# Chapter II

# Literature Review

## 2.1 Definition of Crop Diversity

Biodiversity refers to all forms of life-plants, animals and microorganisms, and the ecosystems in which they exist and interact. Crop diversity refers to the biological diversity found in crops used for food and agriculture (Long et al. 2000). It includes the knowledge of farmers and other users, and is sometimes also referred to as plant genetic resources for food and agriculture.

Genetic diversity refers to the variance among alternative forms of a gene (alleles) at individual gene positions on a chromosome (loci), among several loci, among individual plants in the population or among populations (Brown et al. 1990). Genetic diversity is sum of genetic information contained in plants, animals and microorganisms (Difalco and Perrings, 2002). Within an individual species, genetic diversity allows populations to adapt to changes in climate and other environmental conditions. Genes transferred to domestic crop plants from their wild relatives can increase yield, improve quality, provide resistance to pests and diseases, and extend the growing range. This latter feature reflects the fact that the wild relatives have properties that are favorable under particular environmental conditions.

Genetic diversity refers to the variation of genes within species, and species diversity refers to the variety of species within a region (World Resources Institute, 1998). This covers distinct populations of the same species such as thousands of rice species in India, or within a population. The definition of genetic resources of International Plant Genetic Resources Institute (IPGRI) is 'genetic material of plants, animals and other organisms that is of value as a source for present and future generations of people'. According to IPGRI (1993), biodiversity is the total variability within all the living organisms and the ecological complexes they inhabit. Biodiversity has three levels: ecosystem, species and genetic diversity reflected in the number of different species, the different combination of species, and the different combination of genes within each species.

## 2.2 Measuring Crop Diversity

Ecological techniques exist for describing crop biodiversity at the level of the production system and farm, but have rarely been applied to agroecosystems. Quantifying genetic diversity between and within populations or cultivars has always been problematic (Cox and Wood, 1999). Methods of data generation generally fall into three categories: pedigree-based, phenotype-based, and genetic-based. Each method has strengths and weaknesses. For example, phenotype-based methods even when applicable in the field, suffer from genotype x phenotype interactions, and the fact that similar phenotypes may be expressed by different genotypes.

Yang and Smale (1996) illustrate some of difficulties of using agro-morphological characteristics to measure crop diversity. Some examples of this are as follows:

- Many economically important, observable plant traits (e.g. yield, grain quality) are controlled by no simple gene;
- Environmental variation leads to genetically identical plants appearing to be different and expressing different sets of genes. Conversely, two diverse plants may appear similar in an inhibiting environment.

Variety diversity is genetic diversity measured at the level of the variety. It can be measured as the absolute number of rice varieties found in a study area. Diversity can be measured on accessions held in gene-banks, lines or populations utilized in crop breeding programs, or varieties cultivated by farmers. Species diversity has been defined as "the number of species in a community and their relative abundance" (McNaughton and Wolf, 1979; Dennis, 1987). The relative abundance of species is usually referred to as evenness. The equivalent definitions can be used for varietal diversity. Some phenotypic traits are determined by well-defined (usually single-locus) genotypes and as such, are useful as genetic markers.

For the rice crop, diversity refers to variance among varieties and within populations in a variety. There are several methods of diversity measurement including: morphological characterization, biochemical characteristics (e.g., isozymes), and molecular markers (Brush, 2003). These methods offer numerous ways to measure the amount of variation that can be identified in a population. Measuring diversity depends not only on the method used but also on the unit of analysis, population, individuals, genome, locus, and DNA base sequence (Kresovich and McFerson 1992).

The diversity among cultivars within a species is often not easily described, and its effects are more difficult to evaluate (Cox and Wood, 1999). Most cultivars have names, with a number of different names representing the cultivars in a given field, farm or, of genetic diversity. The relative degree of genetic relationship among cultivars must be considered. Cox and Wood (1999) cited the example of the total number of wheat (*Triticum aestivum*) cultivars grown in the eastern USA. The number of cultivars increased steadily throughout the 1970s, there was a dramatic rise in overall genetic uniformity. Although there were many cultivars in a relatively small area, the most popular cultivars dominated the landscape. This example provides one of the problems encountered when trying to find appropriate means of measuring diversity. Richness, which looks at the total number of variants, or evenness, measures the frequency of different variants. In this context, consideration needs to be given to aspects of intraspecific diversity within a region, including that of unreleased breeding material. Cultivars used at one point in time can be, and usually are, replaced by new ones; unreleased breeding material can be an important and ready source of needed genes.



In recent times, measurements of genetic diversity have been applied mainly to domesticated species and populations held in gene banks and botanic gardens (World Resources Institute, 1998). In such applications, diversity can be measured in many ways. Scientists, however, have yet to settle on a single appropriate method. There are still many methods being used to compare both species and heterogeneity diversity (Margurran, 1983 and Koffey, 2002).

Currently the Margalef's index is widely used for species richness measures. It is calculated from the following formulae:

$$\text{Margalef's index} \qquad D_{mg} = (S-1)/\ln N$$

Where S= the number of varieties and N= the number of seed lots were found.

The above method is usually used to measure species *richness* at the ecosystem and agro-ecosystem levels. They do not give a measure of *evenness*. The assessment of genetic diversity within varieties and at a population level needs to look at both *evenness* and *richness* in a given sample. The Shannon diversity index is widely using to measure diversity within populations and varieties because it incorporates *richness* and *evenness* into a single measure (Ludwig and Reynolds, 1988). This index is measured using the following formulae:

$$\text{Shannon diversity index} \qquad H' = -\sum p_i * \ln p_i$$

Where $p_i$ = the proportional abundance of the *i*th characters = ($n_i$/N).
N= sample size

For example, using above formulae in measuring lemma and palea pubescence of rice grains. Sample size (N)= 50 grain, 10 grains glabrous and 40 grains short hairs so that $p_i$ = 10/50 and 40/50. H'= $-\sum[10/50(\ln 10/10)+40/50(\ln 40/50)]$= 0.50. This value large mean that more diversity within population or sample.

## 2.3 Threat to Rice Genetic Diversity

Genetic erosion in crops is the loss of variability from crop populations (Brush, 2003). Variability refers to heterogeneity of alleles and genotypes with their attendant morphotypes and phenotypes. Populations can be identified at different spatial levels from a local to global distribution of a crop.

The replacement of traditional varieties by improved varieties, changes to cultivation practices, and loss of habitats are factors, which impact on erosion of crop genetic or crop diversity. Rice is the stable food for over 60% of humanity and the 'paddy system' of rice production may be the world's oldest sustainable agro-ecosystem (Thurston et al 1999). These authors provided the understanding of the changes occurring in the traditional management of rice diversity in Southeast Asia, where rice originated. The loss of diversity in rice in Asia since the introduction of high-yielding varieties, and effects of modern rice varieties on traditional management of rice diversity were also considered. In 1966, the high-yielding variety of IR 8 was released. Since that time, the agro-ecological and human environments relating to rice farming have rapidly changed. Only a few modern varieties are usually recommended by local extension agencies in many areas of Asia (Thurston et al 1999). Similarly Bellon et al (1998) report that the average number of rice varieties per farmer in Southeast Asia is low, usually below two and never higher than four. But in Laos, average 3-5 varieties of differing maturity times are grown by individual farmers (Appa Rao, 1997).

In recent times, 'advances' in agriculture have generally been reflected in the establishment of monoculture production systems based on the use of a few profitable varieties, with the concurrent disappearance of traditional land races. This is particularly so in countries with a tradition of growing rice. FAO (1993) has estimated that more than 60% of the world' rice area is planted to varieties of improved plant type. In Indonesia, Philippines, and Sri Lanka, modern rice varieties are currently estimated to cover 82%, 85%, and 87% of the total rice area, respectively. It has been estimated (Zhang et al, 2002) that, in Bangladesh, the promotion of high yielding varieties (HYVs) and development of a rice monoculture has resulted in the loss of nearly 7,000 traditional rice varieties. In the Philippines, HYVs have displaced more than 300 traditional rice varieties that had been the principal source of food for generations (Zhang et al, 2002). Landraces or traditional varieties, although generally have a low yield capacity, they usually have high yield stability, an important characteristic for subsistence farmers (Oka, 1991). Perhaps the greatest example of a decline in genetic biodiversity has taken place for rice in India. Before being colonized it has been estimated that there were up to 400,000 different varieties in the country. By the mid 19$^{th}$ century the number had been reduced to about 30,000. A further several thousand were estimated to have been lost as a result of changes brought about during the green revolution in the 1960s (Heal 2002). Three periods of change to genetic diversity have been recognized for many crop plants, including rice. The first was at the beginning of the 19$^{th}$ century in Europe with the advent of early plant breeding; the second was in the 20$^{th}$ century and was associated with the effort to improve productivity in the non-industrialized countries through breeding for short stature and disease resistance; the third was the more recent program of breeding to achieve uniformity.

Paroda and Arora (1991) have pointed out that there are three processes that operate to affect the genetic diversity and biodiversity of crops that are now being cultivated; these processes are: genetic erosion, genetic vulnerability and genetic wipeout. Genetic erosion of diversity is the replacement of traditional varieties by a relatively small number of varieties bred for high yields and other characteristics that make these varieties suited to high-input agriculture. Genetic vulnerability is the condition that results when a widely planted crop is uniformly susceptible to a pest, pathogen or environmental hazard as a result of its genetic constitution, thereby providing the basis for potential widespread crop losses (FAO, 1998). One of the main causes of genetic vulnerability is the widespread replacement of genetically diverse traditional or farmer varieties by homogenous modern varieties. Industrialized agriculture favors genetic uniformity. Vast areas are typically planted to a single, high-yielding variety or a handful of genetically similar cultivars using intensive capital inputs like irrigation, fertilizer and pesticides to maximize production. A uniform crop is a breeding ground for potential disasters on account of it being highly vulnerable to epidemics of pests and diseases. A pest or disease that strikes one plant spreads quickly throughout the crop. Genetic wipeout is the rapid and wholesale destruction of a wealth of potential species constituting a genetic resource.



Brush (2003) indicates that the main basic cause of genetic erosion is the diffusion of modern varieties throughout the cropping areas from crop improvement programs. Other latent causes include the impact of the effects of population growth, poverty, markets, and cultural changes. Dennis (1987) also reports that among other factors that have had an impact in narrowing genetic diversity has been the demand for uniform quality by agricultural mechanization, urban and export markets, and patent laws.

Although many authors and researchers argue that modern varieties have been responsible for the erosion of traditional varieties. Others say that they are an important and essential component of crop diversity. Witcombe (1999) has addressed the question of whether plant breeding leads to a loss of genetic diversity. He concluded that in areas that already grow modern varieties, plant breeding does not necessarily have a negative impact on genetic diversity; however, in areas that are not already growing modern cultivars, genetic improvement will often reduce biodiversity. The use of participatory plant breeding will limit the rate of loss, and put a ceiling on its reduction. Modern developments in plant breeding, such as genetic transformation and marker-assisted selection, will affect biodiversity. Molecular marker techniques will help in broadening the genetic base of the crop and facilitate the deployment of multi-line varieties (Witcombe, 1999). The impact of genetic transformation is difficult to predict since it depends on socio-economic as well as technical factors.

The International Rice Research Institute (IRRI) initiated a study in 1975 to measure the impact of the early semi-dwarf rices genetic diversity in Asian rice breeding programs (Witcombe, 1999). The most popular single gene source in the 1965-67 sample of crosses was the Taiwanese cultivar 'Taichung native 1' (TN1), probably the first semi-dwarf rice developed through hybridization (Athwal, 1971), and it had the DGWG gene for dwarfing. The diffusion of semi-dwarf genetic materials into breeding programs has reduced the genetic diversity of current and future cultivars. More than 80% of the 1974-75 crosses carry the DGWG gene for dwarfism, and most new semi-dwarfs, were *indica* rices. These largely replaced *japonica* and other races in the breeding programs.

The 'green revolution' in the latter part of the 1960s and through the 1970s, had little impact on Lao agriculture. However, it did have a great impact in other parts of Asia including in such as Thailand, Vietnam, and China. FAO (1993) estimated that by 1981-1984, 'modern' rice varieties covered more than 60% of the world's rice area. In contrast, in Laos at the same time, less almost one percent of the area under rice cultivation was being sown to 'modern' varieties.

**2.4 Disadvantages and Advantages Crop Plant Diversity**

Biodiversity is essential to life, by providing the raw material for evolution and underpinning ecological stability. This also applies to crop diversity. Without it, crop improvement is impossible. It can be regarded as part of natural capital, a resource that can be drawn upon in order to contribute to strengthening people's livelihoods. Over 20 or 30 years, plant breeders have been trying to produce high yielding varieties of crops. As result, for many crops we now rely heavily on a few 'modern' varieties. Each of these modern varieties is very uniform and often contains less genetic diversity than farmers' varieties.

For plant breeders, in their endeavor directed towards increased agricultural production, there is a pressing need for more genetic diversity to work upon, to cater to varied kinds of problems and needs. The wider the range of choice a breeder will have in selecting the appropriate kind of diversity, the better will be the chances for his success for any particular goal.

Homogenization of varieties increases vulnerability to insect pests and diseases (Schoenly et al 1998). History has shown serious economic losses and suffering from reliance on mono-cultural, uniform varieties. The reduction in diversity often increases vulnerability to climate and other stresses, raises risks for individual farmers, and can undermine the stability of agriculture (WRI, 2002). Diversity can serve as an insurance against crop failure. Comparison between rice varieties planted in mixtures and in monocultures in Yunan province of China showed that when the varieties were planted in mixtures, they had 89% greater yield and blast disease was 94% less severe, than when they were grown in monocultures (Zhu et al 2000). In addition, varietal mixtures can not only give a significant reduction in disease incidence, but also help improve product quality by combining complementary characters and by providing increased stability. However, variety mixtures may not always be the solution to disease control and providing stable yields under modern agricultural conditions.

The common principles for crop production in traditional systems are high degree of both intra- and inter specific genetic diversity (Thurston et al 1999); diverse cultural and biological control practices; limited use of external inputs; and sustainable practices which often have multiple use. In contrast, modern farming systems rely on external inputs such as high-yielding, uniform varieties, often with multiple resistance to pests, diseases and stresses, and inputs of inorganic chemicals for both pests and soil fertility controls. In spite these inputs, serious disease and pest epidemics still occur in modern farming systems.

## 2.5 Diversity in Crop-based Agro-ecosystems

Agro-ecosystems vary widely in the amount of biodiversity they contain and how that biodiversity is organized among species, cultivars within species, and within cultivars. Crop ecosystems usually have low species diversity when compared with most non-agricultural systems; the farmer's intention is usually to try and eliminate all but a few species from a field if possible. In general, knowledge of crop diversity at the species level is good, but at the cultivar level it is limited. For improved varieties this knowledge is patchy, but for some crops such as rice, maize and wheat, it is regarded as adequate; however, for landraces it is poor (Cox and Wood, 1999).

### 2.5.1 Diversity among species

Diversity among species in space and in time, are important in crop species to allow complementary contributions to the human or animal diets. At the same time, this diversity contributes to the functioning and productivity of the agro-ecosystems of which they are part. A large part of farmers' skill in managing crops depends on the ability to, first recognize species, and then, to develop a knowledge of the properties of species to allow their development, whether promotion or removal, in the production system (Cox and Wood, 1999).

In modern agriculture, it is more common to minimize diversity of land use than to sustain diversity. This is achieved by applying uniform systems of management, which seek to override biophysical variation over large areas. Shifting cultivation in which fire is the principal means of preparing sites for cropping is also a uniform system of management, though (in the long-term) less destructive of biodiversity because of the importance of the fallow period. Diversity of land use helps sustain diversity among species and cultivars, and can be attained by the use of relatively benign methods. These include crop rotations, the adoption of cultural methods to retain soil moisture, interplanting crops in a mixture (polyculture), or the planting of crops among useful trees, which have either been conserved in the process of land preparation or deliberately planted (agro-forestry). There are various mixed farming systems in agro-ecosystem, which arable crops, trees and livestock are integrated. The value of maintaining landscape level diversity in any of these ways helps sustain both floral and faunal diversity.

**2.5.2 Diversity among cultivars within species**

Most cultivars have names but the number of different names representing the cultivars in a given field, farm or region, is not usually a good indicator of genetic diversity (Cox and Wood, 1999).

Populations of landraces are genetically heterogeneous, and are expected to be evolutionary active under changing environmental conditions. The existence of genetic diversity enables crop plants to evolve and cope with environmental changes. Landraces, however, may be recognized morphologically. Farmers have names for them and different landraces are understood to differ in adaptation to soil type, date of maturity, height, and other properties (Bellon, 2002). There are many reasons for poorer farmers continuing to grow traditional rice cultivars. Small and marginal farmers often have little access to institutional credit for sinking wells (for irrigation) and their investment would not provide the returns necessary to repay loans. Traditional rainfed paddy fares well on marginal lands, and at least assures farmers of food security for the year, the pesticide requirement is very low; and the traditional cultivars have often been selected for their taste and other cooking and eating characteristics. These and other reasons determine why poorer farmers often continue to grow several traditional rice cultivars.

Kshirsagar and Pandey (1993) studied rice cultivation practices in Eastern India revealed that in this region, individual farmers sometimes grow up to 12 rice cultivars. It was also found that most farmers also have an intimate knowledge of each variety and how it fits into specific ecological niches. They also indicted that farmers perceived that improved cultivars perform better under better fertility regimes. On the other hand, the performance of traditional cultivars is recognized as being superior under low fertility conditions. The traditional varieties were also seen as being better able to sustain the soil resources over a long period of time, as well as being better performing under a range of biotic and abiotic stresses.

### 2.5.3 Diversity among plants within cultivars

The amount of genetic diversity within a cultivar depends on the relative frequencies of self and cross-pollination in the species to which belongs, the methodology used by breeders or farmers to develop the cultivar, and the magnitude of natural gene flow (Cox and Wood, 1999). In general, within-cultivar diversity is greater in predominantly cross-pollinated species than in predominantly self-pollinating species; rice, *Oryza sativa* L, is a self-pollinated species. It is also generally greater in landraces than in cultivars developed by in modern breeding programs.

## 2.6 Rice-based Agricultural Systems in Laos

Agriculture is the main economic sector in Laos, and accounts for approximately 52 % of total GDP and employs 86 % of the labor force (Lao-IRRI, 2002). Most agricultural production in Laos has been based on traditional farming systems with little use of external inputs such as chemical fertilizers or pesticides; there is also relatively little mechanization of production. In 1999, only 28 % of 789,000 households involved in agricultural production used chemical fertilizer. In the northern agricultural region, less than 10% were using chemical fertilizer, with more than 50% of households never having used either chemical or organic fertilizers in crop production (Central Agricultural Statistical Office, 2000). Chemical fertilizers are usually only used in association with the planting of improved rice varieties.

Rice is most important crop nationally with regard to both the area under cultivation and grain production; it accounts for more than 80% of the cultivated land area and 87 % of the crop production. The bulk of rice production (71%) is from low-input conditions from single wet-season cropping in the rainfed lowland environment.

According to the Central Agricultural Statistical Office (2000) traditional rice varieties are still grown on about 71 % of total rice area throughout the country. Improved rice varieties, when grown, are to be found in the central and southern agricultural regions, which have been the focus of attempts to increase production in an effort to achieve national rice self-sufficiency. Improved varieties developed in the recently established national rice-breeding program were first released in 1993 (Schiller et al 2001). These early varieties and those developed subsequently have generally not been well suited to the northern agricultural region of the country.

The soils throughout the main lowland rice growing areas in the central and southern agricultural areas are generally infertile, highly weathered, old alluvial deposits that comprise a series of low-level terraces with an elevation of about 200 mean above sea level (Lathvilayvong et al. 1996). Texturally they are predominantly loams, sandy loams and sands. Systematic studies on the soil nutrient status and potential yield responses from fertilizer application commenced in 1991 with the initiation of a national rice research program (Schiller et al. 2001). Linquist et al. (1988) has summarized the main findings of the nutrient response work. Nitrogen is the nutrient most limiting in all regions of the country, with 86% of experimental sites responding to N in the central and southern regions, and 50% in the northern region. Phosphate is the second most limiting nutrient in all regions, with 80% of experimental sites responding to P in the central and southern regions, and 33% in the northern regions. The P deficient soils in the north generally have a higher P requirement than in the central and southern regions. Potassium is the least limiting of the nutrients tested, with 27% of sites in the central and southern regions giving a yield response to K, and 13% in the north.

Soils maps are not yet available for most upland areas. Complex soils generally predominate in the more hilly areas (Schiller et al. 2001). Under the traditional 'slash-and-burn', shifting cultivation systems that have prevailed in the past for upland rice cultivation, natural fallow rotation has been the primary means of soils fertility management. The restoration of soil fertility under these systems is dependent on levels of biomass production of the fallow crops. It is generally recognized that the traditional systems can be sustainable with long fallows, but that the systems will collapse with reduced fallow periods as a result of a failure to restore soil fertility levels (Roder et al. 1997a). Between the 1950s and the early 1990s, average fallow periods in much of northern Laos had dropped from more than 30 years to five years and less (Roder et al. 1997a, b). These authors attributed the decline to increasing population pressure. The low upland rice yields being recorded throughout much of northern Laos reflect, in part, this continued decline in soil fertility. Although there is few systematic studies on potential rice yield responses to fertilizer inputs under upland conditions in Laos, substantial yield increases with the application of N fertilizer have been recorded (Lao-IRRI 1994, 1995). Large differences in yield between sites in on-farm variety trials (Lao-IRRI 1999) can be attributed to differences in soils fertility, which in turn largely reflect differences in the duration of the fallow period between successive rice crops (Schiller et al. 2001).

**2.7 Rice diversity based on ecosystems in Laos**

Almost 80% rice production in Laos is based on rainfed cultivation systems in both the upland and lowland environments (Lao– IRRI, 2002). In 2000 approximately 70 % of total production came from the rainfed lowland environment and 12 % of production came from the rainfed upland environment. In general, different rice varieties are grown under rainfed lowland and rainfed upland conditions. The differences between these varieties are generally so distinct that farmers and experienced researchers can quickly differentiate the varieties grown in different environments, based on plant and grain characteristics. However, a few traditional varieties are grown under both ecosystems (Schiller et al, 2001). The varietal diversity that exists in Laos is different between the lowland and upland environments.

### 2.7.1 Rice diversity in the rainfed lowland environment

In traditional systems, farmers grow a number of varieties in the same field, each variety being confined to a specific area. On average, 3-5 varieties of differing maturity time are grown by individual farmers (Appa Rao, 1997). However, in the southern agricultural region, up to seven varieties have been recorded being grown by individual households, with as many as 18 varieties being found within a single village. The rationale of Lao farmers in growing such a diversity of varieties is to reduce risk, distribute labor demand, and to meet specific consumption requirements (Appa Rao, 1997).

Traditional rainfed lowland varieties are relatively more uniform in terms of maturity, plant height, grain and panicle characteristics, relative to upland varieties. They are generally taller than improved varieties, produce several thin culms, and have long narrow leaves that are hairy, produce small to medium sized panicles, which contain small and well-filled grains (Appa Rao, 1997). Crop duration of the traditional varieties ranges from about 100 to as much 270 days. Most of the rainfed lowland varieties found in Laos belong to the varietal group *indica* (Golomb, 1976). Although many varieties have been found in lowland environment, but how much diversity within these cultivars are no reported and studied. In this thesis was focused on diversity both variety and within seed lot levels, to estimate diversity of traditional rice varieties in the study area.



### 2.7.2 Rice diversity in the rainfed upland environment

Rice cultivation in the upland environment of Laos differs from the lowland environment in that several cultivars with differing phenotypes are sometimes grown in the same upland field (Appa Rao 1997). These mixtures usually comprise varieties of the same height and maturity time, but differing in relation to some panicle and grain characteristics. As many as 13 different phenotypes, with differences in shape and size of panicles and pigmentation have been identified in a single upland field in Luang Prabang province of northern Laos (Schiller et al 2001).

Upland farmers have usually grown several rice varieties in the same field, with different maturity time and characteristics. Individual farmers do seed selection from their own field but only a few farmers sometimes receive seed from other farmers both within village and outside village. Upland varieties tend to be high diversity between varieties and within seed lots than lowland varieties because several varieties are grown in the same field. But this is assumption that potential mixture during growing and harvesting times.

**2.8 Diversity in land races of rices**

The land races or native cultivars grown in subsistence agriculture are diverse and generally carry a great amount of genetic variability in their populations (Oka, 1988). In contrast, populations of improved cultivars or modern cultivars are exceedingly homogeneous. Researchers have used a variation of spikelet length and width to assess diversity within population. Oka (1988) studied populations of land races of *O. Sativa* from India and Thailand by using generalized of variance ( $\sqrt{G}$ ) of spikelet length and width. He found that $\sqrt{G}$ value showed wide range, laregest value of $\sqrt{G}$ was 0.26, exceeded those for hybrid swarms between wild and cultivared plants. He expressed that this highly geterogeneous populations appared to be mixtures of *Indica*- like and *Japonoca* –like plants. Similar published by Sato (1971) the study in north of Japan, earliest rice grains from the Hemudu remains, Zhejiang of China gave a much greater $\sqrt{G}$ value about 0.24, even though this was based on estimated size measurements from photograph.



Zhang et al (2002) studied over 5200 accessions of Yunna rice in southern China. The plant height ranged from 52 to 210 cm, 1000- grain weigh from > 20 to 52 g, grain size of 5 to 13 mm by 2.4 to 4.9 mm, and with small variation in tiller number. They also found that genotypes with large panicles and grains are often valuable for high-yield breeding, but suffered from the disadvantage of their greater height, small number of tillers and undesirable canopy characteristics. The land races populations of rices are diversity in both morphological traits and isozyme levels. Similarly with Dilday et al (1998) evaluated 17, 279 accessions from 110 countries. They found that day from emergence to flowering from 37 to 219 days, kernel length (3.0 to 9.9 mm), Kernel length/width ratio (1.0 to 8.0), plant height (41 to 208 cm), and 1,000-grain weight from 6.9 to 46.0 g.

Oka (1988) found that populations of land races from hilly area of tropical Asia showed a range of within-population genetic diversity, the value of average genetic diversity (Hs) from zero to about 0.20. He suggested that the genetic diversity in both morphological traits and isozymes observed in land races populations carries diverse genes for other unobserved traits. Diversity of rice by using isozymes and molecular marker is applied for evaluation of genetic diversity within populations. Allele frequencies at three esterase isozyme loci of 967 accessions from 94 countries showed that there was large genetic variation in 22 countries and this extended southward from Daying Mountain and Westward from the Yunjiang River towards the borders with Myanmar and Laos (Dai et al, 1995).

**2.9 Conservation of Lao national rice germplasm**

Scientists have tended to conserve crop diversity mainly by collecting samples from farmers' fields and storing them *ex-situ* (off-farm) in genebanks (Holden and Williams, 1984). However, in recent years there has been increasing recognition of the need to complement this with *in-situ* (on-farm) conservation. The definition of *in-situ* conservation as 'on-farm conservation' is considered to be 'sustainable management of genetically of locally developed traditional crop varieties with associated wild and weedy species or forms by farmers within traditional agricultural, horticultural cultivation systems (Maxted et al, 1997). The key feature of on-farm conservation is the traditional knowledge and practical skills of the farmers; thus it is sometimes referred to as on-farm management (Engles and Wood, 1999). An understanding of farmers' management of their crops is one of the important factors in enhancing on-farm conservation of crop diversity at community level. The major of advantage of *in-situ* conservation is the maintenance of exotic characters that are not of interest to the breeders now, but may be in the future (Balakrishna, 1996).

From the 1980s, weaknesses of *ex-situ* conservation began to be evaluated. Some researchers have pointed out that the evolutionary process that gave rise to genetic diversity is stopped in cold storage (*ex-situ*) conservation (Rerkasem and Rerkasem, 2002). In such an environment, the evolutionary processes, whether the result of natural or human selection, cease. However, it is also recognized that both *in-situ* and *ex-situ* conservation have their strengths and weaknesses. *In-situ* conservation allows farmers to select and maintain the crop diversity they have available. However, at the same time it is recognized that useful genes can sometimes be discarded as a result of the selection and decision-making processes of farmers. By contrast, the *ex-situ* conservation preserves the existing crop diversity, but in a form that is mainly of use to plant breeders.

Anticipating changes to this natural bio-diversity associated with the development and release of a range of improved rice varieties, between 1995 and 2000, the International Rice Research Institute (IRRI) in collaboration with the Lao Ministry of Agriculture and Forestry (MAF), undertook an intensive program of collecting the traditional rice germplasm throughout Laos. In a five-year period of collecting, more than 13,000 samples of cultivated traditional rice varieties were collected from all regions and all rice growing environments throughout the country (Appa Rao et al., 2001). Approximately 56% of the samples collected represent the genetic diversity in the upland environment, while 44% are from the lowland environment. Within the collection are 631 samples collected from six districts in Houaphanh province. The majority (82%) of samples from the province were collected in the upland environment, and the majority (88%) has glutinous endosperm



**2.10 Farmer Management of Diversity**

Bellon, 2002 defined “farmers’ management of diversity” as ‘the cultivation of a diverse set of more or less specialized crop populations’. These populations are named and recognized as units by the farmers: they are “farmers’ varieties” as opposed to the "improved varieties". In addition, he identified four components of farmers' management of diversity: (1) seed flows, (2) variety selection, (3) variety adaptation, and (4) seed selection and storage. Aspects of these four components can determine the rate of change of crop diversity at farm level. There are many factors that influence a farmer's decision to maintain crop diversity. Among the most important are: ecological (e.g. use of microniches), cultural (e.g. value systems), including the socio-economic status of the household (Long et al., 2000).

According to Bellon et al 1997, *in-situ* or on- farm conservation of diversity has been defined as 'farmers continued cultivation and management of diverse set of crop populations in the agro-ecosystem where the crop has evolved'. On-farm conservation is dynamic because the varieties that farmers manage continue to evolve in response to selection pressures. In on-farm conservation, the role of the farmer is seen in two ways: First, crop variety development is not only the result of natural selection, but also reflects the effects of human selection and management. Secondly, farmers' decisions determine whether populations are maintained. On-farm conservation therefore depends on the active participation of farmers. Blaskrishna (1996) has listed the major advantage of *in situ* conservation as the maintenance of exotic characters, which are not of interest to the breeders at this moment, but of potential interest in the future.