Chapter IV

Results

4.1 Field Survey

The purpose of the field survey was to document farmer management diversity of rice under normal farming conditions, and to examine the level of diversity of rice cultivars grown under village conditions and at individual farmer level. The survey was undertaken in villages in an upland environment of Samneua district of Houaphanh province of Laos. The survey was conducted in April 2002 during the period of field fallow, prior to the opening of the wet- season rains. Benchmark information was collected from the total of 36 households involved in rice based agricultural production, while more general information was obtained by open meetings that involved representatives of most households in each village.

The general characteristics of households covered by the detailed survey are summarized in Table 2. Mean of rice cultivated area in Ban Lak Sipsong was 1.19 ha per household higher than two villages, and also higher in household size (about 8 persons). Rice cultivated per household in both Ban Kan and Ban Ong was similarly, but household size in Ban Kan was 7 persons higher than Ban Ong. Farm labor in Ban Lak Sipsong was 4 labors per household higher than 2 persons in Ban Kane and Ban Ong.

Table 2 Characterization of respondents in the three villages

Characterization	Descriptive Statistics			
	Min.	Max.	Mean	SD
1. Ban Ong (n=12)				
Interviewer age	23	70	40	13.73
Rice cultivated area (ha/hh).	0.3	1.8	0.84	0.40
Household size (Persons)	2	9	6	2.10
Farm labor	1	4	2	0.83
2. Ban Kan (n=12)				
Interviewer age	25	52	34	9.06
Rice cultivated area (ha/hh).	0.5	1.5	0.85	0.25
Household size (Persons)	5	10	7	1.62
Farm labor	2	4	2	0.70
3. Ban Lak Sipsong (n=12)				
Interviewer age	26	68	41	14.41
Rice cultivated area (ha/hh).	0.5	2.5	1.19	0.70
Household size (Persons)	3	12	8	3.02
Farm labor	2	7	4	1.65

Source: Survey April 2002

4.1.1 Description of each village

Three villages (Ban Kan, Ban Ong, and Ban Lak Sipsong) were selected for the study. These villages are located in Samneua district of Houaphanh province (Figure 2). Ban Kan is only 5 km, Ban Ong is 10 km, and Ban Lak Sipsong is about 12 km far from Samneua City. Ban Kan, Ban Ong are inherited by Lao Lum (lowland Lao), and Ban Kan Lak Sipsong is Lao Sung (highland Lao). Village location of Ban Kan and Ban Ong is about 900 masl, but Ban Lak Sipsong is about 1200 masl. Education status, there are completed primary schools (five years of studying) in Ban Kan and Ban Ong, while there is only 2 years of studying in Ban Lak Sipsong. All of these villages do have electricity availability. Most villagers depend on agricultural productions and forest products for their livelihoods.

The population of the three villages covered by the survey was 634, being divided among 95 households (Table 3). The largest village was Ban Ong with 279 people divided among 42 households, while the smallest was Ban Lak Sipsong with 142 people divided among 21 households. The large household size was in Ban Lak Sipsong with 6.7 persons per household, while Ban Ong and Ban Kan as the same with 6.6 persons per household.

Table 3 Population in the study area.

Village	Households	Population	Average household size
1. Ban Kan	32	213	6.6
2. Ban Ong	42	279	6.6
3.Lak Sipsong	21	142	6.7
Total	95	634	

Source: Field survey, 2002

4.1.2 Agricultural systems

Agricultural production in these villages based on traditional farming system, small planted area, low external inputs application, and intensive labor use. The purpose of agricultural production is to meet the consumption of family demand, and surplus of product for sale.

According to Lao government policy, In general arable land has to be allocated for individual households. However, utilization of land in lowland rice can be separated into two cases: Firstly, which field was expanded before in 1975 is a community property because of under law condition. The agriculture cooperative organization was demonstrated in 1976 after changing of the Lao politic from French' colonial to become Lao independent. Agricultural land allocation under this condition is often allocated in annually depending on farmers' agreement in each village. Secondly, the lowland rice area where was expanded after 1975 by own farmers could be their own property. But there have been less seen in second form because of limited new area availability with higher investment in term of irrigation system construction.

Rice is dominant crop grown in each of the three villages, accounting for an average 68 % of the cultivated area, with the village of Ban Ong having of 82% of cultivated committed to rice, and village of Ban Lak Sipsong 53% (Table 4). The second most important is maize, accounting for 14% of the area, with the village of Ban Lak Sipsong having 28% of the area committed to maize. Other important crops are cucumber (9% 0f the area), pepper (6%), and garlic (5%).

Rice is only grown as a wet- season crop, with upland rice being sown within rains in May, and lowland crops in June. Harvesting is completed in November for lowland rice crops, and in September – October for most upland rice crops. In general, maize is planted in March and harvested in July. Maize is usually used to be feed animals (particularly pigs) rather than for direct consumption or sale. Pepper is grown for household consumption requirements and is usually sown in late March in areas close to the lowland rice fields. Cucumber has become a cash crop in the two villages of Ban Kane and Ban Lak Sipsong.

In the case of Ban Kan, cucumber is grown in February close to the village, while in Ban Lak Sipsong it is grown in the same field and at the same time as the upland rice. In the case of both Ban Kan and Ban Lak Sipsong, the main market for cucumber is the provincial city of Samneua. Garlic is usually grown after the harvest of the rice (in December) and is mainly used for household consumption rather than for sale.

Table 4 Crop cultivated area in villages in the study area

Crop	Cultivated area (ha)			
	Ban Kan	Ban Ong	Ban Lak Sipsong	Total
1. Rice	16.60	20.00	9.50	46.10
	65%	82%	53%	68%
2. Maize	2.70	2.00	5.00	9.70
	11%	8%	28%	14%
3. Pepper	2.70	0.50	0.30	3.50
	11%	2%	2%	5%
4. Cucumber	2.50	0.50	3.00	6.00
	10%	2%	17%	9%
5. Garlic	1.00	1.50	0.00	2.50
	4%	6%	-	4%
Total	25.50	24.50	17.80	67.80

Source: Survey April 2002.

4.1.3 Rice Varieties

There were 19 varieties found growing and maintained by farmers in these communities. Number of varieties ranged from 6 to 12 per a village (Table 5). I found that, most of varieties are glutinous types, only three of non-glutinous of Kaolai (KL), Kaochaodang (KCD), and Kaochaohang (KCH) varieties were found. Farmers in Ban Ong and Ban Kan grow these non-glutinous varieties only for sale, but farmers in Ban Lak Sipsong grow for consumption because villagers in this village prefer to consume both non-glutinous and glutinous types. Three non-glutinous varieties were found only under shifting cultivation condition.

Table 5 Number of rice varieties found in Ban Kan, Ban Ong, and Ban Lak Sipsong

Village	Endosperm Type		Total
	Non-glutinous	Glutinous	
Ban Kan	1	11	12
Ban Ong	2	7	9
Ban Lak Sipsong	1	5	6

Source: survey April 2002.

Farmer management of varietal diversity has been normal still seen in this area because they have grown several traditional varieties with maintaining and selecting varieties by themselves. Totally households rely on their own seed selection from their fields. Based on household survey, number of varieties per household range from 1 to 5 varieties. Thirteen, and seven percent of total respondents in Ban Kan and Ban Ong grow 5 varieties in a season (Table 6). However, higher percentage of household held 2 varieties in Ban Kan, and Ban Ong. While number of varieties per household in Ban Lak Sipsong held at 3 varieties. When farmers were asked their reasons for growing several varieties, most of them told that minimizing of all risks such as insects, diseases, and insufficient rice consumption annually as well as conserve for next season. Unknown various changes of climatic condition during crop season seem to be main reason in growing of several varieties. However, some farmers in Ban Kan reasoned that preference of rice to make alcohol. For instance, Kaokum (KK) variety is grown for alcohol making, farmers believes that product from this variety can be used for folk medicine.

Table 6 Number of rice varieties grown by a household

N. Variety	Percent of household involved		
	Ban Kan N= 32 respondents	Ban Ong N=42 respondents	Ban Lak Sipsong N= 21 respondents
5	13	7	0
4	15	21	0
3	31	17	76
2	41	48	19
1	0	7	5

Source: survey April 2002.

The Margalaf index was used to calculate varieties richness found in each village. Value of index was 1.48 lower in Ban Lak sipsong and 2.63 higher in Ban Kan (Table 7). The highest level of rice varieties was found in Ban Kan (12 varieties) and also higher level of varieties per household, on average are 3 varieties per household. In Ban Kan all of households grow in combination of upland rice and lowland rice.

Table 7 Varieties richness in the study area

N0.	Village	Number of Variety	Avr. Var/hh	Margalaf index	Respondents
1	Ban Ong	9	2.73	1.89	42
2	Ban Kan	12	3.00	2.63	32
4	Ban Lak Sipsong	6	2.71	1.48	21

Source: Survey, April 2002.

4.1.4 Variety Adaptation and Seed lots management

Seed flow refers to exchange and transport of germplasm within or between villages. First of the four components of farmers' management diversity is that, seed flows of farmers in study area has been seen among farmers within village and across village, district, and provincial lines. But mostly often seen within relative in the village. Secondly, variety selection, this process could be seen as farmer's decision to

maintain, incorporate or discard a variety to be planted in a particular growing season. Many criteria of selection such as to plant for marketing, for a good quality eating, wide soil fertility adaptation, lodging resistance, drought resistance, and earlier maturity. Decision-making depends on household economic status, farm labor, and individual farmer preference as well as farm size.

Variety adaptation, because of high variation of climate and geography conditions, farmers have maintained several varieties those well performance in different soil conditions or ecosystems. For instance, Kainoyhai (KNH) variety is suitable and better performs in higher sea level and colder climate in Ban Lak Sipsong, while Kaopu (KP) in Ban Kan performs well in the infertile soil, both of them is glutinous upland varieties.

Seed selection and storage, it was found that in lowland rice, seed is selected the same time with whole area harvesting. But they selected in the plot that was marked before harvesting time which no diseases, pests, lodging, and high filled grains. After the plot is selected, the surrounding area is completed harvested then the selected plot will be harvested later, both men and women harvest this plot. Mostly, rice will be left in sunshine at least 2 days before threshing. Most farmers had been selected seed each season, to minimize mixture of the mixed seed within the seed lot. In contrast, in upland rice is complementary production in Ban Kan and Ban Ong, different varieties were sown in separate patches in one field. Farmers in Ban Lak Sipsong, upland rice is first important crop production so that they grow separately varieties in a single area not like in other two villages. However, all of households selected seed for meeting their demand in next coming season. Bounmeenoy in Ban Kan, who mixed two lowland varieties in the same seed lot, he believed that yield will be increased because one variety is large grain and panicle, and another one is round small grain but more tiller production. Sack is used for keeping the seed lots for next season growing and often put it inside the house without add any pesticides.

The *Kainoyleuang* (KNL), *Kainoydang* (KND),*Kaolai* (KL), *Kaochaohang* (KCH), and *Kaodon* (KD) varieties were popularly grown in both Ban Kan and Ban Ong. The KNL variety was the most commonly grown in lowland condition of Ban Kan and Ban Ong. All of farmers in Ban Lak Sipsong grew a glutinous-upland of the KNH variety adapted to cooler climate and high elevation. Similarly, nearly all of farmers in both Ban Ong and Ban Kan grew a glutinous-lowland of KNL variety. The KNL variety, additional good lodging resistance the price has been also higher than other varieties. A non-glutinous upland of KCH variety found in Ban Ong and Ban Kan was only grown for sale.

According to farmer observation, the KP variety found in Ban Kan adapted widely soil condition but eating quality is low (Table 8). Some farmers considered some criteria such as long maturity and difficulty of threshing were a reason for discard and conservation. For example, there were most of farmers in Ban Ong discarded the KL variety because of difficult to thresh even its yield is moderately.

Table 8 Characteristics of varieties based on farmers' perception

Variety	Characteristics	
	Positive	Negative
1. Kainoydang (KND)	Early maturity	Time lapse of too many days between first and last heading of first and last tiller
2. Kaohom (KH)	Early maturity	Low yield, milled rice percentage moderate
3. Kaochien (KC)	Do well in good and poor soil	Poor eating quality, low percent of milled rice, lodging
4. Kaonon (KN)	Do well in good and poor soil, high percent of milled rice	No information, introduced 2 year ago and still in trial stage
5. Kaodon (KD)	Large panicle and grain, good eating quality	Easy to thresh, but panicle shattering cause yield loss
6. Kaochaodang (KCD)	High percent of milled rice	Difficult to thresh because grain does not separate easily from peduncle
7. Kaolai (KL)	Milled rice percentage high, good eating quality, high percent of milled rice	Difficult to thresh because grain does not separate easily from peduncle
8. Kaodangdane (KDD)	High percent of milled rice, wide adapted to soil fertility	Difficult to threshing because grain does not separate easily from peduncle
9.Kainoyleuang (KNL)	High spikelet number per panicle and milled rice, good eating quality, lodging resistance	Low germination
10. Kaochaohang (KCH)	Good eating quality, high market price and milled rice	Difficult in milling because of long awn
11. Kaoet (KE)	Do well in good and poor soil, high percent of milled rice	No information, introduced 2 year ago and still in trial stage
12. Kaopu (KP)	Do well in good and poor soil	Poor eating quality
13. Kaoleumfoua (KLF)	Good eating quality	Late maturity
14. Kaoletmu (KLM)	Medium maturity, consume grain after milked stage	Low yield
15. Kaokam (KK)	Making alcohol for folk medicine	Late maturity, low yield
16.Kaovan (KV)	Good tillering production, good eating quality, large grain	Late maturity
17. Kainoyhai (KNH)	High yield, adapted in cold climate, high percent of milled rice	Difficult to thresh because grain does not separate easily from peduncle
18. Brachao (BC)	Large panicle and grain, high yield	No information yet, introduced 3 years ago and still in trial stage
19.Brataolai (BTL)	Good tillering production, high yield	No information yet, introduced 3 years ago and still in trial stage

Source: field survey in April 2002

4.1.5 Rice cultivated area in the study area and soil characteristics.

In the village level, distribution of rice cultivated area based on upland and lowland environments. In Ban Ong lowland rice area occupies about 90 % of total rice area (Table 9). Ban Kan is secondly about 88% of rice area under lowland environment, but Ban Lak Sipsong lowland rice area accounts only 16 % of total rice planted area.

Table 9 Cultivated rice production in the study area

Village	Rice cultivated area (ha)			
	Lowland	Upland	Total	Area (ha/hh)
1 Ban Kan	14.60	2.00	16.60	0.52
	88%	12%	100%	
2. Ban Ong	18.00	2.00	20.00	0.48
	90%	10%	100%	
3. Lak Sipsong	1.50	8.00	9.50	0.45
	16%	84%	100%	
Total	34.10	12.00	46.10	0.48
	74%	26%	100%	

Source: Survey April 2002

Result of soil analysis in time of fallow period in April 2002, soil pH ranged 4.2 to 5.2 and available P was 2 to 27 ppm (Table 10). Organic matter ranged from 1.8 % to 6.41 % in upland and lowland soil samples. In lowland field of Ban Ong and Ban Kan soil pH ranged 4.2 to 5.2 while P was vary from 2 ppm in poor soil in the lowland field in Ban Ong to 27 ppm in fertile soil in the lowland field in Ban Kan.

Table 10 Soil characteristics in the study area

Village and soil sample site	Soil characterization			
	PH	%OM	P (ppm)	K (ppm)
1. Ban Ong (Lowland field)				
▪ High fertile soil	4.6	2.88	20	140
▪ Moderate fertile soil	4.5	6.41	4	70
▪ Low fertile soil	5.2	1.8	2	62
2. Ban Kan (Lowland field)				
▪ High fertile soil	4.3	4.8	27	128
▪ Moderate fertile soil	4.2	2.18	6	24
3. Ban Lak Sipsong (Upland field)				
▪ Moderate fertile soil	4.1	1.81	6	167

Fertility of soil in this table is classified based on farmers' experience

4.1.6 Grain characterization of rice varieties in the study area

1000-grain weight of 19 varieties raged from 24 g to 41 g (Table 11). Four lowland varieties ranged from 24 g to 28 g, while 26 g to 41 g for upland varieties. KND is a lowland-round-smaller grain shape and KLM is upland-larger grain shape variety. 1000-grain weight of 3 non-glutinous varieties ranges from 26 g to 35 g and 24 g to 41 g for glutinous varieties. Mean grain length of lowland varieties ranges from 6.41 mm to 8.18 mm shorter than upland varieties (6.84 mm to 9.92 mm). Among lowland varieties, KND is shortest grain about 6.41mm, while upland variety KLM is longest (9.92 mm). Standard deviation of grain length of lowland varieties ranges from 0.33 to 0.56 and 0.13 to 0.96 for upland varieties. Width of lowland varieties ranges from 3.31 mm to 3.47 mm and 2.83 mm to 4.06 mm for upland varieties. Standard deviation of grain width for lowland varieties ranges 0.15 to 0.40 and 0.12 to 0.29 for upland varieties. Length and width ratio was ranged from 1.81 t0 2.44 for lowland varieties, while upland varieties was 0.07 to 3.37. Coefficient of variance (CV %) for lowland ranges from 5.3 % to 8.6 %, 4.7 % to 12.1%, and 4.9 % to 21.7% of grain length, grain width, and grain length and width ratio, in respectively. For upland varieties, CV % ranges from 1.7 % to 10.4 % of grain length, 3.3 % to 12.1 % grain width, and 3.1 % to 11.6% grain length to width ratio.

Table 11 Grain characteristics of rice varieties in the study area

Var.	Ec	Ed	1000 GW (g)	L (mm)			W (mm)			L/W		
				M	SD	CV	M	SD	CV	M	SD	CV
1.KNL	L	G	25	6.54	0.56	8.6	3.31	0.40	12.1	2.03	0.44	21.7
2.KND	L	G	24	6.41	0.40	6.2	3.54	0.20	7.3	1.81	0.15	8.3
3.KH	L	G	28	8.18	0.43	5.3	3.36	0.20	4.7	2.44	0.12	4.9
4. KC	L	G	28	8.18	0.43	5.3	3.36	0.20	4.7	2.44	0.12	4.9
5. KDD	U	G	33	7.97	0.39	4.9	3.77	0.16	7.1	2.12	0.11	5.2
6.BTL	U	G	31	6.84	0.16	2.3	3.67	0.12	3.3	1.87	0.09	4.8
7. BC	U	G	34	7.62	0.32	4.2	3.94	0.15	12.1	1.94	0.12	6.2
8.KNH	U	G	35	7.62	0.13	1.7	3.44	0.19	3.3	2.22	0.15	6.8
9.KP	U	G	34	7.99	0.83	10.4	3.53	0.28	3.8	2.27	0.07	11.6
10.KD	U	G	38	9.24	0.90	9.7	3.47	0.18	5.5	2.67	0.31	3.1
11.KE	U	G	32	7.40	0.53	6.2	4.06	0.18	5.6	1.83	0.17	9.3
12.KLF	U	G	39	9.35	0.58	6.2	3.75	0.18	4.2	2.50	0.19	7.6
13.KLM	U	G	41	9.92	0.20	2.0	3.76	0.24	4.4	2.65	0.18	6.8
14.KK	U	G	32	8.07	0.43	5.3	3.66	0.29	4.8	2.22	0.23	10.4
15.KV	U	G	35	8.33	0.55	6.6	3.65	0.17	6.4	2.29	0.14	6.1
16.KN	U	G	34	7.90	0.33	4.2	3.26	0.22	4.3	2.44	0.19	7.8
17.KL	U	N	27	8.03	0.39	4.9	2.86	0.21	7.9	2.81	0.15	5.8
18.KCH	U	N	35	9.51	0.96	10.1	2.83	0.20	5.2	3.37	0.36	10.7
19.CD	U	N	26	7.62	0.46	6.0	2.90	0.13	6.0	2.63	0.20	6.7

Sample size = 10 grains, Ec = Ecosystem, Ed = Endosperm type, 1000Gw = 1000 grain weight; L= Lowland rice, U= Upland rice; G= Glutinous; N= Non-glutinous; SD= Standard deviation, M= Mean, and CV= coefficient of variance (%)

The 9 popular varieties were collected from three villages. Grain diversity was examined by looking at grain characteristics: grain weight, grain width and length, grain length and width ratio, and morphological grain diversity included: lemma palea pubescence, awning, awn color, apiculus color, lemma and palea color, sterile lemma color, and seed coat color. The detailed of study was presented below.

Grain shape variation based on grain length and width ratio to classify grain into round, slender, and large grain types (Oka, 1988). Varieties found in Ban Ong, they have three types of grain shape (Figure 3). It was found that, KH, KND, and KDD have round grain type. Within KNL population, there were 90% and 10% of round and slender types, respectively. Within KCD variety, 30% and 70% of round and slender types. KC and KN Varieties have three types of grain shapes mixture within population. KD has 80% round and 20% large grain types. KC and KN varieties was mixed of three grain types in the same seed lot (Table 12). Total 8

varieties was classified, over 80 % of 5 varieties is round grain type, only 2 varieties is slender type, and one variety is mixture of large, slender and round types.

Table 12 Variation of grain shape among varieties found in Ban Ong

Variety	Grain types		
	(A) Round (%)	(C) Slender (%)	(B) Large (%)
1. KNL	90	10	0
2. KH	100	0	0
3. KC	10	20	70
4. KND	100	0	0
5. KD	80	0	20
6. KN	20	60	20
7. KCD	30	70	0
8. KDD	100	0	0

Sample size = 10 grains

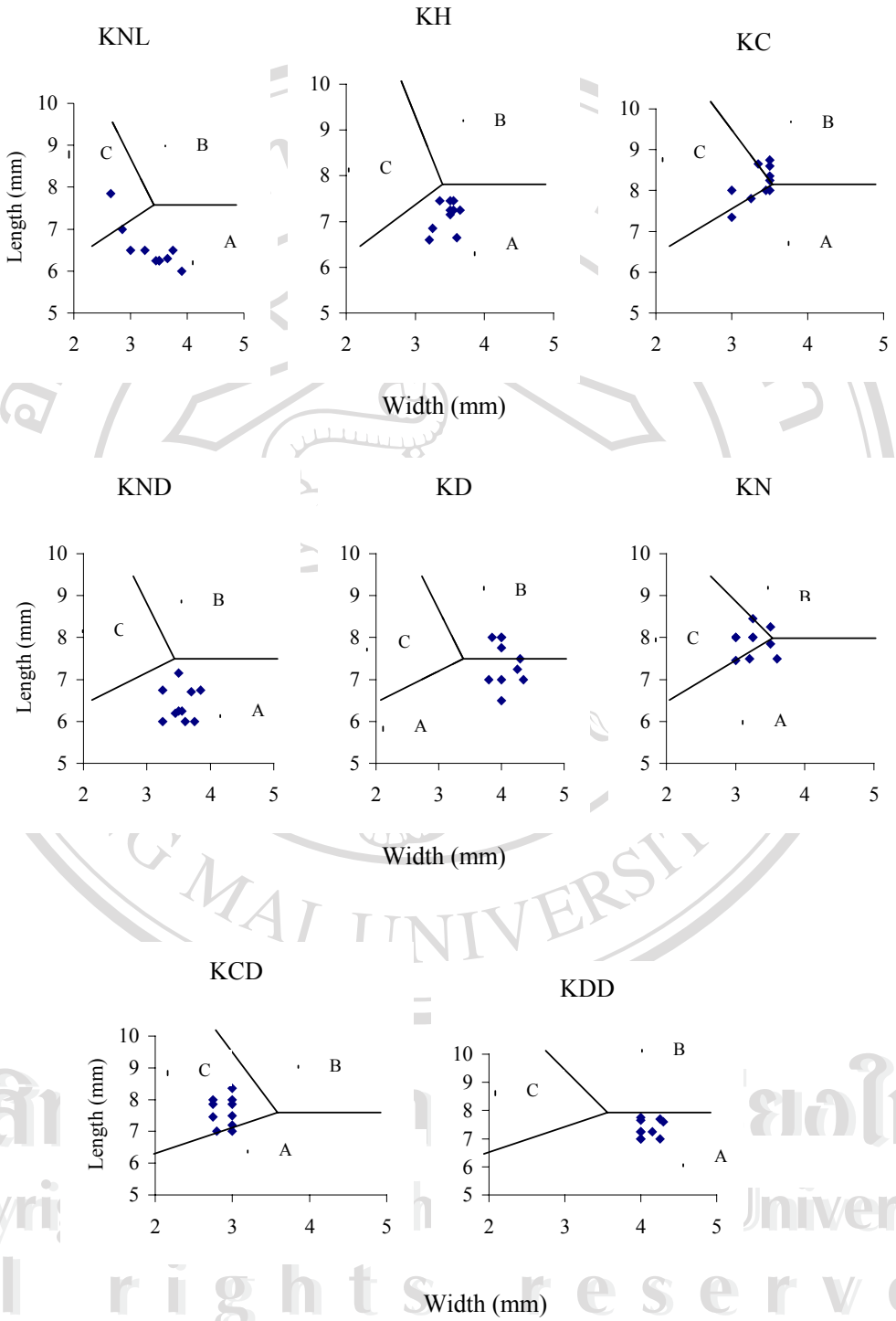

Figure 3 Grain shapes of rice varieties in Ban Ong.

A (round type), B (large type), and C (slender type). KNL= *Kainoyleuang*, KH= *Kaohom*, KC= *Kaochien*, KND= *Kainoydang*, KD= *Kaodon*, KN= *Kaonon*, KCD= *Kaochaodang*, and KDD=*Kaodangdane*.

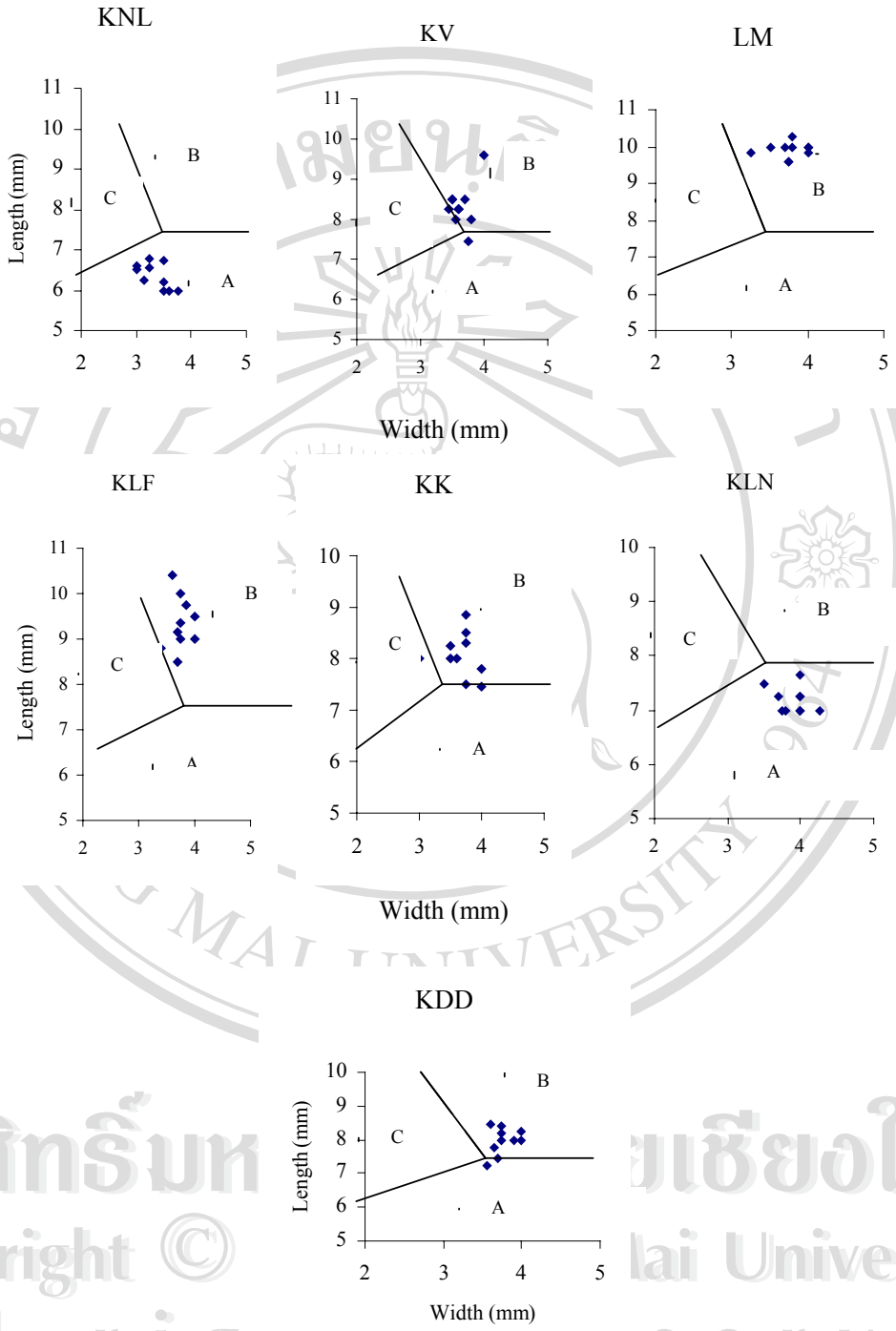

Figure 4 Grain shapes of rice varieties in Ban Kan

A (round type), B (large type), and C (slender type). KNL= *Kainoyleuang*, KV= *Kaovan*, LM= *Letmu*, KD= *Kaodon*, KK= *Kaokam*, KLN= *Kaolainiew*, KDD= *Kaodangdane*, KLF= *Kaoleumfoua*.

Rice grain shape is classified into three types of grain shapes: round, large, and selender types (Oka, 1988). Result of evaluated in Ban Kan rices, within population of KNL, and KLN have a round grain type. KLF, and LM have a large grain type (Figure 4). There was 90% and 10%, 70% and 30%of large and round grain types found within population of KV and KDD varieties, respectively (Table 13). There were three types of grain shape found within KK and KD varieties. In this village, 8 varieties was classified, over 80% 0f grains within seed lot of 3 varieties round grain types, over 70% 0f grains within seed lot of 5 varieties is large grain types.

Table 13 Variation of grain shape among varieties found in Ban Kan

Variety	Grain types		
	(A) Round (%)	(C) Slender (%)	(B) Large (%)
1. KNL	100	0	0
2. KV	10	0	90
3. KLM	0	0	100
4. KLF	0	0	100
5. KK	20	10	70
6. KLN	100	0	0
8. KDD	30	0	70

Sample size = 10 grains

HNL and BTL seed lots have a round grain shape found in Ban Lak Sipsong In the Figure 5, slender grain type of KL variety, there was mixed large and round grain types of BC variety. For KNH is most popular variety in this village has 80% round and 20% slender grain types (Table 14). Four varieties (KNL, BTL, KNH, BC), over 70 % of grains in the seed lot are round grain types. Only, KL variety is slender grain type.

Table 14 Variation of grain shape among varieties found in Ban Lak Sipsong

Variety	Grain types		
	(A) Round (%)	(C) Slender (%)	(B) Large (%)
1. KNH	80	20	0
2. KL	0	100	0
3. BTL	100	0	0
4. BC	70	0	30
8. KNL	100	0	0

Sample size = 10 grains

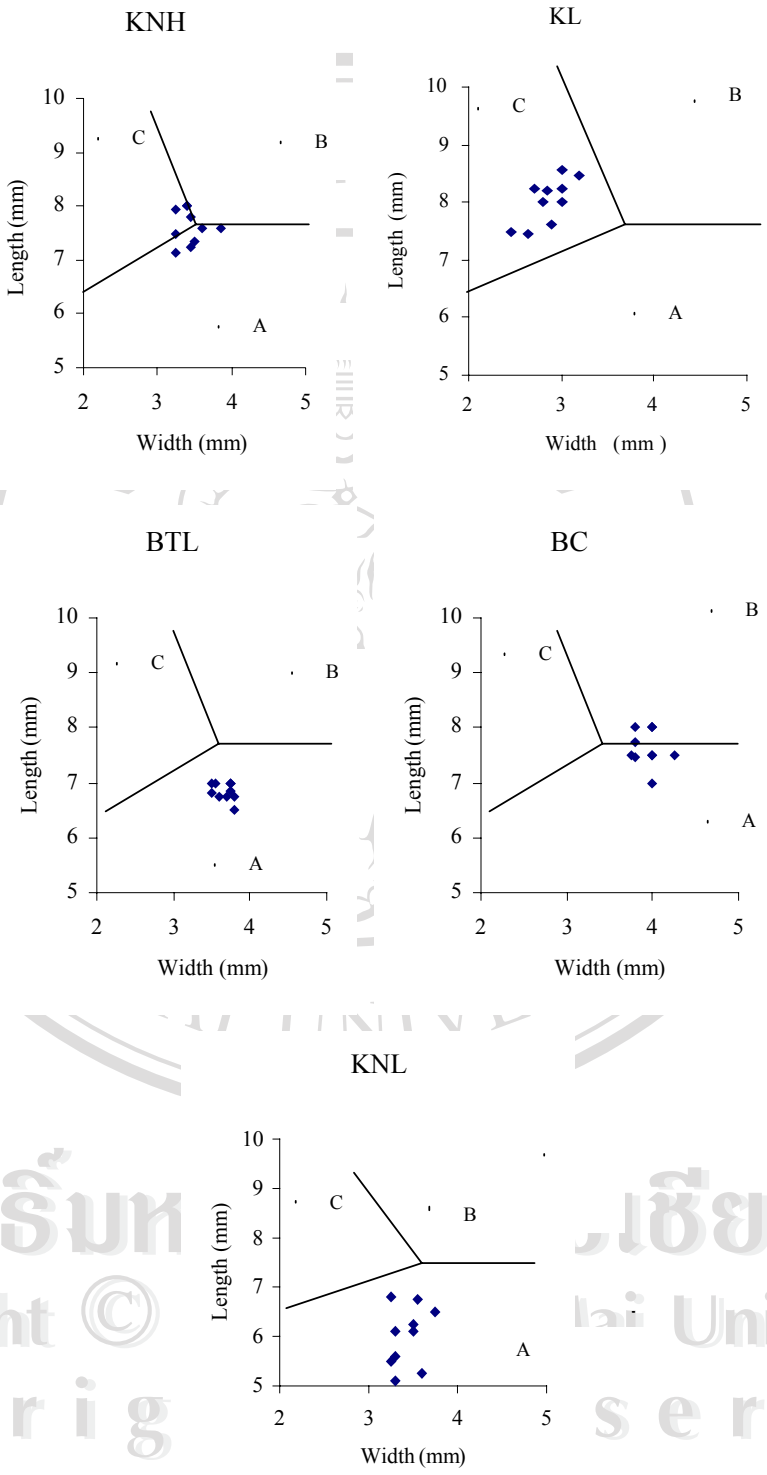

Figure 5 Grain shapes of rice varieties found in Lak Sipsong
A (round type), B (large type), and C (slender type). KNL=*Kainoyleuang*, BTL= *Brataolia*, BC= *Brachao*, KNH= *Kainoyhai*, KL=*Kaolai*.

4.1.6.1 Diversity within rice samples collected from the study site.

Before planting, fifty grains were selected from each of the samples collected from the study site, to examine the variation of apparent diversity of observed characters based on Standard System of Evaluation for Rice. Plant morphology was observed during the vegetative phase. Grain morphology was used to identify difference within populations. Grain morphology was examined in relation to 7 characteristics: lemma and palea pubescence (LPP), awning (AW), awn color (AWC), apiculus color (APL), lemma and palea color (LPC), sterile lemma color (SL), and seed coat color (SCC).

4.1.6.2 Lemma and palea pubescence (LPP)

Most varieties are glabrous, but there was 2% of KNL2 has short hairs on the grain. Diversity index (H') ranged from 0.00 to 0.09 (Table 15). There were 7 samples of KNL1, HNL3, KNH, HP, KD, KL, and KCH2 was no diversity based on lemma and palea pubescence. There was diversity within population of KNL2 and KCH2. Both KCH1 and KCH2 from different village have hair on upper portion of grain.

Table 15 Distribution, diversity index of lemma and palea pubescence

No.	Var.	Source	Lemma and palea pubescence			H'	N
			G	H	S		
	Wetland						
1	KNL1	Ban Ong	50 100%	-	-	0.00	50
2	KNL2	Ban Kan	49 98%	-	1 2%	0.09	
3	KNL3	Ban Kan	50 100%	-	-	0.00	
	Upland						
4	KNH	Ban Lak Sipsong	50 100%	-	-	0.00	
5	KP	Kan	50 100%	-	-	0.00	
6	KD	Ban Lak Sipsong	50 100%	-	-	0.00	
7	KL	Ban Lak Sipsong	50 100%	-	-	0.00	
8	KCH1	Ban Ong	1 2%	49 98%	-	0.09	
9	KCH2	Ban Kan	-	50 100%	-	0.00	

G= glabrous, H = hairs in upper portion, S= short hairs, H'= Shannon diversity index, N= number of grains observation

4.1.6.3 Awing (AW)

Two varieties of KP and KL have no awns on their spikelets while there were mixtures types of awning within the other 7 seed lots. Shannon diversity index ranged from 0.00 of KP and KL to 1.21 of KCH2 (Table 16). Within populations of the same variety from different villages and farmers, there were varying degrees of diversity. For example, sample KNL1 from Ban Ong had a higher level of diversity than the two samples of the same variety (KNL2 and KNL3) which came from Ban Kan. Similarly, the samples of the variety KCH from the two villages Ban Ong and Ban Kan (KCH1 and KCH2, respectively) showed slightly different diversity indices.

Table 16 Awning between varieties and seed lots

No	Var.	Source	Awning				H'	N
			AB	SP	SF	LF		
	Wetland							
1	KNL1	Ban Ong	38	6	4	2	0.79	50
			76%	12%	8%	4%		
2	KNL2	Ban Kan	47	2	1	-	0.26	
			94%	4%	2%			
3	KNL3	Ban Kan	40	7	1	2	0.66	
			80%	14%	%	4%		
	Upland							
4	KNH	BanLak Sipsong	37	13	-	-	0.57	
			74%	26%				
5	KP	Ban Kan	50	-	-	-	0.00	
			100%					
6	KD	BanLak Sipsong	47	3	-	-	0.22	
			94%	6%				
7	KL	BanLak Sipsong	50	-	-	-	0.00	
			100%					
8	KCH1	Ban Ong	11	11	3	25	1.18	
			22%	22%	6%	50%		
9	KCH2	Ban Kan	15	4	8	23	1.21	
			30%	8%	16%	46%		

AB= absent, SP= short and partly awn, SF= short and fully awn, LF= long and fully awn, H= Shannon diversity index, N= number of grains observation

4.1.6.4 Awn color (AWC)

Four awn colors (straw, red, purple, and black) were found among 6 varieties come from the three villages in the study area. Awn color was observed from number of grains with awning among 50 grains. The value of (H') for awn color ranged from 0.00 to 0.63 (Table 17). KNL1 had the highest level of diversity. There was no diversity for awn color within the varieties KNL2, KNH, KD and KCH2.

Table 17 Distribution of awn color among seed lots and varieties

No	Var.	Source	Awn color				H'	N
			Straw	Red	Purple	Black		
	Wetland							
1	KNL1	Ban Ong	-	8 66.7%	4 33.3%	-	0.63	12
2	KNL2	Ban Kan	-	3 100%	-	-	0.00	3
3	KNL3	Ban Kan	-	8 80%		2 20%	0.50	10
	Upland							
4	KNH	Ban Lak Sipsong	-	-	13 100%	-	0.00	13
5	KP	Ban Kan	-	-	-	-		-
6	KD	Ban Lak Sipsong	-	-	-	3 100%	0.00	3
7	KL	Ban Lak Sipsong	-	-	-	-		-
8	KCH1	Ban Ong	38 97.4%	-		1 2.6%	0.11	39
9	KCH2	Ban Kan	35 100%	-	-	-	0.00	35

H= Shannon diversity index, N= number of grains observation

4.1.6.5 Apiculus color (APL)

Three colors (straw, red, and purple) of the apiculus were found within the 9 rice samples (Table 18). Nearly all the samples showed apiculus color diversity; the exception was KNH. The diversity index ranged from 0.00 to 0.68. The variety with greatest diversity was KP while KH showed no diversity for this character. Samples of the same variety from different villages and farmers showed slightly different degrees of diversity.

Table 18 Distribution of apiculus color between and within varieties

No	Var.	Source	Apiculus color			H'	N
			Straw	Red	Purple		
	Wetland						
1	KNL1	Ban Ong	-	8 16%	42 84%	0.43	50
2	KNL2	Ban Kan	-	10 20%	40 80%	0.50	
3	KNL3	Ban Kan	-	7 14%	43 86%	0.40	
	Upland						
4	KNH	BanLak Sipsong	-	-	50 100%	0.00	
5	KP	Ban Kan	-	22 44%	28 56%	0.68	
6	KD	BanLak Sipsong	-	1 2%	49 98%	0.09	
7	KL	BanLak Sipsong	-	48 96%	2 4%	0.43	
8	KCH1	Ban Ong	46 92%		4 8%	0.27	
9	KCH2	Ban Kan	49 98%		1 2%	0.09	

H= Shannon diversity index, N= number of grains observation

4.1.6.6 Lemma and palea color (LPC)

The diversity index based on LPC ranged from 0.00 to 1.35 for the varieties KCH1, KCH2, and KP (Table 19). Comparisons within the same variety but collected from different farmer and village, showed that for the variety KNL1 the diversity within Ban Ong was higher than for KNL2 and KNL3 in Ban Kan. However, within Ban Kan, samples KNL2, and KNL3 from different farmers the diversity was 0.87, and 1.02 of diversity index respectively. However, there was no diversity within KCH1 and KCH2 from different villages in term of the LPC descriptor.

Table 19 Diversity index for lemma and palea color

Var.	Source	Lemma and palea color							H'
		S	BS	BF	RP	PS	PF	P	
Wetland									
KNL1	Ban Ong	32	2	6	-	5	5	-	1.00
		64%	4%	12%		10%	10%		
KNL2	BanKan	38	1	2	6	2	1	-	0.87
		76%	2%	4%	12%	4%	2%		
KNL3	BanKan	33	5	-	1	9	2	-	1.02
		66%	10%		2%	18%	4%		
Upland									
KNH	Ban Lak Sipsong	15	2	-	-	-	-	33	0.76
		30%	4%					66%	
KP	BanKan	13	-	16	13	-	8	-	1.35
		26%		32%	26%		16%		
KD	Ban Lak Sipsong	12	-	4	3	-	27	4	1.24
		24%		8%	6%		54%	8%	
KL	Ban Lak Sipsong	13	-	-	37	-	-	-	0.57
		26%			74%				
KCH1	Ban Ong	50	-	-	-	-	-	-	0.00
		100%							
KCH2	BanKan	50	-	-	-	-	-	-	0.00
		100%							

N= 50
S= straw, RP= reddish to light purple, PS= purple spots, PF= purple furrows, P= purple, BF= brown furrows, BS= brown spots, H'= Shannon diversity index, N= number of grains observation

4.1.6.7 Sterile lemma color (SL)

Three colors (straw, red, and purple) of sterile lemma were found within varieties. The diversity index ranged from 0.09 to 0.91 (Table 20). The highest diversity (0.91) was for of KD collected from Ban Lak Sipsong while the lowest diversity (0.09) was for KCH2 collected from Ban Kan.

Table 20 Sterile lemma color and its diversity

No	Var.	Source	Sterile lemma color			H'	N
			Straw	Red	Purple		
	Wetland						
1	KNL1	Ban Ong	16 32%	-	34 68%	0.62	50
2	KNL2	Ban Kan	30 60%	17 34%	3 6%	0.84	
3	KNL3	Ban Kan	31 62%	19 38%	-	0.66	
	Upland						
4	KNH	Ban Lak Sipsong	43 86%	7 14%	-	0.40	
5	KP	Ban Kan	2 4%	35 70%	13 26%	0.72	
6	KD	Ban Lak Sipsong	4 8%	23 46%	23 46%	0.91	
7	KL	Ban Lak Sipsong	2 4%	48 96%	-	0.16	
8	KCH1	Ban Ong	47 94%	3 6%	-	0.22	
9	KCH2	Ban Kan	49 98%	1 2%	-	0.09	

H'= Shannon diversity index, N= number of grains observation

4.1.6.8 Seed coat color (SCC)

Four colors (white, light brown, brown, and red) were found within the varieties. Most- KNL1, KNL2, KNL3, KL, KCH1, and KCH2, have a light brown seed coat color. The varieties KD, KP, and KNH have a brown seed coat color. Diversity of color within varieties ranged from 0.00 to 0.75 (Table 21). Within populations of the same variety but from different villages and farmers there were different degrees of diversity. For example, the varieties KNL1, KNL2 AND KNL3 differed in this regard.

Table 21 Seed coat color and its diversity within varieties

No	Var.	Source	Seed coat color				H'	N
			White	Light brown	Brown	Red		
	Wetland							
1	KNL1	Ban Ong	7 14%	37 74%	6 12%	-	0.75	50
2	KNL2	Ban Kan	4 8%	46 92%	-	-	0.27	
3	KNL3	Ban Kan	-	50 100%	-	-	0.00	
	Upland							
4	KNH	Ban Lak Sipsong	8 16%	-	39 68%	3 6%	0.65	
5	KP	Ban Kan	2 4%	-	47 94%	1 2%	0.26	
6	KD	Ban Lak Sipsong	-	2 4%	48 96%	-	0.16	
7	KL	Ban Lak Sipsong	-	49 98%	-	1 2%	0.09	
8	KCH1	Ban Ong	-	50 100%	-	-	0.00	
9	KCH2	Ban Kan	-	46 92%	4 8%	-	0.27	

H'= Shannon diversity index, N= number of grains observation

4.2 Field Experiment

To present the results of field experiment in two plots sites (wetland and dry land conditions) were separated in term of data presentation. Three seed lots with only one variety of KNL were planted in wetland and six seed lots with 5 varieties of KNH, KP, KD, KL, KCH1, and KCH2 planted in dry land conditions.

4.2.1 Grain Weight

For the nine samples collected in the study area, 1000-grain weight ranged from 25 g for KNL3 to 41 g for KD (Table 22). The three KNL samples (KNL1, KNL2, and KNL3) were all small grained and did not show a different grain weight even from different farmers and villages. In the upland varieties, all of them over 30 g, but variety KD had the largest grains about 41 g of 100-grain weight.

Table 22 1000-grain weights of most popular varieties in the study area.

Variety	1000-grain weight (g)
1.Wetland rice	
KNL1	25
KNL2	25
KNL3	25
2.Upland rice	
KNH	35
KP	34
KD	41
KL	31
KCH1	38
KCH2	35

4.2.2Grain yield and harvest index.

Grain yield per hectare, the lower was 1.3 t/ha of KP variety and 2.9 t/ha of KNL variety (Table 23). Sample KNL1, KNL2, and KNL3 was the same variety name but collected from different farmers and villages, the resulted of their performance were not equality in term of yield. In statistical analysis, there was not significant between three wetland seed lots (P=0.45). Similar in Upland rice varieties, there was no significantly in statistical between varieties (p= 0.89). In this experiment, the HI ranged from 0.32 to 0.40 (Table 23). The HI for lowland varieties was higher than for upland varieties. For the three samples of the lowland variety KNL (KNL1, 2, 3), the HI ranged from 0.33 to 0.40 while for all of the upland varieties it was less than 0.40. The low HI for lowland sample KNL2 was 0.33 on account of a high level of sterility.

Table 23 Yield of most popular varieties in the field experiment

Variety	Yield (t/ha)			Straw (t/ha)			Harvest index
	Mean	SD	CV (%)	Mean	SD	CV (%)	
1.Wetland rice							
KNL1	2.90	0.73	25.1	4.70	0.50	10.6	0.38
KNL2	2.00	0.25	12.5	4.10	0.22	5.4	0.33
KNL3	2.70	0.49	18.1	4.10	0.34	8.3	0.40
2.Upland rice							
KNH	1.50	0.28	18.6	3.00	0.52	17.3	0.33
KP	1.30	0.30	23.0	2.70	0.24	8.8	0.33
KD	1.50	0.25	16.6	3.00	0.60	20.0	0.33
KL	1.60	0.34	21.2	3.18	0.26	8.2	0.34
KCH1	1.40	0.28	20.0	3.00	0.28	9.3	0.32
KCH2	1.50	0.23	15.3	3.23	0.18	5.6	0.30

LSD 0.05 for yield in lowland rice = 1.02 t/ha

LSD 0.05 for yield in upland rice = 0.62 t/ha

4.2.3 Grain shape

Three pure-line seed lots of Thai Improved Variety of KDML105, NSPT, and RD6 were used for standard checking with the seed lots collected from the study area. The square root of generalized variance was ranged from 0.028 to 0.072 (Table 24). Largest $\sqrt{G}$ value, 0.072 was NSPT variety, but lower than all of varieties collected from the study area. The seed lots collected from the study area, the square root of generalized of variance ($\sqrt{G}$) showed a wide range in the variance of grain length and width (Table 21). The largest $\sqrt{G}$ value, 0.309 was upland variety (KP) collected from Ban Kan and smallest $\sqrt{G}$ value, 0.073 was also upland variety (KL) collected from Ban Lak Sipsong. The same variety of KNL1, KNL2, and KNL3 seed lots collected from different village and farmer showed variance in grain length and width. The largest value $\sqrt{G}$, 0.104 was KNL1 collected from Ban Ong, and 0.075, 0.086 of KNL2 and KNL3 collected from different farmers in Ban Kan.

The varieties collected from the study area, grain width ranged from 2.82 mm for KL to 3.58 mm for KP. Grain length ranged from 6.24 mm for sample of KNL2 to 9.52 mm for sample of KCH2. Upland varieties ranged from 7.61 mm to 9.52 mm in grain length and 2.82 mm to 3.58 mm grain width. Three seed lots of lowland variety

(KNL) ranged 6.24 mm to 6.42 mm, 3.44 mm to 3.50 mm in grain length and grain width respectively.

Table 24 Length and width of spikelets of the seed lots in the study area and pure line variety

Variety	Length (mm)	Width (mm)	L/W	$\sqrt{G}$
1. Wetland rice				
KNL1	6.42±0.48	3.50±0.30	1.84±0.25	0.104
KNL2	6.24±0.49	3.47±0.20	1.80±0.14	0.075
KNL3	6.28±0.41	3.44±0.23	1.83±0.18	0.086
2. Upland rice				
KNH	7.61±0.42	3.31±0.30	2.32±0.27	0.101
KP	8.19±0.82	3.58±0.48	2.35±0.35	0.309
KD	9.04±0.70	3.40±0.28	2.67±0.26	0.130
KL	7.83±0.47	2.82±0.20	2.77±0.20	0.073
KCH1	9.35±0.99	2.90±0.30	3.26±0.35	0.210
KCH2	9.52±0.76	2.94±0.17	3.24±0.29	0.098
3. Pure-line seed lots				
KDML105	10.17±0.47	2.63±0.13	3.88±0.30	0.062
RD6	9.96±0.41	2.76±0.17	3.62±0.22	0.028
NSPT	9.91±0.46	2.74±0.18	3.62±0.29	0.072

Sample size = 50 grains; ±Their Standard Deviation, and Square Root of Generalized Variance ($\sqrt{G}$)

$G = V_{lenght} \times V_{width} - (Cov)^2$

In the figure 6, classification of grain shape based on Oka (1988) rice grain shape classifies into three types: round, slender, and large types. KNL1, KNL2, KNL1 seed lots collected from Ban Kan and Ban Ong belong to round grain type. However, KNL1 2% of slender was mixed within seed lot. About 70% grains in KNH seed lot from Ban Lak Sipsong belong to round type, and about 26 % was slender type and other 4 % of large grain type. KP over 50 % belongs to large grain type and 36 % was round type within the same seed lot (Table 25). In KD seed lot from Ban Lak Sipsong, over 70 % was large grain type and about 22 % was slender type. Within KL seed lot, over 90 % belongs to slender type and other remain was large and round types mixture in the same seed lot. KCH1 and KCH2 collected from Ban Ong and Ban Kan was similar diversity in term of grain shape (over 90% belongs to slender types). KP collected from Ban Kan was high degree of mixture of three types of grain shape.

Table 25 Grain shape variation within 9 seed lots and 6 varieties in the study are

Variety	Grain types		
	(A) Round (%)	(C) Slender (%)	(B) Large (%)
Wetland			
1. KNL1	98	2	0
2. KNL2	100	0	0
3. KNL3	100	0	0
Upland			
4. KCH1	2	96	2
5. KCH2	0	94	6
6. KNH	70	26	4
7. KD	2	22	76
8. KL	4	94	2
9. KP	36	12	52

Sample size = 50 grains

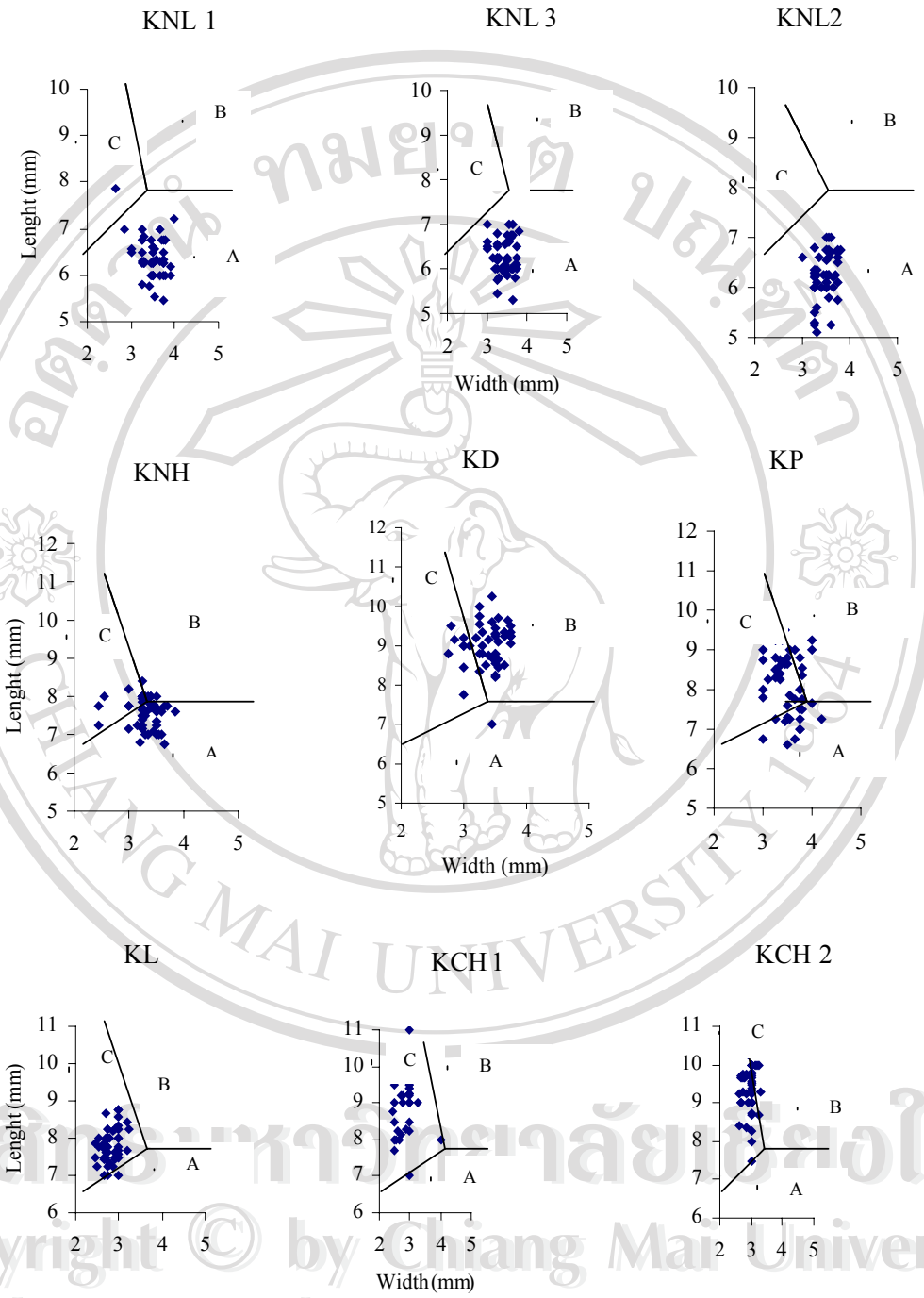

Figure 6 Grain shapes of common varieties in the study area.
A (round type), B (large type), and C (slender type). KNL1 = *Kainoyleuang*, and KCH1= *Kaockaohang* collected from Ban Ong. KNL2 and KNL3 = *Kainoyleuang*, KP= *Kaopu*, and KCH2= *Kaochaohang* collected from Ban Kane. KNH= *Kainoyhai*, KD=*Kaodon*, and KL=*Kaolai* collected from Ban Lak Sipsong.

4.2.4 Leaf width and length

Leaf length and leaf width in first leaf beneath the flag leaf varied widely among the nine samples (Table 26). Mean leaf length ranged from 35.99 cm for a sample of KNH (upland variety) to 45.13 for a sample of KCH2 (upland variety), while the standard deviation ranged from 4.04 for sample of KNL2 to 8.21 for sample of KCH2. Sample of KNL1, KNL3, KL, KCH1, and KCH2 was the same leaf length and slightly different from sample of KNL2 while KP, KD was the same but slightly different from KNL2, and KNH. Leaf width of sample of KNl1, KD, KNL3, KP was the same and slightly different from sample of KCH1, and KNH. The average width of leaves below the flag leaf ranged from 1.10 cm for the lowland variety KNL2 to 1.48 cm for the upland variety KL. Coefficient of variance for leaf length ranged from 10.19 to 19.75 and 12.19 to 22.05 for leaf width.

Table 26 Width and length of leaves in 9 rice samples (cm)

Variety	Leaf length (cm)			Leaf width (cm)		
	Mean	SD	CV (%)	Mean	SD	CV (%)
1.Wetland rice						
KNL1	43.28	5.25	12.13	1.24	0.19	15.32
KNL2	39.63	4.04	10.19	1.10	0.16	14.54
KNL3	43.35	4.88	11.25	1.21	0.15	12.39
2.Upland rice						
KNH	35.99	5.67	15.75	1.19	0.18	15.12
KP	37.33	7.14	19.12	1.21	0.21	17.35
KD	37.40	7.39	19.75	1.23	0.15	12.19
KL	42.73	6.04	14.13	1.48	0.19	12.83
KCH1	44.08	6.61	14.99	1.29	0.24	18.60
KCH2	45.13	8.21	18.19	1.36	0.30	22.05

SD= standard deviation, CV= coefficient of variance

LSD 0.05 for leaf length in upland rice = 3.04 cm

LSD 0.05 for leaf length in lowland rice = 2.10 cm

LSD 0.05 for leaf width in upland rice = 0.13 cm

LSD 0.05 for leaf width in lowland rice = 0.10 cm

4.2.5 Plant height, tiller, and panicle production

For the 9 samples from the study area, plant height ranged from 100.7 cm to 122.8 cm (Table 27). Standard deviation ranged from 5.5 for sample of KNL1 to 14.6 for sample of KCH2. However, generally the lowland varieties have a lower standard deviation than upland varieties. Within the variety KNL, there was a 9.5 cm range in plant height between samples (113.5 to 122.8 cm).

For an average of 40 hills per sample, it was found that, tiller number per hill ranged from 3.6 for KP up to 9.7 for KNL1 (Table 23). Generally, the variety KNL (samples KNL1, KNL2, and KNL3) showed a higher capacity for tillering that other samples. Standard deviation of tillering ranged from 0.9 for KCH1 up to 2.5 for KNL2. Panicle counts generally reflected tiller counts, with the average number of panicles per hill ranging from 3 for all upland rice varieties up to 9 for lowland variety of KNL1. Generally the lowland cultivars (samples KNL1, 2, 3) had both tiller and panicle counts than upland varieties.

Table 27 Tiller and panicle production

Variety	Tillers/hill			Panicles/hill			Plant height (cm)		
	Mean	SD	CV (%)	Mean	SD	CV (%)	Mean	SD	CV (%)
1.Wetland rice									
KNL1	9.7	2.4	24.5	9.1	2.3	24.9	122.8	5.5	4.5
KNL2	9.2	2.5	27.3	8.6	2.3	32.0	113.5	9.5	8.4
KNL3	9.4	2.3	24.6	8.4	2.3	27.1	121.9	7.0	5.7
2.Upland rice									
KNH	4.2	1.6	37.6	3.6	1.3	36.4	100.7	10.5	10.4
KP	3.6	1.1	29.7	3.2	1.1	35.4	108.7	10.9	10.0
KD	4.2	1.2	29.0	3.3	1.2	36.4	114.4	11.1	9.7
KL	4.7	1.4	29.4	3.9	1.5	38.5	120.1	10.5	8.7
KCH1	3.8	0.9	23.6	3.4	1.0	29.6	116.7	10.8	9.2
KCH2	4.1	1.0	24.8	3.5	1.3	37.1	122.5	14.6	11.8

N= 40 Plants, SD= standard deviation, LSD 0.05 for tillers/hill of lowland rice = 1.06, LSD 0.05 for tillers/hill of upland rice = 0.53, LSD 0.05 for plant height (cm) of lowland rice = 3.34, LSD 0.05 for plant height (cm) of upland rice = 5.06

4.2.6 Variation between and within seed lots

The experiment was conducted in dry-land conditions for upland rice varieties, and in wetland conditions for lowland variety. Statistical analysis was separated between upland plot and lowland plot.

4.2.6.1The upland plot

There were six rice samples (seed lots) tested, but five different varieties, and KCH was two comprise samples collected from Ban Kane and Ban Ong. The summary of results was shown in (Table 28). Standard deviation of grain length ranged from 0.38 to 0.90, grain width 0.14 to 0.40 and length and width ratio 0.20 to 0.36. Coefficient of variance (CV %) of grain length and width ratio ranged 7.4 % to 11.6 %, KNH was highest (CV= 11.6%) and lower of KL (CV = 7.4 %). The CV of grain length to width ratio of two seed lot of KCH1 and KCH2 from Ban Ong and Ban Kan, showed varying from 9.1% to 11.0 % respectively. When mean comparison of yield among varieties was not significant in statistical analysis (Table 29). Mean of yield ranged from 1.3t/ha to 1.6 t/ha.

Table 28 Variation of grain shape among seed lots and varieties

Variety	Grain length (mm)		Grain Width (mm)		Length to width ratio	
	SD	CV (%)	SD	CV (%)	SD	CV (%)
1. KNH	0.38	5.2	0.26	8.4	0.26	11.6
2. KP	0.56	6.3	0.40	11.5	0.36	15.2
3. KD	0.56	6.3	0.26	7.8	0.28	10.8
4. KL	0.44	5.7	0.17	6.7	0.20	7.4
5. KCH1	0.90	9.7	0.24	8.8	0.36	11.0
6. KCH2	0.70	7.4	0.14	5.3	0.28	9.1

SD= standard deviation, CV= coefficient of variance, Sample size = 50 grains

Table 29 Summaries of variance analysis in upland plot.

Sources of variance	Significant levels (F. test)						
	Yield (t/ha)	SW (t/ha)	LL	LW	T	P	PH
Rice sample	ns	ns	**	**	**	ns	**
CV (%)	16.9	16.4	17	16.81	29.62	36	10

**, *, ns = Significant at 1%, 5%, and non significant respectively. SW= straw weight, LL= leaf length (cm), LW= leaf width (cm), P= panicles/hill, and PH= plant height (cm).

4.2.6.2 The lowland plot

Three samples of KNL were tested in wetland conditions. As results of variance analysis was shown in (Table 30). Standard deviation of grain length ranged 0.38 t0 0.45, width 0.17 to 0.26, and length to width ratio showed varying from 0.14 to 0.24. KNL1 collected from Ban Ong was higher coefficient of variance (CV = 13 %) in length to width ratio compared with 7.9 % and 9.8% of KNL2 and KNL3 from Ban Kan.

Table 30 Variation of grain shape within seed lot

Variety	Grain length (mm)		Grain Width (mm)		Length to width ratio	
	SD	CV (%)	SD	CV (%)	SD	CV (%)
1. KNL1	0.42	6.7	0.26	7.8	0.24	13.4
2. KNL2	0.45	7.4	0.17	5.4	0.14	7.9
3. KNL3	0.38	6.2	0.22	6.6	0.17	9.8

SD= standard deviation, CV= Coefficient of Variance

Comparison grain length and width between seed lots was not significant (Table 32). But lower mean grain length of KNL2 is 6.23 mm and higher is 6.38 mm of KNL1. Grain width is 3.43 mm of KNL3 and 3.49 mm in KNL1.

Table 31 Variance analysis of grain shape

Source of variance	Significant levels (F. test)	
	Grain length (mm)	Grain width (mm)
Between seed lots	ns	ns
CV (%)	6.7	6.5

Table 32 Variance analysis of lowland plot

Sources of variance	Significant levels (F. test)						
	Yield (t/ha)	SW (t/ha)	LL	LW	T	P	PH
Between varieties	ns	ns	**	**	ns	**	**
CV (%)	26.0	13.0	11.3	16.8	14.0	28.0	6.3

**, ns = Significant at 1%, 5%, and non significant respectively. SW= straw weight, LL= leaf length (cm), LW= leaf width (cm), P= panicles/hill, and PH= plant height (cm).

Testing difference between seed lots in term of L/W ratio among KNL variety collected from different village and farmer, it showed that KNL1 was not significant from KNL2 and KNL3 (Table 33).

Table 32 Comparison grain L/W ratio between seed lots using paired T test

Paired test	df	Mean	SE	T	P
KNL1*KNl2	48	0.02	0.03	0.52	0.60^{ns}
KNl1*KNL3	48	0.02	0.04	0.37	0.71^{ns}
KNL2*KNL3	48	0.03	0.04	0.85	0.40^{ns}

T test (0.05), *, ns = Significant at 5%, and non significant respectively.

4.2.7 Diversity of Plant Morphology

Forty plants a sample was observed in field experiment. Diversity based on plant morphology, it could identify into six descriptors of plants: Leaf blade color (LBC), Basal leaf sheath color (BLSC), Leaf blade pubescence (LBP), Ligule color (LC), Collar color (CC), and Auricle color (AC).

4.2.7.1 Leaf blade color (LBC)

It was found that, diversity index ranged from zero to 0.67 (Table 34). The same variety name diversity of KCH1 and KCH2 that collected from Ban Ong and Ban Kan was not significant. Similarly within KNL1, KNL2, and KNL3 was green homogenous color. However, diversity of KL variety was about 0.67 highest than other varieties.

Table 34 Distribution of leaf blade color

No.	Variety	Source	Leaf blade color		H'	N
			Light green	Green		
	Wetland					40
1	KNL1	Ban Ong	-	40 100%	0.00	
2	KNL2	Ban Kan	-	40 100%	0.00	
3	KNl3	Ban Kan	-	40 100%	0.00	
	Upland					
4	KNH	Ban Lak Sipsong	32 80%	8 20%	0.50	
5	KP	Ban Kan	26 65%	14 35%	0.64	
6	KD	Ban Lak Sipsong	29 72.5%	11 27.5%	0.58	
7	KL	Ban Lak Sipsong	24 60%	16 40%	0.67	
8	KCH1	Ban Ong	25 62.5%	15 37.5%	0.66	
9	KCH2	Ban Kan	15 37.5%	25 62.5%	0.66	

H' = diversity index, N= number of hills observation

4.2.7.2 Basal leaf sheath color (BLSC)

Four basal leaf sheath colors was observed from 9 populations. Diversity index ranged from zero to 0.92 (Table 35). Basal leaf sheath of KNL1, KNL2, KNL3, and KL is single green color uniform was observed. Within population diversity of KCH2 collected from Ban Kan was about 0.92 more diverse than other populations. Light purple color was observed from KD population that collected from Ban Lak Sipsong.

Table 35 Basal leaf sheath color

No	Variety	Source	Basal leaf sheath color				H'
			Green	Purple line	Light purple	Purple	
	Wetland						
1	KNL1	Ban Ong	40 100%	-	-	-	0.00
2	KNL2	Ban Kan	40 100%	-	-	-	0.00
3	KNl3	Ban Kan	40 100%	-	-	-	0.00
	Upland						
4	KNH	Ban Lak Sipsong	35 87.5%	-	3 12.5%	2 7.5%	0.46
5	KP	Ban Kan	14 35%	-	24 60%	2 5%	0.82
6	KD	Ban Lak Sipsong	-	-	40 100%	-	0.00
7	KL	Ban Lak Sipsong	40 100%	-	-	-	0.00
8	KCH1	Ban Ong	30 75%	-	10 25%	-	0.56
9	KCH2	Ban Kan	25 62.5%	7 17.5%	8 20%	-	0.92

Sample size = 40 plants

H' = diversity index, N= number of hills observation

4.2.7.3 Leaf blade pubescence (LBP)

Three scales of identification of leaf blade pubescence can be used, glabrous, intermediate, and pubescence. Leaf blade pubescence diversity ranged from zero to 0.82 (Table 36). Population of KNL1 was highest diversity, while KNH, KD, and KP was no diversity. Within population of the same variety as KNL1, KNL2, and KNL3 was 0.82, 0.37, and 0.69 of diversity index, respectively.

Table 36 Leaf blade pubescences

No	Var.	Source	Leaf blade pubescence			H'	N
			Gla.	Int.	Pub.		
	Wetland						
1	KNL1	Ban Ong	26	4	10	0.85	40
			65%	10%	25%		
2	KNL2	Ban Kan	35	-	5	0.37	
			87.5%		12.5%		
3	KNl3	Ban Kan	20	-	20	0.69	
			50%		50%		
	Upland						
4	KNH	Ban Lak Sipsong	40	-	-	0.00	
			100%				
5	KP	Ban Kan	40	-	-	0.00	
			100%				
6	KD	Ban Lak Sipsong	40	-	-	0.00	
			100%				
7	KL	Ban Lak Sipsong	23	16	1	0.77	
			57.5%	40%	2.5%		
8	KCH1	Ban Ong	24	16	-	0.67	
			60%	40%			
9	KCH2	Ban Kan	32	8	-	0.50	
			80%	20%			

Gbl = glabrous, Int = intermediate, Pub = pubescence, H' = diversity index, N= number of hills observation

4.2.7.4 Ligule color (LC)

Ligule color can be divided into three colors: white, purple line, and purple. Most of populations have both white and purple color except KD population (Table 37). Diversity index ranged from zero to 1.00, KCH1 was more diverse than other populations. Diversity between populations of the same variety of KNL1, KNL2, and KNL3 was about 0.66, 0.68, and 0.69 respectively. There was different diversity index of KCH1 and KCH2 populations.

Table 37 Ligule color distribution

No	Var.	Source	Ligule color			H'	N
			White	Purple line	Purple		
1	**Wetland**						40
	KNL1	Ban Ong	15	-	25	0.66	
			37.5		62.5%		
2	KNL2	Ban Kan	22	-	18	0.68	
			55%		45%		
3	KNL3	Ban Kan	20	-	20	0.69	
			50%		50%		
	Upland						
4	KNH	Ban Lak Sipsong	36	4	-	0.32	
			90%	10%			
5	KP	Ban Kan	31	-	9	0.53	
			77.5%		22.5%		
6	KD	Ban Lak Sipsong	-	-	40	0.00	
					100%		
7	KL	Ban Lak Sipsong	16	-	24	0.67	
			40%		60%		
8	KCH1	Ban Ong	19	6	15	1.00	
			47.5%	15%	37.5%		
9	KCH2	Ban Kan	23	1	16	0.77	
			57.5%	2.5%	40%		

H' = diversity index, N= number of hills observation

4.2.7.5 Collar color (CC)

There was less diversity in term of collar color. Most populations have a single color (Table 38). However, there were two populations of KP and KNH have diversity within population. Almost varieties have a green collar color.

Table 38 Collar color distribution

No	Var.	Source	Collar color		H'	N
			Green	Light green		
	Wetland					
1	KNL1	Ban Ong	40 100%	-	0.00	40
2	KNL2	Ban Kan	40 100%		0.00	
3	KNL3	Ban Kan	40 100%	-	0.00	
	Upland					
4	KNH	Ban Lak Sipsong	39 97.5%	1 2.5%	0.11	
5	KP	Ban Kan	36 90%	4 10%	0.32	
6	KD	Ban Lak Sipsong	40 100%	-	0.00	
7	KL	Ban Lak Sipsong	40 100%	-	0.00	
8	KCH1	Ban Ong	40 100%	-	0.00	
9	KCH2	Ban Kan	40 100%	-	0.00	

H' = diversity index, N= number of hills observation

4.2.7.6 Auricle color (AC)

Only two auricle colors was observed from the experiment. There was not much diversity between and within populations. Diversity index ranged from zero to 0.63 (Table 39). Many populations as KNL1, KNL2, KNL3, KNH, and KD were no diversity, but there was highest diversity index of KL population than another populations. Within population of KCH1, and KCH2 as the same variety was significant.

Table 39 Auricle color distribution

No	Var.	Source	Auricle color		H'	N
			Light green	Green		
	Wetland					
1	KNL1	Ban Ong	40 100%	-	0.00	40
2	KNL2	Ban Kan	40 100%		0.00	
3	KNL3	Ban Kan	40 100%	-	0.00	
	Upland					
4	KNH	Ban Lak Sipsong	-	40 100%	0.00	
5	KP	Ban Kan	3 7.5%	37 92.5%	0.37	
6	KD	Ban Lak Sipsong	40 100%	-	0.00	
7	KL	Ban Lak Sipsong	13 32.5%	27 67.5%	0.63	
8	KCH1	Ban Ong	10 25%	30 75%	0.56	
9	KCH2	Ban Kan	5 12.5%	35 87.5%	0.37	

H' = diversity index, N= number of hills observation

4.2.7.7 Flag leaf angle (FLA)

There were four scales of flag leaf angle were observed (erect, intermediate, horizontal, and descending). Almost of varieties have a horizontal and descending of flag leaf angle. Between varieties, diversity index based on flag leaf angle ranged from 0.66 up to 1.28 (Table 40). Within populations of the same variety as KNL1, KNL2, KNL3, KCH1, and KCH2 was similar diversity index.

Table 40 Flag leaf angle distribution

No	Var.	Source	Flag leaf angle				H'	N
			Erect	Int.	Hor.	Des.		
1	**Wetland**							
	KNL1	Ban Ong	-	12	26	2	0.78	40
				30%	65%	5%		
2	KNL2	Ban Kan	-	14	23	3	0.89	
				35%	57.5%	7.5%		
3	KNL3	Ban Kan	-	5	25	10	0.90	
				12.5%	62.5%	25%		
	Upland							
4	KNH	Ban Lak Sipsong	4	9	9	18	1.26	
			10%	22.5%	22.5%	45%		
5	KP	Ban Kan	-	-	15	25	0.66	
					37.5%	62.5%		
6	KD	Ban Lak Sipsong	5	7	11	17	1.28	
			12.5%	17.5%	42.5%	27.5%		
7	KL	Ban Lak Sipsong	13	9	16	2	1.21	
			32.5%	22.5%	40%	5%		
8	KCH1	Ban Ong	5	6	8	21	1.20	
			12.5	15%	20%	52.5%		
9	KCH2	Ban Kan	1	10	11	18	1.15	
			2.5%	25%	27.5%	45%		

Int = intermediate, Hor = horizontal, Des = descending, H' = diversity index, N= number of hills observation

4.2.7.8 Awning (AW)

Observation from forty hills in each population, it was found that there was absent up to long awn. Awning diversity among varieties was ranged from zero up to 0.71 (Table 41). There are four varieties of KNH, KP, KD, and KL was no awn by observation within forty hills. But KCH1 had awning more diverse than other populations. Within population of the same variety as KNL1, KNL2, and KNL3, it was found that KNL3 that collected from Ban Kane shown more diverse than KNL1 and KNL2.

Table 41 Awning distribution

No	Var.	Source	Awning				H'	N
			Ab.	SP	SF	L		
	Wetland							
1	KNL1	Ban Ong	35	4	1	-	0.43	40
			87.5%	10%	2.5%			
2	KNL2	Ban Kan	37	2	-	1	0.31	
			92.5%	5%		2.5%		
3	KNL3	Ban Kan	31	3	-	6	0.67	
			77.5%	7.5%		15%		
	Upland							
4	KNH	Ban Lak Sipsong	40	-	-	-	0.00	
			100%					
5	KP	Ban Kan	40	-	-	-	0.00	
			100%					
6	KD	Ban Lak Sipsong	40	-	-	-	0.00	
			100%					
7	KL	Ban Lak Sipsong	40	-	-	-	0.00	
			100%					
8	KCH1	Ban Ong	29	9	-	2	0.71	
			72.5%	22.5%		5%		
9	KCH2	Ban Kan	31	4	-	5	0.68	
			77.5%	10%		12.5%		

Ab = absent, SP = short and partly awn, SF= short and fully awn, L = long awn
H' = diversity index, N= number of hills observation

4.2.7.9 Apiculus color (APL)

There was diversity in all varieties based on apiculus color. Straw color was mainly found in KNL1, KNL2, KNL3, KNH, KL, KCH1, and KCH2 (Table 42). Within population diversity index ranged from 0.19 to 0.95, KP was more diverse than another, while KNl1 was less diversity. There was 0.19, 0.31, and 0.58 of the same variety that come from different village and farmers of KNL1, KNL2, and KNL3, respectively.

Table 42 Apiculus color distribution

No	Var.	Source	Apiculus color					H'
			St	Red	Brown	RA	Purple	
	Wetland							
1	KNL1	Ban Ong	38 95%	2 5%	-	-	-	0.19
2	KNL2	Ban Kan	37 92.5	2 5%	-	-	1 2.5%	0.31
3	KNL3	Ban Kan	29 72.5%	11 27.5%	-	-	-	0.58
	Upland							
4	KNH	Ban Lak Sipsong	33 82.5%	1 2.5%	3 7.5%	1 2.5%	2 5%	0.68
5	KP	Ban Kan	1 2.5%	8 20%	5 12.5%	-	26 65%	0.95
6	KD	Ban Lak Sipsong	4 10%	-	2 5%	-	34 85%	0.51
7	KL	Ban Lak Sipsong	36 90%	-	4 10%	-	-	0.32
8	KCH1	Ban Ong	36 90%	-	-	-	4 10%	0.32
9	KCH2	Ban Kan	34 85%	-	2 5%	2 5%	2 5%	0.58

Sample size 40 plants
St = straw color, RA = red apex color, H' = diversity index.

4.2.7.10 Seed coat color (SCC)

Seed coat color can be divvied into light brown, brown and red. KL has light brown, and over 70% of KNL1, 2, and 3 have also light brown color (Table 43). There was red color mixed within population of KNH, KD collected from Ban Lak Sipsong and KCH1, and KCH2 come from Ban Ong and Kan Kan. Diversity index was ranged from zero up to 0.58, a higher of KNL2 and lower of KP and KL varieties.

Table 43 Seed coat color distribution.

No	Var.	Source	Seed coat color			H'	N
			Brown	Red	LB		
	Wetland						
1	KNL1	Ban Ong	8 20%	-	32 80%	0.50	40
2	KNL2	Ban Kan	11 27.5%	-	29 72.5%	0.58	
3	KNL3	Ban Kan	3 7.5%	-	37 92.5%	0.26	
	Upland						
4	KNH	Ban Lak Sipsong	36 90%	2 5%	2 5%	0.39	
5	KP	Ban Kan	40 100%	-	-	0.00	
6	KD	Ban Lak Sipsong	39 97.5%	1 2.5%	-	0.11	
7	KL	Ban Lak Sipsong	-	-	40 100%	0.00	
8	KCH1	Ban Ong	-	1 2.5%	39 97.5%	0.11	
9	KCH2	Ban Kan	-	1 2.5%	39 97.5%	0.11	

LB=light brown color, H' = diversity index, N= number of hills observation

4.2.7.11 Lemma and palea pubescence (LPP)

Glabrous, hairs on upper portion, and short hairs were observed. It was found that, there was 100% of KL variety collected from Ban Lak Sipsong has hairs on upper portion of lemma and palea (Table 44), but KNH, KP, KD, KCH1, and KCH2 was glabrous by observation from forty hills. Diversity index was ranged from zero up to 0.99. KNL2 collected from Ban Kane was higher diversity index more than other. Within KNL1, KNL2, and KNL3 have three forms of lemma and palea pubescence appearance.

Table 44 Lemma and palea pubescence distribution

No	Var.	Source	Lemma and pubescence			H'	N
			Gl.	S	HP		
	Wetland						
1	KNL1	Ban Ong	32 80%	3 7.5%	6 15%	0.65	40
2	KNL2	Ban Kan	22 55%	8 20%	10 25%	0.99	
3	KNL3	Ban Kan	30 75%	5 12.5%	5 12.5%	0.73	
	Upland						
4	KNH	Ban Lak Sipsong	40 100%	-	-	0.00	
5	KP	Ban Kan	40 100%	-	-	0.00	
6	KD	Ban Lak Sipsong	40 100%	-	-	0.00	
7	KL	Ban Lak Sipsong	-	40 100%	-	0.00	
8	KCH1	Ban Ong	40 100%	-	-	0.00	
9	KCH2	Ban Kan	40 100%	-	-	0.00	

Gl= glabrous, HP = hair on upper portion, S = short hair, H' = diversity index, N= number of hills observation

4.2.7.12 Lemma and palea color (LPC)

There were four colors (straw, reddish to light purple, purple, purple spots, and purple furrows) as observed from each population. Three colors observed from KNL1, KNL2, and KNL3; the other there was two colors appearance (Table 45). Diversity index was ranged from zero up to 0.77; KNL1 was more diverse than another. KL and KCH2 was on diversity within population as observed. There was 0.77, 0.73, and 0. 63 of KNL1, KNl2, and KNl3 as the same variety come from different farmers and villages.

Table 45 Lemma and palea color distribution

No	Var.	Source	Lemma and palea color					H'
			S	RP	P	PS	PF	
	Wetland							
1	KNL1	Ban Ong	29 72.5%	-	-	5 12.5%	6 15%	0.77
2	KNL2	Ban Kane	30 75%	-	-	4 10%	6 15%	0.73
3	KNL3	Ban Kane	32 80%	-	-	3 7.7%	5 12.5%	0.63
	Upland							
4	KNH	Ban Lak Sipsong	12 30%	-	28 70%	-	-	0.61
5	KP	Ban Kane	16 40%	24 60%	-	-	-	0.67
6	KD	Ban Lak Sipsong	1 2.5%	-	-	39 97.5%	-	0.11
7	KL	Ban Lak Sipsong	-	40 100%	-	-	-	0.00
8	KCH1	Ban Ong	39 97.5%	1 2.5%	-	-	-	0.11
9	KCH2	Ban Kane	40 100%	-	-	-	-	0.00

Sample size 40 plants
S= straw color, RP= reddish to light purple color, P= purple, PS = purple spots on straw, PF = purple furrows on straw, H' = diversity index, N= number of hills observation

4.2.7.13 Sterile lemma color (SL)

Three colors (straw, purple, and red) of sterile lemma were observed from 6 varieties. It was found that, KCH1 and KCH2 have straw color, but KNL1, KNL2, and KNL3 have bicolor of straw and purple (Table 46). Diversity index was ranged from zero up to 0.77; KP was more diverse than other populations. Within population diversity as the same variety of KCH1, and KCH2 was no significant. But KNL1, KNL2, and KN3 as the same variety but come from different farmers and villages shown significant in diversity index.

Table 46 Sterile lemma color distribution

No	Var.	Source	Sterile lemma color			H'	N
			Straw	Purple	Red		
	Wetland						
1	KNL1	Ban Ong	3 87.5%	5 12.5%	-	0.37	40
2	KNL2	Ban Kan	38 95%	2 5%	-	0.19	
3	KNL3	Ban Kan	40 100%	-	-	0.00	
	Upland						
4	KNH	Ban Lak Sipsong	4 10%	-	36 90%	0.32	
5	KP	Ban Kan	3 7.5%	9 22.5%	28 70%	0.77	
6	KD	Ban Lak Sipsong	1 2.5%	39 97.5%	0	0.11	
7	KL	Ban Lak Sipsong	4 10%	-	36 90%	0.32	
8	KCH1	Ban Ong	40 100%	-	-	0.00	
9	KCH2	Ban Kan	40 100%	-	-	0.00	

H' = diversity index, N= number of hills observation

4.2.8 Variety maturity

Duration of growing to 50% of panicle emergence in the samples was depended upon different varieties (Table 47). The upland rice of KNH variety was about 80 days and lowland rice of KNL variety about 100 days. Maturity was also different between varieties. They were about 127, 106 days of the KNL and KNH varieties respectively.

Table 47 Variation of rice samples collected from farmers in the study area

Variety	Heading (Days)			Maturity (Days)		
	Mean	SD	CV (%)	Mean	SD	CV (%)
Wetland						
1. KNL1	94.43	2.20	2.3	124.35	3.70	2.9
2. KNL2	98.80	3.14	3.2	127.68	3.32	2.6
3. KNL3	93.70	2.44	2.6	126.27	2.78	2.2
Upland						
4. KNH	80.67	3.96	4.9	108.82	2.04	1.9
5. PU	81.82	2.77	3.4	107.80	1.95	1.8
6. KD	83.90	2.78	3.3	109.47	2.37	2.2
7. KL	82.57	1.81	2.2	109.45	1.41	1.3
8. KCH1	81.27	3.14	3.8	106.50	3.24	3.0
9. KCH2	81.70	3.25	3.9	108.18	2.71	2.5

Sample size = 40 hills, SD = standard deviation.

4.3 Crop survey

The broad objective of the crop survey in farmer's fields was to examine range of yield on farm condition of one popular lowland variety *Kainoyleuang* (KNL). In addition, the diversity among farmers' field was also measured. The field survey was undertaken in the village of Ban Kane.

Rice production in Bane Kan is based on the cultivation of both rainfed upland rice and rainfed lowland rice. Rice production area is very less in particular in paddy area. On average per household of rainfed lowland rice area was about 4560 m^2. A single wet-season rice crop is grown in both environments, the crops being grown in the period May to November. Rice fish culture has been practiced for a long time, 100 % of respondents (23 households) adopt this practice. Fish culture begins from after first plowing to harvest after 30 days of transplanting. The stages of the production cycle for the lowland environment, in which the variety KNL is grown, are described below.

Animals draft and walking tractors have been used for land preparation. Thirty- five percent and 65 % of respondents used animal draft and walking tractor, respectively. Farmers who those use walking tractor, after plowing field will be left until 30 to 35 days before harrowing. For farmers who use animal harrowing will be done after15 days, 30 days, and 35days of plowing. These practices depend on individual farmers' practices and weeds emergence. The purpose of harrowing practices is to get rid of weeds. Before one week of transplanting, weeds in the lees have been also cleared. This is a cultural practice of farmers in this area. There were 60.86 %, 39.14 % of respondents plowed one and two times respectively. Harrowing in one, three, and four times were 60,86%, 21,73%, and 17,4% of respondents.

There are two methods for raising rice seedlings in this area. The first method is known locally as 'Karpong'. Karpong is raised in seedbeds, and are transplanted at 25-30 days. The second method, 'Karchome', involves double transplanting. After being raised for 25-30 days in seedbeds, the Karchome is transplanted into another seedbed, where they will grow for another 25-30 days before the second transplanting into the field proper. The larger seedlings of Karchome enable them to be transplanted into with fields with deeper water. Some 97 % of respondents in the study village use this method. Farmers believe the higher yield and with higher proportion of filled grains justify the extra work involved.

There is very little fertilizer use in the study area. Any chemical fertilizer use is usually only during the seedling stage on the seedbed, when a single, low application of urea might be given. Generally farmers in the area have a poor knowledge of chemical fertilizers, their use, and fertilizers availability in Samneua markets. The paddy soils in the area is acid soil with pH ranges from 4.2 to 4.3 and 6 ppm in moderate fertile soil to 27 ppm in good soil of phosphorus (Table 10). Minimum soil levels of phosphorus nutrient for satisfactory rice yield, critical value ranges from 6 ppm to 9 ppm (Hill et al 2003). Organic fertilizer in the form of animal manure is sometimes applied to the seedbed. The lowland crops are grown under natural rainfed conditions. However, farmers often will divert or control the

movement of water through their rice crops during the growing season. The water level in the rice fields ranges from 10 to 30 cm.

The level of weed competition usually reflects the level of land preparation and water management. Good land preparation usually results in few weeds. Most farmers do not regard weeds as a serious problem. Only 13% of respondents indicated the presence of weeds, while the rest (87%) did not observe serious infestation of weeds requiring manual weeding. Herbicides are not available or used. Insect pests and diseases are also not regarded as serious problems. Plant hoppers are sometimes observed during the seedling stage of crop development but they are generally not regarded as being a significant problem.

4.3.1 Yield components

In my study, on averaged 23,156,151,172, and 88 of number hills/m^2, tillers/m^2, panicles/m^2, number of grains panicle^{-1}, and percent of filled grain, in respectively (Table 48). Standard deviation was 16,15,3,15, and 3 for tiller, panicle, hill, grain per panicle, and % filled grain in respectively. Coefficient of variance (CV) of 23 fields was 13.0 %, 10.2%, 9.9 %, 8.7 % , and 3.4 % of hiils/m^2, tillers/m^2, panicles/m^2, number of grains panicle^{-1}, and percent of filled grain respectively. For more detail of the comments in each farmer' fields showed in the Appendix 4.

Table 48 Yield components of KNL variety on farm condition

Yield components	Descriptive analysis					
	Min	Max	Mean	SD	CV (%)	No
Hills/m^2	18	28	23	3	13.0	69
Tillers/m^2	128	189	156	16	10.2	69
Panicles/m^2	125	184	151	15	9.9	69
Grains/panicle	137	184	172	15	8.7	276
% Filled grain	82	93	88	3	3.4	276

SD= standard deviation, CV = Coefficient of Variance

Table 49 Mean of grain and straw weight among farmers' fields

Field	Farmer			Yield (t/ha)		Straw (t/ha)		HI
	Lao	English Lao	Thai	Mean	SD	Mean	SD	
23		Bounma	บุญมา	5.67	0.26	11.87	0.76	0.32
20		Chankham	จันทร์คำ๗	4.82	1.30	9.73	4.62	0.33
10		Lom	ล้อม	4.70	0.69	9.00	1.73	0.34
15		Bounkham	บุญคำ	4.65	1.18	9.00	0.92	0.34
21		Bouapheng	บังแพง	4.50	1.04	7.40	2.42	0.38
11		Siengkham	สิงห์คำ	4.47	0.23	9.47	1.50	0.32
4		Mon	มั่น	4.46	0.60	7.93	1.30	0.36
2		Lienthong	เรือนทอง	4.42	0.18	7.07	0.83	0.38
6		Phengsee	แพงศรี	4.14	0.37	9.20	1.06	0.31
1		Khammeenoy	คำมีน้อย	4.08	0.40	7.40	0.20	0.36
17		Thong	ทอง	4.01	0.48	7.13	1.17	0.36
18		Phanhthong	พันทอง	3.99	0.52	6.73	1.10	0.37
5		Bounsee	บุญศรี	3.95	0.19	7.87	0.64	0.33
8		Kamphanh	คำพัน	3.93	0.44	7.67	1.29	0.34
14		Maipheng	ไมแพง	3.79	0.44	6.47	1.55	0.37
7		Siengphone	สิงห์พร	3.74	1.04	6.93	2.61	0.35
12		Khampheng	คำเพ็ง	3.70	1.37	5.93	2.39	0.38
9		Kong	คง	3.69	0.19	6.60	1.22	0.36
3		Thongmee	ทองมี	3.66	0.43	7.07	0.70	0.34
19		Vanxai	วรรณชัย	3.62	0.42	6.47	0.61	0.36
22		Maiphon	ไมพร	3.50	0.48	5.80	0.72	0.38
16		Khammeeyai	คำมีใหญ่	3.47	0.70	6.07	1.90	0.36
13		Vat	วาด	3.45	0.27	6.27	0.76	0.35

HI= Harvest Index
LSD 0.05 for yield = 1.12 t/ha
CV for yield = 16.6 %

The range of yield in 23 farmers' field was ranged from 3.45 t/ha to 5.67 t/ha (Table 49). Field closed to primary canal as the field of Bounma was about 5.67t/ha highest yield than other field, and lowest was about 3.45 t/ha in the field of Vat as far from canal and medium fertility. Straw weight was ranged from 5.80 t/ha to 11.87

t/ha, while harvest index was varied from 0.31 in the field of Phengsee to 0.38 in the field of Lienthong, Bouapheng, and Maiphon. Standard deviation of yield ranged 0.04 to 1.37 and 0.20 to 4.62 for straw weight. Mean the yield from total 23 farmers' fields was 4.15 t/ha, with 0.53 t/ha of standard deviation (Figure 7). Most of the yield was ranged from 3.5 t/ha to 4.5 t/ha. The yield ranked 3.5 t/ha to 4.0 t/ha occupied 9 fields (39.13 %) of total surveyed and 30.44 % of yield ranged from 4.0 t/ha to 4.5 t/ha. There was only one field higher yield reached to 5.67 t/ha (Figure 8).

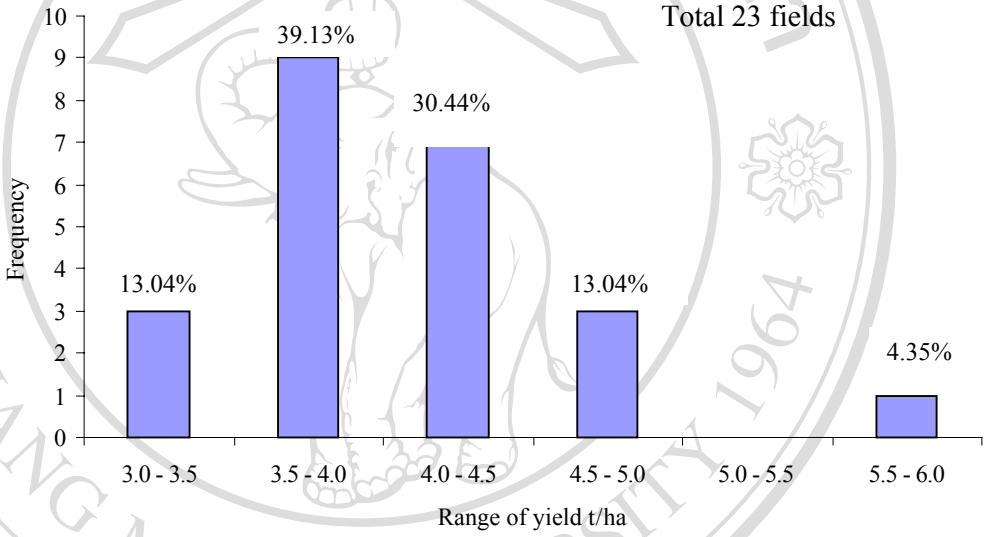

Figure 7 Distribution of KNL yield (t/ha) on farm condition in Ban Kan

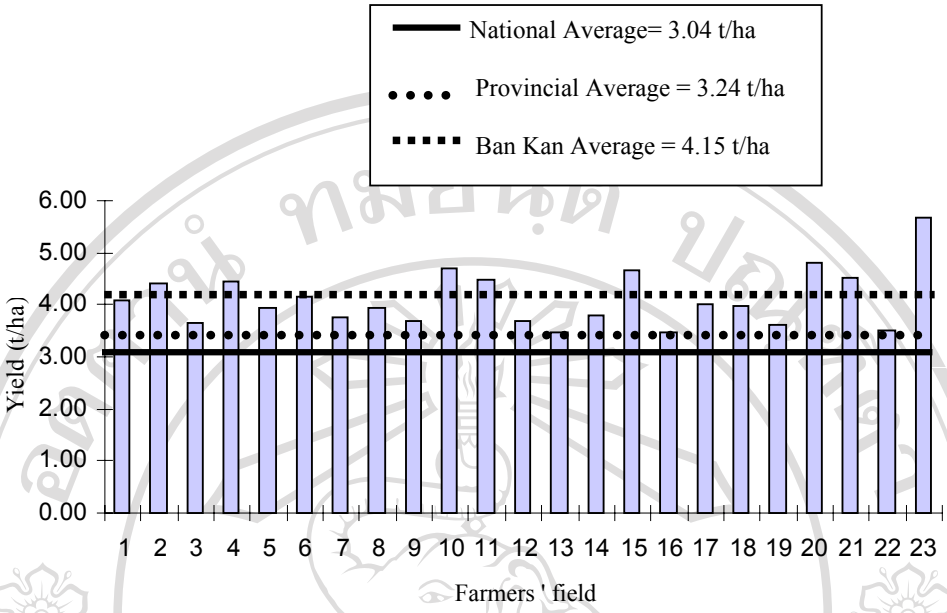

Figure 8 Grain yield and diversity index for the variety KNL in Ban Kan

4.3.2 Diversity within farmers' fields

Before crop cutting, in each sample the following were recorded - number of off-type plants, number of plants showing leaf pubescence, and number of awn panicles. The number of off-type plants, number of plants showing leaf pubescence and number of awn panicle were separated to calculate proportion of each characters and Shannon diversity index among farmers' fields. It was found that percentage of lemma and palea pubescence panicles ranged from zero to 2.7% (Table 50), most of lemma and palea found glabrous type. The percent of panicles with awn ranged from 0.8 to 100%, but most of field was no awn panicles. All of the fields the mixing of number of awn panicles and without awn panicles were observed. In seed selection, most farmers undertook selection annually at the time of harvest. In selecting plants for seed, most farmers selected one of their best plots then they selected the better plants within this plot or field.

Table 50 Lemma and palea pubescence, and awning among distribution on fields

Field	Panicles/m^2	Percent of panicles with pubescence on lemma and palea		Percent of awning	
		Glabrous	Short hairs	No awn	With awn
1	150	99.3	0.7	15.3	84.7
2	130	100.0	0.0	0.0	100.0
3	153	97.4	2.6	9.1	90.9
4	163	97.5	2.5	90.2	9.8
5	158	100.0	0.0	93.0	7.0
6	164	100.0	0.0	98.8	1.2
7	150	98.7	1.3	96.7	3.3
8	138	98.5	1.5	97.83	2.2
9	162	98.7	1.3	93.8	6.2
10	166	98.8	1.2	98.2	1.8
11	166	98.2	1.8	94.6	5.4
12	131	99.2	0.8	99.2	0.8
13	147	98.0	2.0	91.8	8.2
14	146	97.3	2.7	97.3	2.7
15	166	98.8	1.2	97.0	3.0
16	125	98.4	1.6	93.6	6.4
17	139	99.3	0.7	91.4	8.6
18	147	100.0	0.0	96.0	4.0
19	136	100.0	0.0	91.9	8.1
20	161	99.4	0.6	95.6	4.4
21	165	98.8	1.2	98.7	1.3
22	126	99.2	0.8	90.5	9.5
23	184	100.0	0.0	94.0	6.0

The percent of panicles with leaf blade pubescence ranged from 0.5 to 3.7 % (Table 51). Over 90 % of leaf blade of KNL variety was glabrous type. The percent of off-type plants mixture ranged zero to 3.5 %. Off-type plants characteristics are: early or late maturity, taller, large panicle, and high sterile than the variety grown.

Table 51 Leaf blade pubescences, and off-type plants distribution on fields

Field	Tillers/m^2	Percent of leaf blade pubescence		Percent of off-type panicles
		Glabrous	Pubescent	
1	152	96.7	3.3	0.0
2	134	96.3	3.7	0.0
3	158	96.8	3.2	0.0
4	171	98.2	1.8	1.2
5	163	98.8	1.2	0.0
6	170	98.2	1.8	2.3
7	158	98.7	1.3	2.5
8	144	97.9	2.1	3.5
9	168	98.2	1.8	0.0
10	170	97.6	2.4	2.9
11	172	98.3	1.7	0.0
12	136	98.5	1.5	1.5
13	154	98.1	1.9	1.3
14	152	97.4	2.6	1.3
15	170	98.8	1.2	0.0
16	130	98.5	1.5	1.5
17	140	99.3	0.7	0.0
18	150	98.7	1.3	2.7
19	138	98.5	1.5	0.0
20	169	98.8	1.2	0.0
21	169	99.4	0.6	1.2
22	128	99.2	0.8	0.0
23	189	99.5	0.5	0.0

The Shannon diversity index (H') based on lemma and palea pubescence in 23 farmers' field ranged zero to 0.125 (Table 52). Awning diversity ranged zero to 0.428 and 0.021 to 0.176 for leaf blade pubescence. Based on three characters, it ranged 0.007 to 0.204 on average of diversity index among farms' fields.

Table 52 Summaries of the Shannon Diversity Index (H') on farmers' fields

Field	Lemma and palea pubescence	Awing	Leaf blade pubescence	Average
1	0.040	0.428	0.144	0.204
2	0.121	0.306	0.176	0.201
3	0.099	0.342	0.096	0.179
4	0.115	0.321	0.088	0.175
5	0.042	0.356	0.042	0.147
6	0.046	0.314	0.045	0.135
7	0.082	0.237	0.079	0.133
8	0.090	0.210	0.087	0.129
9	0.125	0.125	0.122	0.124
10	0.041	0.231	0.089	0.120
11	0.000	0.280	0.075	0.118
12	0.000	0.252	0.092	0.115
13	0.070	0.146	0.067	0.094
14	0.075	0.104	0.101	0.093
15	0.065	0.090	0.122	0.092
16	0.037	0.166	0.064	0.089
17	0.065	0.135	0.064	0.088
18	0.000	0.226	0.033	0.086
19	0.000	0.170	0.070	0.080
20	0.065	0.065	0.036	0.055
21	0.044	0.044	0.076	0.055
22	0.000	0.053	0.088	0.047
23	0.000	0.000	0.021	0.007

4.3. 3 Variance analysis

In statistic analysis, there was significant at 1% of number of hills/m^2 (Table 53). In contrast, other components were not significant. It showed farmers' practices in spacing of transplanting was different, and depended on individual farmers. Grain weight g/m^2 was significant at 1 % as similar with straw weight.

Table 53 Summaries of variance analysis of crop survey on farm conditions

Sources of variance	Significant levels (F test)						
	Nh/m^2	Nt/m^2	Np/m^2	Nsl/p	% FG	GY t/ha	SW t/ha
Field	**	ns	ns	ns	ns	**	**
CV (%)	12	13.62	14	14	6.7	16.6	21.68
SD	2.74	21.26	21.00	24.30	5.61	69.90	166.93

** = Significant at 1%; ns= not significant
LSD 0.05 for yield (t/ha) = 1.12
Nh= number of hills, Nt= number of tillers, Np= number of panicles, Nsl= number of spikelets, FG= filled grain, GY= grain yield, and SW= straw weight