Integration of farmer participatory plant breeding for rainfed lowland rice improvement in North and Northeast Thailand

I Bio-physical and socio-economic characterization of rainfed lowland rice production systems of the North and the Northeast of Thailand



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Introduction

The rainfed lowland rice covers 75 percent of the total rice planted area in Thailand, which is equivalent to 43.5 million rai. Within the region, the rainfed lowland in the Northeast constitutes 91 percent or 29.2 million rai, and the North occupies 72 percent or 9.2 million rai. These two regions are the main production areas of high quality rice for domestic and export markets, notably the high quality rice varieties such as KDML 105, RD 15, and RD 6. The planted areas of these three varieties cover 81 percent in the Northeast, and 76 percent in the North (OAE, 1999). Therefore food security and income stability of the farmers in these two regions are strongly depended on production and price stability of these three rice varieties. The three varieties are genetically related, both RD 6 (glutinous rice) and RD 15 (non-glutinous rice) are mutated materials derived from KDML 105, and being released as recommended varieties since 1977. The varieties are well adapted to the low yielding rainfed environment, but are vulnerable to blast disease and gall midge (Sarkarung and Pantuwan, 1999).

Rice yield in the rainfed lowland environment are highly variable, and drought has been identified as the main yield- limiting factor. The dry spell of about four weeks period, which occur at the vegetative as well as the reproductive growth stages, could have detrimental effect on rice growth and grain yield (Farmer workshop, 2001; Sarkarung and Pantuwan, 1999). The yield reduction due to drought could account for 35 percent (Wiboonpongse *et al*. 2001), and as low as 50 percent (Farmer workshop, 2001).

The rainfed lowland rice ecosystems are diverse (Farmer workshop, 2001). Farmers in the Upper North have identified three ecosystems, namely the drought prone upper-lower paddy interface, the favourable lower paddy, and the flood-prone lower paddy. While farmers in the Northeast classify the rainfed lowlands into the undulating upland, within which three sub-systems namely, the upper paddy, the middle paddy and the lower paddy are distinguished, and the lower plains, which are subjected to flood and non-flood conditions. The areas under high risks, either due to drought or flood, and under favorable growing environment varies from province to province, thus giving the rainfed lowlands with different production potentials. Farmers' coping strategies to overcome production constraints and to stabilize rice productivity are not well understood. The preliminary farmer workshops in 2001 have revealed different production practices that enable farmers to make better use of the varying landforms and to reduce risks, such as choice of varieties, cultural practices, and farming systems to fit different ecological niches.

Understanding farmers' management strategies, and responses to ecological and socio-economic changes within the rainfed lowland context, would help researchers formulate better intervention, particularly the design of rainfed lowland rice ideotypes and the handling of breeding population in which farmers will become partnership.

The participation of farmers in the formal, researcher-oriented plant breeding programs, is entirely new in Thailand. The modern high yielding rice varieties, being developed and selected under more favorable station conditions, are not always suitable under rainfed environment, and even if adapted well, grain quality is not accepted by farmers, resulting in poor adoption. The participatory plant breeding (PPB), which is commonly known as the demand-driven breeding program for the heterogeneous small farmers, has been implemented successfully elsewhere, and with many crops in addition to rice. The Participatory Research and Gender Analysis (PRGA), a CGIAR system-wide project being implemented since 1995, has provided the evidence that farmers priorities are better understood, and in many cases participatory approach results in change in breeding goals, or conformation that goals are consistent with farmers needs. The PPB has increased adoption and economic benefits from adoption (Lilja and Ashby, 2002). The principles, methodology and analysis of the PPB, which has been developed and made available by various institutes and IARCs, would help provide valuable and practical guidelines for implementation.

The project "Integration of farmer participatory plant breeding for rainfed lowland rice improvement" is an interagency- collaborated research activity funded by the Rockefeller Foundation to improve the rainfed lowland rice production systems of the North and the Northeast of Thailand. The collaborating institutions include Department of Agriculture, Khon Kaen University, and Chiang Mai University. The productivity of the rainfed lowland rice is governed by tolerance of rice varieties to abiotic stress and integrated management approaches that improve the efficient use of plant nutrient and water availability, and pest management. The project will emphasize on the varietal improvement approach within the existing farming system context.

This report will describe the bio-physical and socio-economic characteristics of the rainfed lowland rice ecosystems of the Northern and the Northeastern regions of Thailand through the participatory rural appraisal (PRA), semi-structure, and formal survey conducted during 2001-2002 period.

The report will first describe the findings of the North, and then of the Northeast. Then it will be followed by general discussion and conclusion.

The rainfed lowland rice production system of the Upper North

The rainfed lowland rice production system of the Upper North

The Upper North consisting of eight provinces namely Chiang Mai, Lamphun, Mae Hong Son, Chiang Rai, Phayao, Lampang, Phrae, and Nan, is regarded as the mountainous region. In terms of rice production and consumption, it is a rice sufficiency region, despite the fact it has about 10 percent of lowland ecosystem. On the contrary, the Lower North, which possesses more flood plains, is a rice-exporting region, fully benefiting from the Green Revolution technology through farmer adoption of modern high yielding rice varieties, and provision of favorable irrigation facilities.

Among the eight provinces of the Upper North, Chiang Rai and Phayao, which have a combined rice land over 1.5 million rai, have rice surplus and produce premium Hom Mali rice (KDML 105 and RD 15) in the rainy season for export.

The rural livelihoods in the rainfed lowland in the Upper North depend on the productivity and stability of rainfed lowland rice. Ecological as well as economic disturbances of rainfed lowland rice would lead to disruption of rural economy with consequence of mass out-migration.

The rainfed lowland rice ecosystem is heterogeneous with different problems and potentials. One approach of dealing with local heterogeneity is to encourage participation of local community in the research process.

Methodology

The common methodology adopted by the North and the Northeast research groups was RRA, PRA, and formal survey by questionnaire. The process involved group discussions of key informants, farmer community consisting of both male and female members, and individual household interview. The farmer meeting always provided two-way dialogue, enabling farmers to express and exchange their experience, knowledge, and problem solving approaches. The data collection was not meant to just extract information from farmers, but to encourage the exchange of information among the farmer members and researchers, so that toward the end of data gathering process, farmers felt that they had learnt something in return.

Field visits were made to observe rice growth with farmers at certain stages such as booting, flowering, maturity and harvesting. Plant samples of 1 sq.m plots were taken by farmers to determine grain yields of individual farms.

Site selection

Studies in the Upper North were confined to three provinces, namely Chiang Rai, Phayao, and Lumpang, with a total of 290 households were sampled for interview (Table 1). The key farmer representatives from eleven district towns attending the first farmer workshop in May 2001 at the Phrae Rice Research Center were included. Chiang Rai and Phayao represented the commercial production areas of premium rice for export, while Lampang was rice sufficiency area.

Table 1. Study area and number of sampling sites.

Province	District	Sub-district	No. of samplings
1. Lam Pang	Hang Chat	Wor Kaew	25
(92 samplings)	Ngao	Ban Heng	33
	Sop Prab	Sa-mai	18
	Ko Kha	Ta Pha	17
2. Chiang Rai	Chiang Khong	Huay Sor	12
(83 samplings)		Krung	18
	Phaya Mengrai	Mae Pao	18
	Thoeng	Mae Loi	16
		Nong Rad	18
3. Pa Yao	Muang	Ban Tum	18
(115 samplings)	Chun	Chun	18
		Huay Yang Kham	17
	Dok Kham Tai	Dok Kham Tai	18

		San Khong	17
	Chiang Kham	Yhuan	9
		Ang Thor	18
Total 3 Provinces	11	16	290

Results

The information obtained by RRA, PRA and structured interview at group discussion level and household level are given below:

1. The rainfed lowland ecosystems

Farmers had defined the lowland rice ecosystems slightly different from the May workshop. The terracing upland was developed from the upland-lowland interface. Its contribution to lowland rice production was insignificant. The upper paddy consisted of the flat upper paddy, and the undulating upper paddy, of which the flat upper paddy constituted about 37.4 percent, twice the size of the undulating upper paddy. The lowland also consisted of the non-flooded plains, about 45 percent of rainfed lowlands, and the flood plains, less than 1 percent, lying along the Ing river system in Chaing Rai and Phayao provinces (Table 2).

The farmer classification of the rainfed lowlands, which was based on the natural resources of water and land, indicated that adaptation of rice varieties to the toposequence would increase lowland rice production potential. The 45 percent of the non-flooded lowland plains would consider being less risk, and more favorable to improving rice productivity, if soil fertility, water delivery and drainage were in place. The undulating upper paddy and the upper paddy together constituted almost 55 percent, required an integrating land use approach to reduce drought damage through developing early maturing rice varieties, and better soil management practices. Incorporation of livestock was observed as another farming enterprise to increase land productivity and farm income.

Table 2. The rainfed lowland rice ecosystems in three provinces of the Upper North

Rice ecosystems	Lam Pang	Chiang Rai	Pa Yao	Total
	%	%	%	%
1. Terracing upland	0.5			0.1
2. Upper paddy	42.0	32.3	38.5	37.4
3. Undulating upper paddy	19.1	18.3	15.1	17.2
4. Lower paddy	38.3	48.1	46.5	44.9
5. Flooded lowland	-	1.3	-	0.4
Total	100	100	100	100.0

Note: Farmers classified the ecosystems of their land by themselves.

2. Soil characteristics

Majority of the lowland soils were clay soils (48.7 percent). The sandy loam soils constituted about 31 percent (Table 3). While the rest distributed among various types, such as sandy-clay (9.3 percent), sandy soil (6 percent), and loamy-clay soil (3.6 percent). It could be seen that almost 40 percent of the rainfed lowland soils were weathered soils having sandy texture, which was more widely occurred in Lampang. When climatic conditions were considered, Lampang would be relatively higher risk-prone area than Chiang Rai and Phayao, because it had less rainfall and shorter growing season. Soil improving cultural practices should be included as an integrated crop management practices.

Table 3. Water resources supported in rice cultivation in three provinces of the Upper North

Water resources	Lam Pang	Chiang Rai	Pa Yao	Total
	%	%	%	%
1. Annual rainfall	29.3	45.5	30.1	34.9
2. Rainfall with water supplement from natural river systems	14.9	20.4	20.4	19.0
3. Rainfall with water from water resources development projects; reservoirs, small irrigation schemes, etc.	46.3	25.1	41.1	37.3
4. Rainfall with water from farm ponds	9.6	8.9	8.4	8.9
Total	100	100	100	100

3. Water resources

The cultivation of rainfed lowland rice was mainly depended on annual rainfall (34.9 percent), and rainfall with water supplement from natural river systems (19 percent). The water resource development projects, overseen by various governmental agencies, were introduced in the rainfed lowland in the form of reservoirs, small irrigation schemes, farm ponds, etc. The projects had relieved water shortage, and enabled farmers to plan and prepare rice nurseries in the early rainy season with certainty. In certain districts, such as Ngao of Lampang province, water supply was sufficient to support the cultivation of garlic as a second crop after rice. The lowland rice areas under natural rainfall and water developmental schemes occupied about 37 percent (Table 4). Farmers also dug farm ponds on their own lands to provide stable water supply through water pumps. At the sub-district level, the local authority could request for the government assistance to provide heavy equipment services for digging of farm ponds, whereby farmers would share certain expenses, such as fuels, food and overtime for the personnel.

Water-wise or water-saving production system for the rainfed lowland rice that being developed at the IRRI and the collaborating institutions, were still unknown in the rainfed lowland environment.

Table 4. Soil characteristics of the paddy field in three provinces of the Upper North

Soil Characteristics	Lam Pang	Chiang Rai	Pa Yao	Total
	%	%	%	%
1. Clay soils	37.2	57.8	49.0	48.7
2. Sandy-clay soils	21.8	7.8	2.7	9.3
3. Sandy loam soils	28.2	24.1	38.9	31.3
4. Loamy-clay soils	0.0	4.7	5.0	3.6
5. Sandy soils	11.7	5.2	3.0	6.0
6. Others	1.1	0.4	1.3	1.0
Total	100	100	100	100

4. Socio-economic circumstances

4.1 Family labor.

Those who were the full time farmers engaging in rainfed farming systems had an average age of 46 years old (Table 5), which was considered being the mid-level, experienced farm hands, and able to make sound judgment. The average family members were 4.3, with having two full time family members of 63 percent of the total households.

Off-farm employment was important to sustain the rural livelihoods. About 24 percent of the households having family members either worked part-time on-farm and full time off-farm to support the families. The phenomenon was more pronounced in Lampang, perhaps the provincial city offered more opportunity for off-farm employment.

Table 5. Background information of farmer and household in three provinces of the Upper North

	Lam Pang (n=92)	Chiang Rai (n=83)	Pa Yao (n=115)	Total (n=290)
Average age (years)	49	41	44	46
Average family member	4.5	4.1	4.4	4.3
Percent of full-time on-farm family members				
1	28.3	14.5	20.0	21.0
2	58.7	65.1	65.2	63.1
3	7.6	15.7	9.6	10.7
> 3	5.4	4.8	5.2	5.2
Number of household that family members helping as part-time for on-farm activities (%)	39.1	4.8	26.1	8.3
Number of household that family members having full-time off-farm activities (%)	31.5	19.3	20.0	7.9

4.2 Household income.

Table 6 shows amounts and sources of family incomes of the rainfed lowland farmers in three provinces of the Upper North. The average annual income was Baht 78,413 having Lampang the lowest (Baht 53,718), followed by Chiang Rai (Baht 86,313) and Phayao (Baht 92,466). The income derived from agriculture average 59 percent, with Lampang 39 percent, Chiang Rai 58 percent, and Phayao 68 percent. In Lampang, the contribution of off-farm employment to the total household income was highest, about 51 percent. While in the other two provinces, it constituted 20-28 percent. The income from selling rice was higher in Chaing Rai (48.6 percent) and Phayao (45.8 percent) than in Lampang (18 percent). The contribution of non-rice crops and livestock was more significant than rice in Lampang province, but the reverse relationship was more pronounced in Chiang Rai and Phayao.

The annual household income varied significantly within province and between provinces. The average annual household of Lampang was lower than the regional average. As far as agricultural intervention was concerned, it would require more developmental effort at the local level to fit more local needs, so that wider income gap as it existed could be narrowed down.

4.3 Capital. About 30 percent of the farm households invested their income and saving on farming, and 57 percent used both their own money and borrowed money for farming activities (Table 7). Only 13 percent of the households depended solely on the loan. It was noted that in Lampang, even the income from agriculture was lowest, and yet the proportion of households used their own money in farming was highest, about 57 percent. Presumably, the remittance from the off-farm employment had helped eased household financial requirement.

The main source of financial credit was the Bank for Agriculture and Agricultural Cooperatives (BAAC), which provided various loans to 74.5 percent of the households. The informal credit supplies, such as local traders and relatives, contributed 15.7 and 6.0 percent, respectively to the households. It was surprisingly to find that the Agricultural Cooperatives provided credits to only 3.8 percent of the households.

Table 6. Source of incomes of the rain-fed lowland farmers in three provinces of the Upper North

Source of income	Lam Pang	Chiang Rai	Pa Yao	Total
Source of income				
1. Agricultural sector	20,965 (39)	50,439 (58)	63,028 (68)	46,081 (59)
Rice crops	9,692	41,945	42,317	31,860

Non-rice crops	7,906	5,283	14,700	9,849
Livestock	3,368	3,211	6,011	4,371
2. On-farm employment	5,533 (10)	12,130 (14)	10,543 (11)	9,408 (12)
3. Off-farm employment	27,220 (51)	23,745 (28)	18,896 (20)	22,924 (29)
The ratio of incomes from rice crops per total incomes of household (Percentage)	18.0	48.6	45.8	40.6

Source: The data was from farmer interview.

Table 7. Source of Agricultural capitals of farmers in three provinces of the Upper North

Source of capitals	Lam Pang	Chiang Rai	Pa Yao	Total
	%	%	%	%
Capitals in Agricultural activity (Percentage)				
Used their own money	56.5	16.9	19.1	30.3
Both of their own money and loan	35.9	67.5	65.2	56.6
Solely on the loan	7.6	15.7	15.7	13.1
Total	100	100	100.0	100.0
Source of loan (percentage)				
Bank of Agriculture and Agricultural Cooperatives	64.6	77.2	76.9	74.5
Agricultural Cooperatives	6.3	3.8	2.8	3.8
Local traders	22.9	16.5	12.0	15.7
Relatives	6.3	2.5	8.3	6.0
Total	100.0	100	100	100

Note: Some farmers borrowed money more than 1 source.

4.4 Farmer debt.

The present government has implemented farmer debt moratorium, by giving farmers three years of grace period before paying their debts. During these debt relief period, the local Agricultural Extension office will provide technical advice, help develop farm plan and make arrangement for free deliveries of certain input supplies, such as seedlings, seed, etc. so that farmers could make financial recovery after three years. Table 8 shows that the average farm debt of Baht 45,967 was almost equal to the average household income as given in Table 6. In fact, it could be seen that income from rice alone could not pay for the farm debt. Therefore lowland rice farmers in the Upper North must first fulfill their household food need by growing glutinous rice for home consumption, and then will allocate farm resource for the production of non-glutinous rice such as KDML 105 and RD 15 for cash.

Table 8. The average farm debt in 2001

Unit: Household

Value of debt	Lam Pang	Chiang Rai	Pa Yao	Total
Average	51,305.00	41,233.00	47,183.00	45,967.00
Maximum	300,000.00	200,000.00	200,000.00	300,000.00
Minimum	1,000.00	3,000.00	2,000.00	1,000.00
Standard Deviation (SD)	61,868.00	43,763.00	44,805.00	48,203.00
No. of farmers borrowed money for farm activities	40	69	93	202

4.5 Land holding.

Majority of the lowland rice farmers in the Upper North owned land and used their own land for rice cultivation (66.6 percent) (Table 9). About 29 percent of the households had to rent more land to plant rice, simply because the size of land property was not large enough to earn the living. However, only 4.5 percent of the farm households who were landless and had to rent the land for rice cultivation.

The payment of land rent could either be in cash or in kind. The annual rent was ranging from 450 Baht/rai in Lampang to 600 Baht /rai in Chiang Rai. The Phayao farmers paid Baht 530/rai. When rice was used to pay for land rent, the amount ranged from 12.8 tang (128 kg) to 20.7 tang (207 kg) /rai, which was equivalent to one-fourth to one- third of the rice productivity per rai. The price of rough rice in the village was 4.5 to 5.5 Baht/kg. Thus the payment in rice was turned out to be higher in value than in cash.

Table 9. Land holding of farmers for rice cultivation in three provinces of the Upper North

Land holding and land rent	Lam Pang	Chiang Rai	Pa Yao	Total
	%	%	%	%
Land holding				
1. Owned land	79.3	67.5	55.7	66.6
2. Owned land + Rent more land	15.2	28.9	40.0	29.0
3. Only rent the land	5.4	3.6	4.3	4.5
Total	100	100	100.0	100.0
The payment of land rent				
Pay with cash (Baht / Rai)	450	600	530.0	550.0
Pay with rice (Tang / Rai)	20.7	17.0	12.8	15.3

4.6 Areas planted to rice.

The rainfed lowland rice farmers would use all their rice land for annual production. Those who owned land more than they could farm would rent out the land to others. Therefore one would hardly see rice land being left fallow during the rainy season, unless the land had been changed its ownership and being used for non-agricultural purposes.

The average farm size planted to rice was 17.2 rai, being larger in Chiang Rai and Phayao, with 23.3 and 21.4 rai, respectively (Table 10), while Lampang had the smallest average rice land of 6.5 rai. The rice land distribution in Table 10 also showed that 85 percent of farm households in Lampang had rice land less than 10 rai, which was considered being less sufficient for rainfed rice farming. While in Phayao and Chiang Rai, about 19 to 23 percent of farm households had rice land less than 10 rai. With larger farm size planted to rice, farmers with less capital input would normally adopt extensive farming strategies to achieve high total annual production.

Table 10. Farm size for planted rice of farmers in three provinces of the Upper North in 2001

	Lam Pang	Chiang Rai	Pa Yao	Total
Farm size (Rai)				
Average	6.5	23.3	21.4	17.2
Maximum	18	35	138	138
Minimum	1	4	3	1
Standard Deviation	3.55	13.98	15.7	14.52
Distribution of farm size (Percentage)				
≤ 5 Rai	47.8	2.4	3.5	17.2
6 - 10 Rai	38.0	20.5	15.7	24.2
11 - 20 Rai	14.2	25.3	40.9	27.9
21 – 30 Rai	-	27.7	26.1	18.3

30 – 50 Rai	-	20.5	10.4	10.0
> 50 Rai	-	3.6	3.5	2.4
Total	100	100	100	100

5. Preferential Rice varieties

The rice varieties selected by farmers for rainy season planting varied from province to province (Table 11). In Lampang, about 55 percent of the farmers chose RD 6, 26 percent for RD 10, and 11 percent for Niew San Patong. Only 6.5 percent of farmers planted KDML 105, and none for RD 15. In Chiang Rai, RD 6 was the most preferable variety (95 percent), followed by RD 15 (64 percent), and KDML 105 (25 percent). In Phayao, the varietal choice was similar to Chiang Rai, with RD 6 was the most popular (90 percent), followed by RD 15 (53 percent) and KDML 105 (48 percent).

The farmer selection of rice variety was also indicative of production objectives. In Lampang farmers would grow rice for subsistence with emphasis on glutinous rice, and they selected the high quality rice RD 6. The surplus could be sold at the village and district markets. In fact Lampang is not the rice-exporting province. On the contrary, Chiang Rai and Phayao are the main rice exporting provinces of the Upper North, producing high quality non-glutinous rice RD15 and KDML 105. The Chiang Rai farmers preferred RD 15 to KDML 105, while the opposite was true for the Phayao farmers.

The lowland rice farmers in Chiang Rai and Phayao would plant more than one varieties of rice. RD 6 was a must, planting for home consumption and the surplus was for sale. Then the next choice between RD 15 and KDML 105 would depend on farmer preference, water status, demand from the rice mills. The price differential between RD 15 and KDML 105 was not much, both were of same quality, and the rice mills practically mixed both varieties if needed.

The RD 15 was so popular in Chiang Rai simply because the variety is early maturing, which would reduce drought damage through drought escape, making the variety appropriate for planting in the upper paddy. Its quality is comparable to KDML 105, thus the large rice mills in Chiang Rai as well as Phayao provinces promoted the variety.

RD 10, a non-photoperiod sensitive glutinous rice, is a mutated derived line from RD 1, has been used by farmers in the Upper North to fit irrigated cropping systems. In the study sites, farmers in Ngao district of Lampang adopted RD10 in rice-garlic cropping system. The double cropping system was possible through the construction of small irrigation and reservoir in the district. The quality of RD 10 was not comparable to RD 6, and the price was about 20 percent lower, but the variety was more flexible to arrange planting time to fit double cropping.

Farmers selected other rice varieties, which were local selections and old released varieties, to fit specific ecological niches. For instance, Lampang farmers selected Dor Siew, RD 2, RD 4, RD 8, RD 10 and RD 7, which possessed early to medium maturity when compared to RD 6 or KDML 105, while Phayao farmers selected Dor Sayan, Dor Lane and RD 19 for the flood-prone lowland. With the exception of RD 10, these varieties were planted on small areas, and the product was almost entirely used for home consumption.

Table 11. Rice varieties selected by farmers for rainy season planting in 2001

Unit: Percentage

Rice varieties	Lam Pang (n=92)	Chiang Rai (n=83)	Pa Yao (n=115)	Total (n=290)
1. RD 6	55.4	95.2	89.6	80.3
2. RD15	-	63.9	53.0	39.3
3. KDML 105	6.5	25.3	47.8	28.3
4. RD 10	26.3	-	-	9.0

5. San Patong	10.9	2.4	-	4.1
6. Etc.	15.2	2.4	7.0	8.3

Note: Almost farmers in Chiang Rai and Pa Yao planted more than 1 varieties of rice.

: Other varieties of rice in Lam Pang are such as Dor Siew RD 2, 4 ,7 ,8 while Chiang Rai farmers selected Khao Chao Loi and Rd 2 . And Pa Yao farmers selected Dor Sayan, Dor Lane, RD 16, RD 19, and Pathum Thanee 1.

6. Desirable and undesirable characteristics of major rice varieties and farmer rice ideotype

The major rice varieties in the Upper North consisted of RD 6, RD 15, KDML 105 and RD 10 arranging in descending order of preferential ranking by farm households. Tables 12, 13, 14, and 15 show farmers' assessment on desirable and undesirable characteristics of the four major rice varieties respectively. RD 6, being grown for home consumption, farmers would give highest ranking on eating quality, which possessed soft, and good texture. High yielding and good price, and easy saleable would follow. Farmers considered RD6 had certain disadvantages, such as vulnerable to pests and diseases, and susceptible to lodging.

RD 15 and KDML 105, which were grown for sale, were ranked first for their good price and ease of marketing. The other important characters for RD 15 were favorable yield and early maturity, while for KDML 105 were good grain size, aromatic, soft when cooked, and high percentage of head rice. The disadvantages of these two varieties were susceptible to pests and diseases. It seemed that the price of KDML 105 was more fluctuating than RD15.

RD 10, which was specifically selected by the Ngao farmers, was preferred for its high yielding, acceptable eating quality, early maturing, drought tolerant, and high percentage of grain filling. The undesirable characters were susceptible to pests and diseases, and less easy to thresh. This last character was common among the modern high yielding varieties, which were bred for resistance to seed shattering. RD 10 is a mutant of RD 1, which is a high yielder.

Table 16 shows the desirable characteristics of farmer rice ideotype (ideal plant type). High yielding with good test weight, and resistance to pests and diseases were ranked first. The preferential ranking was followed by high price and lodging resistance, which received similar weight. High price was associated with grain quality and eating quality that were demanded by market. Farmers perceived high yielding and pest resistance depended on farmer ability to manage and manipulate the production strategies, which were under individual farmer decision and control. But price and drought were less controllable by individual farmers, so there was a trade-off between high yielding and price.

Table 12. Farmers' assessment on desirable and undesirable characteristics of RD 6

Desirable and undesirable characteristics	No. of answers	Percentage of answers	Percentage of farmers planted this variety
Desirable characteristic	(n=428)		(n=233)
1. Soft and good texture	234	54.7	80.7
2. Aroma	70	16.4	24.1
3. High yield	51	11.9	17.6
4. Good price and easy saleable	35	8.2	12.1
5. Easy for plant and management	11	2.6	3.8
6. Consumer preference	10	2.3	3.4
7. Etc.	17	4.0	5.9

Undesirable characteristic	(n=60)		(n=233)
1. Disturbances of pests and insects	24	40.0	8.3
2. Vulnerable to pests and diseases	16	26.7	5.5
3. Susceptible to lodging	12	20.0	4.1
4. Etc.	8	13.3	2.8

Note: The information was from the open-end question that the farmers can give the reasons more than 1 answer. And the percentages were calculated from the number of samplings in each study areas.

: Other desirable characteristics included high tillering ability, drought tolerant, easy to harvest and short maturity.

: Other undesirable characteristics included non-photoperiod sensitive, grow slowly, low tillering ability, long maturity, susceptible to water lacking, needed intensive management, and low yield in case of continue growing for a long time.

Table 13. Farmers' assessment on desirable and undesirable characteristics of RD 15 variety

Desirable and undesirable characteristics	No. of answer	Percentage of answer	Percentage of farmer samplings planted this variety
Desirable characteristics	(n=138)		(n=114)
1. Good price and easy saleable	58	42.0	50.9
2. High yield	29	21.0	25.4

3. Early maturity	24	17.4	21.1
4. Soft when cooked and good taste	10	7.2	8.8
5. Etc.	17	12.3	14.9
Undesirable characteristics	(n=27)		(n=114)
1. Vulnerable to diseases	15	55.6	13.2
2. Susceptible to pests and diseases	9	33.3	7.9
5. Etc.	3	11.1	2.6

Note: Other desirable characteristics included market favorable, easy to manage, moderate height, easy to harvest, drought tolerant and suitable for the areas.

: Other undesirable characteristics of farmers in RD 15 variety included fluctuating price, and small tillers.

Table 14. Farmers' assessment on desirable and undesirable characteristics of KDML 105 variety

Desirable and undesirable characteristics	No. of answer	Percentage of answer	Percentage of farmer samplings planted this variety
Desirable characteristics	(n=107)		(n=82)
1. Good price and easy saleable	54	50.5	65.9
2. Good grain size, aromatic, soft when cooked, and high percentage of head rice	20	18.7	24.4
3. High yield	15	14.0	18.3
4. Market favorable	10	9.3	12.2
4. Etc.	8	7.5	9.8

Undesirable characteristics	(n=16)		(n=82)
1. Disturbances of pests and diseases	5	31.2	6.1
2. Susceptible to disease	4	25.0	4.9
3. Fluctuating price	3	18.8	3.7
4. Etc.	4	25	4.9

Note: Other desirable characteristics included market desirable, easy to manage, broaden seed, and mature in drought season.

: Other undesirable characteristics included long maturity, high height, susceptible to lodging, and less of tiller.

Table 15. Farmers' assessment on desirable and undesirable characteristics of RD 10 variety

Desirable and undesirable characteristics	No. of answer	Percentage of answer	Percentage of farmer samplings planted this variety
Desirable characteristics	(n=38)		(n=26)
1. High yield	11	28.9	42.3
2. Soft when cooked and good taste	10	26.3	38.5
3. Etc.	17	44.7	65.4
Undesirable characteristics	(n=21)		(n=26)
1. Disturbances of pests and diseases	6	28.6	23.1
2. Susceptible to diseases	5	23.8	19.2
3. Difficult to thresh	3	14.3	11.5
4. Etc.	7	33.3	26.9

Note: Other desirable characteristics included good test weight, early maturity, drought tolerant, easy to harvest, high percentage of grain filling and easy saleable.

: Other undesirable characteristics included low eating quality, lower price and susceptible to lodging.

Table 16. The desirable characteristics of farmer rice idotype (ideal plant type)

Rice characteristics	Lam Pang (n=92)		Chiang Rai (n=83)		Pa Yao (n=115)		Total (n=290)	
	No.	%	No.	%	No.	%	No.	%
1. High yield and good test weight	56	60.9	43	51.8	67	58.3	166	57.2
2. Resistance to pests and diseases	44	47.8	47	56.6	57	49.6	148	51.0
3. Lodging resistance	10	10.9	8	9.6	13	11.3	31	10.7
4. Early maturity	7	7.6	5	6.0	8	7.0	20	6.9
5. High price	4	4.3	10	12.0	24	20.9	38	13.1
6. Drought tolerant	11	12.0	8	9.6	17	14.8	36	12.4
7. Not mutate	6	6.5	4	4.8	8	7.0	18	6.2
8. Etc.	7	7.6	5	6.0	4	3.5	16	5.5

Note: The answers were from open-end questions that farmers can give more than 1 answer.

: Other desirable characteristics included good taste and equal height.

7. Farmer cultural practices of rainfed lowland rice

7.1 Seeding rate.

The seeding rate used in the nursery plot for rice transplanting averaged 10 kg/rai, which was considered being higher than necessary. Farmers would claim that they customally had to prepare seed of such amount as a safety precaution for second or third nursery preparation in the event of drought occurrence. Table 17 shows that 59 percent of the farm households used seeding rate less than 10 kg/rai. About 41 percent used more than 10 kg/rai. Only a few over seeded at the rate higher than 15 kg/rai. So there were rooms for improvement to reduce seeding rate by carefully selecting quality seed for planting. This would also imply that good quality seed was essential to cut down seeding rate and production cost.

Table 17. The seeding rate used in the nursery plot for rice transplanting

	Lam Pang (n=92)	Chiang Rai (n=83)	Pa Yao (n=115)	Total (n=290)
Seeding rate (Kg. / rai)				
- Average	11.8	9.8	9.5	10.3
Distribution of seeding rate (percentage)				
- < 10 Kg. / Rai	39.1	65.9	68.7	58.5
- 10 – 15 Kg. / Rai	50.0	26.8	27.8	34.6
- 15 – 20 Kg. / Rai	6.5	6.1	3.5	5.2
- > 20 Kg. / Rai	4.3	1.2	-	1.7

7.2 Use of chemical fertilizers.

Almost all the lowland rice farmers now applied chemical fertilizers to increase rice yield (Table 18). On the average, farmers applied twice with a total rate of 24 kg/rai. However the range of chemical fertilizers extended from less than 10 kg/rai to as high as 40 kg/rai. The type of fertilizers used as showed in Table 19 indicates that 85 percent of the farm households preferred 16-20-0, and 63 percent used 46-0-0. When the amount of element was determined, it was found that nitrogen fertilizer was used at 6 kg/rai, which was about 30 percent less than recommended rate (8.6 kgN/rai). The rate of phosphorus was 3 kg/rai, which was 40 percent lower than the recommended (5 kg P_2O_5/rai). It was a common practice of farmers to broadcast or top-dress chemical fertilizers on the patches with poorer rice growth, as indicated by yellowing of rice leaves. Therefore the overall rate was found to be less than the recommended, but farmers would have relatively uniform yield over the plots.

Table 18. Use of chemicals fertilizers in rice production

	Lam Pang (n=92)	Chiang Rai (n=83)	Pa Yao (n=115)	Total (n=290)
The ratio of farmers applied chemical fertilizers (Percentage)	94.6	98.8	100	97.9
Frequency of applying fertilizers (Times)	1.7	1.9	1.9	1.8
Total rate of fertilizers applied in rice production (Kg. / Rai)				
- Average	25.5	22.6	24.8	24.4
Distribution of chemicals fertilizers application (Percentage)				
- Not used	5.4	1.2	-	2.1
- < 10 Kg. / Rai	12.0	8.4	7.0	9.0
- 10 - 20 Kg. / Rai	35.9	41.0	34.8	36.9
- 20 - 30 Kg. / Rai	19.6	26.5	36.5	28.3
- 30 - 40 Kg. / Rai	15.2	18.1	13.9	15.5
- > 40 Kg. / Rai	12.0	4.8	7.8	8.3

Table 19. Type of fertilizers and amount of element used in rice production

Type of fertilizers and element	Lam Pang	Chiang Rai (n=83)	Pa Yao (n=115)	Total

	(n=92)			(n=290)
The ratio of farmers applied chemical fertilizers (Percentage)				
16-20-0	71.7	84.3	95.7	84.8
46-0-0	43.5	80.7	65.2	62.8
15-15-15	16.3	7.2	13.9	12.4
Etc.	3.3	2.4	19.1	9.3
Average amount of elements (Kg. / Rai)				
- N	5.2	6.1	5.6	5.6
- P	3.6	2.6	3.5	3.3
- K	0.6	0.04	0.2	0.3

Note: Almost farmers used chemical fertilizers more than 2 types.

7.3 Seedling preparation, land preparation, and other management practices.

Table 20 depicts the lowland rice farmers' management practices on rice production covering land preparation, seedling preparation, transplanting, weeding, fertilizing, and harvesting. The basic practices across provinces were similar. Land would be ploughed twice. Rice seeds prepared for broadcasting in the nursery would be soaked for two days, and were then allowed to air-dry in the shed for one and a half days before broadcasting in the nursery plots. The seedling age was generally over 30 days old, which was physiologically late for transplanting. However, farmers would claim that old seedling was more tolerant to drought and flood, and to attack from crab and pink snail. A few had experienced using younger seedling, and observed vigorous plant growth with good tillering, but it would be too risky under their growing environment. It was noticed that on average 76 percent of farm households needed to replant the missing hills 20 days after transplanting.

Weed management was carried out consciously in the production process. For instance, land was ploughed twice to turn over weed and submerged under flooding. After planting, either pre-emergence herbicide or post –emergence herbicide was used to control weed population. Hand weeding was done twice.

The lowland rice farmers applied chemical fertilizers twice, one at four weeks after planting with compound fertilizers mainly 16-20-0 at 15.8 kg/rai. The second was about five weeks thereafter by top-dressing with 46-0-0 at 9.6 kg/rai.

Most of the rice varieties grown by farmers would be matured and ready for harvest 30 days after flowering. In the study areas, farmers harvested their rice about 33 days after flowering. The rice fields would be drained about 15 days before harvesting, so that the operation could be easily done under dry soil condition. The harvested materials would be dried on the fields for about 4 days before threshing. The procedure was meant for manure harvest. With the combine harvester, drying on the field was not necessary.

Table 20. Seeding preparation, land preparation, and other management practices in rice production in 2001

Management practices	Lam Pang (n=92)	Chiang Rai (n=83)	Pa Yao (n=115)	Total (n=290)
Timing for soaking rice seeds in the water before broadcasting (day)	2.1	2.1	2.0	2.06
Timing for waiting the seed dry after soaking (day)	1.6	1.6	1.7	1.64
Frequency of ploughed before transplant (Times)	1.4	2.1	2.1	1.88

Seeding age (day)	31.2	36.8	36.5	34.90
Average spacing for transplant (cm. X cm.)	25*25	25*25	25*25	25*25
The ratio of farmers needed to replant (Percentage)	68.5	86.7	76.5	76.9
Age of rice after transplanting when replant (day)	20	24	16	19.71
The ratio of farmers used pre-emergence herbicide (Percentage)	57.6	44.6	28.7	42.4
Frequency of using pre-emergence herbicide (Times)	1.02	1.1	1.0	1.04
The ratio of farmers used post-emergence herbicide (Percentage)	17.4	14.5	7.8	12.8
Frequency of using post-emergence herbicide (Times)	1.1	1.2	1.2	1.16
The ratio of farmers weeding by hand (Percentage)	44.6	53.0	65.2	55.2
Frequency of weeding by hand or machinery (Times)	3.3	2.3	1.8	2.32
Frequency of fertilizing in paddy field	1.7	1.9	1.9	1.84
Fertilizer rate at the 1st application (Kg. / Rai)	15.2	13.6	14.8	15.8
Age of rice at the 1st application (day)	30.4	28.4	23.5	27.0
Fertilizer rate at the 2nd application (Kg. / Rai)	10.3	9.0	10.0	9.6
Age of rice at the 2nd application (day)	58.6	64.2	62.6	62.1
Harvesting day after flowering stage (day)	32.5	32.2	33.4	32.8
Timing for draining the water out before harvesting (day)	13.3	18.3	16.1	15.8
Timing for drying rice in the fields before threshing (day)	3.8	3.5	4.5	4.01

Note: Fertilizer rate applied in 1st and 2nd time averaged by the total samplings.

: The ratio of farmer in each practices calculated from the number of farmers doing in each practice divided by the number of total farmers in each area.

8. Rice yield and varietal performance

The overall average rice yield was 541 kg/rai with coefficient of variation of 32 percent (Table 21). The farmer maximum yield plots across three provinces were 980 kg/rai, indicating that under favorable rainfed lowland environment, rainfed rice could achieve attainable farm yield as high as irrigated rice.

The distribution of rice yield across farms indicated that 25 percent of the farm households received yield below 400 kg/rai, and about 45 percent obtained yield of 400 to 600 kg/rai. The rest 30 percent achieved yield of over 600 kg/rai. The low yield of 400 kg/rai and those below could be treated as below subsistence production level. The group should receive high priority to improve rice productivity to meet subsistence need with the existing farmer production technology, which had shown promising yield. Farmers-to-farmers learning model would help speed up the process. The second group of farmers, about 45 percent, with yield ranging from 400 to 600 kg/rai would require strong researcher-farmer partnership to collectively plan, design and implement so that higher yield level could be achieved. It would be seen later that with yield lower than 600kg/rai, the economic return from growing and selling rice were not attractive. Those having rice yield over 600 kg/rai should try to work out ways of reducing production cost while maintaining productivity. A few farmers with outstandingly high yields would serve as the model farms for local resources. Management as well as environmental factors leading to high yields should be identified and mapped out in detail so that the production system could be replicable at wider scale.

Table 22 shows the yield performance of dominant rice varieties planted by farmers. RD 6 and RD 15 had provided relatively higher yield (572 and 521 kg/rai, respectively) than KDML 105 (497 kg/rai), and RD 10 was at the lowest ranking (475 kg/rai). Genetically, RD 10 had higher yielding potential than RD 15 and KDML 105, but its lower yield observed in Lampang was mainly due to less favorable growing environment. However, all these four varieties could attain yield over 900 kg/rai, which would be exceptionally high under rainfed conditions. Ecologically, the varieties had the high yielding potential, and with good management practices, all these varieties were capable of providing high yield.

Other minor varieties, such as Dor Siew, RD 2, RD 4 and RD 8 as reported by farmers, also collectively provided high yield under good management.

Therefore, with the existing available rice varieties, management practices that fit production niches would contribute significantly to higher yield than that of the varieties.

Table 21 Average yield and distribution of rice yield in three provinces of the Upper North

Rice yield	Lam Pang	Chiang Rai	Pa Yao	Total
Average rice yield (Kg. / Rai)	537	503	570.00	541.00
Distribution of yield (Percentage)				
< 300 Kg. / Rai	14.5	13.0	3.0	8.9
300 – 400 Kg. / Rai	14.4	19.2	14.5	16.0
400 – 500 Kg. / Rai	16.2	21.2	18.0	18.6
500 – 600 Kg. / Rai	24.3	24.7	28.5	26.4
600 – 700 Kg. / Rai	10.8	9.6	19.5	14.2
> 700 Kg. / Rai	19.8	12.3	16.5	15.9

Table 22 Average rice yield in three provinces of the Upper North in 2000 classified by rice varieties

Unit: Kg. / Rai

Yield / Varieties	RD 6	RD 15	KDML 105	RD 10	Other varieties	Total
Average yield	572	521	497	474	537	541
Maximum	980	960	865	933	850	980
Minimum	100	96	200	192	210	96
Standard Deviation	174	173	146	184	188	174
No. of farmer samplings	231	106	63	36	21	457

Note: Almost farmers planted more than 1 variety of rice.

Other varieties of rice included San Patong, Dor Siew, RD 2, RD 4 and RD 8

9. Production constraints

The overall production constraints that would affect rice yield with a consequence of leading to lower economic return are listed in Table 23. The top three constraining factors were drought (34.5 percent), low rice price (23.4 percent), and pest and disease incidence (15.9 percent). The factors of rodents, crab, and pink snail, lack of capital, and lack of labor collectively accounted for 21.3 percent. Others factors including flood, poor soil, lodging, low tiller numbers, high cost of fertilizers accounted for 17.2 percent.

The low rice price would provide disincentive to farmers to invest and intensify their commercial rice production. It was often observed that when the rice price was attractively high, farmers would willingly invest to achieve higher return.

Incidences of drought and pests and their impact on rice yields were examined further as shown in Tables 24 and 25. The drought incidence in Lampang was more frequent than Chiang Rai and Phayao, with the frequency of occurrence of 5 in 10 years in Lampang as against 2 to 3 in Chiang Rai and Phayao. The drought occurred at two periods, one at the tillering stage, and the second at booting and flowering stage, with almost equal frequencies. Yield loss due to two periods of drought was slightly different, being higher in the reproductive stage than at the vegetative stage, averaging 42 percent and 39 percent, respectively, lower than yield obtained from the normal growing condition.

Table 25 shows incidence of diseases and insect pests and their severity. Blast was identified as the major disease constraining rice yield and accounting for 41 percent. The disease was found to be more serious in Chiang Rai and Phayao than in Lampang. Other diseases included bakanae disease caused by *Gibberella fujikuroi*, and root rots.

Gall midge and thrips were the major insect pests, accounting for 47 and 32 percent of the damaging households, respectively. Plant hopper accounted for 15 percent.

The seriousness of the problems caused by crab, rodents, and pink snail were 17, 10, and 4 percent, respectively. The damages were reported as not serious.

Table 23. The constraints in rice production

Constraints	Lam Pang (n=92)		Chiang Rai (n=83)		Pa Yao (n=115)		Total (n=290)	
	No.	%	No.	%	No.	%	No.	%
1. Drought	38	41.3	28	33.7	34	29.6	100	34.5
2. Low rice price	2	2.2	14	16.9	52	45.2	68	23.4
3. Pest and disease	10	10.9	28	33.7	8	7.0	46	15.9
4. Rodents, crab and pink snail	19	20.7	8	9.6	9	7.8	36	12.4
5. Lack of capital	5	5.4	4	4.8	5	4.3	14	4.8
6. Lack of labor, high wages	5	5.4	3	3.6	4	3.5	12	4.1
7. Others	11	12.0	18	21.7	21	18.3	50	17.2

Note: Others factors included flood, poor soil, lodging, low tillering ability and high cost of fertilizers.

The answers were from the farmers' ranking for the most of important constraints in rice production at the present time.

Some farmers identified that no problem for rice production while someone identified more than 2 problems.

Table 24. Incidence of drought and pests and their impact on rice yields

	Lam Pang	Chiang Rai	Pa Yao	Total
Drought Incidence				
- Frequency of occurrence at the tillering stage in 10 years.	4.0	2.5	2.2	2.8
- Frequency of occurrence at the booting and flowering stage in 10 years.	5.6	2.1	1.9	2.4
The impacts on rice yield				
- Average rice yield (Kg. / Rai)	662.0	535.0	651.0	603.0
- Average rice yield when drought occurred at the tillering stage (Kg. / Rai)	414.0	315.0	367.0	371.0
: Losing yield ratio (Percentage)	37.5	41.1	43.6	38.5
- Average rice yield when drought occurred at the booting and flowering stage (Kg. / Rai)	393.0	312.0	352.0	350.0
: Losing yield ratio (Percentage)	40.6	41.7	45.9	42.0

Note: Average rice yield estimated by farmers.

Table 25. Incidence of diseases and insect pests in rice production

Characteristic of rice variety	Lam Pang (n=92)		Chiang Rai (n=83)		Pa Yao (n=115)		Total (n=290)	
	No.	%	No.	%	No.	%	No.	%
1. Diseases of rice								
- Rice blast disease	24	26.1	38	45.8	57	49.6	119	41.0

- Etc. (Bakanae disease, Fungi, Root rot)	18	19.6	8	9.6	12	10.4	38	13.1
2. Insect pests								
- Gall midge	17	18.5	68	81.9	51	44.3	136	46.9
- Thrips	56	60.9	19	22.9	17	14.8	92	31.7
- Plant hopper	12	13.0	9	10.8	22	19.1	43	14.8
- Others (worms, grasshoppers, leafhoppers)	10	10.9	9	10.8	8	7.0	27	9.3
3. Crabs								
- Severity	14	15.2	17	20.5	19	16.5	50	17.2
- Less severe	38	41.3	62	74.7	93	80.9	193	66.6
4. Rodents								
- Severity	22	23.9	2	2.4	4	3.5	28	9.7
- Less severe	53	57.6	31	37.3	70	60.9	154	53.1
5. Pink snail		0.0		0.0		0.0	0	0.0
- Severity	7	7.6	4	4.8	1	0.9	12	4.1
- Less severe	23	25.0	27	32.5	18	15.7	68	23.4

Note: Percentage calculated by the number of samplings in each area.

10. Production cost and economic return

The rice yield used in the estimation of economic return in Table 26 was obtained from crop-cut samples, which was about 20 percent higher than the yield data obtained from the farmer estimate. The estimation of production cost and return was done separately for RD 6, RD 15, and KDML 105. The total costs, including variable and fixed costs, of three varieties were comparable, ranging from 2656 to 2902 Baht/rai. Cost of labor constituted about 63 percent of the total cost.

The rice price varied substantially between varieties, being higher in non-glutinous rice, RD 15 and KDML 105, than in glutinous rice, RD 6, five Baht/kg as against four Baht/kg. RD 15 and KDML 105 received the same price of five Baht/kg. The net return was found to be much lower in RD 6 (109 Baht/rai) than in RD 15 (440 Baht/rai) and KDML 105 (389 Baht/rai).

The return to labor for RD 6 was 106 Baht/manday, RD 15 was 126 Baht/manday, and KDML 105 was 121 Baht/manday. So based on economic criteria alone, it would be more profitable to grow non-glutinous rice than glutinous rice. As discussed earlier, farmers planted more than one varieties, one for home consumption, and one for cash. Farmers would not take risk to allocate all their land to plant non-glutinous rice for cash. The practice was not socially and culturally accepted. For rice farmers in the Upper North, rice sufficiency and security received the highest priority.

Table 26. Cost and benefit of rice production classified by rice variety

Cost and benefit	RD 6	RD 15	KDML 105
1. Variable cost (Baht / Rai)	2,364.13	2,207.52	2,484.64
2. Fixed cost (Baht / Rai)	445.63	448.84	417.77
3. Cash cost (Baht / Rai)	1,198.08	1,283.89	1,434.25
4. Non-cash cost (Baht / Rai)	1,611.68	1,372.48	1,468.16
5. Labor cost (Baht / Rai)	1,784.40	1,660.74	1,841.42
6. Total cost (Baht / Rai)	2,809.76	2,656.36	2,902.41

7. Yield (Kg. / Rai)	608.20	619.30	658.30
8. Average price (Baht / Kg.)	4.80	5.00	5.00
9. Total revenue (Baht / Rai) = (7) *(8)	2,919.36	3,096.50	3,291.50
10. Net return over variable cost (Baht / Rai) = (9) - (1)	555.23	888.98	806.86
11 Net return over cash cost (Baht / Rai) = (9)-(3)	1,721.28	1,812.61	1,857.25
12. Profit (Baht / Rai) = (9) - (6)	109.60	440.14	389.09
13. Return to labor (Baht / Man-Day)	106.14	126.50	121.13
14. Production cost per kilograms (Baht / Kg.) = (6)/(7)	4.62	4.29	4.41
15. Net profit per kilograms (Baht / Kg.) =(14) - (8)	0.18	0.71	0.59

Note:

Return to labor = (Total revenue – Total cost without labor cost) / Labor cost

= ((9) – (6) + (5))/(5)*100

The rice yield used in the estimation of economic return was obtained from crop-cut samples.

Price of rice is estimate price that equalize in every area because of farmers haven't harvest their products yet

Estimate yield by farmer	555.4	512.8	498.8

11. Post harvest handling

Utilization of rice was many (Table 27). On average 25 percent was consumed, 68 percent for sale, and 5 percent used to pay for land rent, About 1 to 2 percent were stored as seed for the next season planting, and less than 1 percent used as animal feed.

Table 27 provides evidence to support that Chiang Rai and Phayao were the rice exporting provinces, where farmers sold more than 65 percent of their rice harvest, while Lampang was strikingly different, where farmers sold less than 40 percent of their harvest. Based on the volumn of rice sale, the Lampang farmers were considered being subsistence rice farmers, while the Chiang Rai and Phayao farmers were commercial rice farmers.

Farmers stated four reasons why they had to sell rice after harvest (Table 28). Fifty-five percent of the farm households pointed out that they needed money to pay for the loan and household expenses. Twenty- two percent indicated that they were concerned the rice price might drop. It was often found that during the rice harvest, farmers would monitor on price changes through various sources, such as from the local traders, local extension agents, radio news, etc. Farmers would first compare the current price with price of last year before they made decision. The other two reasons were concerned with limited space available for storage and loss of grain weight, if farmers decided to keep rice for longer period.

However, there were farmers who did not want to sell rice immediately after harvest. The reasons as indicated in Table 29 pointed out that farmers would wait and hope for higher price (84 percent) before they decided to sell rice. Other reasons commonly found were that they would sell rice when they needed cash to invest in second crop after rice; when they ran out of cash; and they would sell the surplus from household consumption.

Majority of farmers, about 56 percent, would sell rice to the traders at the farms. It was a common phenomenon to observe local traders with pick-up trucks traveling over the places to buy rice during the harvesting season. Rice trading was carried out on farm, particularly when the demand was high. Thirty-seven percent of households sold their rice to rice mills. Only a few, less than 10 percent, sold to Farmer Cooperatives or mortgaged to the Bank for Agriculture and Agricultural Cooperatives (BAAC).

Recently, the BAAC had played an increasing role in arranging a rice mortgage, whereby farmers would place their rice with the authorized rice mills and receive money from the bank. Farmers would pay off a mortgage when the rice was sold. However, when the farm gate price was reasonably high and acceptable, farmers would prefer to sell their rice directly to the local traders, whom would provide cash payment on the same day.

Table 27. Distribution of rice productions in 2000

Production/ distribution	Lam Pang	Chiang Rai	Pa Yao	Total
Total production (Ton)	362	827	1,356	2,545
Percentage of distribution				
1. Consumption	53.5	24.3	17.0	24.6
2. Sell	38.1	66.2	77.4	68.1
3. Pay for land rent	6.1	7.0	4.2	5.4
4. Store as seed	1.5	2.3	1.2	1.6
5. Animal feed	0.8	0.2	0.2	0.3
Total	100	100	100	100

Note: Total production and distribution calculated by the production in 2000.

Table 28. The reasons of farmer for sell the products immediately after harvesting

	Lam Pang	Chiang Rai	Pa Yao	Total	
	%	%	%	No.	%
1. Cash requirement	52.63	57.69	54.17	38	55.07
2. Limited space available for storage	21.05	11.54	4.17	8	11.59
3. Concerned the rice price	10.53	15.38	37.50	15	21.74

might drop in the future					
4. Concerned with losing grain weight	15.79	15.38	4.17	8	11.59
Total	100	100	100	69	100

Table 29. The reasons of farmer for store the products instead of selling immediately after harvesting

	Lam Pang	Chiang Rai	Pa Yao	Total	
	%	%	%	No.	%
1. Waited for the higher price	62.0	90.2	92.6	174	84.5
2. Sold when need to invest in second crop after rice	14.0	1.6	2.1	10	4.9
3. Sold the surplus from household consumption	12.0	-	-	6	2.9
4. No cash	12.0	8.2	5.3	16	7.8
Total	100.0	100.0	100.0	206	100.0

Characterization of rainfed lowland rice production systems in the Northeast

Characterization of rainfed lowland rice production systems in the Northeast

The Northeast is the largest region covering approximately one-third of the total land area (170,000 sq.km). About one-third of population lives in the Northeast (26 million), of which 80 percent are engaging in agriculture.

It is estimated that about 80 percent of farming population depends on rainfed agriculture, which is considered to be the lowest per capita income in the country. These are mainly due to instability of rainfed farming, poor soil quality, fluctuation of market demand and price of major crops, such as rice, cassava, kenaf, maize and sugarcane. In general, agricultural systems in the Northeast are closely related to marginalized rainfed farming operated by resource poor farmers.

Rice production area in the Northeast occupies 29.2 million rai or about 91 percent within the region. The region is well known for its production of quality Hom Mali rice, particularly in the Lower Northeast provinces.

The objective of the research is to investigate the bio-physical and socio-economic aspects of rainfed rice production systems in the Northeast.

Methodology

Site selection

Twelve provinces were selected based on average annual rainfall. The North east can be divided into three distinct zones:

- Areas with annual rainfall 1400 mm and above: Nongkai, and Nakhonphanom
- Areas with annual rainfall between 1200-1400 mm: Roi-et, Surin, Udonthani, Sakhonakhon, and Yasothon

- Areas with annual rainfall less than 1200 mm: Nakhomratchasima, Chaiyaphum, Mahasarakham, Loei and Khon Kaen

Within a province, two districts were randomly selected. Within a district, three villages were selected based on three levels of off-farm incomes, high, medium and low.

The household selection was carried out by randomly selected 25-35 households in each village for interview. Questionnaire interview was developed to include sub-topics in relation to agroecosystem characteristics and socio-economic aspects of rice production system under rainfed condition.

Results

This report describes rainfed rice agroecosystem and farmer practices, which were obtained from field survey. However, attempts had been made to preserve the content, meaning, and cognitive response of farmers as much as possible to provide a better understanding of the current rice production system of the farmers, which would lead to formulation of research agenda and planning.

1 Land type

Farmers classified paddy land into four types, namely upper paddy, upper-lower paddy interface, unflooded lowland, and flooded lowland. The upper paddy constituted 37.4 percent, which is a dominant paddy land, is a drought prone ecosystem. The flooded lowland was insignificant, occupying about 1 percent of paddy land. The more favorable unflooded lowland, covered 36.6 percent, is considered being the most potential rainfed lowland rice production area, while the upland-lowland interface, constituting 25.4 percent, would require location-specific cultural practices in order to increase land productivity (Table 1).

2. Soil type

Farmers were able to identify six soil types in the rainfed lowland rice ecosystem (Table 2). These are clay, loam, sandy, clay loam, sandy loam, and gravel soils, of which the sandy soil dominated the rainfed lowland. The clay and clay-loam soils together constituted about 40 percent were considered to have better water holding capacity than the sandy soil nature, which in the Northeast occupied about 60 percent. Thus the water stress in rice was more pronounced in the Northeast than the North simply because of the more sandy soil nature of lowland rice ecosystem, despite the fact that the rainfall was abundant.

3. Drought and flooding

The incidence and effect of drought on rice production were more often and serious than that of flood. The occurrence of drought had affected 75 percent of the rainfed lowland farm households, while flood was reported to affect 32 percent of the farm households (Table 3). It was noted that about 35 percent of the farm households had experienced drought incidence for four to over four times in ten years, and about 28 percent of the farm households reported to experience flooding at the similar frequency of occurrence (Table 4).

Both incidences greatly affected rice productivity. Thus in addition to inherent poor soil quality, the lowland rice farmers in the Northeast had to encounter the climatic consequences, which collectively lowered the rice yield.

The most frequent drought occurrence was observed to be at the vegetative growth stage (58.4 percent), of which 39.5 percent reported to occur at the tillering stage (Table 5). If the drought or dry spell period did not prolong, chance of recovery through fertilization application was possible. A few farmers in the North and the Northeast in fact practiced this.

Flooding more frequently occurred at tillering stage, with over 56 percent reporting. The period was to coincide with the peak of rainy season in August and September. Thus in the flood prone areas, farmers insisted in using tall plant types, or adapted double transplanting technique to overcome long submergence.

4. Rice cultivars

Over 95 percent of rice cultivars being grown in the Northeast were either improved local selections, such as KDML 105, and Niew Sanpatong (NSPT), or the mutated lines derived from KDML 105, such as RD6 and RD 15, or modern high yielding cultivars, such as RD 8, RD 10. Table 6 shows the frequency distribution of these cultivars across 12 provinces in the Northeast. It was obvious that RD 6 was the most popular cultivar and grown by 58 percent of farm households, covering all the provinces in the Upper Northeast, where farmers planted the cultivar for household consumption and for domestic market.

In the Lower Northeast, farmers in the provinces of Surin, Nakhonratchasima and Yasothon preferred the non-glutinous rice, KDML 105 and RD 15, with 95, 63 and 46 percent, respectively (Table 6).

Surin and Nakhonratchasima were the only two provinces in the Northeast where the larger proportion of non-glutinous rice was consumed (Table 7). Surin people preferred KDML 105 to RD 15, while Nakhonratchasima people consumed RD 15. These two provinces also had large numbers of largest private rice mills in the country.

The cultivars RD8, RD10 and NSPT, all are glutinous rice, were less significant in terms of planted areas and market demand. They were continued being used for planting because of specific need, and compatibility with farmers’ cropping systems.

5. Farmer assessment on RD 6 and KDML 105 rice cultivars

Two rice cultivars, RD 6 and KDML 105, were the most popular rice cultivars in the Northeast. Rd 6 represented the home consumption rice, while KDML 105 was well known for export rice.

Farmers preferred RD 6 because of its supreme grain quality. Farmers would normally give the highest ranking to the grain quality for the varieties used as home consumption (Table 8). Therefore any new glutinous rice cultivars introduced should have comparable grain quality as RD6 for acceptance. Farmers in Loei province indicated that local price of RD 6 was relatively higher than other glutinous cultivars, thus superior grain quality and high price provided good incentive for farmers to select RD 6 for planting.

The yielding performance of RD 6 was assessed differently among farmers in 12 provinces. About 40 percent of farmers from Nongkai and Khon Kaen indicated that RD 6 was high yielder. Incidentally, larger proportion of farmers in the Upper Northeast considered RD 6 as a high yielder than farmers from the Lower Northeast (Table 8). This observation might be indicative of better adaptation of RD 6 in the Upper Northeast than the Lower Northeast.

The undesirable characteristics of RD 6 as identified by farmers were susceptible to insects and lodging (Table 9). Diseases were more prevalent in Mahasarakham province as distinctively indicated by farmers. Nearly all provinces had problem of seed purity. Farmers thought of such character as “mutation”. In fact seed quality had recently become big problem, and most farmers, particularly commercial rice farmers, would not keep their own seed as traditionally practiced. The DOAE had come out with community rice seed production and extension program, which had been implemented in 2001. The program attempted to capacitate local faming community to achieve demand of quality rice seed, and to enable the extension of quality seed to the neighbouring communities. However the success of the program remained to be seen. (The program was considered successful by the Ministry of Agriculture and Cooperatives among many programs launched by the MOAC during the first two years of the Taksin Administration, June 2003).

The advantage of growing KDML 105 for market was because of its high price, when compared to other non-glutinous rice cultivars (Table 10). The KDML 105 rice had been branded as national pride for premium quality export rice, and internationally known as “Hom Mali”. The Lower Northeast was considered the home of “Hom Mali”. It is widely adapted, even in the saline affected soils. However, the cultivar was susceptible to lodging, leaf and neck blast, and insect pests (gall midge), as indicated by farmers as shown in Table 11.

6. Cultural practices

6.1 Land preparation and planting method.

Over 80 percent of farmers ploughed their lands twice before planting (Table 12). The system was found to be similar throughout the Northeast and the Upper North. The first ploughing was to turn over the soil and eradicate the weedy species. The field was either flooded or exposed to decompose all the weedy biomass. The second ploughing was to harrow the soil to facilitate land leveling before planting.

Transplanting method was still a common planting method in the Northeast, but broadcasting technique was becoming more pronounced in a few provinces such as Yasothon and Nakhonratchasima (Table13).

6.2 Nutrient management.

Traditionally, the rainfed farmers in the Northeast seldom applied chemical fertilizers. Instead, animal manure was used. The promotion of commercial rice production by DOAE and the private sectors had encouraged farmers to increase the use of chemical fertilizers. However, as discussed earlier, rice soils in the Northeast were more sandy soils, the Department of Land Development (DLD) had promoted the use of green manure and cover crops

(GMCCs), notably *Sesbania rostrata*, cowpea, mungbean, sword bean, etc. to improve fertility and productivity of rice soils in the Northeast.

Table 14 shows that farmer management of soil nutrient in rice production was chemically based, either sole use of chemical fertilizers (56.5 percent), chemical fertilizers mixed with manures (41.8 percent), or a small proportion of farmers incorporating chemical fertilizers with GMCCs.

Farmers in most provinces had adopted split applications of fertilizer, preferably two times (Table 15). Higher proportion of farmers in Loei (64 percent) and Udonthani (57 percent) of the Upper Northeast still preferred one application. The practice of one time application would be less effective. When the choice of rice cultivars to be planted was limited, one approach of improving productivity was through the efficient use of fertilizers. Therefore extension of appropriate use and application method of fertilizers should receive high priority in the Northeast.

About 40 percent of farmers applied basal fertilizers at the rate of 11 to 20 kg/rai (Table 16). Those who used more than 20 kg/rai of chemical fertilizers accounted for about 39 percent. It was often observed that the commercial rice farmers would use higher rate of fertilizers when the price of rice was attractive. Farmers who used less than 10 kg/rai of fertilizers as basal application would less likely to achieve high yield.

The common types of chemical fertilizers used as basal were mainly compound fertilizers such as 15-15-15, 16-16-8, 16-8-8, 18-12-6, and 16-20-0. Traditionally, 16-20-0 was general grade recommended by DOA and DOAE throughout the country. Recently, for sandy soil in the Northeast, new form of fertilizers being recommended and made available by private companies. Table 17 shows that about 51 percent of farmers used 16-16-8 as basal fertilizer, replacing the 16-20-0, which was still used by about 14 percent of rice farmers. The compound fertilizer 16-8-8, which cost less than 16-16-8, were used more by farmers in Nakhonratchasima and Khon Kaen. The 15-15-15 fertilizer, which had been reported being widely used during the Farmer May Workshop 2001, was found to be less popular, with only 9 percent. Change in fertilizer use was rapid, particularly when rice was grown more for commercial purpose.

The second application was at the stage of panicle initiation. Here most farmers (43.5 percent) used about 10 or less than 10 kg/rai (Table 18). About 34 percent of farmers used 11 to 20 kg/rai. But farmers continued to use the same types of fertilizers as they were as basal, preferably 16-16-8 (Table 19). DOA and DOAE would recommend urea (46-0-0) for the second application at the rate of 10 kg/rai. Therefore in general the nitrogen rate in the second application was considered being lower than the recommended.

6.4 Weed management.

In the rainfed environment, weed is inherent problem of rice production. In the Northeast, about 67 percent of rice farmers practiced weed control (Table 20). Forty percent of farmers controlled rice weed by hand weeding, and about 20 percent used herbicide. But in Loei province, more than 50 percent of rice farmers adopted herbicides as weed control practice. Farmers in Loei province were more accustomed to herbicide use, as the practice was common among the farmers in both dry land farming of soybean, cotton, cassava and maize. Majority of rice farmers were also the upland farmers, so the information flow between the two groups would get across more readily.

6.5 Incidences of insect pests and diseases.

Farmers reported that damage from insect pests was more serious than from diseases, particularly in Sakonnakhon, Chaiyaphum and Nongkai, where 72 to 85 percent of farm households reported to be affected by insect pest damage (Table 21). The frequency of pest outbreak varied from province to province. For instance, in Sakonnakhon, although the damage was more widely distributed, the outbreak occurred only 1 to 3 times in 10 years (Table 21) by rice stem borer and thrips (Table 23). In Nakhonphanom, about 44 percent of rice farmers stated that pest outbreak occurred more than 6 times in 10 years. The key pests were rice stem borer and thrips, while brown plant hopper was not widely spread, only four provinces reported to have the incidence.

Two provinces in the Upper Northeast, Khon Kaen and Nongkai, reported to have disease outbreak over 50 percent of farm households (Table 22), with frequency of occurrence of 1 to 3 times in 10 years (Table 22). The main diseases were leaf blast and neck blast, of which the former was more widespread than the latter (Table 23).

6.6 Rodents and crab.

About 51 percent of farm households reported to have their rice fields damaged by crab and rodents (Table 24). Crab damage was normally occurred in the early stage of growth before the rice stem became strong. Younger stems were more vulnerable to crab, in some instance, rice regrowth could be achieved, but growth would be uneven. Rodents could attack at the tillering as well as maturing stage. Damage would be more serious than crab damage. The DOA and DOAE did not consistently implement rodent control in rice. The common recommendation for rodent control was by using poisonous baits.

6.7 Rice harvesting.

The surveyed areas in 12 provinces revealed that on average 91 percent of farm households still had their rice harvested by hand (Table 25). Rice farmers in Loei, Nakonphanom and Nakonratchasima had contracted their rice harvest by combined harvester. In fact, the main production areas of Hom Mali rice (KDML 105 and RD 15) in Thung Kula Rong Hai in the Lower Northeast, farmers increasingly used the hired service of combined harvester to harvest their rice.

6.8 Rice grain yield.

The overall rice yield was low, averaging 374 kg/rai (Table 26). Only three provinces namely Mahasarakham, Loei, and Yasothon, had rice yield higher than 400 kg/rai, with Loei was the top yielder of 505 kg/rai.

7. Production cost and economic return

The rainfed lowland rice farmers in the Northeast invested on their rice production annually about 12,353 Baht/household (Table 27), with a range from 6,011 Baht/household in Loei to 26,576 Baht/household in Surin. This represented the total variable cost consisting of hired labour, and material inputs (seed, fertilizers, herbicides and pesticides as shown in Table 28). When the average rice planted areas per household of 15.8 rai as shown in Table 31 were considered, the variable cost for rice production would average 781 Baht/rai, which was lower than what had been found in the Upper North.

The household income derived from rice sale averaged 17,521 Baht, with a range from 10,179 Baht in Roi-Et to 33,093 Baht/household in Yasothon (Table 29). The overall income from rice could be considered being low, only farmers in two provinces, Surin and Yasothon, could achieve rice income more than 30, 000 Baht/year. Udonthani and Nakhonratchasima had the rice income between 22,000 and 23,000 Baht/year, while the rest of the provinces earned income from rice less than 20,000 Baht/year.

8. Rice in household economy

If the subsistence rice production system is defined as the system upon which less than 50 percent of product is marketed, then the household survey studies in 12 provinces revealed that 5 provinces were under subsistence production. This would include Chaiyaphum, Khon Kaen, Mahasarakham, Loei, and Roi Et. It was found that the main rice exporting provinces were from the Lower Northeast, notably, Surin, Yasothon and Nakhonratchasima, where 86 to 98 percent of households engaged in commercial rice production (Table 30).

Table 32 shows that income from rice constituted about 54 percent (17,521Baht) of income from farming, which had a total of 32,375 Baht. In general, income from rice was higher than incomes from upland crops (7,360 Baht), and from livestock (7,495 Baht). Three provinces, Mahasarakham, Roi-Et, and Nakhonphanom, showed incomes from upland crops comparable to that of rice. One province, Chaiyaphum, had income from livestock similar to that from rice.

The total income of farm households in the Northeast, averaging 67,131 Baht as shown in Table 33, indicated that income derived from off-farm employment (52 percent) was slightly higher than that obtained from farming (48 percent). Only four provinces, Khon Kaen, Roi-Et, Nongkai, and Loei showed higher incomes from off-farm, ranging from 0.6 to 2.6 times, than that from on-farm, with Khon Kaen, being the highest. Yasothon, the province in the Lower Northeast, had the highest income from farming, averaging 60,902 Baht, about 2.4 times higher than the off-farm income. This amount of farm income mainly derived from rice (54 percent) and from livestock (40 percent).

When the income from rice was compared with income from off-farm, only two provinces, Surin and Yasothon, showed the higher income from rice. These two provinces from the Lower Northeast were well known for their Hom Mali rice production. Recently, Surin was the first province to be officially promoted for production of organic Hom Mali rice for export. This would add value to locally produced Hom Mali rice. In fact, farmers in Kut Chum district of Yasothon province, in collaboration with NGO, had produced organic rice for export.

General discussion and conclusion

The rainfed lowland ecosystems in the Upper North and the Northeast are the major producing areas of premium grade fragrant rice Hom Mali rice for export, and high quality glutinous rice for consumption and for domestic market. The rainfed lowland rice is dominated by a few varieties, notably, RD 6, KDML 105, and RD 15. The farmers' varietal preference would suggest that varietal selection should consider multiple criteria, such as productivity, stability, palatability, and market acceptability,

Despite the fact that the rainfed lowland ecosystems are diverse, and the farmers are heterogeneous, there are certain commonalities emerged from the farmers' basic production strategies. That two basic production goals are pronounced: subsistence and commercial rice farming, with generally referred to the following statements:

- What to produce and what rice varieties are best suited to the different rainfed lowland ecosystems?
- How to produce it? This would include, for instance, the choice of farming techniques, for instance cropping system, selection of suitable varieties, intensive use of inputs when there is window of opportunity, and the choice of production technologies. such as types of fertilizers, planting methods.

Since the rainfed lowland rice ecosystems are highly variable, where abiotic stresses (drought, submergence, nutrient deficiency) have greater impact in affecting rice productivity than the biotic stresses, farmers would generally follow basic production strategy of risk minimization. This would mean that the rainfed rice farming is affected by the existence of location specific constraints. Farming technique of intensive use of inputs in more favorable rainfed lowland would not be feasible and affordable in the drought stricken upper paddy. One would expect to obtain trade-offs, when farmers aim for stability, for instance by adopting double transplanting method in the drought-prone and flood-prone areas, certain level of productivity would be lowered. When assessing the effect of technological change in the lowland rice system, a whole farm system performance would be necessary.

The rural economy of the rainfed lowlands in the Upper North and the Northeast depends on the productivity and price stability of three rice varieties, RD 6, RD 15 and KDML 105. The rainfed lowland farmers have diversified livelihoods, earning their incomes from rice, upland crops, livestock, and off-farm employment. Income from rice contributes significantly to the household income particularly in the provinces where rainy rice is also planted as cash crop, such as Chiang Rai and Phayao in the Upper North, and the majority of the provinces in the Northeast. The estimation of cost and return of the lowland rice production reveals that the average economic return per unit area is small; the total rice income is derived from extensive production of larger planted areas. However the analysis does not take into account the quantity for household consumption.

The rainfed ecosystems are diverse; this would reflect the significance of location specific farming techniques and subsequent production technologies. This would also mean that a package of optimum production technology designed or selected and extended by researchers and extension officials once and for all would not be appropriate. In general, two production options are envisaged. The first would be yield-enhancing technology in the more favorable rainfed lowlands, where drought and submergence are less likely to occur. Improved nutrient-use efficiency technology in combination with varietal selection would help increase productivity. As pointed out by various authors, and summarized by Fischer (1998), that the rainfed lowland experienced repeated wetting and drying, accompanied by radical changes in soil chemistry caused by the shift from the oxidative to a reducing environment, would contribute to their uncertain fertility. Fertilizer placement and timing might improve nutrient-use efficiency, but unless the cultivar is responsive, farmers would not adopt more labor-intensive or costly practices.

The second would deal with productivity maintenance. This risk-minimizing approach would be appropriate in the drought-prone, and less favorable lowland environment. The principle is to maintain existing level of acceptable yield level with attempting to reduce production cost. Use of locally available resources, quality seed and agronomic practices based on thorough understanding of farm agroecosystem are necessary. The well proven IPM technology and bio-fertilizers made from local materials, which show promising results, should be extended through the farmer-field school learning approach. The farmer volunteers trained as soil consultants by the Department of Land Development or locally known as “soil doctor” are important resource persons, whom should be included in the rainfed lowland rice improvement process, as these people would help provide soil analysis services for better decision in fertilizer use, even detailed laboratory analysis has not yet performed. Other services include acquisition of seed material of various green manure legumes. Experimentally, the green manures are very good source of biologically fixed N, but large-scale adoption of green manures in rice farming has not been achieved. The DLD has now launched the nation-wide campaign on the use of green manures and other related soil improvement program.

The rainfed lowland farmers give the highest ranking on grain quality for varietal selection. Any promising high-yielding lines should be tested for grain quality in early generations in rice breeding programs to ensure that new high yielding lines also meet high grain quality standards (Romyen, *et al* 1998). It has been suggested that screening for drought resistant characters should be conducted in areas where soil conditions are representative of the region, and genotypes should be compared within each phenology group (Wonprasaid *et al.*1996). Early maturing cultivars are suitable for drought-prone upper paddy with low soil fertility. This is the case where farmers would select RD 15 for planting in the upper paddy, and KDML 105 in the lower paddy.

The field survey studies on bio-physical and socio-economic circumstances of rainfed lowland rice farmers indicate that the farmers are capable of identifying desirable rice characters suitable for their production environment. Their analysis of rice agroecosystem and their rice preferences provide sufficient information for planning the next stage of on-farm farmer participatory varietal selection. It is also recognized that during the research-farmer dialogue, bringing researchers into closer contact with the local processes of innovation and appreciation of local knowledge, formal research in plant breeding would be benefited. This research-driven farmer participatory plant breeding research would also increase the effectiveness of rainfed lowland rice improvement program, with the ultimate goal is to have positive impact on the livelihoods of rainfed lowland rice farmers, through the development of improved lowland rice cultivars and associated production technology.

ANNEX.

Table 1 The paddy field land type (% household) classified by the farmers of 12 provinces in Northeast Thailand

Province	**Land type**			
	upper paddy	Upper and lower	Lowland-unflooded	Lowland-flooded
Nakhonratchasima	54	26	20	-
Chaiyaphum	32	39	29	-
Khon Kaen	47	20	33	-
Mahasarakham	38	20	41	-
Loei	31	22	47	-
Roi-Et	43	17	40	-
Surin	33	32	35	-
Udontani	29	34	32	5
Sakonnakhon	35	13	55	-
Yasothon	33	18	44	5
Nongkai	21	40	37	3
Nakhonphanom	53	24	23	-
Average	37.4	25.4	36.3	1.1

Table 4 Frequency of the drought and flooding event (% household) of 10 years round reported by the farmers of 12 provinces in Northeast Thailand.

Province		***Drought***			**Flooding**		
	Occurrence (number)	1-3	4-6	>6	1-3	4-6	>6
Nakhonratchasima		40	46	14	83	17	-
Chaiyaphum		56	30	14	94	6	-
Khon Kaen		58	33	9	100	-	-
Mahasarakham		71	24	5	95	5	-
Loei		66	30	4	60	28	12
Roi-Et		56	32	12	58	32	10
Surin		70	26	4	75	25	-
Udontani		67	18	15	74	13	13
Sakonnakhon		76	18	6	61	21	18
Yasothon		73	19	8	75	19	6
Nongkai		58	20	22	44	23	33
Nakhonphanom		81	14	5	42	35	23
Average		64.3	25.8	9.8	71.8	18.7	9.6

Table 5 The crop growth stage (% houslehold) was subjected to drought and flooding reported by the farmers of 12 provinces in Northeast Thailand.

Province	Growth stage	*Drought*					Flooding		
		P	T	PI	GF	A	T	PI	GF
Nakhonratchasima		11	25	4	4	56	-	100	-
Chaiyaphum		14	29	12	3	42	8	25	22
Khon Kaen		19	30	3	-	48	38	62	-
Mahasarakham		19	34	4	3	40	45	55	-
Loei		30	34	18	5	13	75	25	-
Roi-Et		24	44	18	6	8	95	5	-
Surin		24	40	3	1	32	60	20	20
Udontani		20	54	20	5	-	92	8	-
Sakonnakhon		20	53	20	7	-	80	20	-
Yasothon		12	55	12	5	16	42	30	28
Nongkai		11	20	25	20	24	76	24	-
Nakhonphanom		22	56	17	5	-	68	26	6
Average		18.9	39.5	13.0	5.3	23.3	56.6	33.3	6.3

P = Planting (caused delay planting)

T = Tillering

PI = Panicle initiation

GF = Grain filling

A = All growth stage

Table 6 Rice cultivars (% household) grown by the farmers of 12 provinces in Northeast Thailand

Province	**Cultivars**						
	RD 6	RD 8	RD 10	RD 15	KDML 105	NSPT	local
Nakhonratchasima	36	1	-	42	21	-	-
Chaiyaphum	57	-	3	12	18	5	5
Khon Kaen	82	3	-	7	8	-	-
Mahasarakham	80	-	-	15	-	5	-
Loei	48	17	3	10	4	-	18
Roi-Et	77	-	-	1	20	1	1
Surin	-	-	-	35	60	-	5
Udontani	88	-	2	-	6	2	2
Sakonnakhon	67	-	3	-	23	3	4
Yasothon	43	5	-	9	37	6	-
Nongkai	79	9	4	3	-	2	3
Nakhonphanom	39	8	5	4	29	2	13
Average	58	3.6	1.8	11.5	18.8	2.2	4.3

Table 7 Preference RD 6 rice cultivars (% household) by the farmers of 12 provinces in Northeast Thailand

Province	**Preference**							
	GD	LP	HT	HY	DR	PR	GQ	HP
Nakhonratchasima								
Chaiyaphum	5	-	-	28	-	-	67	-
Khon Kaen	7	6	-	43	5	-	30	9
Mahasarakham	-	-	-	30	-	-	70	-
Loei		-	-	19	-	-	59	22
Roi-Et	15	6	14	19	-	-	37	9
Surin				-	-	-		
Udontani	-	-	-	11	-	-	89	-
Sakonnakhon	11	-	-	12	-	-	77	
Yasothon	-	-	-	5	-	-	95	-
Nongkai	-	-	-	42	-	-	58	-
Nakhonphanom	15	-	-	29	-	-	56	-
Average	5.3	1.2	1.4	23.8			63.8	4.0

Note :

GD = Growth duration

LP = Large panicle

HT = High tillering

HY = High yield

DR = Drought resistant

PR = Pest resistant

GQ = Good guality

HP = High price

Table 8 Non-preference RD 6 rice cultivars (% household) by the farmers of 12 provinces in Northeast Thailand

Province	Non-preference					
	LG	SD1	SI	SD2	MV	NUM
Nakhonratchasima	-	-	-	-	-	-
Chaiyaphum	30	56	-	-	14	-
Khon Kaen	21	24	35	-	20	-
Mahasarakham	25	25	50	-	-	-
Loei	75	19	-	-	6	-
Roi-Et	13	51	5	-	31	-
Surin	-	-	-	-	-	-
Udontani	20	50	12	-	18	-
Sakonnakhon	23	20	16	-	32	9
Yasothon	42	58	-	-	-	-
Nongkai	13	65	-	-	19	-
Nakhonphanom	27	36	-	17	20	-
Average	28.9	40.4	21.8	1.7	16.0	0.9

Note :

LG = Lodging

SD1 = Susceptible to disease

SI = Susceptible to insect

SD2 = Susceptible to drought

NUM = Non umiform maturity

MV = Mutation variety

Table 9 Preference KDML 105 rice cultivar (% household) by the farmers of 12 provinces in Northeast Thailand.

Province	**Preference**							
	GD	LP	HT	HY	DR	PR	GQ	HP
Nakhonratchasima	-	-	-	-	-	-	-	-
Chaiyaphum	-	-	-	6	-	-	-	94
Khon Kaen	-	-	-	-	5	-	5	90
Mahasarakham	-	-	-	-	-	-	-	-
Loei	-	-	-	-	-	-	-	-
Roi-Et	-	-	-	8	-	-	2	80
Surin	-	-	-	8	-	-	-	82
Udontani	-	-	-	-	-	-	-	-
Sakonnakhon	-	-	-	-	-	-	13	87
Yasothon	-	-	-	11	-	-	-	89
Nongkai	-	-	-	-	-	-	-	-
Nakhonphanom	-	-	-	11	-	-	-	89
Average	-	-	-	6.2	0.71	-	2.9	87.3

Note :

GD = Growth duration

LP = Large panicle

HT = High tillering

HY = High yield

DR = Drought resistant

PR = Pest resistant

GQ = Good guality

HP = High price

MA = Market available

Table 10 Non-preference KDML 105 rice cultivar (% household) by the farmers of 12 provinces in Northeast Thailand

Province	Non-preference			
	LG	SD1	SI	SD2
Nakhonratchasima	-	-	-	-
Chaiyaphum	29	22	31	18
Khon Kaen	38	30	29	3
Mahasarakham	-	-	-	-
Loei	-	-	-	-
Roi-Et	43	32	11	14
Surin	47	33	10	10
Udontani	-	-	-	-
Sakonnakhon	51	29	18	2
Yasothon	42	28	21	9
Nongkai	-	-	-	-
Nakhonphanom	54	24	18	4
Average	43.4	28.3	19.7	8.6

Note :

LG = Lodging

SD1 = Susceptible to disease

SI = Susceptible to insect

SD2 = Susceptible to drought

Table 11 Rice cultivar (% household) for home consumption and marketing of the farmers 12 provinces in Northeast Thailand

Province		Consumption				Marketing			
	Rice cultivars	RD6	RD15	KDML 105	other	RD6	DR15	KDML 105	other
Nakhonratchasima		63	37	-	-	3	55	42	-
Chaiyaphum		89	-	11	-	22	15	63	-
Khon Kaen		95	-	-	5	47	30	23	-
Mahasarakham		98	-	-	2	90	10	-	-
Loei		51	-	-	49	39	15	10	36
Roi-Et		92	-	5	3	8	7	85	-
Surin		-	32	62	6	-	36	63	1
Udontani		89	-	11	-	67	-	20	13
Sakonnakhon		81	-	13	6	11	-	87	2
Yasothon		78	-	16	6	16	-	84	-
Nongkai		79	-	-	21	69	21	-	-
Nakhonphanom		60	-	16	24	-	8	92	-
Average		72.9	5.8	11.2	10.2	31.0	16.4	47.4	4.3

Table 12 Land preparation (% household) by the farmers of 12 provinces in Northeast Thailand

Province	Plowing number			
	1	2	3	4
Nakhonratchasima	4	83	13	-
Chaiyaphum	31	67	2	-
Khon Kaen	15	74	9	2
Mahasarakham	11	89	-	-
Loei	-	99	1	-
Roi-Et	-	95	5	-
Surin	-	92	8	-
Udontani	2	98	-	-
Sakonnakhon	11	89	-	-
Yasothon	4	88	8	-
Nongkai	8	85	7	-
Nakhonphanom	11	89	-	-
Average	8.1	87.3	4.4	0.17

Table 13 Planting method (% household) by the farmers of 12 provinces in Northeast Thailand

Province	**Broadcasting**	Transplanting
Nakhonratchasima	25	75
Chaiyaphum	8	92
Khon Kaen	11	89
Mahasarakham	2	98
Loei	3	97
Roi-Et	13	87
Surin	8	92
Udontani	5	95
Sakonnakhon	3	97
Yasothon	39	61
Nongkai	9	91
Nakhonphanom	2	98
Average	10.7	89.3

Table 14 Fertilizer sources (% household) application to rice by the farmers of 12 provinces in Northeast Thailand

Province	**Fertilizer sources**		
	Chemical	Chemical+Manure	Che+Green manure
Nakhonratchasima	67	33	-
Chaiyaphum	90	10	-
Khon Kaen	87	10	3
Mahasarakham	47	53	-
Loei	38	62	-
Roi-Et	48	50	2
Surin	48	48	4
Udontani	73	25	2
Sakonnakhon	28	66	6
Yasothon	20	78	2
Nongkai	89	11	-
Nakhonphanom	43	55	2
Average	56.5	41.8	1.8

Table 15 Time of chemical fertilizer application (% household) to rice by the farmers of 12 provinces in Northeast Thailand

Province	Time of application (number)		
	1	2	3
Nakhonratchasima	-	100	-
Chaiyaphum	42	53	6
Khon Kaen	34	66	-
Mahasarakham	23	77	-
Loei	64	36	-
Roi-Et	10	82	8
Surin	19	78	3
Udontani	57	43	-
Sakonnakhon	28	72	-
Yasothon	12	82	6
Nongkai	30	70	-
Nakhonphanom	38	56	6
Average	29.7	67.9	2.4

Table 16	Chemical fertilizer rates (% household) applied to rice at basal by the farmers of 12 provinces in Northeast Thailand

Province	Fertilizer rate (kg/rai)			
	1-10	11-20	21-30	>30
Nakhonratchasima	4	38	42	16
Chaiyaphum	10	30	43	17
Khon Kaen	26	47	16	11
Mahasarakham	5	46	36	13
Loei	26	43	17	14
Roi-Et	21	28	38	13
Surin	13	21	27	39
Udontani	38	52	8	2
Sakonnakhon	18	50	24	8
Yasothon	20	31	35	14
Nongkai	39	48	9	4
Nakhonphanom	33	43	18	6
Average	21.1	39.8	26.1	13.1

Table 18 Chemical fertilizer rates (% household) applied to rice at panicle initiation growth stage by the farmers of 12 provinces in Northeast Thailand

Province	Fertilizer rate (kg/rai)			
	1-10	11-20	21-30	>30
Nakhonratchasima	36	33	26	4
Chaiyaphum	45	28	17	10
Khon Kaen	30	42	20	8
Mahasarakham	20	44	25	11
Loei	49	38	13	-
Roi-Et	19	48	33	-
Surin	22	33	24	21
Udontani	52	29	16	3
Sakonnakhon	60	28	12	-
Yasothon	58	36	3	3
Nongkai	65	30	5	-
Nakhonphanom	67	23	9	-
Average	43.5	34.3	16.9	5.0

Table 17 Chemical fertilizer formular (% household) applied to rice at basal by the farmers of 12 provinces in Northeast Thailand

Province	**Fertilizer formular**					
	15-15-15	16-16-8	16-8-8	18-12-6	16-20-0	Others
Nakhonratchasima	-	8	47	24	13	8
Chaiyaphum	35	6	4	-	31	24
Khon Kaen	6	36	34	-	10	14
Mahasarakham	4	62	28	-	5	1
Loei	14	3	-	-	52	31
Roi-Et	3	91	-	-	3	2
Surin	-	80	20	-	-	-
Udontani	7	48	25	-	12	8
Sakonnakhon	5	69	6	-	5	15
Yasothon	7	75	3	-	7	8
Nongkai	21	58	1	-	16	4
Nakhonphanom	3	76	4	-	9	8
Average	8.8	51.0	14.3	2.0	13.6	10.3

Table 19 Chemical fertilizer formular (% household) applied to rice at panicle initiation by the farmers of 12 provinces in Northeast Thailand

Province	Fertilizer formular					
	15-15-15	16-16-8	16-8-8	18-12-6	16-20-0	Others
Nakhonratchasima	8	13	42	19	6	12
Chaiyaphum	40	13	10	-	22	15
Khon Kaen	14	26	33	-	17	10
Mahasarakham	16	43	38	-	-	3
Loei	9	-	-	-	32	59
Roi-Et	8	69	12	-	5	6
Surin	16	65	19	-	-	-
Udontani	27	50	12	-	8	3
Sakonnakhon	13	58	4	-	2	23
Yasothon	27	56	-	-	6	11
Nongkai	32	35	12	-	9	12
Nakhonphanom	21	55	5	-	4	15
Average	19.3	38.6	15.6	1.6	9.3	14.1

Table 20 Weed control (% household) by the farmers of 12 provinces in Northeast Thailand

Province	Weed control			Unweeded
	Manueal	Chemical	M+C	
Nakhonratchasima	39	33	-	28
Chaiyaphum	47	14	6	33
Khon Kaen	34	23	5	38
Mahasarakham	30	11	5	54
Loei	8	50	7	34
Roi-Et	30	17	10	43
Surin	50	22	9	19
Udontani	23	20	5	52
Sakonnakhon	69	8	4	20
Yasothon	61	11	11	17
Nongkai	21	26	17	36
Nakhonphanom	71	3	-	26
Average	40.2	19.8	6.6	33.3

Table 21 Insect damage to rice (% household) of 10 years round reported by the farmers of 12 provinces in Northeast Thailand

Province	None	Damage	Outbreak frequency		
			1-3	4-6	>6
Nakhonratchasima	31	69	32	34	34
Chaiyaphum	22	78	46	32	22
Khon Kaen	44	56	53	20	27
Mahasarakham	44	56	60	13	27
Loei	69	31	67	29	4
Roi-Et	64	36	45	42	13
Surin	56	44	49	20	31
Udontani	40	60	55	38	7
Sakonnakhon	15	85	75	21	4
Yasothon	58	42	64	31	5
Nongkai	28	72	40	43	17
Nakhonphanom	34	66	27	29	44
Average	42.1	57.9	51.1	29.3	19.6

Table 22 Disease damage to rice (% household) of 10 years round reported by the farmers of 12 provinces in Northeast Thailand

Province	None	Damage	Outbreak frequency		
			1-3	4-6	>6
Nakhonratchasima	62	38	76	16	8
Chaiyaphum	55	45	71	18	11
Khon Kaen	45	55	55	16	16
Mahasarakham	65	35	57	29	14
Loei	73	27	58	34	8
Roi-Et	94	6	82	18	-
Surin	72	28	55	27	18
Udontani	70	30	58	29	13
Sakonnakhon	51	49	61	25	14
Yasothon	90	10	79	16	5
Nongkai	50	50	68	3	30
Nakhonphanom	66	34	72	19	9
Average	66.0	33.9	66.0	21.8	12.2

Table 23 Major insect and diseases species damage to rice (% household) reported by the farmers of 12 provinces in Northeast Thailand

Province	Insects			Diseases	
	Stem borer	thrip	Brown plant hopper	Blast	Nect blast
Nakhonratchasima	51	39	-	66	13
Chaiyaphum	32	58	-	48	21
Khon Kaen	42	15	-	50	19
Mahasarakham	52	43	-	56	28
Loei	42	56	-	51	21
Roi-Et	54	34	-	44	36
Surin	45	27	8	56	32
Udontani	46	40	-	43	36
Sakonnakhon	51	41	8	55	31
Yasothon	64	12	10	58	16
Nongkai	54	-	-	81	22
Nakhonphanom	28	29	14	71	18
Average	46.8	32.8	3.3	56.6	24.4

Table 24 Rat and crab damaged to rice (% household) reported by the farmers of 12 provinces in Northeast Thailand

Province	Rat	Crab	Rat + Crab	Other
Nakhonratchasima	21	12	64	3
Chaiyaphum	29	8	49	14
Khon Kaen	18	2	67	13
Mahasarakham	20	4	45	37
Loei	25	10	40	25
Roi-Et	15	22	38	25
Surin	9	5	67	19
Udontani	19	6	69	6
Sakonnakhon	18	11	64	7
Yasothon	14	39	38	9
Nongkai	20	7	32	41
Nakhonphanom	21	35	33	11
Average	19.1	13.4	50.5	17.5

Table 25 Rice harvesting method (% household) by the farmers of 12 provinces in Northeast Thailand

Province	Manual	Machine
Nakhonratchasima	85	15
Chaiyaphum	98	2
Khon Kaen	97	3
Mahasarakham	100	-
Loei	66	34
Roi-Et	93	7
Surin	92	8
Udontani	90	10
Sakonnakhon	96	4
Yasothon	97	3
Nongkai	100	-
Nakhonphanom	79	21
Average	91.0	8.9

Table 26 Average rice yield obtained by the farmers of 12 provinces in Northeast Thailand in year 2000

Province	Average yield (kg/rai)
Nakhonratchasima	342
Chaiyaphum	384
Khon Kaen	328
Mahasarakham	455
Loei	505
Roi-Et	357
Surin	387
Udontani	344
Sakonnakhon	397
Yasothon	410
Nongkai	297
Nakhonphanom	286
Average	374

Table 27 Rice selling year round (% household) reported by the farmers of 12 provinces in Northeast Thailand

Province	Selling	None
Nakhonratchasima	86	14
Chaiyaphum	30	70
Khon Kaen	44	56
Mahasarakham	44	56
Loei	47	53
Roi-Et	42	58
Surin	98	2
Udontani	80	20
Sakonnakhon	65	35
Yasothon	94	6
Nongkai	53	47
Nakhonphanom	89	11
Average	64.3	35.7

Table 31 Land holding for rice production of the farmers of 12 provincer in Northeast Thailand

Province	Minimum	Maximum	Average
	Rai/household		
Nakhonratchasima	4	81	28
Chaiyaphum	2	54	20
Khon Kaen	3	50	13
Mahasarakham	0.8	50	10
Loei	0.7	17	5
Roi-Et	3	39	12
Surin	3	70	23
Udontani	5	77	16
Sakonnakhon	1	58	13
Yasothon	2	55	17
Nongkai	3	54	22
Nakhonphanom	1	30	11
Average	2.4	52.9	15.8

Table 28 Average rice cash income of the farmers of 12 provinces in Northeast Thailand

Province	Cash income (baht/household)
Nakhonratchasima	23,958
Chaiyaphum	15,184
Khon Kaen	10,549
Mahasarakham	15,953
Loei	10,177
Roi-Et	10,079
Surin	31,925
Udontani	22,675
Sakonnakhon	14,040
Yasothon	33,093
Nongkai	11,648
Nakhonphanom	10,966
Average	17,521

Table 29 Average variable cost for rice production of the farmers of 12 provinces in Northeast Thailand

Province	Variable cost (baht/household)
Nakhonratchasima	18,562
Chaiyaphum	12,120
Khon Kaen	10,176
Mahasarakham	10,161
Loei	6,011
Roi-Et	11,886
Surin	26,576
Udontani	12,691
Sakonnakhon	8,767
Yasothon	15,840
Nongkai	8,964
Nakhonphanom	6,478
Average	12,353

Table 30 Materials cost for rice production of the farmers 12 provinces in Northeast Thiland

Province	Seed	Fertilizer	Herbicide	Pesticide
	baht/rai			
Nakhonratchasima	5	241	15	7
Chaiyaphum	13	179	17	8
Khon Kaen	8	192	12	8
Mahasarakham	6	245	22	6
Loei	24	52	49	11
Roi-Et	0.91	282	9	12
Surin	11	339	3	3
Udontani	5	111	4	4
Sakonnakhon	8	190	25	13
Yasothon	7.4	313	5	4
Nongkai	-	98	30	9
Nakhonphanom	20	201	0.62	3
Average	8.9	203.5	15.9	7.3

Table 32 Farm cash income of the farmers of 12 provinces in Northeast Thailand in year 2000

	baht/household			
Province	Rice	Upland crops	Livestocks	Total
Nakhonratchasima	23,958	11,839	8,427	44,224
Chaiyaphum	15,184	9,685	15,308	40,177
Khon Kaen	10,549	1,661	4,781	16,991
Mahasarakham	15,953	14,032	649	30,634
Loei	10,177	5,560	2,238	17,975
Roi-Et	10,079	10,415	9,840	30,334
Surin	31,925	1,110	4,442	37,477
Udontani	22,675	7,880	2,468	33,023
Sakonnakhon	14,040	2,296	5,627	21,963
Yasothon	33,093	3,189	24,620	60,902
Nongkai	11,648	8,780	8,267	28,695
Nakhonphanom	10,966	11,868	3,274	26,108
Average	17,521	7,360	7,495	32,375

Table 33 Total household income of the farmers of 12 province in Northeast Thailand in year 2000

Province	Farm income	Off-farm income	Total
	Baht/household		
Nakhonratchasima	44,224	40,886	85,110
Chaiyaphum	40,177	28,443	68,620
Khon Kaen	16,991	61,172	78,163
Mahasarakham	30,634	27,966	58,600
Loei	17,975	28,262	46,237
Roi-Et	30,334	63,612	93,946
Surin	37,477	22,361	59,838
Udontani	33,023	34,071	67,094
Sakonnakhon	21,963	16,210	38,173
Yasothon	60,902	17,814	78,716
Nongkai	28,695	54,191	82,886
Nakhonphanom	26,108	22,084	48,192
Average	32,375 (48%)	34,756 (52%)	67,131

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