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# Landraces: A review of definitions and classifications

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**Summary**

The first reference to landraces as genetic resources dates from 1890. Some 20 years later the first definitions of a landrace were published. In the period 1909–1952 several definitions of the term landrace have been presented. No definitions were discovered in articles published in the period 1953–1974. The reason could be that after the Second World War attention of plant breeders and others was focussed on making instant progress. New definitions have been presented since 1974. Genetically related landraces form a landrace group. Synonyms of the term landrace and landrace group as cited in the literature are also given. The classification of types of landraces given by Mayr in 1934 had been discussed and an amended classification provided, paying attention to contamination caused by seed change.

As a landrace has a complex and indefinable nature an all-embracing definition cannot be given. However, I suggest the following: an autochthonous landrace is a variety with a high capacity to tolerate biotic and abiotic stress, resulting in a high yield stability and an intermediate yield level under a low input agricultural system.

## Introduction

A review is presented of the various definitions of a landrace. The intention is to show how these definitions have evolved since the end of the 19th century.

At the 'Internationaler land- und forstwirtschaftlicher (agriculture and forestry) Congress' at Vienna in 1890 for the first time the participants E. von Proskowetz and F. Schindler proposed to discuss the conservation of landraces as genetic resources, but 'The question of maintenance of our primitive cultivated forms in the regions of provenance of the species and the wild relatives of our cultivated crops was formerly not a subject of consideration and will also not be discussed extensively here' *(Die Frage der Erhaltung primitiver Kulturformen in den Ausgangsgebieten der Arten und den wilden Verwandten unserer Kulturgewächse war damals nicht Gegenstand der Betrachtung und soll auch hier nicht erörtet werden)* (Fruwirth, 1928; Mayr, 1935; Lehmann, 1990). This proposed point of discussion was based on the knowledge that, although by line selection good cultivars of (inbreeding) crops were selected from landraces, this did not mean that even better parental plants could not be found within the landrace. Therefore, they stated that the landrace, already used as a source, should be maintained.

The subject of conservation of landraces as a point for discussion, was raised again at the Congress held in 1906, but apparently without outcome. However, after 37 years, during the International Agricultural Congress at Rome in 1927 organized by the International Agricultural Institute (the predecessor of the FAO) the conservation of landraces was extensively discussed. It was recommended that participants should organize in their native countries the conservation of landraces by growing landraces on farms (*in situ* conservation) and in school plots. However, only in Austria, Fruwirth's and Mayr's native country, was a start made but even there after a few years the organisation broke down (Zeven, 1996). Later Harlan & Martini (1936) advocated the conservation of landraces as genetic resources in North America and since

ca. 1960 so did those involved in the International Biological Programme (Worthington, 1975).

Earlier, since the end of the 19th century, extremely large numbers of accessions had been and still are collected, stored and maintained in genebanks of the USA and the GIS (formerly the USSR) genebanks. In Russia, and later the USSR, a large number of researchers under the guidance of N.I. Vavilov were put into action to collect genetic resources up to ca. 1939. Both federations house large genebanks. Similarly, in Germany, an early start was made with the establishment of a genebank on a world scale (Lehmann, 1981).

In some countries, intensive breeding of several crops started some 150 years ago. This means that for more than 140 years landraces had to compete with cultivars grown under improved conditions. However, not all crops were improved by breeders and even at the present time in highly developed countries with well-established breeding programmes landraces of some minor crops may still be grown. An example is the white clover landrace 'Fries-Groninger' which was registered and listed on the Dutch List of Varieties of Agricultural Crops up to 1979 (Zeven, 1991). The same is true for the many unregistered garden forms of dry bean (*Phaseolus vulgaris* L.) which still are grown in The Netherlands (Zeven, 1979, 1997).

The above discussion shows that from time to time and from country to country researchers and others have been interested in landraces as sources of breeding parents, and hence, in their conservation. Therefore, landraces have often been discussed but only a few authors has tried to define them. In this paper a review of concepts and definitions published through the years will be given. The paper is concluded with a new definition, based on those reviewed.

## Cultural heritage

A point which has receive too little attention is the conservation and maintenance of landraces as a part of the cultural heritage of a region or country. Landraces are in many ways comparable with monuments, regional dresses, and folk songs to mention a few examples of regional or local cultural heritage.

## Landraces

When man started to domesticate wild plants he developed plants which had phenotypes surviving not only natural selection but also artificial selection. The phenotypes and genotypes of the wild plant changed as man selected for plants with certain desirable characteristics, which either were already present or else arose during cultivation. Man maintained and multiplied these desirable plants. In addition to man's selection activities nature also selected phenotypes suitable to be cultivated on man-made land and gardens. These combined actions resulted, for some crops, in populations which we call landraces. The term landraces also includes garden-races. These were and still are grown, in remote areas or in small garden plots, as Hawkes (1983) suggested: remote to those trying to collect landraces, but not for the growers themselves.[1]

Landraces have originated together with agriculture and horticulture, during the past 10,000 years or so. Hence, landraces of many crops have probably been grown for several millenia. Although landraces are commonly considered as endemic to a particular region, they have always been moved over short or even long distances, and thus brought into competition with autochthonous landraces if present. They may disappear, or they may replace these autochthonous landraces or more likely, they may together form a new landrace. For each site and for each year their composition becomes adapted to the conditions of that site and that year. These adaptations have taken place by changing the frequencies of phenotypes and hence genotypes for self-fertilizing and vegetatively propagated crops, and of alleles for outbreeding crops, and by absorbing new genotypes either introduced from elsewhere or else which have originated by mutation or by a low degree of interplant hybridization.

Depending on the economic importance of a crop, the degree of the national and local breeding efforts, and the introduction of exotic cultivars, landraces will disappear sooner or later. They will be replaced because they were developed for their yield stability, whereas cultivars are bred for high yield capacity under improved cultivation methods. Yield stability of landraces under traditional low input agricultural systems is due to the fact that whatever the varying biotic and abiotic stress for each plant one or more genotypes within the landrace population will yield satisfactorily. Landraces were and still are grown by farmers, market and private gardeners all over the world for this reason.

[1] In this paper the term landrace will also include garden-race. A cultivar is as described in the section on the ICNCP. Although the ICNCP equates variety and cultivar, the term variety is used here as no better inclusive word is available for the taxa landrace and/or cultivar.

We must consider these special qualities of landraces, that have enabled man to obtain sufficient food to survive during some 10,000 years (Zeven, 1975).

## Definitions

What are landraces? During some 90 years various researchers have coined definitions of a landrace. Some are too concise, whereas others are merely long descriptions. The following definitions have been collected and are discussed here. Especially in definitions from the first few decades of the present century several words are now out of use and modern words have been added [in brackets] to explain the intended meanings.

## International Code for Nomenclature for Cultivated Plants – ICNCP

The term landrace is not mentioned in the ICNCP (Trehane, 1995). The item landrace cannot be included in the term cultivar as the cultivar is described as 'a taxon that had been selected for a particular attribute or combination of attributes, and that is clearly distinct, uniform and stable in its characteristics and that, when propagated by appropriate means, retains those characteristics.' As already stated no, or only limited, human selection is carried out to maintain a landrace, it may clearly be distinct from other landraces, but repeated cultivation especially under other circumstances, often results in a different appearance of the landrace. Hence, a landrace is not uniform and stable, and thus is different from a cultivar.

*Period 1909–1952*

(–, ACZ) text added, [–, ACZ] word/s explained.

The first definition found was that by von Rümker (1908), who stated for cereal varieties, that landraces are varieties, which in the region, of which they carry the name, were grown since time immemorial (*Landsorten sind Sorten, welche in dem Gebiete, dessen Namen sie tragen, seit unvordenklichen Zeiten angebaut werden*). In fact von Rümker says in his definition that a landrace is a landrace, because it carries the name of the region where it has been grown for a long time. Since landraces migrate that 'time immemorial' is much shorter than many have considered it in the past and at present. Von Rümker further mentioned that landraces are adapted to their growing conditions and that no human selection is carried out. If grown outside its native region it will continue to preserve its original characters and characteristics. Therefore, a barley landrace foreign to the Hanna region in Czechia but grown in that region will never become the 'Hanna' barley landrace. Further, he added in his elucidation that a landrace is also typified by its own characters. Concluding, von Rümker needed a lengthy elucidation to clarify his too simplistic definition.

The second definition was by Mansholt (1909) who pointed out that landraces have a high 'stability of their characteristics' and great 'resistance capacity to tolerate adverse influences'. Their production capacity, however, is less than that of cultivars and when grown outside their home region, their genetic composition will change.

Kiessling (1912) defined a landrace (of a particular region) as a mixture of forms [phenotypes, ACZ] with a certain external uniformity and with a composition specific for that region and a great adaptability to the natural and technical-economical conditions of that home region. Natural selection determines the frequencies [of the phenotypes, ACZ], including those of mutants and segregants. The best adapted phenotypes and therefore genotypes will increase in frequency.

In the same year Tschermak (1912) discussed Kiessling's definition. He stated that a landrace was introduced from one region into another, and he added that a landrace as a variety, may be given the name of a particular region, where it has been grown since time immemorial. Furthermore, its (the landrace's) present (genetic) composition is influenced by its composition at the time of introduction into the present home region and by later changes. These changes may have been influenced by the methods of cultivation, the environment and hybridisation. Through hybridisation new variants originate which endure both natural and artificial selection pressures. Times of sowing and of harvesting, preparation of sowing seed, and manuring will influence the relative frequencies of old and new forms [phenotypes, ACZ]. Therefore, annual fluctuations of these frequencies occur.

Schindler (1918) stated that a landrace should not be compared with a cultivar, because yield stability is the major characteristic of a landrace, whereas a high yielding capacity under optimal conditions characterises a cultivar. This statement was recently repeated by Falcinelli et al. (1994).

Fruwirth & Roemer (1921) noted that landraces have been cultivated for many generations under ad-

verse conditions in a particular region without conscious selection, and have become adapted to those adverse conditions. Fruwirth (1930) re-defined landraces. In his new definition he included the capacity of a landrace to adapt itself to a new region by changing (its genetic composition, ACZ). Further, he mentioned the conditions for the origin of landraces: long-term cultivation in a particular region under natural selection, which results in a stable appearance. Selection by man is mostly done unconsciously; nature selects for characters such as frost tolerance, drought tolerance, and low temperature adaptation.

Banga's (1944) definition is: 'a landrace is a population which naturally developed in a certain region under the influence of the regionally prevailing conditions of climate, soil and management, without or with only little mass selection.'

Kuckuck (1939, 1952, see also Kuckuck et al., 1991) defined a landrace as 'mixture of a great number of different hereditary types [genotypes, ACZ] which, due to their genotypic diversity is well adapted to annual changes in the environmental conditions of its habitat. Due to many years of cultivation in a certain region, natural selection promotes those genotypes which are adapted to that region. (A landrace of, ACZ) an inbreeding crop consists of many homozygous plants, whereas (that of, ACZ) an outbreeding crop consists mainly of plants that are heterozygous at most loci and homozygous at some.'

*Period 1953–1974*

I did not discover any definitions of landraces in publications of the period 1953–1974. Their absence may be caused by the post-World-War-II activities in which people were using all kinds of resources to restore what had been destroyed and to create possibilities for further economic growth. The same activities were needed to restore the plant breeding world. Damaged properties were rebuilt and new genetic variation created to breed new cultivars, which had to replace the pre-war landraces and cultivars.

However, at the end of the sixties and the beginning of the seventies time became available for looking into both the past and the future. Attention was again paid to genetic resources with special interest in the genetically rich landraces that had disappeared from, or were quickly fading away in, many countries. Plant breeding researchers, plant breeders and others realized that with the disappearance of landraces essential genetic variation was being lost. Many activities were concentrated in the International Biological Programme. From 1975 onwards new definitions and descriptions were published.

*Period 1975-present*

Harlan (1975) realized the complexity of a landrace. Therefore he did not define a landrace, but described it as follows 'While landrace populations are variable, diversity is far from random. They consist of mixture of genotypes all of which are reasonably well adapted to the region in which they evolved but which differ in detail as to specific adaptations to particular conditions within the environment. They differ in reaction to diseases and pests, some lines being resistant or tolerant to certain races of pathogens and some to other races. This is a fairly effective defense against serious epiphytotics. Some components of the population are susceptible to prevalent pathogenic races, but not all, and no particular race of pathogen is likely to build up to epiphytotic proportions because there are always resistant plants in the populations. Landraces tend to be rather low yielding but dependable. They are adapted to the rather crude land preparation, seeding, weeding and harvesting procedures of traditional agriculture. They are also adapted to low soil fertility; they are not very demanding, partly because they do not produce very much.'

Harlan (1975) continues: 'Landraces have a certain genetic integrity. They are recognizable morphologically; farmers have names for them and different landraces are understood to differ in adaptation to soil type, time of seeding, date of maturity, height, nutritive value, use and other properties. Most important, they are genetically diverse. Such balanced populations – variable, in equilibrium with both environment and pathogens, and genetically dynamic – are our heritage from past generations of cultivators. They are the result of millennia of natural and artificial selections and are the basic resources upon which future plant breeding must depend.' (end of quotation).

Brown (1978) also described landraces as geographically or ecologically distinctive populations which are conspicuously diverse in their genetic composition both between populations [i.e. between landraces, ACZ] and within them. They differ from their wild relatives because they have evolved under cultivation upon which most of them have come to rely for their survival. They differ from the cultivars developed by modern scientific plant breeding in that they

have not been deliberately intensively selected to a predetermined reduced level of genetic heterogeneity.

Frankel & Soulé (1981) added: The genetic diversity of a landrace has two dimensions: **between** site and population (the first dimension, ACZ) and **within** site and population (the second dimension, ACZ), the former mainly generated by heterogeneity in space, the latter by heterogeneity in space and time. These authors continued: 'In general, landraces have developed at low levels of cultivation, fertilization (i.e. inputs such as artificial fertilizers, ACZ), and plant protection; they are subject to selection pressures for handiness and dependability rather than for productivity.' These two dimensions are not very distinct. I explain them as the genetic variation of the 'first dimension' which means the variation between two populations of the same landrace (inter-site variation, ACZ), and that of the 'second dimension', i.e. the variation of a population of a landrace on a particular site (intra-site variation, ACZ).

Hawkes (1983) refers to landraces as 'highly diverse populations and mixtures of genotypes.' He further says that 'genetic resources (the total genetic diversity of cultivated species and their wild relatives) can be classified into various types of material.' Two of them are 'Old landraces' and 'Primitive forms'. Old landraces (are) obtained from remote areas or small garden plots where the new highly bred cultivars have not been introduced. These are races or populations that have not been bred as cultivars, but, under natural and artificial selection (notably largely of an unconscious nature), have become adapted to the conditions under which they are cultivated. 'Primitive forms of crop plants (are) collected from the Old Vavilovian centres of origin and diversity. They are highly diverse genetically, often having been grown as mixtures of species as well as diverse populations of one species.' Hawkes correctly added 'Some authors do not distinguish these from land races.' He mostly used the term 'old land races'.

Martin & Adams (1987) defined a landrace of the common bean (*Phaseolus vulgaris* L.) as a genotypic mixture of a predominantly inbreeding species that is grown by a subsistance farmer at a particular farm site. So these authors consider the mixture (of colour and other types) to be the landrace, whereas Voss (see below) mentioned that such a mixture consists of several landraces. In this connection we should bear in mind that beans with the same seed colour type may differ for other genes.

Jacquemart (1987) stated that for fruit trees a 'variété paysanne' (i.e. a farmer's variety, ACZ) is a variety of which the origin is unknown. He further distinguished between a 'variété regionale' [regional variety, ACZ], having an international distribution, and a 'variété locale' [local variety, ACZ] with a restricted distribution. An example of the first kind of variety is the apple variety 'Cwastrèsse Double', which is grown around Namur in Belgium and in Luxemburg. An example of the second is the prune variety 'Wignon'. He called varieties with a known origin 'variétés anciennes' (ancient varieties, ACZ). His example is the apple 'Golden Delicious'.

In the same year, Marchenay (1987) mentioned that there are 'variétés locales, variétés traditionelles, variétés anciennes, variétés de pays, variétés du commerce and variétés domestiques', (i.e. local varieties, traditional varieties, ancient varieties, landraces, commercial varieties and home-grown varieties, ACZ). No definitions were given. However, he stated that it is difficult to draw boundaries, as a local variety can be ancient too. Further, a newly introduced variety may be old, but is not a local variety. Often the period of introduction is unknown. Marchenay continued that some varieties exist in the boundary zone between being cultivated or growing (in and collected from the, ACZ) wild. Some could be considered as ecotypes, i.e. according to Turesson (1922 as cited by Rieger et al., 1991) a landrace is a local or ecological race with genotypes adapted to a particular restricted habitat as a result of natural selection within the local environment. This definition also refers to wild and weedy plants. Some of the formerly home-grown varieties now being wild (or feral or run wild, ACZ), are difficult to distinguish from true wild plants.

Rieger et al. (1991) included a definition of a landrace for the first time in the 5th edition of their 'Glossary of Genetics'. They defined a landrace as 'any of the geographically distinct populations which evolved under cultivation and are conspicuously diverse in their genetic composition both within and between populations. They differ from varieties developed by modern breeding in that they have not been deliberately selected to a predetermined (reduced, ACZ) level of heterogeneity and (desired, ACZ) performance.'

Astley (1991) stated that 'The conscious and unconscious selection of variants within crop populations by primitive agriculturalists led to localized diversification within populations, now termed landraces.' This definition would have been clearer if Astley had not used plurals for population and land-

races. Further, he described that selection results in 'localized diversification', meaning that each farmer may develop his own distinct landrace. Hence, the diversification also refers to 'between populations.' He did not explain the term 'primitive'.

Voss (1992) defined a landrace as a variety that is more or less in a state of (genetic, ACZ) homeostasis. He described farmer's mixtures of beans (*Phaseolus vulgaris* L.) in Central Africa, as consisting of several landraces: in his definition each bean seed colour phenotype is a separate landrace.

Prospéri et al. (1994) defined a landrace as an assemblage of genotypes of the same species on which the grower in a certain region and with certain growing methods, carries out more or less directed mass selection during several generations *(une variété de pays est assimilée à un ensemble de génotypes d'une même espèce sur laquelle un agriculteur d'une région donnée pratique, depuis plusieurs générations, une sélection massale plus ou moins dirigée.)*

Bellon & Brush (1994) stated that (in maize, ACZ) the term farmer variety is used. They define it as an actual unit of human selection in the general population. The 'general maize population' is a landrace in which subpopulations are maintained by selection. These authors use the term landrace in the meaning of race, which has been used commonly since Anderson & Cutler (1942).

A new word was introduced by Cleveland et al. (1994). They used the term folk varieties. A folk variety of a crop may be grown by various farmers; material collected from one farm (household) was described as a farmer population. They equated the folk variety to terms found in literature: landrace, traditional variety and primitive variety. The term folk variety was also used by Soleri & Smith (1995) when describing Hopi maize landraces. An advantage of the term folk variety is that it can be applied to both landrace and garden-race.

Louette et al. (1997) describe a landrace as a farmers' variety which has not been improved by a formal breeding programme. Teshome et al. (1997) defined, or better described, landraces as 'variable plant populations adapted to local agroclimatic conditions which are named, selected and maintained by the traditional farmers to meet their social, economic, cultural and ecological needs.' They continue that 'In the absence of farmer's manipulations, landraces may not exist in the ecological dynamics that are known today. Thus landraces and farmers are interdependent, in need of each other for their survival.'

**More classifications**

Baur (1914) called landraces 'primitive Kulturrassen'. The English version 'primitive varieties' was used by Cleveland et al. (1994), whereas Hawkes (1983) used in addition to landraces the term 'primitive forms'. Falcinelli et al. (1994) also stated that landraces are primitive cultivars. However, these authors did not explain the term primitive. Maybe primitive means unimproved. Astley (1991) suggested that landraces developed because they were grown by primitive agriculturalists. He also did not explain the term primitive.

Mayr (1934, 1937) divided landraces into five categories (wording adapted, ACZ): 1.1 autochthonous (in German: *landeigene*, in English: indigenous, sprung from the land itself, aboriginal, the original inhabitant, ACZ): a landrace cultivated for more than a century in the same region. 1.2 autochthogenous (in German: *landbürtige*, ACZ): a landrace derived from a new genotype (a spontanous mutant or a derivative of a natural cross, ACZ) originating from an autochthonous landrace. This suggests that the new variety would be homogeneous, but, although Mayr did not say so, due to contamination it would develop with time into a landrace. 2.1 allochthonous (in German: *landfremde*, ACZ): an autochthonous landrace from one region introduced into another region and adapting itself to the new environment. 2.2 allochthogenous (in German: *fremdbürtige*, ACZ): a landrace having been grown for a longer period in a non-native region, being changed by this new environment although the original type is still recognizable.

Mayr's fifth category is the improved-landrace ('*Zucht-Landsorte*', ACZ) which is not a landrace improved by mass selection, but which derives from a 'reversed' cultivar. However, it is not yet an allochthogenous landrace. So it is not a landrace that has been improved to become an elite-landrace (Berg, 1993), or locally-improved variety (Dennis, 1987).

This classification needs some additional clarification here. It emphasises the breeding history of the landrace. Landraces belonging to type 1.1 are indigenous landraces. They have been grown for many generations in a certain area where agricultural practices remained almost unaltered. If an important mutant occurred, or if by introgression foreign alleles entered the landrace, a new landrace of type 1.2 would originate. With time this landrace would develop into type 1.1.

Since time immemorial farmers and gardeners have changed seed and seed ware as it is believed that

'fresh' seed produces better than seed and seedware grown already for one or more years on the farm or in the garden (Zeven, in preparation). They also like to experiment with material obtained form elsewhere, for instance from a market in a neighbouring region, or from a friend or relative living in a neighbouring region. When accepted, this landrace belongs to type 2.1. With time it will develop via type 2.2 into type 1.1. The difference between landrace types 2.1 and 2.2 is not easy to explain, as landraces of either types are in the process of becoming type 1.1.

Christiansen-Weniger (1931) distinguished primary and secondary landraces. A primary landrace is the uncontaminated landrace as indicated in the above definitions. This means that a primary landrace equals Mayr's type 1.1. The secondary landrace is a primary landrace contaminated with 'foreign' material, such as another landrace, or a cultivar. This is not Mayr's type 1.2 as that type only includes new genotypes originating from genotypes belonging to the landrace. After many generations of cultivation a secondary landrace could become a primary landrace (Mayr's type 1.1). Christiansen-Weniger (1931), studying landraces *in situ*, also paid attention to allochtho(ge)ous landraces, that were in the process of becoming Mayr's type 1.1. In connection with the classification as used by Christiansen-Weniger, Zeven (1975) used the terms that are applied for multiline varieties, i.e. a clean multiline and a dirty multiline, and hence a clean landrace (Mayr's type 1.1) and a dirty landrace. The dirty landrace is a primary landrace contaminated with landrace-foreign material.

Mayr (1937) also divided landraces according to their (probably breeding) value into 1. primitive (in German: *primitives/urtümliches*, ACZ) landraces, and 2. secondary (in German: *sekundäres/abgeleitetes*, ACZ) landraces. A primitive landrace is the original landrace (Mayr's type 1.1), still possessing all characters and characteristics typical for a landrace. A secondary landrace is a landrace which may have been derived from a cultivar, but due to absence of maintenance breeding the variety has degenerated. It equals a creole cultivar (see below). Hence, a secondary landrace started as a cultivar but developed into Mayr's type 5, and in due course into type 1.1.

Bellon & Brush (1994) refer for maize to a creole cultivar (or variety, ACZ) which derives from a bred variety, when grown without maintenance breeding for several generations becomes mixed with material of other landraces. They obtain the appearance of having acquired many characteristics of locally grown maize landraces. Hence, a creole variety starts as a cultivar, and develops with time into Mayr's type 1.1.

Louette et al. (1997) defined the term 'seed lot' as all kernels of a specific type of maize selected by a farmer and sown during a cropping season. A variety or cultivar consists of all seed lots held by farmers that bear the same name and are considered by them to form a homogeneous set. 'Local' is defined as grown in the area for more than 30 years, whereas 'foreign' refers to (any) recent introduction. They further used: 1. own seed, which is seed selected by the farmer from his own harvest, 2. seed acquired within the neighbourhood (i.e. in the same valley), and 3. introduction.

A special paragraph is required for the various old and new clones of grapevine. Negrul (1946) in Russia proposed the term sortotype for a group of related clones, whereas Levadoux (1948) in France proposed ecological-geographic groups. However, the term cépage is commonly used. It should not be translated. The term defines an assemblage of closely related similar individuals or clones (de Blij, 1983). Some cépages consist of only one clone, for instance 'Muscat de Hambourg Noire' (Boursiquot, 1969): others include many, for example the cépage 'Pinot noir' consists of many distinct clones, including colour mutants, such as 'Pinot gris' and 'Pinot blanc' (Bowers et al., 1993).

Dennis (1987) defined several terms for rice material, grown in Thailand:

- local varieties (LV) are crop varieties that have been grown in an area for many years or have been bred (Mayr's type 1.1) or selected from varieties long used in the area (Mayr's fifth category). Dennis also said that a local variety (in northern Thailand) is a pre-Green Revolution variety,
- traditional varieties (in northern Thailand) are all rice varieties which are either landraces, i.e. have never been improved by breeders, or cultivars which have not been supported (maintained, ACZ) by the Thai Government in the past ten years, i.e. also Mayr's fifth category.

By pure-line selecting within a local variety of rice one could obtain a locally-improved variety (LIV). For northern Thailand such an improvement should have taken place before 1969. After this year was taken as after 1969 new cultivars were developed by modernized breeding methods. By lack of maintenance breeding a LIV would turn into a LV.

The term ‘local varieties’ to indicate varieties bred for a certain locality as used for millet by Khairwal et al. (1990) is rather confusing.

## Landrace groups

Zeven (1986) described that landraces may be genetically related because either one landrace derives from another landrace or two landraces derive from the same parental landrace. Genetically related landraces form together a landrace group. An example is the group of winter wheat landraces ‘Gelderse Ris’, ‘Limburger Kleine Rode’, ‘Ommelander’ and ‘Oldambter’, cultivated in the Netherlands. They all descend from a landrace grown in the area around Geldern, Jülich and Goch in Germany near the border of the Netherlands. In Germany related landraces may have been grown. Originally, this landrace group may have derived from landraces grown in Poland and Russia. If so, together with their Polish/Russian ‘sister’ landraces the Dutch and German related landraces were part of a landrace group (Zeven, 1990). It would then be difficult to say whether two populations are part of one landrace, or whether they represent two related landraces belonging to the same landrace group. I believe that taxa such as the common bean (*Phaseolus vulgaris* L.) Andean and Middle-American races include landrace groups. This may also be the case for the lettuce Cultivar-Groups (e.g. Cos, Cutting, Asparagus, Butterhead, Crisp/Iceberg, Latin and Oilseed Groups). Each Cultivar-Group may consist of several landrace groups.

## Discussion and proposal

The main subjects to be discussed to describe landrace are: synonyms, types of crop, breeding history, diversity/integrity, adaptation, yield stability/lower yield, resistance/tolerance and human selection.

### *Synonyms of landrace and landrace group*

In English and other languages quite a number of synonyms for the term landrace has been used. They are listed in Table 1, together with synonyms for the term landrace group and their relationship. They are not further discussed here.

Names for landraces in a few other languages are landras (Dutch), boerenras (Dutch), farmer’s variety (e.g. Hawkes, 1991), Landrasse (German, Baur, 1914; Schindler, 1918), Landsorte (German), Natursorte (German, Fruwirth, 1930), Hofsorte (Switzerland, Nüesch, 1976), variété rustique (French), and variété paysanne (French, Jacquemart, 1987), variedad local (Spanish), baladi (Arabic), COPT MESTHUU (Russian, pronounce sort mestnoeoe).

*Table 1.* Synonyms for landrace (small entity) and landrace group (large entity) as used in the Literature, and their mutual relationship

| Size of entity | | Authors |
|---|---|---|
| *Landrace or small entity* | *Landrace group or large entity* | |
| race | race group | Leng et al., 1962 |
| local variety | | Brandolini, 1969 |
| ecotype | local variety | Brandolini, 1969 |
| landrace population | | Harlan, 1975 |
| local population | race | Camussi, 1979 |
| landrace | landrace group | Zeven, 1986 |
| landrace or traditional cultivar | | Oldfield & Alcon, 1987 |
| race | racial group | Goodman & Brown, 1988 |
| race | racial/race complex | Sevilla, 1994 |
| (local) variety | race | Bellon & Brush, 1994 |
| farmer variety | | Bellon & Brush, 1994 |
| farmer population | folk variety | Cleveland et al., 1994 |

### *Types of crop*

It is curious that most authors do not mention the reproductive biology of the crop. Exceptions are Kuckuck (1952) who referred to in- and outbreeders, Martin & Adams (1987) and Voss (1992) who mentioned inbreeders, maybe, because, they were working with the predominantly inbreeding common bean, and Jacquemart (1987) who was actively collecting vegetatively propagated old fruit tree varieties. However, there are landraces of agricultural crops, ornamental plants, fruit trees, vegetables and forest trees; and there are also landraces of inbreeders, outbreeders and vegetatively propagated crops. Due to their reproductive system inbreeders consist of plants with many loci in homozygous conditions, whereas outbreeders consist of plants with many loci in heterozygous conditions. Individuals within a clone are genetically identical irrespective of whether they are heterozygous or homozygous.

The methods of harvesting in addition to the choosing of sowing and planting material may be considered

the major factors influencing the composition of a landrace. For, we may harvest the crop as single plant parts, or as single plants, or in bulk (as many crops are at present). If we harvest parts of plants or whole plants we have a good look at the plants and hence attractive ones are put aside for evaluation in the next growing cycle. Attractive plants bulk harvested have less chance to be observed unless the harvesters mark these plants before the actual harvest.

However, the name 'variété paysanne' (i.e. farmer's variety) by Jacquemart (1987) is not correct for all 'landraces' of fruit trees as many of them have originated in the gardens of villages, cities, monasteries and castles. A farmer would have grown only a few fruit trees as the large-scale cultivation of fruit trees was mainly in the hands of monks and noblemen. Maybe, in a farm compound volunteer fruit tree seedlings would have more chance to develop into adult trees and attract the attention of the farmer than in an enclosed orchard.

*Breeding history*

Tschermak (1912) stated that a landrace originates from another after the introduction of the latter into a certain area; hence, the genetic relationship of these landraces. Therefore, they can be grouped into a landrace group. As already stated it depends on the researcher where boundaries are drawn between landraces, and between landrace groups.

Landraces move from one place to another. Especially for outbreeding crops landraces may 'meet' which can result in an explosion of new genotypes and phenotypes. 'Meeting points' (or better regions) are described by Harlan (1951) as microgenecentres.

The division of landraces according to their breeding history as presented by Mayr (1937) is to some extent a useful one. However, the difference between type 2.1 allochthonous and type 2.2 allochthogenous is very difficult to observe. One has to know the original type to be able to classify an introduced landrace. The classifications presented by Christiansen-Weniger (1931) and Mayr (1937) only deal with landraces as they are observed during a field trip and without knowledge about their breeding history.

*Diversity/integrity*

Kiessling (1912) mentioned that a landrace is a mixture of phenotypes, and that (the majority of) these phenotypes have a common appearance (Harlan's integrity), making them at least somewhat different from another landrace of the same crop. Landraces may receive names if more than one are grown in the same region. If only one landrace is cultivated the farmer may use its general or local crop name only. However, a farmer of a neighbouring region may name the landrace after the region of provenance. Further, other characteristics of a landrace are included in its name (Tschermak, 1912). So the winter wheat landrace 'Limburgse Kleine Rode' (little red from Limburg) points to the region Limburg, i.e. the area of cultivation, to the size of the plant or of the grains and to the colour of the grain. Other wheat landraces are called red after the brown colour of the ear. Some landraces receive apparently peculiar names. So, some landraces of the andigenum potato consist of a mixture of clones, each clone (i.e. sublandrace) carrying its own name. The various clones composing the landrace carry names according to some characters such as their skin colour (La Barre, 1974).

In addition to the fact that a landrace has a common appearance, it is mostly described as being diverse. However, this diversity does not hold for all characters as indicated by Zeven & Schachl (1989). For instance all wheat plants of a landrace may possess awns and red grains, and possess winter hardiness when belonging to a winter type. A wheat landrace harvested on the Haunsberg, Austria looked very uniform. However, 50 randomly chosen grains possessed 31 gliadin phenotypes.

*Adaptation*

Mansholt (1909) mentioned that a landrace would change when grown in another area. The capacity to adapt to a new environment depends on the genetic composition of the mixtures. At each growing cycle directional selection takes place; the selection criteria depending on site and year. As in general the average growing conditions over many years change little, annually opposing microdirectional selection criteria resemble stabilising selection to the viewer. Although the frequencies of genotypes in a landrace in a particular environment may vary from year to year, some genotypes with a great adaptation capacity predominate whereas other survive at low frequencies or have no progenies.

Some landraces are able to adapt themselves to a wide range of environments, whereas others are able to adapt themselves only to a few environments. The speed of change of frequencies of genotypes or alleles under directional selection depends on the char-

acters involved. Frequencies of some characters may increase almost nil to their maximum (f = 1), and frequencies of other characters may become nil (f = 0). Finally there are also characters of which the frequencies may remain more or less unchanged. This may often concern crop types as Ehdaie & Waines (1989) observed that the spring wheat landraces in comparison with cultivars were better adaptable, more stable and performed better in stress environments. Ceccarelli (1994) discussed the cause of why landraces may yield more than cultivars under farmer's conditions in marginal environments. Landraces differ from non-landraces in a number of traits which together appear to form an adaptive complex. Moreover, these traits are not present in just one combination within landraces, but they are present in different combinations in different individuals.

*Yield stability/lower yield*

High yield stability and moderate yield level are the main characteristics of a landrace as already mentioned by Mansholt (1909) and Schindler (1918). The latter added that a landrace should not be compared with a cultivar, because the two are different entities.

*Resistance/tolerance*

Mansholt (1909) mentioned that the presence of a great 'resistance capacity' to tolerate adverse conditions is an important component of yield stability (see above). This character of landraces has been acknowledged by many subsequent authors.

*Human selection within landraces*

Fruwirth (1930) stated that selection by man to maintain a landrace is mostly done unconsciously. He meant that human 'selection' is generated by the farmer by changing the growing conditions. Banga (1944) wrongly writes that no selection or only mild mass selection is carried out, whereas Hawkes (1983) mentions several examples of conscious selection of traits of individual plants. However, selection intensity will depend on the farmer and his family. This intensity will have varied from nil to quite strong selection. Unfortunately, little has been recorded. As already said, some farmers like to experiment with new material and in the literature one often reads about a new variety which derives from a single plant found growing 'in a hedge' (see for instance for wheat Percival, 1921; Zeven, 1990). Such experiments must have occurred since the start of agriculture. Certain attractive types found either among their own material or elsewhere, will have been harvested and grown separately under observation. When approved they were propagated and multiplied. The more people moved over greater distances, the more new types were imported and tried out. Also natural selection pressures will have changed in direction and intensity and new conditions. Hence, the evaluation of foreign common wheat (*Triticum aestivum* L.) varieties such as 'Australian velvet-eared' and 'Australian golden wheat' in the Netherlands around 1860. Similarly, the so-called 'Syrian wheat', being a *Triticum turgidum* accession (Zeven, 1990). Selection by farmers (most of whom are women) has been reported for instance for maize, sorghum, rice and beans, the biggest ear or panicle or the nicest looking, healthy bean plant with a desirable seed colour and colour pattern being harvested. Here the 'closeness' of (wo)man and plant plays a part. Wheat, barley and rye are harvested as a crop, whereas maize, sorghum, rice (in Southeast Asia), vegetables, fruit trees, herbs and ornamentals are harvested as individuals. One chooses the best plant, the best ear or panicle, the best fruit, pod, seed or flowerhead. This may result in choosing a healthy plant or a plant with a deviating attractive phenotype. Some 2000 years ago Roman farmers separated small and big seeds of cereals to use the latter as sowing seed. This practice was carried out as it was experienced that the crop derived from the bigger seeds yielded higher than a crop derived from unselected seeds. The bigger seeds may derive from plants with a genotype for big seed, but also from healthy plants, from tall and from late plants. Hence, these farmers unconsciously selected for genotypes for big seeds, resistance, height and lateness. Nature selected especially against too tall and too late as too tall would result in lodging and too late in immature, shrivelled seeds. Domesticated tef (*Eragrostis tef* (Zucc.) Trotter) types with improved nutritional value were selected (Lester & Bekele, 1981). This change could have been 'unconsciously' observed, when farmers after eating 'improved' landraces were physically and mentally fitter than others (R.N. Lester, pers. comm. 1997). Whether human selection criteria are always good ones is open for discussion. For instance, annual selection for the biggest ear of maize may probably result in the selection of plants with a low number of stems. If the biggest fruit of an apple seedling population has a bad taste it will be discarded.

The conclusion of Teshome et al. (1997) that landraces and farmers are interdependent, in need of each

other for their survival, is, in the light of the continuous evolution of a landrace and the everywhere occurring seed change, somewhat exaggerated. The reason is that Teshome et al. (1997) refer to the interdependency of farmer and certain landraces, whereas a farmer may easily switch from one landrace to the other. Human selection – both conscious and unconscious, and depending on the selection intensity – has had a great influence on the development of landraces, however, often nature may counteract human selection as also happens for cultivars. Landraces and wild populations have in common that nature selects for survival i.e. yield stability.

## Proposal

Mayr (1937) thinking of crops with a short growing cycle wrongly divided landraces into autochthonous landraces (type 1.1) and autochthogenous landraces (type 1.2) as in fact type 1.1 does not exist for such crops. Maybe, only for fruit trees and similar crops with a long growing cycle autochthonous landraces exist. In each landrace, mutations and, even in an inbreeding crop, hybridization between plants belonging to that landrace do occur. Moreover, landraces often move over short or long distances. Further, in Mayr's classification it would be difficult to recognize the difference between types 2.1 and 2.2. He does not pay attention to contamination with landrace-foreign material (other landrace(s), or cultivar(s)). When a landrace is introduced into another region, it will become contaminated with material of the autochthonous landrace. The reason is that farmers like to experiment with new material and often mix seed to increase the yield stability. The same is true for introducing cultivars. The (unnamed) rye landrace grown in Northern Netherlands became mixed with genetic material originating from the cultivar 'Petkuser Roggen'. As this latter cultivar was repeatedly introduced it replaced the landrace after several years of cultivation. Many accessions of winter wheat collected in the Austrian Alps by Dr. R. Schachl (see Zeven & Schachl, 1989) were mixtures of two or more landraces and cultivars. The same is true for the so-called creole varieties (see above).

Considering the above and based on Mayr's classification I propose the following classification:

1. *autochthonous landrace* is a landrace grown for a long period in the farming system concerned. As the environment changes annually and as the landrace becomes 'contaminated' – purposely or not – with few genotypes of other landrace(s), or cultivar(s)) it will continously adapt itself. This type of landrace is the common type, whereas Mayr's type 1.1 will be rare.
2. *allochthonous landrace* is an autochthonous landrace of a foreign region recently introduced into the region concerned (Mayr's type 2.1). Similarly to Mayr's type 1.1 this will be a rare type, as after its introduction it frequently becomes contaminated – purposely or not – with a few genotypes of the autochthonous landrace or locally grown cultivar(s). Depending on the number of generations of aftergrowth and on the frequency of seed change (Zeven, in preparation) it may become an autochthonous landrace.

## Conclusion

As landraces have a rather complex nature it is not possible to give an all-embracing definition as it would result in a description. Maybe, Mansholt's (1909) amended definition is still the best: an autochthonous landrace is a variety with a high capacity to tolerate biotic and abiotic stress resulting in a high yield stability and an intermediate yield level under a low input agricultural system.

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