profitability of the crop cannot be fully assessed at this point, it appears to be very promising.

The Thai Wheat Program was initiated without a very clear picture of potential production or profitability. The above study would indicate that work done by the program has reached a level that makes economic domestic wheat production an achievable reality, which was very much in doubt until recent years.

Besides profitability, other factors influence farmers' attitude towards and interest in the crop, namely:

- ◆ Timely seeding of wheat in irrigated paddy allows harvest in late March or early April (compared to soybean harvesting, which doesn't begin till the end of April), before the traditional Thai New Year in mid-April. This encourages farmers to devote some land to wheat, to be able to finance their New Year celebrations.
- ◆ Successful farmers in both rainfed and irrigated areas see wheat as an easy crop that needs little care or attention.
- ◆ Farmers are increasingly reluctant to spray chemical pesticides and fungicides on crops for reasons of health as well as cost. To date, no chemical control for disease or pests has been recommended for wheat.
- ◆ Under the present scheme, wheat receives a guaranteed price from the flour mills. By comparison, other crops experience price fluctuations, which cannot be predicted at planting time.

When there is little difference in returns between competing crops, these factors should influence farmers to grow wheat.

Role of free inputs supplied by the DOAE to farmers.

From the beginning of the current program (1983), the DOAE has supplied farmers with seed (125 kg/ha) and fertilizer (1620-0; 125-155 kg/ha). The supply of these free inputs has played a key role in attracting farmers to attempt growing the crop, and it softened the blow when they achieved poor results in their first attempts.

While current average wheat yields are still under the break-even level and the expected yields, free inputs continue to make the crop attractive to farmers. However, their continued supply without restriction for the number of years farmers have grown the crop, or the area they cultivate, is beginning to have negative implications and distortions for the crop.

- ◆ Farmers who have "accepted" the crop and expanded their area of production to 2 - 4 ha, still receive inputs. Established farmers in Mae Sai growing up to 30 ha

have continued to receive inputs as an easy way to achieve extension quota for the district. Providing such large amounts to single farmers no longer contributes to crop expansion, especially when each year the DOAE has insufficient seed for farmers in other areas.

- ◆ If seed is supplied free, farmers have no incentive to keep seed themselves. If seed is delivered late, particularly in rainfed areas where the seeding date is so critical, crop establishment can be seriously affected or the crop not planted at all. Such events can cause farmers to lose their commitment to the crop. The work of many seasons to build up a production area can thus be lost by late seed delivery. This situation has already arisen in one province, and the issue continues to be of major concern.
- ◆ As long as seed availability remains in the hands of the DOAE, wheat production and expansion will be determined entirely by the quantity of seed produced by the Seed Multiplication Centers, and the sites to where the seed is delivered. If seed is not stored by farmers themselves, there is no possibility for crop expansion through farmers distributing the seed amongst themselves.

The DOAE continues to be concerned that yields are not high enough for them to stop this support. This issue should be addressed by examining the technical support being given to farmers by extension workers, not by continuing free inputs. As well, the issue of developing practical seed storage methods on the farm still has to be faced.

There are some areas where farmers are already storing small quantities of seed, following bad experiences with late seed delivery, and where local merchants and farmers are selling stored seed to other farmers (Mae Chai, Pai). In a number of districts where production has become well established (Omkoi, Fang, Pai, and Pua), extension workers have encouraged farmers to pay the cost of the inputs into a village revolving fund. While the benefits remain with the villagers, they no longer count the inputs as personal income.

A final area of concern over the continued support for the crop is that there will come a time when economists and administrators will question whether the crop is in fact viable without government support. Without any areas where farmers have established production without support, it would be difficult for the department to demonstrate the ultimate feasibility of the crop to justify budgetary support.

Constraints to Production Development

Poor crop performance in farmers' fields was not due to major technical problems caused by Thailand's warmer climate, such as disease susceptibility and poor plant development. Poor performance was due simply to a set of management errors, consistent with the mind set of traditional wet rice farmers.

Over-irrigation, over-seeding, or inefficient land use occurred in perhaps 70-80% of the fields during multi-location trials and the early years of the crop promotion campaign. When these errors were observed and explained to farmers and extension workers, they had no chance to put recommendations into effect, as few sites grew the crop two years running. The problem was dealt with in a "piecemeal" fashion, and no institutional awareness of the management errors developed.

Scientist/extension worker interactions

In any extension system, the extension worker-farmer interaction is critical. Since wheat is new to both extension workers and farmers, extension needs to be considered as a two step process: from scientists to extension workers, and from extension workers to farmers.

The first training workshop for extension workers was conducted in 1983 by the DOA at Pungda Experiment Station, Samoeng, at that time the only DOA facility with any wheat experience. In the following years, other institutions (CMU, ARTC Lampang) also provided training courses for DOAE, but the DOA took the main training load.

Presentation of information to extension workers relied heavily on lectures, with little time in the field. Training was generally held at an experiment station and included a visit to experimental plots, where the issues at stake were not the same as in farmers' fields. In the last few years, field visits have included on-farm trials and nearby farmers' fields.

Information was structured according to subject matter, e.g., plant development, soils and fertilizers, and pests and diseases. Extension activities followed a sequence of field activities, i.e., site selection, soil preparation, seeding, irrigation, etc. At each extension step, information from different subjects needed to be integrated. However, there was no session to collate subject matter data according to the sequence of activities. This was left for extension workers to work out for themselves.

Attempts were made to improve the training by increasing the length of training sessions. As additional technical subjects were added to the training sessions, essential management practices, such as soil preparation and seeding, tended to be de-emphasized even further—yet these were the very practices that were causing farmers problems and crop failure. For example, of the subjects in a typical training session (Table 2.8), only subjects 2, 4, and 5 relate directly to the establishment of a good stand of wheat. Less than 20% of the total training time was spent on what would now be accepted as topics important for production.

As a result, extension workers acquired a lot of background information, which they found "interesting", but not directly useful. What was lacking was a clear understanding of the key factors to be considered by them and the farmers at each stage of the crop cycle; guidelines on how to present key information to farmers; and the skills or confidence to identify problems in the field.

The problem is that training is technical, but lacks the elements of extension training. However, as the involvement and experience of the DOA scientists in on-

Table 2.8. Typical training schedule for DOAE extension workers, Phrae Rice Research Center.

Subject	Time (hours)
1. Seed germination	3
2. Practice of planting wheat	3
3. Varieties of wheat	2
4. Methods of seeding in the paddy	2
5. Rainfed wheat production	1
6. Diseases and pests	2
7. Weeds	4
8. Control of weeds and pests	2
9. Plant development of wheat	2
10. Appearance of wheat varieties	2
11. Selection of foundation seed	3
12. Harvest and post harvest	4
Total	31

farm trials has increased, their understanding of field issues has also increased, and this is beginning to be reflected in extension worker training.

Extension worker/farmer interactions

When extension workers instructed farmers how to plant wheat, they tended to follow the same pattern of instruction that they themselves had received, i.e., the information was subject matter-oriented, rather than following the steps or activities that the farmer need to perform. And even though these sessions lasted only 1 day or less, the extension workers valiantly tried to present as much of the material as possible. The mundane, but critical, points of soil preparation, irrigation, etc., tended to be passed over quickly as the extension workers covered the more technical data.

Recommendations provided to farmers were given in technical terms. For example, seed rate was expressed as 20 kg/rai. While this may appear a clear and precise recommendation, it is not in a form that farmers can implement. It merely tells them how much seed they will need to plant for any particular area. The recommendation did not inform them how to perform the seeding or how to judge the correct seed rate while seeding. Similarly, recommendations such as “don’t irrigate too much”, did not provide instructions on judging how much is too much. Thus, the extension message should: a) be in common farming terms; b) form

an image or describe how to perform a set of actions; and c) give farmers a set of parameters to judge whether they have implemented the recommendation correctly (i.e., how should it look?).

A deeper problem is that many extension workers saw their role simply as an information delivery service. Particularly for a new crop such as wheat, farmers need follow-up field visits to help them identify the cause of problems. Very few extension workers did this, as could be expected, given their own experience with the crop was limited, and they often had little confidence in their own ability to tackle the problems that were emerging in farmers’ fields.

It should be possible to include new elements in the sessions to fill some of the gaps left by the old subject matter-based approach:

- ◆ Element 1: Provide subject matter instruction.
- ◆ Element 2: Relate subject matter to sequence of production activities.
- ◆ Element 3: Improve communication skills to effectively present subject matter to farmers.
- ◆ Element 4: Trouble shooting during the crop season.

Influence of production technologies on farmers’ management errors

The officially recommended technology could deliver high yields if implemented correctly. Farmers themselves tend to interpret, or misinterpret, recommendations according to their experience with other crops.

The typical extension (transfer of technology approach) response to these management errors would be to launch a campaign to emphasize the recommendations more forcefully to farmers. This would not have addressed the underlying causes of failure. The evolution of new alternative technologies side-stepped these problems. The interaction between various underlying constraints, habits, and misconceptions of farmers is complex and the descriptions here are necessarily anecdotal. However, this sort of interaction is important to appreciate if appropriate and robust technologies are to be developed.

Over-irrigation. Different land preparation and seeding methods produced different field topographies. These, in turn, led farmers to use different irrigation practices.

The recommended practice of raised seed-beds created a series of ditches around the seed-beds. Farmers naturally took advantage of these ditches to irrigate the field. Once water had been let into the field, it was often left to flow through ditches overnight, and in some cases, up to 2-3 days as farmers felt that additional water could only “do the crop some good”. Under the resulting saturated soil conditions, root rot caused by *Sclerotium rolfsii* occurred frequently. When farmers observed the plants turning yellow, they interpreted this as a lack of water and hastened to irrigate again. All this created a very strong impression that wheat was very susceptible to disease (Plate 12).

Direct drilling of the seed in rows across unprepared paddy fields was attempted by farmers to avoid plowing. With no ditches between the seed beds, they changed their irrigation method to flash flooding. In flash flooding, farmers waited until the field was flooded and then drained it (similar to the irrigation method used for soybeans). Thus, the shift from raised seed-beds to a flat field changed the irrigation procedures and indirectly reduced the incidence of over-irrigation!

A second influence of the recommended technology on over-irrigation resulted from the recommendation to apply a top-dressing of urea two weeks after seeding. To ensure fertilizer uptake, farmers irrigated when applying the top-dressing. In most cases, the soil was still moist from the first irrigation. The second irrigation caused water-logging before the plants developed crown roots and they were thus susceptible to damping-off. The damage caused by water-logging was far greater than any increase in efficiency by splitting the fertilizer application (Plate 13). DOA scientists are now stating that increases in fertilizer uptake due to split application are not significant (Saunders 1990). In the field, extension workers and farmers have been encouraged to apply all fertilizer when seeding.

Over-seeding. In the early phase of crop promotion, farmers row-seeded as recommended, but typically at 2-4 times the recommended rate. This high seed rate seriously affected plant development through interplant competition. In rainfed production, this contributed directly to crop failure. Farmers seed no other crop in rows, and so have no point of comparison to estimate a reasonable seed rate. The tendency to over-seed arises first, because farmers like to seed heavily in case germination is poor (e.g. soybeans) and second, when running seed into the furrow, the line of the small wheat seeds is difficult to see. Without a method for judging seed rate other than visual observation, farmers invariably seeded to achieve a satisfyingly thick line of seed.

An increasing number of farmers have begun to broadcast seed. Even without detailed instructions, they used seeding rates that were reasonably appropriate, based on their experience with other crops. Seed rates over the recommended rates still occur with broadcast seeding, but rarely at the disastrously high rates occurring with row seeding. The adoption of broadcast seeding has increased the frequency of another management error, i.e., shallow seeding.

Direct drilling, while helping to avoid the problem of over-irrigation, led to the problem of over-seeding by 30-50%. This is not enough to cause crop failure, but still reduces yields, and indicates extension is lacking. A small hand-tool dubbed the rolling seeder (Plate 14), which was developed at ARTC Lampang, may help alleviate the problem. The seeder delivers seed at only one rate, determined by the size and spacing of holes around its circumference (see Ch. III, p. 45).

Inefficient land use. Inefficient land use, in itself, does not affect plant development, but does result in low overall yield. This management error occurs in two forms:

- ◆ Wide irrigation channels: where raised seedbeds were formed, farmers tended to create unnecessarily wide irrigation channels (0.5 m or wider), occupying 30-50% of the field area. This followed seedbed

preparation for other second crops, such as peanuts and tomatoes (Plates 14 and 15). When zero tillage is used, almost the whole field area is covered by the crop and land waste does not occur. Reported yields per area increased accordingly.

- ♦ Wide spacing between rows of wheat: seed rows are often spaced too widely, i.e., 30-50 cm instead of 20-25 cm as recommended. This error arose when farmers dug furrows by hoe; soil dug from the furrow is pulled towards the farmer and lies on the inside of the furrow. Farmers would walk backwards from the dug furrow and then judged the distance to start digging the next furrow. In this way the width of soil heaped outside the furrow was added to the spacing.

Interestingly this was overcome *not* by emphasizing the recommended 20 cm, but by recommending that farmers *walk forward* over the rows. In this way they can judge the distance of 20 cm from the clean furrow line.

.Shallow seeding. Shallow seeding is a serious problem, particularly for rainfed wheat seeded in October. Sunlight is still strong and capable of heating the topsoil layer and causing the wheat to “bolt”. In addition, shallow seeded wheat (i.e. < 2 cm) is more likely to be affected by early drought. Wheat seeded at 3-5 cm established far more reliably. If using hoes to dig furrows for row seeding, as per the recommended technology, it requires more than double the work to dig a 3-5 cm furrow than to scratch a shallow 2 cm furrow.

Hilltribe farmers dibble seed wheat using the same method they use for seeding upland rice and maize. This placed seed deeper in the soil, providing a cooler and moister environment that allowed better plant establishment if a hot dry spell followed seeding.

Broadcast seeding, which is gaining popularity, has added new aspects to the shallow seeding problem. Farmers frequently broadcast seed onto the soil surface, leaving it uncovered. This tendency not to cover the seed is in fact derived from practices used with other crops. There is no special entry point for extension to overcome this, other than by educating the farmer.

Late seeding. Late seeding has not been a major cause of wheat failures in irrigated areas. However, very late seeding (late January +) will push the crop into rising temperatures and possibly late drought during grain-filling, resulting in reduced grain size. This also increases the risk of total loss or sprouting damage due to violent rain and hail storms in March and April.

The recommended technology seeding time for wheat (mid November) conflicts with other work for paddy farmers (e.g., harvesting and threshing rice, planting other second crops). Emphasizing the need to plant wheat earlier is rarely effective. Alternative technologies such as zero tillage and broadcast seeding can reduce the time required to plant wheat by 1/2 to 2 days for typical areas. This enables farmers to get the wheat in as soon as the field is free and then continue with their other tasks.

In rainfed production, timely seeding is critical to good crop establishment. By seeding too early to receive more rain, farmers place the crop under conditions of higher temperature and moisture, which promote the development of diseases such as spot blotch (*Bipolaris sorokiniana* syn. *Helminthosporium sativum*) and fusarium root rot. If on the other hand farmers delay seeding too long in order to escape humidity and disease, the probability of obtaining rain drops quickly. Thus they have to choose between early seeding and disease and later seeding and drought. However, there does seem to be a period (October 10-20) during which farmers can seed with little risk. Because the DOA has not conducted research under rainfed conditions, it has no clear instructions for seeding date. Farmers' adjustment of seeding dates have been too great, falling on either side of the Oct. 10-20 period.

Late seeding has been more of a problem than early seeding. Farmers' seeding practices for other rainfed crops have probably contributed to their casual attitudes. Crops such as maize or early soybeans are planted at the beginning of the wet season. Delaying seeding of these crops is a conservative strategy that

puts them into a period of increased rain. But this strategy if used for wheat has the opposite effect of putting the crop into a period of increased drought risk.

Farmer education is critical to overcoming this common error. Apart from farmers' lack of knowledge regarding seeding dates, a major factor leading to late seeding has simply been the late delivery of seed to farmers by the DOAE. This problem is likely to continue until farmers begin to keep and maintain their own seed stocks.

Environmental constraints

Both heat and heavy disease pressure were expected to constrain the establishment of wheat production in Southeast Asia. Both factors have affected production, but they have not proven to be obstacles to production.

Heat. The early seeding date for rainfed production in mid-October exposes the crop to warmer temperatures than the November/December-seeded irrigated crop (Figure 2.1). This may be a factor in the reduced tillering observed in the rainfed crop compared to the later seeded irrigated crop (moisture availability being another one). In areas seeded earlier than October, the plants "bolt" with short stems and small heads.

Farmers could mitigate the effects of temperature by seeding deeper (3-5 cm) or by mulching. This, however, tends to produce plants with fewer tillers. It is worth noting that October-seeded rainfed wheat has only been established at sites well to the north of Chiang Mai at elevations above 400 masl. Thus there appears to be a limit to the areas where rainfed wheat can be established due to temperature.

Diseases. Diseases that do damage in the field are spot blotch (*B. sorokiniana*), *Fusarium* spp., *Sclerotium rolfsii*, and leaf rust (*Puccinia recondita*). The last has been observed only in irrigated production.

Spot blotch can be a problem on the October-seeded rainfed crop. To a large extent, farmers can escape it by seeding after temperatures and humidity have begun to drop. Field observations of rainfed wheat during the

1990/91 season at Fang showed that crops sown within the October 10-20 period had far less infection than earlier-sown crops, although the rains extended well into October that year.

Fusarium spp. as foot rot can occur when rainfed farmers attempt to seed their crop during September to catch more of the wet season rains. Low level infections of seedling blight, attributed to *Fusarium* spp., have been regularly observed in rainfed fields in recent seasons. The first one or two leaves wither and turn brown. Some plants are lost, and others recover without further symptoms. In some fields, 5-10% of the seedlings are lost.

Sclerotium rolfsii, a soilborne pathogen, was a major worry for wheat in the early seasons. There has been little problem observed in recent seasons as farmers have learned not to over-irrigate the plots.

Leaf rust has been observed only in irrigated fields. Typically it has been a minor infection, occurring too late in the season to do any damage. Heavy infection was observed on Samoeng 2 for the first time in 1990-91. At Pua, where there were 96 ha of wheat planted, the infection rating was 40S, resulting in some yield loss. Incidence of leaf rust extended from as far south as Tung Hua Chang District, Lamphun Province.

Structural and bureaucratic constraints

Most of the key stages of production (i.e., seed supply, instructions for planting, and marketing) rest in the hands of the DOAE. Thus, while the DOAE has orchestrated the successes achieved to date, a critical examination of its operation has also revealed some constraints.

Extension objectives. Extension objectives have been stated in terms of production area quotas for local extension workers, which has led them to encourage farmers to plant as large an area as possible. However, when a large area of new crop fails, farmers' disappointment is proportionately large, making it unlikely that they will attempt the crop again the next season. Some other criterion to guide and monitor the

work performance of extension workers seems to be warranted to avoid promoting large areas to inexperienced farmers.

There have been several instances where an extension worker's opinions have taken precedence over the farmer's. During the first year of crop promotion, about half of the farmers obtained yields of less than 0.625 t/ha. Many farmers seemed to take this in stride and were prepared to adjust their cultivation practices and try again in the coming season. However, most extension workers assessed these instances as failures, and were unwilling to return to promote the crop in the same areas a second year.

Discontinuity within bureaucratic operations. Within the DOAE, a range of discontinuities or poor linkages have affected wheat production. Late delivery of seed has been the most common. Other types of discontinuity can be more subtle. Production in Fang District during the 1989/90 season serves as a typical example of these.

The ATT project had effectively developed rainfed production in a cluster of four villages. After the project ended, it was the DOAE's responsibility to maintain and expand production. However, discontinuities occurred at the local and provincial levels:

- ◆ The local extension worker did not contact farmers before the growing season to determine the need for seed. This lack of preparation became apparent less than a month before the seeding date. It was solved when the Deputy Head of the district DOAE office stepped in and contacted two of the four villages. Despite the late date, there was an increase in the number of farmers wanting to plant wheat. Without the last minute effort by this one officer, the accomplishments in this area, going back five years, would have been lost.
- ◆ In another year, the DOAE Seed Division delivered seed, but fertilizer from the provincial DOAE office did not arrive. Again it was not until the Deputy stepped in that it arrived just in time for seeding. Due to the inaction of one person in the provincial office,

the crop would have been either planted late or without fertilizer. Either way, considering the drought that year, the result would have been a crop failure.

- ◆ A village in a subdistrict of Fang had intended to grow wheat in paddy fields following the harvest of an early maturing rice variety. However, when the new rice variety did not arrive in time for planting, farmers planted their traditional variety and discarded the idea of planting wheat.

The opportunities for discontinuity are numerous whenever farmers rely on seed supplied by an outside agency. The DOAE department that multiplies and supplies seed is separate from the one that promotes the crop to farmers. Thus it is unrealistic to rely on the normal procedures of a bureaucratic organization to develop an experimental venture that requires constant monitoring and adjustment.

Yet the DOAE has succeeded in establishing a number of wheat production centers mainly because, at each such site, there has been one officer who took on the development of wheat production in his area as a personal goal. Such self-motivated individuals exist in any organization, but there are limits to what they can achieve on their own. Thus it was only by identifying them and providing them with the moral support and technical backup they needed that they could perform. One of the main tasks of the author was to provide this back-up and integration across institutions.

Institutions and Implementation Strategies

Multiple-source initiatives in the Thai Wheat Program

The Thai Wheat Program should have a coherent program with specific goals, but in fact has never operated under the authority of one institution or committee coordinating research and extension. Each institution obtained its own budget and retained its independence and authority over its activities. There was no pilot program that integrated production and purchase of the crop. Over the past decade, as the initiative has

begun to taper off in one group in the consortium, another has been able to advance the program another step. What follows is a rough picture of how this has progressed, at the same time giving credit to each institution for its role.

CIMMYT. When CIMMYT established its regional office in Bangkok in 1981, there was no wheat production other than that of the Mae Sai farmers. A small number of scientists were carrying out research on wheat independently of each other. The initiatives of the liaison officer for CIMMYT's Southeast Asian Wheat Program have already been mentioned. Through a series of meetings and workshops, CIMMYT networked scientists and gave the research a focus. The technical feasibility of wheat was established and the number of scientists working on the crop expanded.

"Local use" of wheat and the DOAE. The first flush of enthusiasm from this consolidation of efforts was beginning to wane by 1983. The difficulties involved in mobilizing funds and coordinating the effort to achieve actual wheat production were becoming clearer.

The local use concept introduced a new element to the program. In the absence of a budget to purchase the crop, the DOAE went ahead with its multi-location trials on the basis that farmers would dispose of their harvest by consuming it or processing it into snack foods for sale. This changed wheat from being a research topic to a real crop in farmers' fields. CIMMYT continued to have the major role in supporting seminars and workshops to focus and coordinate research.

ARTC. The Agricultural Research and Training Center at Lampang first became involved in the program through its participation with the CIMMYT/IRRI rice-wheat rotation trials. In 1985/86 cool season, ARTC extended its work to farmers' fields and established the first convincing production of irrigated wheat in paddy fields, with yields of 3.75 t/ha. This brought the irrigated paddy into focus as an alternative target area for wheat besides the rainfed areas. Research and extension in paddy areas developed from this point on.

DOA. In early 1986, the DOA began to take responsibility for coordinating the program. DOA-sponsored committees were set up to plan production and research in both the North and Northeast. The DOA proposed that wheat be included in the 6th NESDP as a new crop for development—a critical step for obtaining research funds and for DOAE's promotion of the crop. In the field, DOA demonstration plots (as part of the ATT project) provided the main examples of the crop's potential. The issue then became, not whether the crop could be produced under field conditions, but whether it could be extended effectively.

The DOAE and farmers. By 1989 farmers, under the DOAE crop promotion program, had finally begun to obtain good stands of wheat in both rainfed and irrigated areas, thus demonstrating the feasibility of extensive production. The number of farmers, area and crop yields increased. Technologies were evolving in farmers fields which were effective and cost efficient. Altogether this began to indicate that wheat could be established through extension provided by the DOAE.

The final step initiated by the DOAE was links with the commercial flour mills and the introduction of buying centers for wheat in the province to provide a market and encourage production expansion.

Implications of the multiple-source initiatives for program implementation

The contributions of various institutes at different times have been essential in maintaining the impetus of the overall program. As one agency ran into problems or tapered off in its efforts, one of the others was able to make some sort of progress to provide needed encouragement and stimulus. For example, the multi-location trials of the DOAE were initially having poor results. Without the encouragement from the work of the ARTC in farmers' fields, it is possible that the DOA would not have included wheat in the 6th NESDP.

The wheat program was an experimental venture for the Thai Government, without any certain payoff. Given the time required for the program to develop tangible results,

it is doubtful whether a single institution could have maintained its impetus and budget through all the difficulties the program has faced. This suggests that for experimental ventures in developing countries, a consortium of institutions will provide greater resiliency and longevity against changes in heads of departments, budgets and policy.

There has been considerable discussion in the literature on the apparent and real influences of agricultural centers on advances in agricultural production (Biggs 1990). The development of wheat production in Thailand, assuming its eventual success, would seem to have demonstrated this model. There are special circumstances which have facilitated this multiple-source strategy to function, for example, the mutual interest and respect that the individual agencies have given to each other's work and the ample opportunities for meeting and exchange through annual workshops. This model has been facilitated by the fact that since 1991 CIMMYT's Southeast Asian Program was based in Thailand, a country with the freedom and flexibility to provide the opportunity to identify and pull together the different institutions.

Outside interventions and organizations supporting the program

While the direction of the program was very much determined by key government departments, outside regular government budgets, there were special budgets and independent organizations that played critical functions at different stages of the project.

The Agriculture Transfer of Technology project (ATT) was a USAID loan fund administered by the MAC to "provide a short-cut to get recently developed technology to where it was needed in the field." An umbrella project was drawn up for the Wheat Program which involved all the government institutions (DOA, DOAE, Chiang Mai University, Hui Si Ton station and the Agriculture Research and Training Center). Each institution worked independently in the field and networked through regular planning and annual workshops, and joint monitoring trips to the field.

The ATT project was critical for the wheat program, first, in that it overlapped the end of Phase I and the beginning of Phase II of DOAE's program promoting wheat production. DOAE funding for extension of wheat actually lapsed between the multi-location trials and the beginning of the crop promotion phase. The ATT demonstration plots filled in for a couple of seasons until funding for crop promotion became available. Without this, extension activities would have lost continuity. Altogether, the project covered three seasons (1986/87, 1987/88, and 1989/90) and was extended to a fourth season (1990/91) only for the DOA, DOAE, and Hui Si Ton.

The project also came at the time when the scientists involved in wheat research had become confident in the potential for wheat, but had also become frustrated by the poor extension impact of the DOAE's multi-location trials. The ATT project provided an outlet to channel their energies towards demonstrating the viability of wheat in the field.

Demonstration plots were the mainstay of the work of most the institutions. Despite the name of the project, most emphasis of the field work was placed on technologies in demonstration plots, rather than on how this information was being transferred to local extension workers or farmers. Each institute identified its own target area and developed its own approach. The exception to this was Chiang Mai University's implementation strategy, which focused on rainfed production, because of experience with previous on-farm work at Fang. The University made a conscious attempt to progressively minimize the role of the ATT project and increase the role of the DOAE and local merchants during the three years of the project.

In the first year, inputs and all production costs were provided to five cooperating farmers, and all stages of production were supervised and monitored by project staff. The crop was purchased by the project for its second component, which was local use. As a result of this demonstration, additional farmers began planting in the second year of the project.

With the crop successfully demonstrated and farmers committed, only the standard DOAE inputs of seed and fertilizer were supplied to farmers. The project was still able to purchase the whole crop for local use. This year was also used to train the local DOAE extension workers.

By the third year, technical back-up to farmers had been transferred by project staff to the DOAE. The main emphasis of the project in the third season, with expected larger output, was to develop the interest and market links with local grain merchants. Following the end of the project, DOAE staff continued to expand production in the villages in the original project area within the framework of DOAE's crop promotion campaign.

Impact of the ATT project. The ATT Project led directly to sustained production of wheat at three sites: 1) Fang, Chiang Mai (CMU), 2) Omkoi, Chiang Mai (DOA), and 3) Ngao, Lampang (DOA). The ATT project in Fang had significance beyond just the development of production in that district. This was the only area where rainfed production was successfully developed. This led the DOAE to re-include rainfed production areas as a target for extension.

In addition to an impact on production, the project had a significant effect on scientists' attitudes and approaches to research. In farmers' fields, scientists were exposed to farmers' conditions and constraints first-hand, which led to reassessing technologies developed on-station. Despite the fact that on-farm trials are far more difficult and frustrating to carry out, scientists from all the rice experiment stations in the North have developed a genuine and sustained interest in this type of research. This will ensure that a problem-solving perspective is maintained.

Two additional independent types of programs were engaged in the development of wheat production: bilaterally funded development projects and non-government organizations (NGOs). In certain years, the combined areas of production with these projects, scattered over many sites reached almost 50 ha.

Bilaterally funded development projects. During the period of the Thai Wheat Program, there were several bilaterally funded projects in the North, aimed at reducing opium production. The strategy of these projects in the early eighties was crop substitution of opium (Plate 15). By the second half of the decade, projects had broadened their strategies to development of living standards and watershed protection. The following projects were approached with the suggestion that they include wheat to provide both an additional cash crop and dietary supplement:

- ◆ Royal Highland Development Project (R-HDP), funded by His Majesty King Bumiphol;
- ◆ Thai-Norwegian Highland Development Project (TN-HDP), funded by Norwegian Church Aid;
- ◆ Thai-German Highland Development Project (TG-HDP), funded by GTZ;
- ◆ Mae Chaem Watershed Project (MC-WSP), funded by USAID;
- ◆ Thai-Australia Highland Agriculture and Social Development Project (TA-HASD), funded by AIDAB.

From 1984, a considerable effort was made to work with these projects. It appeared that their extension programs had a number of advantages over the DOAE extension program. Project extension workers appeared to be highly motivated and familiar with managing exotic crops. The environment in the highlands was more favorable for wheat production and the projects usually facilitated marketing of any new crop they introduced to farmers. Most of the ethnic hilltribe villages were rice deficient and so there was a definite role for home consumption of wheat. Cooperation was in the form of training in wheat production and utilization, and back-up field visits.

Most of the production introduced was rainfed. Excellent production was achieved in some areas. At one site of the TN-HDP (Pha Daeng village, Mae Chai District, Phayao), at 1100 masl, farmers achieved yields of 2.5 t/ha under rainfed conditions. In this environment, the rainfed crop often did not appear to suffer water stress (Plate 16).

In general, no sustained production in rainfed sites resulted from the efforts of any of these projects. Despite the favorable environment, development of production in the highlands is problematic. Highland swidden fields are small (0.5 - 0.8 ha) and scattered, so that development of extensive production in a few farmers fields is not likely. Damage by grazing livestock is a perennial problem, as fencing of temporary swidden fields is not attractive to farmers.

Market links were not well developed by most of these projects. Emphasis was given to using wheat as a diet supplement. This was not a strong enough incentive to maintain production and most projects tended to have had a crop replacement rather than a community development approach. Farmers often had far more serious concerns, such as uncertain citizenship and proposed resettlement of villages, which interrupted the efforts of establishing wheat production.

One of projects, TA-HASD, working with the Karen ethnic group in Tung Hua Chang, District of Lumphun, was the last project where this form of support was provided. It does appear to have developed sustained wheat production. By the 1994/95 season, two years after the project had ended, wheat production area was approximately 60 ha. The reasons this highland development project was successful where others had failed were that the hilltribe village site was actually located in the lowlands, production was irrigated rather than rainfed, giving a more stable production environment, and by the early 90's, marketing was no longer a problem as "buying centers" for wheat were available. Once production was established, the project was able to pass extension over to the DOAE. The production area has continued to expand.

Non-government organizations. Similarly to the highland development projects, NGOs were seen as a group that could provide attention to wheat extension. Just as in the bilateral programs, NGO workers appeared to be more motivated than regular production-oriented extension workers. For three seasons (1983/84-1986/87), attempts were made to interest and assist various NGOs

in developing wheat production in their project areas. The assistance provided took the same form as for the bilaterally funded projects, i.e., training and back-up site visits.

Despite the high expectations and regard that we had for the work of the NGOs, they produced very few solid results. One notable exception to this was the Ockenden Venture Project. The production initiated by this project in Don Chai village, Pua district, Nan, was later developed by the DOAE into one of the main production centers for wheat.

The lack of persistence in introducing wheat to their farmers was not entirely the fault of the NGOs. Appropriate technologies and a market were still not clear at the time when they were approached. While no recent attempts have been made to involve NGOs, they could be effective now that appropriate technologies are available and a market network has been established.

Development of a Market Structure for Domestic Wheat

General trends in imports and consumption

The commercial flour mills in Bangkok, 690 km south of Chiang Mai, are the primary market targeted for domestic wheat production. The mills purchase wheat as a consortium mainly from the United States, Canada, and Australia, with spot sales from Saudi Arabia and other countries. Wheat imports to Thailand almost doubled between 1987 and 1990 (Table 2.9). Projections for wheat imports based on population growth and income put wheat imports at over 600,000 t/yr by the 2000 (Tiravattnaprasert *et al.* 1992).

However, the mills would appear to project an even higher figure. All five established mills have expanded their capacity in recent years, and three new mills have been established. The total milling capacity (1994) was already over 1.1 M t/yr (Table 2.10). Domestic consumption will not likely support this expansion, and the mills must envision an increase in their export of finished products.

Table 2.9. Wheat imports to Thailand, 1975-1994.

Year	Milling capacity (t)	Wheat grain imports (t)	Price of wheat C.I.F (Bt/kg)	Total value (million Bt)
1975	250,560	57,289	4.796	274.78
1976		130,062	3.807	495.08
1977		60,296	2.857	172.29
1978		103,188	3.115	321.43
1979		129,921	3.912	508.25
1980		201,224	3.020	607.65
1981	293,760	189,308	5.269	997.51
1982		116,417	4.675	544.24
1983		156,394	4.115	643.51
1984		116,523	4.466	520.80
1985		100,021	4.836	483.75
1986		110,893	4.195	465.20
1987		160,969	3.767	606.44
1988		212,825	4.397	936.74
1989		250,355	5.331	1,334.56
1990	475,200	270,455	4.607	1,245.87
1991	822,240	394,598	4.080	1,611.68
1992		443,074	5.067	2,245.26
1993	894,240	528,724	4.954	2,619.56
1994	1,213,760	670,509	5.037	3,377.54

Source: Department of Customs, Thailand.

Table 2.10. Increase in milling capacity in Thailand, 1980-94.

Company	Year established	Milling capacity/day (t/day)		
		1980	1990	1994
United Flour Mills	1964	370	500	1080
Siam Flour Mill	1970	250	250	515
Laem Thong Sahakarn	1975	250	500	750
Thai Wheat Flour Mill	1981	150	400	400
Bangkok Flour Mill	1991	-	-	400
Charoen Porkapun	1992	-	-	500
Nissin	1993	-	-	250
Kurrie/Thai President	1994	-	-	250
DAILY Milling Capacity		1,020	1,650	4,145
ANNUAL Milling Capacity		293,760	475,200	1,213,760

^a Milling capacity/year, calculated on the basis of 24 days/month of operation.

Source: United Flour Mills, Bangkok.

Table 2.11. Patterns of wheat consumption in Thailand.

Product	Flour protein-content	1980	1990
Bread, other baked products	13-14	29	28
Instant noodles	12-13	22	20
Wet noodles, doughnuts, pastry	10-11	34	20
Cookies, biscuits	8-10	10	12
Cakes and Chinese pastry	7.5- 8	8	5
Animal feed	na	-	15

Source: United Flour Mills, Bangkok.

Bread is often automatically considered the main use for wheat flour, but in Thailand it accounts only for 29% of wheat utilization. The main reasons for the increase in wheat imports were for export-oriented products, such as animal feed for prawn production (up from 0 to 15% since 1980), instant noodles and manufactured biscuits (up 5% since 1980) (Table 2.11).

Since the MOI initiated its project in the 1960s, the flour mills have indicated a willingness to purchase domestically produced wheat. However, in the production areas, very few local merchants in the townships were familiar with wheat, the location of the mills, or the price it could bring. The prices the mills offered were too low to interest local grain merchants, while the crop volumes were still too low for efficient operation. The problem for wheat in Thailand then was not the lack of a market, but the lack of a marketing structure.

As already described during the DOAE multi-location phase, an attempt was made to side-step this issue by encouraging farmers to consume the crop themselves. When this failed, it was the lack of market access for the up-country producers, perhaps more than the initial poor performance of the crop, that prejudiced the farmers and extension workers against the crop.

Traditional domestic markets for wheat

Some local markets did exist for wheat grain and some of the farmers were able to contact these. The *be sae* factories purchased approximately 200-300 t/yr, and the mushroom industry used a further 50 t/yr. The *be sae* market actually favored local wheat due to its better malting characteristics, and farmers could receive prices as high as Bt 10-11/kg—substantially more than the cost of imported grain. As production of wheat increased and more farmers have approached the *be sae* factories, the factories have found themselves in a buyer's market and the prices have dropped to about Bt 6-7/kg, the same as the farm-gate price provided by merchants delivering to the mills in Bangkok.

Seed multiplication was the key market for the crop when the DOAE promotion phase began. The whole of the 1988 harvest from the DOAE program was sold to the Seed Multiplication Division. By 1991 the percentage of the harvest sold for this purpose had dropped to approximately 25%, but remained significant in some areas (particularly rainfed areas where yields were lower), as the price for seed material was relatively high, Bt 7-8/kg. The disadvantage of selling to the Seed Multiplication Division was that farmers had to wait until the grain was certified as seed before they received payment. In areas where the grain was rejected, they then had to look for alternative markets. While the farmers were still in the process of evaluating the market for wheat, these delays and rejections added to the uncertainty of the crop.

Initiating a market for an unknown crop based on existing market structures

In the second season of the crop promotion phase (1988/89), production was expected to exceed the quota to be purchased as seed. In mid-1988, the DOAE initiated a series of meetings with the mills to purchase domestic production. The DOAE was represented in these meetings by a section head. At this level, the government sector had no authority to demand or pressure the mills regarding the price or volume to be purchased. Yet the mills did agree to facilitate buying centers and set a favorable price for wheat.

The first harvest that this proto market structure was initiated, only two buying centers operated: Chiang Mai and Chiang Rai. In an attempt to establish a uniform price for wheat in all districts, the flour mills recommended a price of Bt 6.40/kg to be paid farmers and a factory door price of 7.30 Bt/kg, giving merchants a margin of 0.9 Bt/kg.

The mills initially accepted all lots of wheat without considering quality. Starting in the 1991 harvest, the mills issued standards for moisture content (12%), foreign matter (2%) and sprouting damage (0%). Despite this, they have yet to penalize off-standard lots.

As the number of buying centers has increased, they have tended to move from the provincial townships (the "Muang" district of each province) out to the districts where substantial production has developed (Table 2.12). It appears that once a district reaches a production area of approximately 16 ha, the volume of the crop (equivalent to a 6-wheel truck load) begins to be attractive to the local merchants.

Total domestic production in 1994 was estimated at 830 t, which was marketed through nominated buying centers, the DOAE Seed Division, and the *be sae* factories. Some of the buying centers sold to the *be sae* factories instead of shipping to Bangkok (Table 2.13). The *be sae* factories' portion of the crop has decreased since the program began, but is still significant at 50%. While the *be sae* prices are now lower than in the 1980s, local merchants familiar with this market still favor them as the transport costs to the factories in Lampang Province (<100 km south of Chiang Mai) are lower than shipping to the mills in Bangkok.

As production centers develop, the network of merchants should continue to expand until a normal marketing structure for wheat exists. This approach

Table 2.12. Expansion of marketing points for wheat, 1989-94.

Harvest 1989	Marketing points for wheat	
	Harvest 1991	Harvest 1994
CHIANG MAI - Muang	CHIANG MAI - Muang - Fang - Chai Prakarn	CHIANG MAI - Fang
CHIANG RAI - Muang	CHIANG RAI - Muang - Pan NAN - Pua MAE HONGSON - Pai PHAYAO - Muang	CHIANG RAI - Muang NAN - Pua MAE HONGSON - Pai PHAYAO - Chiang Rai
2 locations	10 locations	4 locations

Note: Wheat production in Lampang Province goes directly to Be Sae factories located in the province. Wheat production of Lamphun Province is all purchased by the Seed Multiplication Center.

appears to work, in general, but there are still difficulties from one site to another:

- ◆ Despite the flour mills' good intentions to establish a fixed price for wheat, most merchants have been paying farmers only about Bt 6.0/kg because volumes are still low, and wheat is arriving at the merchants' warehouses over a considerable time span, which slows the merchants' cash turnover. This price still appears acceptable to farmers.
- ◆ Some merchants have had up to 6-week delays in receiving payment from the mills, which do not yet have an efficient system for making quick payments. Such delays are not acceptable to small local merchants who have limited operating capital.
- ◆ In the initial stages of a new production center, total output may amount to a few tons and no local merchants will become involved. An existing buying center may be quite distant from the new pocket of farmers. The local DOAE officers have not always been quick to collect the farmers' harvest and moving it to the buying centers.

In the absence of a pilot project with a crop purchase program, the DOAE has succeeded in fostering a rudimentary market structure for the crop. This is a notable achievement as it has been done, not through direct control, but through bringing the interested parties together, providing them with needed information, and negotiating workable procedures. The DOAE has focused on two levels. In Bangkok, it negotiated with the flour mills for price and buying procedure each year. At the district level, local DOAE officers have identified

suitable grain merchants to act as buying centers, introduced them to the mills prior to harvest, and directed farmers to these merchants.

If this approach does prove to be successful in stimulating the development of an independent market structure for wheat, the DOAE will have established a market structure for an exotic crop at an exceptionally low cost to the government. The success of this approach must also be credited to the willingness of the flour mill consortium to cooperate, particularly by setting a price for domestic grain slightly above the price of imported grain. This price has been maintained for four years, giving a sense of stability to the crop. This was further strengthened by the millers' willingness to accept wheat of all qualities without penalty.

Future market issues

Five mills received less than 200 t each from the 1995 season crop. This is a trivial quantity compared to normal, e.g., United Flour Mills processes over 1000 t/day. Thus, it has been easy for the mills to leave the issues of price, quality, etc. aside. But these must be dealt with once the volume of domestic production becomes significant.

Price. The initial factory-door price paid by the mills for domestic wheat, 7.40 Bt/kg⁵ was more or less the price mills paid for imported wheat in 1989 (after taxes added 34% to the CIF Bangkok price of 5.33 Bt/kg). World prices then dropped, but the mills maintained the same price in a cooperative effort to avoid affecting farmers' confidence in the crop. The average CIF price for

Table 2.13. Shifts in marketing of wheat, before 1985-94.

Marketing channels (from farmers →)	Harvest year								
	Before 1985			1988			1994		
	price (Bt/kg)	vol. (t)	mkt. shre(%)	price (Bt/kg)	vol. (t)	mkt. shre(%)	price (Bt/kg)	vol. (t)	mkt. shre(%)
Be Sae factories	9-11	200	100	8-9	100	62	6-7	411	50
DOAE Seed Division	-	-	-	7-8	60	38	7-8	186	22
Marketing Points	-	-	-	-	-	-	-	-	-
→ Flour mills, Bangkok	-	-	-	-	-	-	6	233	28
	(av) 10	200	100	(av)8.1	160	100	(av)6.9	830	100

⁵ The exchange rate for the Thai Baht has remained pegged at 25Bt to the \$US for some time. This fixed exchange rate could be distorting the price. With the Bt floating, the price of local wheat could well be competitive with imported wheat.

imported grain had by 1994 risen to 5.037 Bt/kg, making the factory-door, after-taxes price 6.781 Bt/kg. Thus the mills are still subsidizing the price for domestic wheat by 0.6 Bt/kg, or just under 10% over what they pay for imported wheat.

There could come a point where domestic wheat at its current factory-door price of 7.40 Bt/kg would be cheaper than imported wheat. Given the current tax structure, this import/domestic break-even price would be 5.52 Bt/kg (\$144/t CIF Bangkok). While the official figures for wheat imports and prices are not yet available, the 1996 CIF prices reported for wheat to Bangkok are now \$180/t well over this. This new level of world wheat prices could encourage the mills to take a more active role in the development of domestic production.

Quality. Wheat quality is highly susceptible to the production environment and farmers' management practices. Samples of Samoeng 1 taken from different sites (1984 harvest) varied in grain protein (10.4 -17.1%). The corresponding loaf volumes varied from 700 to 1025 cc (Connell 1982). However, the mills have consistently stated that they are willing to accept domestic wheat up to 10% of their milling requirements without restrictions on grain quality. At the current import levels, this amounts to 60,000 t. It will be quite some time before Thailand is producing this volume, and so grain quality should not be an obstacle to production and marketing. While quality in itself may not become an extension issue, the management practices that give good quality also give better yields, so that extreme variations in quality should decrease as farmers become more familiar with the crop.

Bulk handling. Large quantities of wheat will need specific handling facilities for cleaning, storing, and blending domestic grain with imported grain. This will require capital investment on the part of the flour mills. None of these issues will become important for the next few seasons. Before the mills commit themselves to any effort or investment to cope with large quantities, they will also want to be assured of the Thai government's commitment to the crop and its continued production.

Current Trends and Future Directions for Wheat Production

The bulk of this report was written in 1992, before the author left the program. In the period between then and 1995, trips were made back to the program as an advisor to the IDRC funded Participatory Extension Project. While this did not allow detailed data to be gathered, it did make it possible to follow the general trends and progress of the program.

Overall trends in production area and yield

The last three seasons are of particular interest, as they represent the period when the wheat program has been operating without the support of CIMMYT wheat staff based in-country.⁶ But perhaps what is more important is the gradual dissolution of the informal consortium of institutions which provided mutual support and gave the program its vigor. Attempts were made in 1992 for the informal consortium to rationalize itself and to develop a master plan for wheat. This has not happened, and each agency continues its own wheat activities independently, meeting only occasionally. Without a national plan or a vigorous informal consortium, progress now depends to a large degree on the DOAE's planning and policy. At the functional level, it is the DOAE which supports the crop through distribution of free inputs and annual meetings with mills to establish prices. Without this support, production would end abruptly. At this point, the DOAE's policy is to continue to provide free inputs,⁷ to ensure that production *remains at the present levels*. However, this support cannot continue indefinitely and at some point production will either expand without support or shrink to become a relic of this attempt to establish wheat production in Thailand.

To summarize the main trends in wheat production in the three seasons since 1992, in the 1992/93 season the

⁶ 1992 was the last year that CIMMYT wheat staff were based in-country. Since then, the CIMMYT Kathmandu office has provided occasional support.

⁷ Beginning in the 1996/97 season, the DOAE increased seed supply to farmers from 125 to 155 kg/ha of seed and reduced fertilizer inputs from 155 to 125 kg/ha.

production area jumped to 1500 ha, but has remained static for the last three seasons; irrigated production area is increasing at the expense of rainfed production; and average yields for both irrigated and rainfed production show an upward trend.

Expansion of the production area. In some areas wheat has become the dominant dry-season crop. For instance in Pai district, wheat has now almost replaced soybean as the winter crop in paddy areas. However, the crop has probably reached the limits of its expansion in this district, but this does not apply to most areas, and is certainly not the reason for zero growth in production area over the past three seasons.

As long as seed is supplied free, any expansion of production area is entirely determined by the DOAE seed distribution policies. In the plans for 1996/97, there are a number of new districts introducing wheat production in relatively small areas. If these districts are successful, the demand for seed will only continue to grow. Thus while there is potential for expansion, seed supply has reached a ceiling.

Zero growth in production area seems to be more a result of insufficient seed distribution, than of the lack of farmers' interest in the crop. Seed limitation is claimed not to be caused by budget constraints for wheat within the DOAE, but due to its capacity to produce and store sufficient seed. This would not seem a difficult bottleneck to solve, and indicates the rather neutral status wheat has within the department.

Some comment should be made on the expansion of barley production. As the other temperate cereal being promoted to farmers, it sometimes competes directly with wheat. Two of the areas that had the highest average wheat yields, Omkoi and Samoeng, and most of the area in Pua, have switched to barley. In 1995/96 the production area for barley was 4480 ha (1740 ha irrigated and 2740 ha rainfed). This was three times the total wheat production area. This expansion has been gained through active support for the crop by the private sector (the breweries). The farm gate price for barley is

quoted as 8 Bt/kg (for A grade grain, though the bulk of the crop is purchased as B grade @ 7 Bt/kg). This switch was not necessarily the farmers' choice, as they depend on local DOAE staff to supply seed for both crops.

The expansion of barley has occurred despite serious technical problems. The average yields quoted for barley are only marginally lower than for wheat.⁸ But these average yields are for the harvested area only. Of the total area planted to barley in the last season, only 60% was harvested (compared to 90% for wheat), the other 40% being lost to disease and drought. In one province only 25% of planted barley area was harvested. It is difficult to see how the momentum for barley can be maintained in the face of such losses and risk for the farmers. Without the exceptional support and incentives provided by the brewery, it is doubtful barley would remain on the extension agenda.

Shift to cultivation in paddy. The shift from rainfed to irrigated production is part of an effort by the DOAE to increase average yields and the total output of the crop (a little over 1000 t in 1996). Rainfed production had been increasing at a faster rate than irrigated production, but the yield levels and overall production in rainfed areas were low and susceptible to drought. Rather than devote too large a proportion of the limited seed to rainfed areas, the DOAE decided to give preference to irrigated areas beginning in the 1995/96 production season. Thus in the 1995/96 season, the irrigated area increased by nearly 2/3, with the rainfed area correspondingly reduced by 1/3. Experienced rainfed farmers still persist with the crop, as no other crop matches wheat's drought tolerance; thus this production domain does appear to be feasible.

Yield increases and production technologies. As a second measure to increase productivity, the DOAE has dropped districts which have performed poorly from the program, as well as farmers who have proved inefficient. As a result, the overall number of wheat farmers has

⁸ Average barley yields (1996 harvest): rainfed prod. - 0.63 t/ha; irrigated prod. - 0.70 t/ha (cf wheat 0.64 t/ha and 0.99 t/ha).

been reduced by half of the 1993/94 total (Table 2.4). This could be a worrying trend; however, under the present circumstances the effect has been as intended. Average yields in irrigated and rainfed areas increased by 20% and 70%, respectively, over the last three seasons.

Due to the elimination of inefficient farmers, the average area cultivated per farmer has risen to 0.7 ha and 1.0 ha for irrigated and rainfed production areas, respectively. With this larger area to cultivate, farmers in both irrigated and rainfed areas have shifted to broadcast seeding as the preferred seeding technology. However, the process of technology evolution has not stopped yet and there is considerable variation within the generic technology of broadcast seeding. In some cases, rice straw from the previous crop is burnt to fertilizer wheat; in other areas, it is used as mulch to provide seed cover and conserve soil moisture. Seed cover is gained in other areas by covering the seed with soil from the digging of irrigation channels.

Yields remain below the calculated break-even level. Field inspection in 1995 and 1996 showed that many of the old management errors still persist, though they are no where near as severe as they were in the early years of the program. Thus the adoption of good cropping practices across the board has yet to be achieved.

Issues for establishing sustainable wheat production

It is now nearly a decade since the DOAE began its promotion of wheat. From the brief description of current trends, it is clear that wheat has not been successfully established; expansion of production area is still an artifact of seed distribution, and crop yields, while having an upward trend, are still below the break-even levels. Yet wheat does seem to have found a niche where it can compete with other crops. This appears to depend, not so much on price, but on its tolerance to drought. It thus should be feasible for wheat to be established as an alternative second season crop. What are the key issues which need to be resolved to realize this potential?

Ensuring seed availability and production area expansion. The long term solution to the problem of insufficient seed is to phase out free seed distribution, and for farmers to take responsibility for storing seed themselves. The DOAE has been reluctant to do this, fearing that as long as yields are low, free inputs are critical to maintaining farmers' interest in the crop. To compensate for the free seed and fertilizer,⁹ farmers would need to increase yields by an additional 280 kg/ha, which represents a 30-45% increase over average irrigated and rainfed yields in 1996. Thus achieving higher yields will be a key factor in allowing elimination of free inputs without threatening production areas.

A still un-addressed factor in ending free inputs is the storage of wheat seed on-farm. Simple technologies are available, but a campaign of at least three years would be needed to ensure farmers would adopt them. If budget support for wheat were to end without giving sufficient time for farmers to become adept at storing seed, most of the current production area would be lost. Thus how and when the supply of free inputs is phased out are critical issues for the long term viability of wheat as a crop in Thailand.

Raising crop yields. The DOAE's strategy of dropping low-performing districts and farmers has led to an upward trend in average yields. If this continues for a few more seasons, average yields will rise above the break-even level, and the withdrawal of free inputs should be possible. Three or four years ago, experienced farmers were already obtaining yields well above the current average yields. During a field trip to Pua, in Feb. 1994, a CIMMYT Wheat staff member recorded that the average yield for a village with three years' production experience was 1.6 t/ha, and estimated that the better fields¹⁰ produced over 2.2 t/ha (Mann 1994). However, the persistence of typical management errors indicates that extension still has a job to do providing farmers with

⁹ The free inputs, 155 kg of seed and 125 kg of fertilizer, have a grain equivalent of 280 kg.

¹⁰ In these fields, farmers applied 125 kg of fertilizer in addition to that supplied by the DOAE. This additional fertilizer was purchased by farmers themselves.

technical advice. A reduction just of these errors would significantly improve yields.

Streamlining the marketing process. In a non-traditional wheat producing country, pricing and marketing are the ultimate factors in farmers' deciding to grow the crop. The wheat price (6-6.3 Bt/kg) has not changed since the 1989 season, when the mills first began to purchase the crop. On the basis of price, barley would seem a more attractive option than wheat.

Aside from the price, one of barley's main advantages has been the private sector's active involvement in establishing convenient farm-gate purchase of the crop. When the breweries purchase the crop directly, farmers do not face the uncertainty of delayed payments from merchants. This has facilitated the expansion of barley among farmers and has provided the barley lobby with the argument at policy level that "wheat has no market." In comparison, wheat farmers often face delays of weeks before receiving payment. Though suggestions can be made to solve this issue, the problem will continue in one form or another as long as the mills remain passive purchasers.

Final comment

With these issues still unresolved, the firm establishment of the crop is still uncertain. However, much has been achieved:

- ♦ production areas have been established where wheat is a significant cool-season crop, and there appears to be a demand for it to continue to increase in both rainfed and irrigated areas;

- ♦ appropriate technologies have been developed to reduce time and labor inputs, and simplify extension efforts; and
- ♦ despite continuing difficulties in disposing of the crop, market links with the mills have been established.

Thus the basis for establishment has been achieved, essentially by the government sector. And while input from the government sector is still needed, at some point the private sector must become a driving force rather than a passive cooperator. However, there needs to be some benefit to the private sector before it will assume this dynamic role.

During most of the crop promotion campaign, world wheat prices have been low, and the mills were purchasing domestic wheat at a small premium over imported wheat. Thus they did not have a strong incentive to actively support its expansion. However, the situation has changed in the last few years. World wheat prices have risen and appear stable. At the current mill-door price, domestic wheat should be cheaper than imported wheat.

At the beginning of the program, wheat imports were an insignificant element in the economy, and there was little political interest or commitment in the wheat program. But wheat imports have experienced a six-fold increase, reaching nearly 1 million tons. The changes in world prices and the greater role of wheat in the national economy do not seem to have been noted by the mills or policy makers. The time is ripe for the policy towards domestic wheat to be reviewed by both the private and the government sectors. Such a review could provide a more vigorous policy and bring the private sector into a more active role.

Chapter III.

Developing Appropriate Technologies in a Diverse Production Environment

Introduction

A major obstacle to the introduction of wheat in Thailand was the lack of robust and appropriate technologies that fit local conditions and would allow the crop to survive mismanagement by inexperienced farmers. The recommended technologies developed on experiment stations were too intensive and delicate to be extended without direct supervision. This difficulty was compounded by the fact that the target area for wheat production, the Northern Region of Thailand, is extremely diverse and presents both research and extension problems.

Appropriate technologies developed through cross-fertilization between scientist-led, on-farm trials and farmers' informal experimentation. Informally developed technologies quickly replaced recommended technologies in the field. In this chapter, the dynamics of farmers' evolution of technologies is examined, as are the limitations of farmer experimentation.

Farmers' informal trials were stimulated by an extension approach dubbed "participatory extension," which has the potential to transform extension from a technology transfer process into something far more interactive. In diverse production environments, it could replace a large portion of adaptive research, thus reducing the demand on scarce research resources and enabling appropriate technologies to reach farmers with less delay and at reduced cost.

Evolution of Research Strategies for Developing Appropriate Technologies

Historical influences on research agendas

Responsibility for wheat research in Thailand has resided in the DOA's Rice Institute because the main production area initially envisaged for wheat was irrigated paddy following the rice harvest. This arrangement made efficient use of the Rice Institute's facilities and manpower during the cool season, when the workload for rice research is relatively light.

Historically, most rice research has focused on germplasm development and the improvement of pest and disease resistance. Agronomic issues have received less attention. Early wheat research efforts followed this pattern, emphasizing variety selection and establishing appropriate planting dates and fertilizer rates. This basic work began in the 1960s at the DOA Horticulture Experiment Station in the Fang District of Chiang Mai.

In the early 1980s, the Rice Institute opened an upland station with a specific mandate for upland rice and temperate cereals at Pungda, in the Samoeng District of Chiang Mai. This station had several disadvantages for wheat research. Wheat trials had to wait until December to be seeded following harvest of the rice experiments. By this time, the rains had ceased and the plots had to be irrigated. Thus the trials represented neither rainfed production in upland fields nor irrigated production in the paddy. It was not until 1985 that the DOA experiment stations for irrigated rice began to conduct trials with irrigated wheat in their paddy fields.

These stations faced another set of problems. The heavy soils on the stations were exceptionally difficult to irrigate without causing water-logging. Scientists' main concern during this early period was to ensure a crop. As a result, a fairly intensive technology was developed for planting wheat in these difficult paddy soils. During the DOAE crop promotion campaign targeting paddy areas, this technology was recommended to farmers, who had difficulties adopting it. In hindsight, it seems doubtful that an extension program based on the original recommended technology would ever have been successfully extended to farmers.

Scientists' "freelance" innovations during on-farm trials

Alternative production technologies began to emerge from the work of a few scientists who were conducting on-farm research (OFR). Generally, protocols for OFR trials are prescribed in detail to fit into a large set of multi-location trials. A few scientists, confronted with the real issues in farmers' fields, carried out additional "freelance" trials alongside official trials. At the same time, researchers based in the universities, operating within the context of a freer research environment, also began to look at more innovative technologies for establishing the crop.

Two important elements that fostered innovative research were exposure to field conditions and scientists' greater freedom to make independent decisions. Away from the experiment stations, they were able to look at new ideas without the pressure to be immediately successful (Sanmaneechai 1985, Neeyomtum 1985, Jongdee and Limpiti 1987, Sampech *et al.* 1990).

Alternative technologies promised to be easier for farmers to adopt, seemed to require fewer inputs and to promote more reliable crop establishment. These alternative technologies were:

- ♦ *Minimum tillage/row seeding:* A hoe is used to open a furrow across the unprepared field. Seed and fertilizer are then dribbled into the furrow and covered with soil.

- ♦ *Dibble seeding:* Holes are punched into the unprepared paddy by a dibble stick. Seed and fertilizer are dropped into the hole and covered.
- ♦ *Broadcasting and ditching:* Seed and fertilizer are broadcast onto unprepared paddy. Soil from digging irrigation/drainage channels is thrown across the bed to cover seed and fertilizer.
- ♦ *Broadcasting and harrowing:* Seed and fertilizer are broadcast onto plowed fields and covered by harrowing.

Two other innovative technologies involving small farm tools should be mentioned:

- ♦ A rolling seeder developed at the Agriculture Research and Training Center in 1984: holes are punched around the circumference of a tin can. As the tin is rolled along the soil, it drops seed into the furrow at the correct seed rate (Plate 16).
- ♦ A ridging seeder developed at Hui Si Ton in 1984, which is suited for light, well drained soils. It can be pushed through the prepared soil, simultaneously covering broadcast seed and forming irrigation channels between the beds.

Despite the promising results from these technologies, which were reported at the annual technical workshops and demonstrated on study tours, none were included in DOAE recommendations to farmers. The reasons can only be surmised: 1) the farmers' poor stands were still considered to be due to inept/inexperienced extension and, therefore, effort was to be put into "getting the recommended technology right" before attempting to introduce "exotic" technologies; 2) identifying a technology that produced high yields was considered essential for wheat to become an attractive crop, rather than technologies requiring lower labor input, etc.

Thus these innovative technologies were not approved for extension purposes, and research continued to be directed toward finding technologies that achieved higher yields, rather than technologies to lower production costs or that would be readily adopted by novice wheat farmers.

The ATT project

The role of the ATT project was discussed earlier, but it should be mentioned again briefly in the context of technology development. All five rice experiment stations in the North were responsible for implementing demonstration plots in the vicinity of the stations. The ATT project thus placed a large number of scientists in farmers' fields, exposing them to the constraints and conditions there.

During the first two seasons of the ATT project, the demonstrated production technologies were selected before going to the field and limited to different fertilizer levels and varieties. It was not until the third year that scientists were given freedom to adjust the basic technology used "on the spot." Some of the alternative technologies stimulated new lines of research when they were brought back to the stations for closer examination and confirmation.

Mulching arose from OFR work. It entailed broadcasting seed and fertilizer onto a cleared, but unprepared paddy and then covering the seed with a light mulch of rice straw (Plate 17). Mulch reduces soil temperature and soil moisture evaporation, and at the same time reduces farmers' time and labor inputs.

Mulching first showed promise in on-station trials at the Phrae Rice Research Center (1987/88), but experimentation was discontinued despite good performance. At the 1990 Wheat and Barley Technical Seminar, the virtues of mulching were espoused by a visiting CIMMYT agronomist (Wall 1990), which renewed interest in the technique. Mulching then reappeared in the OFR trials and, since then, individual extension workers and farmers have adopted it.

Current status of OFR for wheat

While OFR may be conceptually attractive, it is difficult to implement. Factors such as rats, grazing stock, or farmer mismanagement often seriously affected the results and quality of data from wheat OFR trials. Despite these difficulties, scientists developed an extremely positive attitude and commitment towards this

research approach. This was confirmed by the fact that when ATT funds supporting OFR ceased, the DOA allocated special funds to continue the work with the possibility that it could become a regular budget line item. Recent reports from the Phrae Rice Research Center indicate that approximately one third of the regular budget for wheat research is still for OFR.

The ATT period of OFR helped scientists to recognize that farmers do not have to change their cultivation strategies to comply with an ideal production technology. Instead, technologies should fit farmers' basic constraints. Problems such as cost, time, and labor requirements were given more serious consideration.

A further research limitation became apparent following a study tour of all OFR trials in the 1991-92 season, i.e., that particular technologies, while giving the best results at one site, had not performed well at other sites. The diversity of production environments of the Upper North was recognized, as well as the limitations this posed for developing one general technology for all situations.

The wheat research agenda has since shifted from maximizing yields to generating appropriate technologies and may now even be moving towards looking at the broader issues that affect wheat production, e.g., soil pH, heat, and sustainability.

Farmers' Technology Development

Evolution of participatory extension

The initial recommended technology which the DOAE extended to farmers was developed on the lowland DOA wetland rice experiment stations. This involved full soil preparation, raised seedbeds, and seeding in rows. New wheat farmers who tried to follow these recommendations encountered many difficulties and repeated crop failures, as already described.

The first assessment of this poor extension effort focused on the formulation of recommendations, which were presented in technical terms. Attempts were made at a

few sites to describe the technology better but failed to make farmers apply the technology and establish wheat more reliably. It gradually became clear that the recommended technology itself was part of the problem; digging furrows was tedious, row seeding resulted in over-seeding, etc. As a result, farmers either short-cut the recommendations or misinterpreted them. The only way to ensure good establishment was through direct supervision. As many of the extension workers' were also inexperienced in the crop or had no time to devote to it, this was an unrealistic expectation.

During field trips in the 1984/85 to 1986/87 crop seasons, several technologies were suggested by CIMMYT agronomists as being more appropriate: broadcast seeding, zero tillage, and dibble seeding. Freelance OFR trials began to include some of these technologies, providing practical demonstrations in the field. One group of farmers in Phang Ma Pha District planted their rainfed wheat by dibble seeding and produced better plants than those in an adjacent plot sown according to the recommended technology. This indicated that not only were there viable alternative technologies, but that the farmers themselves could contribute to their development.

In an effort to see if farmer involvement in identifying technologies appropriate to their conditions could be gained more generally, an experiment was conducted the following season in a village where an NGO (Ockenden Venture) had successfully grown a small plot of wheat (0.1 ha) with one farmer using the recommended technology. As a result of this success, a significant number of farmers were interested in attempting the crop. Farmers were shown slides of alternative technologies used at various OFR sites, including the recommended technology, minimum tillage with row seeding, and full tillage with broadcasting, and encouraged to select the one they preferred.

Of the 26 farmers who grew wheat that season (1987/88), 11 selected non-recommended technologies, even though the recommended technology had performed well in demonstrations the previous season. Six farmers used

more than one technology. Altogether there were 11 different component technologies used. At least two (dibble seeding and mulching) could be considered as original farmer innovations.

This extension approach was again applied the following season (1988/89) but within the general extension program. Alternative technologies were presented to farmers along with the recommended technology. A survey of farmers' practices at six sites showed that at almost every site, nearly half of the farmers tried an alternative technology or an altered component of the recommended technology, regardless of the extension agency, ethnic origin, or production domain.

Key elements of participatory extension

At all the sites where a range of technologies was employed by farmers, the extension approach had two key elements:

- ◆ It presented farmers with alternatives and required them to exercise critical thinking beyond merely following a set of directions. In some cases, this led them to further modify or adapt the given technologies to meet local conditions.
- ◆ It limited the initial plot size. This not only limited risks, but also expectations of a high cash return at such a preliminary stage.

Using this approach, extension workers were able to involve farmers in their own trials. The participatory nature of the approach lies with the farmers rather than the practitioners, since it clearly gives farmers the opportunity to select, encourages analysis and stimulates innovation. As it does not include other aspects of more idealistic participatory interaction with farmers, it has been dubbed a "minimalist" approach to participation (Connell 1992).

This approach is not a new idea. It has been phrased in various ways before, e.g., as offering farmers a "menu" or a "supermarket of technologies" (Conway 1986), or "a basket of choices" (Chambers 1988, Chambers and Jiggins 1986). Presenting farmers with choices has been

a feature of many participatory research schemes (Ashby 1986, Maurya *et al.* 1988). This approach is more like those used by some NGOs, such as World Neighbors (Gubbels 1988). However, none of these experiences have occurred within the context of an on-going national program.

Impact of participatory extension

In 1988-89, a DOAE field survey of technologies used by farmers over the whole extension area showed a very large shift away from the recommended technology (Table 3.1). Just over 60% of farmers were using a technology other than the recommended one. The two most favored technologies were full tillage with broadcast seeding (upland rainfed areas) and minimum tillage with row seeding (irrigated paddy areas). While participatory extension played a key role in this dramatic shift away from the recommended technology, it was the problems with the recommended technology that encouraged farmers to seek alternatives. Any technology that saved farmers time and labor for what was a low value crop was bound to have immediate appeal.

This shift away from the recommended technology was not universal, and was directly related to the extension approach used at a particular site. Omkoi (Chiang Mai Province) and Pua (Nan Province) Districts had by the 1990 season effectively established themselves as production centers. In both these districts the transfer of technology approach to extension had been used. Farmers' fields were 10 minutes away from the extension office, which allowed extension workers to provide direct supervision to farmers during critical activities, thus ensuring the recommended technology was applied correctly. This high degree of time input is rarely

possible for extension workers. While the crop was effectively established at these two sites, there was notably little innovation or adaptation of technologies by the farmers (Table 3.2).

In comparison, at Pai and Fang, which also developed as production centers, extension workers had been active, but not to the extent of direct supervision during planting. Instead of directing the use of the recommended technology, they had provided farmers alternative technologies to choose from (see Sect. 3 below). As a result, farmers were active in evaluating and adapting the technologies (Table 3.2).

It could appear that as the recommended technology was effective in Omkoi and Pua, farmers' technology adaptation is not important. Certainly in the short term, this is the case. However, once farmers accept the crop and want to expand production, they find the recommended technology limiting in terms of its high time/labor requirement. As a result, they begin to innovate and adapt the technologies themselves. The participatory approach to extension merely speeds up this process.

Dynamics of Farmers' Technology Development

The following case studies illustrate the characteristics of unstructured trials by farmers and the dynamics of change resulting from successful trials by one or two farmers within a village. They clearly show that the benefit of the participatory extension approach is not simply that it gives farmers the opportunity to select a technology for local conditions. Farmers' trials show that

Table 3.1. Range of production technologies in farmers' fields, Northern Thailand, 1988-89.

Seeding method	Number of farmers	% of farmers surveyed
Recommended technology	167	39
Minimum tillage + row seeding	70	17
Tillage + broadcast seeding	179	42
Others	8	2
Total	424	100

Table 3.2. Effect of extension approaches on farmers' adaptation of production technologies, 1990-91.

	Site (district)	Wheat area (ha)	Production system	Farmers' adaptation of technologies
	Omkoi	64	Irrigated	Little
	Pua	96	Irrigated	Little
				(until 91-92 season)
Informal	Fang	69	Rainfed	Significant
PE Used	Pai	24	Rainfed	Significant

they continued to respond to their production conditions over time. This is an important attitude to engender in farmers, as production conditions are not constant but change over time.

Irrigated production in paddy areas: Pai District

In the 1985/86 cool season, irrigated wheat production was introduced to Pai District beginning in the Wieng Neua subdistrict. For the first two seasons (1985/86 and 1986/87), farmers used the recommended technology. Success in Wieng Neua led to a decision to expand wheat extension to two additional subdistricts in the 1987/88 season.

This involved three extension workers, one from each subdistrict, who became party to an informal trial of participatory extension. The district was supplied with a slide set of the alternative technologies and the extension workers instructed in their use. During the season, 60% of the farmers in each of the subdistricts used or tried at least one alternative technology and continued to experiment with various technologies in subsequent seasons (Table 3.3).

During the 1988/89 season, farmers' preference for different technologies in irrigated wheat production in paddy areas (depending on the particular constraints in each subdistrict) was becoming apparent. In Mena Dtern, only one technology was preferred, minimum tillage/row seeding for small plots. The farmers—mostly women—

found this technology convenient because they didn't have to ask men to assist in plowing. In Wieng Neua, minimum tillage/row seeding predominated, with a trend to full tillage/broadcast seeding. Plot size was increasing and broadcasting saved considerable time. The farmers were male, so plowing was no problem. In Tung Yao, three technologies were used, with dibble seeding giving the best stands in high elevation paddy with sandy soils. Farmers there are hill tribesmen accustomed to dibble seeding of upland rice and maize. It is thus evident that a range of factors, from the physical and socioeconomic environments to cultural and gender-related circumstances, affected the farmers' choice of technology, which indicates that a range of technologies needs to be available.

In two subdistricts, wheat production did not continue. In Mena Dtern, wheat was replaced by garlic when garlic prices rose in 1989/90; in Tung Yao, wheat production shifted to upland areas, where it has increased dramatically. However, in Wieng Neua, the third subdistrict, there was a steady expansion of wheat, as well as a steady evolution of production technology. Over successive seasons, a definite evolution of the technologies in response to changing conditions became apparent (Table 3.4).

Technology Shifts for Wheat in Paddy

Full tillage + row seeding (recommended technology)

Shift 1 minimum tillage + row seeding

Shift 2 full tillage + broadcast seeding

Shift 3 zero tillage + broadcast seeding and mulching

Table 3.3 Evolution of production technologies by farmers over five seasons, Wieng Neua Village, Pai, Mae Hongson.

	Growing season	Total no. wheat farmers	Farmers using different technologies (#)			
			Recmd. tech.	Min. till. /row sdg	Full till. /b.cast	Other tech.
PE Methods Used	1986-87	6	6	-	-	-
	→ 1987-89	6	3	3	-	-
	→ 1989-90	7	-	7	(1)	-
	→ 1990-91	7	-	3	4	(1)
	→ 1991-92	18	-	1	14	2 (1)

Note: Shading indicates the preferred technology of the season.

Min. Till/row: Minimum tillage with row seeding.

Till/B.cast: full tillage and broadcast seeding.

() indicates farmers who experimented with another technology in addition to their main production plot.

Shift 1, from the recommended technology, was made while plot size was still small (0.18 ha/farmer). In using minimum tillage, farmer were attempting to reduce inputs, but the real benefit was that it eliminated irrigation/drainage channels and increased the productive field area by 20-30%. This led farmers to change their irrigation method to flash flooding (Ch.II, p. 29) which improved stand establishment.

Table 3.4. Range of component technologies observed in farmers' fields.

(a) Rainfed Production		(b) Irrigated Production	
Operation	- Component technology; sub-component	Operation	- Component technology; sub-component
Soil preparation	<ul style="list-style-type: none"> - by hoe - by tractor <ul style="list-style-type: none"> single axle or large tractor variation in number of passes and depth variation in implement (disc, etc.) - no soil preparation - spacing of tractor passes for weed control 	Soil preparation	<ul style="list-style-type: none"> - construction of raised seed-beds or flat field - hoe (shallow and deep hoeing to cover all weeds) - tractor (single axle and large) - no soil preparation - burning of rice stubble or weeding
Seeding method	<ul style="list-style-type: none"> - in rows <ul style="list-style-type: none"> dug by hoe or harrow - broadcast seeding - variation of seed rates - seed cover <ul style="list-style-type: none"> by harrow by disc plow by moldboard plow by hoe by driving a single axle tractor backwards! by dragging log across the furrows - dibble seeding using various implements <ul style="list-style-type: none"> shovel tipped stick hoe pointed stick small chipping hoe - seeding date <ul style="list-style-type: none"> according to calendar seed in afternoon/cover next morning ("dew aids germination") 	Seeding	<ul style="list-style-type: none"> - row seeding <ul style="list-style-type: none"> opening furrows by hoe by harrow by disc plow - seeding by hand <ul style="list-style-type: none"> using rolling seeder using tin can with holes or bottle to distribute seed - seed cover <ul style="list-style-type: none"> by soil with manure + rice husk mix - seed spacing <ul style="list-style-type: none"> varied from 20 to 35 cm - seed rates <ul style="list-style-type: none"> varied from 16 to 30 kg/rai (100-188 kg/ha) - seed direction <ul style="list-style-type: none"> east-west vs. north-south seeding across vs. along beds - broadcast seeding <ul style="list-style-type: none"> seed covered by harrow, by rice straw by thick mat of rice straw - dibble seeding <ul style="list-style-type: none"> various implements which affected seed depth and seed cover
Weed control	<ul style="list-style-type: none"> - hand - none - chemical (Lasso, Machete) 	Irrigation	<ul style="list-style-type: none"> - use of pre-seeding irrigation - various application methods which affected cover and saturation <ul style="list-style-type: none"> by seepage from furrows by splash from furrows by flash flooding
Intercropping	<ul style="list-style-type: none"> - young orchards (mango, coffee, lychee) - traditional vegetables seeded into wheat plot 	Weed control	<ul style="list-style-type: none"> by hand by straw cover by chemical control by hilling up as for peanuts
		Disease control	<ul style="list-style-type: none"> - chemical control of root rot
		Intercropping	<ul style="list-style-type: none"> - traditional vegetables seeded within wheat stand

Source: Author's observations, 1986-92.

Most farmers who used this technology in 1987/88 and 1988/89 seasons obtained yields above 1.88 t/ha, considered high at the time.

As the crop expanded, the minimum tillage approach, which requires digging furrows by hoe across the unprepared paddy, became too laborious and time consuming. *Shift 2* to broadcast seeding, though it included the cost of plowing, provided significant savings in time and labor. One farmer said that his 4-rai

(0.64 ha) plot took more than 10 days to seed when using minimum tillage, but only 1 day for him and his wife when they hired a tractor for tillage then broadcast seeded (Plate 18).

Recent technology adaptations aimed at further reducing costs by eliminating land preparation have resulted in unique zero-till/broadcast techniques. During the 1989/90 season, one farmer burned the rice stubble creating a thick bed of residue and ash. He flooded the field and

broadcast the wheat seed. Once the seed absorbed water and sank, the field was drained and the ash floating on top of the water dropped to cover the seed. With this extremely low labor technique, he obtained 1.39 t/ha. Another farmer did not burn the rice stubble but used it as a light mulching as described earlier (Plate 17). During the 1991/92 season, additional farmers were observed using both methods as well as full tillage/broadcasting. It remains to be seen whether this heralds Shift 3.

Rainfed production in upland areas: Fang District

In Fang District, wheat was first introduced to a cluster of three villages through the ATT project in 1986/87. The villages lie among low rounded hills, and agriculture is predominantly rainfed. By the third and final year of the project, the farmers were effectively implementing the recommended technology and obtaining good yields on small plots (1.14 t/ha on plots 0.24 ha). The number of farmers interested in the crop increased.

At this point, the farmers were introduced to two alternative methods of broadcast seeding through a field trip to Mae Sai, where all wheat was broadcast seeded, and through a small on-farm trial (Insumphan *et al.* 1991). Following their success with the crop, farmers increased their wheat area to 1-2 ha in some cases. This increase in area, plus the exposure to broadcast seeding, resulted in 32% of the farmers broadcast seeding in the following season (1989/90). Use of this method has increased steadily in subsequent years.

Though at first glance there appears to have been only one shift in technology for rainfed production (i.e., from row seeding to broadcast seeding), the components of this technology have been progressively refined. During the first season of broadcast seeding (1989/90), farmers used a large variety of component technologies. To prepare the land they used moldboard plows, disc plows, disc plow plus pick-toothed harrow (normally used behind power tillers to puddle the paddy), and other methods, to cover the seed. The other methods included

the use of a pick-toothed harrow, disc plow and harrow, and planking by drawing a log across the field. These minor variations in component technologies have significant effects on the depth and distribution of seed in the soil, which are critical for good stand establishment and the crop's ability to withstand an early drought.

After seeding, most farmers harrowed using a pick-toothed harrow, but they took little care to obtain complete seed cover. The initial performance of broadcast seeding for most farmers was poor due to poor seed cover and poor seeding dates (Ch.II, p. 30). The importance of obtaining good seed cover by any method was explained to farmers during a pre-season meeting. Following this, farmers adjusted their harrowing techniques and achieved better seed cover. (Optimum seeding date has been a little more difficult to achieve.)

Farmers' initial shift to broadcast seeding was aimed at reducing time and labor. This allowed them to expand their production areas, and their subsequent modifications of land preparation and harrowing have aimed at improving stand establishment and final yields.

Range of production technologies in farmers' trials

Over recent seasons, farmers have used a wide range of technologies in their fields. Most farmers have chosen these technologies, which were introduced to them as alternatives to the recommended technology. Thus farmers generally have "selected" or "evaluated" a technology for their conditions, and only in a few cases has there been genuine innovation.

Farmers have been most active in initiating a great deal of variation and developing specific practices. Table 3.5 provides an extensive list of the component technologies observed in farmers' fields over a five-year period. In many cases, what appears to be a simple or minor change can have significant effects on stand establishment and yield. In other cases, alternative component technologies may not affect plant development, but may reduce time and labor.

allowed a rationale for participatory extension to be developed. The second phase of the project tested procedures for OFR in diverse production environments and implemented a participatory extension approach (Wunnapee *et al.* 1992).

The project developed a curriculum for training extension workers in implementing the approach. It was tested in nine subdistricts where wheat was being extended. As a result of the training, seven of the nine extension workers adopted the approach. In these subdistricts, over half of the farmers made some modification of the technologies they were provided. Statistical analyses showed that the incidence of farmers' adaptation of production technologies did correlate with the extension workers' use of participatory extension (Sukanuntapong *et al.* 1994).

While the project has not affected the way extension is practiced in Thailand, it has generated a general acceptance of two important premises:

1. Diversity of the production environments in many areas is too fine-grained to be dealt with by existing research and extension strategies. This has prompted re-examination by both research and extension of the traditional boundaries of their roles.

2. The project has been able to describe farmers' capacity to make real contributions to technology development, in particular for wheat, but also for other crops.

A direct outcome of the project has been the commitment of the DOAE to allocate internal funds to the continued evaluation of participatory extension. The scope of the evaluation is to expand from just wheat to include established crops, in particular rice.

On a more conceptual level, the results of this study may contribute to resolving the current impasse in FSR/E. Thailand may well become the first country in Southeast Asia to establish viable wheat production. If it becomes clear that farmers and extension workers have contributed significantly to the development of appropriate wheat production technologies, this would be a good indication that participatory approaches could be implemented effectively in national extension institutions in other countries.

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Plate 1. Construction of a clay oven. Clay is packed onto a bamboo frame, then sun-dried and finally fire-hardened. Nam Yao Refugee Camp, Pua District, Nan (1982).



Plate 3. Commercial stone grinder. Large stone grinders are commonly used for wet-grinding rice for noodle manufacture. Used 'dry', they produce good quality whole-wheat flour. Chiang Mai University (1984).



Plate 2. Bread baking in a hilltribe village. Wheat was introduced as an opium crop replacement. Here, the daughter of household kneads dough. Note the kerosene-tin oven, insulated with cardboard in the foreground. Pha Kha village, Wang Neua District, Lampang (UN-HAMP Project, 1983).



Plate 4. Boiled wheat, confection. Children sample a preparation using boiled wheat grain. This is sprinkled with sugar and shredded flesh of young coconut. This has been accepted as a novelty for festivals, and has been sold by vendors at fairs and school stalls. Fang District, Chiang Mai (1984).



Plate 5. Thai style tabooli salad. Tabooli is a common Middle Eastern food (using bulghur wheat) which is turned into a typical spicy Thai salad ('Yum'), by adding chili peppers, dried shrimp and fish sauce.



Plate 6. Food demonstration. Farm women's groups, organized by the DOAE, were entry points for promoting local use of wheat. Active participation was an important element of village food demonstrations to encourage a sense of familiarity with wheat. Muang District, Phrae (1984).

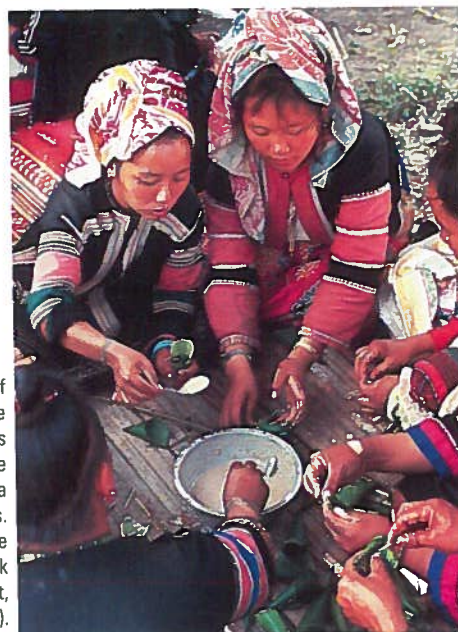


Plate 7. Hilltribe cakes. Many of the hilltribes use rice flour to make a steamed festive cake. The girls of the Lahu ethnic group here are pouring whole-wheat batter into a cone formed from banana leaves. This is then boiled or steamed. The cake has a rubbery texture. Luk Khao Lum, Pang Ma Pah District, Mae Hongson (TG-HDP 1986).



Plate 8. Wheat in the local marketplace. Many of the fast foods found in the marketplace are made from wheat. Noodles, cakes, baked buns, and deep-fried puff-balls are for sale at this stall. These are all factory made and imported to the village, but can easily be made locally. Sop Bong village, Pang Ma Pah District, Mae Hongson (1986).



Plate 9. Rainfed wheat production. A farmer planting wheat for the second year surveys a well established field wheat (variety Fang 60). Bong Terp village, Fang District, Chiang Mai (1988).



Plate 10. Irrigated wheat production. Wheat grown in association with other crops in paddy following the main rice harvest. Mena Dterng village, Pai District, Mae Hongson (1990-91).



Plate 11. Uneven stand, typical of new farmer's first attempts to grow wheat. The farmers' lack of understanding of the crop's low water requirements and their inconsistent management led to the uneven stand depicted here. Good patches resulted by chance (e.g., on high spots which escaped water-logging). The variation in fields such as this provided teaching opportunities. Omkoi District, Chiang Mai.



Plate 12. Effects of over-irrigation. Raised seedbeds encouraged farmers to irrigate by seepage from channels into the beds. Yellowing was typically interpreted by farmers as a lack of water or disease. Chaiwattana village, Pua District, Nan (1991).

Plate 13. Over-irrigation resulting from the recommended fertilizer application method. The recommendation to top-dress urea at approximately two weeks led farmers to irrigate when seedlings were still susceptible to saturated soil. Don Chai village, Pua District, Nan (1990).



Plate 14. Rolling seeder. The improved version of the seeder developed by scientists at ARTC Lampang being used by farmers. Mena Dterng village, Pai District, Mae Hongson (1988-89).

Plate 15. Wheat as an opium replacement crop. In highland areas, wheat fits into the same agronomic niche as opium. As a result, a number of projects have included it in their programs. A woman from the Yao ethnic group harvests opium from a small, non-economic plot for family use. Wheat can be seen in the background (1986).



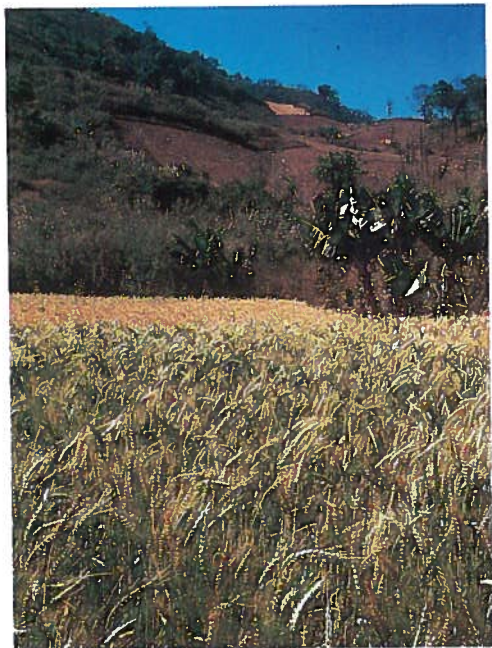


Plate 16. Highland wheat production. Due to more favorable temperature and moisture conditions at high elevations, wheat plant development is excellent. However, plots are small and scattered and shift from one year to the next, making extension difficult. Pha Daeng village, Mae Chai District, Phayao (TN-HDP, 1988).



Plate 17. Use of mulch for wheat production in irrigated paddy areas. The seed and fertilizer are broadcast onto the cleared field without soil preparation. A thin layer of straw from a long strawed local rice variety is then broadcast back onto the field to cover the seed and provide a light mulch. This reduces soil temperatures and moisture losses. (The dark area is incidental, resulting from burning of trash. Broadcast seed can be seen in this blackened area). Wieng Neua village, Pai District, Mae Hongson (1991).



Plate 18. Technology shift from row to broadcast seeding in paddy area. Farmers changed from the recommended technology to 'min. till + row seeding' to reduce soil preparation. With its success, they expanded the wheat area, but then labor and time inputs became a constraint. Here a farmer was comparing 'min. till + row seeding' with 'tillage + broadcast seeding'. In following years, most farmers shifted to this. Wieng Neua village, Pai District, Mae Hongson (1988-89).



Plate 19. Farmers' informal fertilizer trial. A group of highland rice farmers (Karen ethnic group), with no previous fertilizer experience, examined its effect by not applying any to half of one plot (the lighter area on the left of the second plot from the bottom). Mae Jom village, Samoeng District, Chiang Mai (1988-89).



Plate 20. Diverse production environments: upland production area. Cultivation histories of individual plots can affect soil texture, fertility, and weed populations. All these can influence the technology chosen by the farmer. Fang District, Chiang Mai (1990).

