LANDRACE GROUPS OF BREAD WHEAT (T R I T I C U M A E S T I V U M L. em. THELL.)

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Abstract

Bread wheat was introduced in the Old World some 8000 years ago. Owing to local specific natural and human selection a landrace spread over a large area fragmented into locally adapted landraces. These related landraces can be grouped again in a landrace group indicating their evolution from a common source.

It is advocated that greater effort be devoted to research of relatedness of crops as bread wheat, other wheats, rye, barley, and oats. The results will help to explain the evolution of these crops and that of their landraces. Examples are given of two landrace groups of bread wheat, formerly available in the Netherlands.

1. Introduction

Up to now little research has been carried out on the relationships between landraces of bread wheat and hence not much is known about the grouping of landraces into landrace groups. When more investigations have been conducted and results become available, conclusions may become possible on the evolution of land race groups and on member landraces.

When the amount of time spent on the study of these subjects is compared for wheat and maize (for example Goodman & Bird, 1977; McClintock et al., 1981), wheat scores low. The cause of such a great difference may perhaps be that wheat researchers are more interested in research on the origin of bread wheat, and hence on the relationships of species of T r i t i c u m , A e g i l o p s and other genera within the Triticinae.

I wish to appeal to researchers to pay more attention to the evolution of land varieties of bread wheat, of other cultivated T r i t i c u m species, of rye, of barley and of cultivated oat species. In this paper I will only discuss landraces of bread wheat.

2. Landrace and landrace groups

When studying landraces and landrace groups these taxa should be first defined. A landrace is a population of a cultivated crop which has evolved in a certain region under the centuries-long influence of climate, soil and crop husbandry methods in that region and on which no or only slight rough mass selection has been carried out (Banga, 1944). Banga suggested that centuries long influences from outside are needed, but for an annual crop half a century i.e. 50 generations may be sufficient. The definition allows some selection by the grower. For instance, he may select for the biggest cob in a maize landrace. This and similar actions and the influence of natural selection make a landrace look uniform. Most landraces receive a name which refers to their 'native' area or to a special character or to both. For instance, the name of landrace Zeeuwse Witte (Zeeland White wheat) reveals that

it was grown in the Dutch province of Zeeland and that the ears and the grains are white.

A landrace of a certain region may be related to a landrace of a neighbouring region, because one is derived from the other or both originate from a parental landrace. Owing to regional differences in soil and crop husbandry methods, and perhaps climate, they differ. A landrace group is divided into related landraces. Related landraces together form a landrace group.

The main character of a landrace is yield stability, and not high yield per unit area or any other characteristic that provides the grower a high income for his efforts. As is said, a landrace may look very uniform and this is caused by human and by natural selection. So for wheat in East Europe, nature selects for bearded, and in West Europe for beardless plants. (See further below).

Owing to the mixing of seed of two land races - one indigenous the other exotic - or of a landrace and a bred cultivar the indigenous landrace becomes heterogeneous. The extent of its heterogeneity depends on the difference in appearance of the landrace and the contaminating one. A uniform landrace is called by Christiansen-Weniger (1931b) a primary landrace and a heterogeneous landrace is named a secondary landrace. My terms are 'clean landrace' and 'dirty landrace' respectively; both terms are borrowed from clean and dirty multiline.

3. Unrecorded and recorded migration of landraces of bread wheat

When studying relationships of landraces of bread wheat it would be helpful to know their history. Unfortunately not much is known about it. We know that wheat spread from the Near East, to reach Europe in 6000-4000 B.C., but what happened afterwards?

In the definition of a landrace it is included that no selection or only rough mass selection is carried out by man. But landraces may migrate, owing to the choice of man, i.e. the grower believe that the race of his neighbour or of a neighbouring region is better than the one he is growing. Hence landraces are transferred from neighbour to neighbour and from region to region. For instance Gelderse tarwe (Gueldre wheat) probably 'originated' in the region around Geldern, West Germany, near the Dutch border. From this region it moved to the Netherlands to reach the province of Gelderland and neighbouring regions, and later the province of Groningen, where it was named Groninger Ommelander.

Some more examples are described in literature. For instance, Lange (1926) studied 278 plant progenies collected from 20 populations obtained from 19 farms in south-west Poland. He observed that among the plants with a dense ear a higher frequency of hairy chaffed plants occurred, than among the plants with a lax ear (Table 1). He stated that this could have been caused by the immigrating landrace Blumenweizen from Silesia (Poland), which has hairy glumes and apparently a dense ear. (This landrace differs from 'Blumenweizen', described as ssp. m i l t u r u m by Werner (1885)). If the data of the 278 plants were still available a cluster analysis would probably separate the plants into two groups: 1. the old, indigenous landrace and 2. Blumenweizen (and maybe a third group being derived from hybrids between both varieties).

Janossy et al. (1963) described the flow of wheats from Poland and western Russia into Hungary. This flow was strongly promoted by a bad harvest in 1863. From Hungary 'Banatka wheats' (from the Banat area) migrated into south Poland (Kostecki & Wolski, 1963).

Earlier Kiessling (1912) mentioned that wheat seed had been obtained from the border area of Bavaria and Bohemia to be grown in Lower Bavaria. Spelt wheats grown in Swabia, southern Germany, like cv. Lustenauer Veesen (Lustenau spelt) degenerated there and had to be replenished with seed from the Vorarlberg region.

Landraces of wheats were also transported over large distances. The North American winter landrace groups 'Crimea' and 'Mediterranean' obtained from the Krim - Ukraine and adjacent regions in Russia. Landraces grown in Mexico were obtained from Spain and from North America (Bukasov, 1930). A cluster analysis of these Mexican races, if data would still be available, would probably also classify them into two groups: 1. Spanish and 2. North American (and probably a third group being derived from hybrids of plants of both groups).

Whiteman (1980) described the conscious mixing of the late maturing generally awnless, pubescent chaffed white-grained 'Trogka' (ssp. l e c o s p e r m u m) and early maturing short 'Doma' (ssp. t u r c i c u m). A cluster analysis would probably classify this material in three groups: 1. awnless 'Trogka', 2. awned 'Trogka' and 3. 'Doma'. Groups 1 and 2 probably would merge if the character awnless was disregarded.

From a geographical distribution of certain genes of bread wheat (Zeven) 1980) could show old and recent migration routes of this wheat. Some examples are given. The Ne2ms/s carrying bread wheats of North-west and West Europe must have derived from wheat grain shipments from Eastern Europe since the 14th Century. This could mean that these landraces are more similar to the west Russian and Polish landraces than to the indigenous landraces.

The Ne1w carrying land wheats of North Nigeria must have come from India after about 1940 (Olugbemi et al., 1979). They differed with the indigenous landraces in Ne-genotype, in white grain, high susceptibility to powdery mildew (Zeven, 1974) and a higher percent of B and D cereal lectins (W. Peumans & A.C. Zeven, unpublished, 1985). Similarly, the Ne2-carrying landraces of Japan probably originate from imports from the USA (Zeven, 1980). During a famine US wheats, transported to China (Shen, 1933), have reached farms and evolved into a landrace. Also in recent time Italian landraces and improved cultivars were taken to Ethiopia to become adapted there (Syrobatokii, 1931; Harlan, 1969).

4. Former landrace groups in the Netherlands, Belgium, France and Great Britain

Before the large-scale introduction of unimproved and improved cultivars in the 19th century wheat in the Netherlands could be divided into two groups which Ten Rodengate Marissen (1907) named 1. 'Zeeuwse' group and 2. 'Gelderse' group. Landraces and improved cultivars of a third group, 'English Squarehead', where introduced later.

1. Zeeuwse group

This group has plants with awnless ears, hairless (smooth) glumes, white glumes and white grains; the landrace belong to ssp. a l b i d u m (Table 1). Five landraces have been included:

1. 'Zeeuwse tarwe' (Zeeland wheat), Blé blanc de Flandres, which was commonly grown in the Dutch province of Zeeland, adjacent regions in the Netherlands, and in Flanders.

2. 'White Victoria', 'Challenge wheat', which very likely came from Great Britain. Some selections of this landrace are 'Hallett's pedigree Victoria white wheat' and 'Webb's Challenge white wheat'
3. 'Chiddam wheat', which is derived from a plant found in a hedge at at Chidham, Great Britain, It was grown in France and elsewhere as 'Chiddam'.
4. 'Hundredfold' was probably introduced from Great Britain. In the Netherlands it was an unimportant cultivar.
5. 'Rode Prolific' (Red Prolific), an unimportant cultivar, although included by Ten Rodengate Marissen (1907) in this group the term 'red' indicates that this is uncorrect. No description is available and therefore it is not known whether red refers to the colour of the glume or that of the grains or to both.

2. Gelderse group

The Gelderse group has varieties with mainly awnless plants, with hairless, red glumes and red grains. The awnless plants belong to ssp. m i l t u r u m and the few awned to ssp. f e r r u g i n e u m. The awned plants in Gelderse tarwe were named 'Angelris'. Four landraces have been included in this group:
1. 'Gelderse tarwe' (Gueldre wheat), 'Gelderse risweit' was introduced from Geldern, W. Germany (see above).
2. 'Limburger tarwe' (Dutch Limburg wheat), 'Petit rouge' was grown in the Dutch province of Limburg and adjacent regions of Belgium.
3. 'Kleefse tarwe' (Cleve wheat), 'Rijntarwe' (Rhine wheat). The name refers to Cleve as the region of provenance.
4. '(Groninger) Ommelander. Grown in the Ommelanden region of the Dutch province of Groningen. It probably was derived from introduced Gelderse tarwe.

3. English 'squarehead' wheat is a relatively new group; this type of wheat was discovered in 1865 in Great Britain and introduced in the Netherlands in 1874. When studying the descriptions of the various 'Squarehead' wheats it appears that the clavate shaped ear 'squarehead' is often the only common character. Therefore, they do not belong to one group. This is supported by data obtained by G. Kema (pers. comm. 1984) who tested about 20 'Squarehead' and 'Dickkopf' wheats from various parts of Europe for their seedling reaction to 13 races of yellow rust (P u c c i n i a s t r i i f o r m i s Westend.). He could classify these cultivars into five groups. Squarehead wheats may have had the appearance of a landrace. Those grown at the turn of the century are 'Rode Dikkop' (Red Squarehead), 'Witte Dikkop' (White Squarehead), Y-tarwe (named after the IJ-polders near Amsterdam, probably a selection of 'Witte Dikkop'), Ruwkaf Essex', ('Rough-chaffed Essex', 'Blé á duvet', 'Blanc à duvet') and 'Gladkaf Essex' ('Smooth chaffed Essex'). The latter was said to be an intermediate of the Squarehead group and the Zeeuwse group.

For our study it would have been worthwhile to study living material. But breeding in Europe started some 100 years ago and at that time nobody had any idea about maintaining landraces as genetic resources and as cultutal heritage. So most material has been lost and the few genotypes still available may either represent the commonest genotype in the landrace or not, while during the long time of maintenance

mistakes may have been made. But as we have no better material available we have to use what is left.

When we study the origin of the varieties belonging to the Zeeuwse group, we observe that 'White Victoria' and 'Chiddam' were both grown in Great Britain and that 'Smooth-chaffed Essex' might be related to it. It might be of interest to mention here that when 'Zeeuwse' and 'Smooth-chaffed Essex' (of each only one genotype is available) were tested for seedling reaction to 13 races of yellow rust, it appeared that both landrace had the same seedling reaction (G. Kema, pers. comm. 1984). Vilmorin (1880) mentioned the similarity between 'Blé blanc de Flandres' and English landraces. Werner (1885) stated that 'White Essex' is closely related to 'Zeeuwse' (syn. 'Blé blanc de Flandres'). 'White Essex' (var. a l b i d u m) must be synonymous to 'Smooth-chaffed Essex'. Further, Percival (1921) grouped 'White Victoria' and 'Blé de Flandres' in one group and 'Chiddam' and 'Zeeuwse' in another. This is an indication of a landrace group present in England, NW. France, Flanders (Belgium) and the province of Zeeland (the Netherlands).

Another landrace group will certainly be the landraces mentioned above: Gelderse group with 'Gelderse', 'Limburger', 'Kleefse' and 'Groninger Ommelander'. 'Gelderse Ris' had another seedling reaction to yellow rust than 'Zeeuwse' (G. Kema, pers. comm. 1984). Percival's (1921) 'Gelderse' was bearded and therefore not true-to-type. Originally this material was probably introduced from Eastern Europe.

A third landrace group is formed by 'Rough chaffed Essex' and 'Blé à duvet' (syn. 'Blanc à duvet'). The first landrace was grown in Essex and Kent, Great Britain and from there it migrated to the Netherlands (as 'Ruwkaf Essex') and France ('Blé à duvet') (Vilmorin, 1880; Percival, 1921). So even in a small country such as the Netherlands we find three landrace groups.

More information can be obtained by studying herbarium material of wheat collected in the past. But in the Netherlands unfortunately only a few specimens are preserved.

Additional data may be obtained from a study of paintings made from the 16th to the 19th century. Paintings made in Flanders and W. Netherlands show wheat ears similar to 'Zeeuwse' (Zeven, 1984). These wheat ears may belong to the Zeeuwse landrace group.

More such landrace groups can be found. For instance Schachl (1974, 1975) could group the landraces of Upper Austria and the Salzburg area into two groups: 1. the older 'Bartweizen' ('awned wheat') and 2. the newer 'Sipbachzeller', which reached its present region from the eastern direction since the middle of the 19th Century. Its further spread was interrupted by the introduction of improved cultivars. In the higher Alps of Austria still an older group of wheats can be found. They are spring wheats consisting of v u l g a r e and c o m p a c t u m plants. The latter look similar to T r i t i c u m a n t i q u o r u m which was grown some 3000 years ago. They may have survived as such owing to their isolation and adaption to growing conditions of the high Alps (Köck, 1973; Zeven, 1980). It would be of great interest to compare these Alpine spring wheat landraces with their neighbouring winter types.

Grouping Sicilian landraces of durum wheat was done by Porceddu et al. (1981), but the results were not commented on. It would have been interesting to know whether landraces with short genetic distances were related.

The literature gives many examples of grouping of wheats from various regions (for example Lein, 1943; Bogyo et al., 1980; Konisi, 1983; Spagnoletti Zeuli et al., 1984; Damania et al., 1985), but they do not mention the landraces investigated.

5. Invalid discriminating characters

The four most conspicuous characters 1. awned vs. awnless, 2. pubescent (hairy, rough, velvet, woolly) glume vs. glabrous (smooth) glume, 3. red (brown) ear (glume) vs. white ear (glume), and 4. red (brown) grains vs. white grains, are mostly used to classify wheat plants or when uniform, wheat cultivars. Körnicke (1873) used these four characters to describe 16 taxa at the subspecies level (Table 2). These characters are widely used to compare landraces. For instance, Christiansen-Weniger (1931a) when travelling through Poland of before 1939 observed that in West Poland the landraces were mostly mixtures of awned and awnless plants and that in East Poland the varieties were awned. He also mentioned that a mixture of awned and awnless plants maintained in the USSR would change in an awned crop within a few years. Apparently nature in that region selects against awnless plants. In West Europe nature selects for awnless plants as was experienced and scientifically investigated by Olugbemi et al. (1976). So, although awned and awnless landraces could be closely related, researchers using the presence/absence of awns discriminating characteristic, would classify them into two groups.

The same is true for presence/absence of hairy glumes and of red grains. These three characters are strongly influenced by natural selection. This means that a West European awnless landrace (with a few awned plants) would turn into an awned variety when maintained in East Europe. Inspite of their close genetic relationship researchers would classify them in different groups. The presence of red or white ear is also used as a discriminating characteristic, but as this character is not stable since under certain weather conditions the production of pigments will not take place, it can only be used when one is sure that the character can manifest itself (Zeven, 1983).

Witcombe and Gilani (1979) questioned the character awned as they found ears with apical, middle or basal awns. Porceddu et al. (1981) also discussed these points which could be summarized as: which characters are of diagnostic value?

6. Percival's descriptions

So characters strongly influenced by selection pressure or which have an unstable expression cannot be used to classify landraces into landrace groups. To test this statement I used data presented by Percival (1921). He described many accessions of diploid, tetraploid and hexaploid wheat species. Among them there are 99 vulgare wheat cultivars obtained from various parts of the world. Some 58 came from Europe and 'Russia'. We have used Percival's descriptions to investigate the effect of awns, of hairy glume, of red glume and of red grain as descriminators in a cluster analysis. Therefore for all 99 vulgare wheats the characters were divided into three states in such a way that in each state 33 varieties were present (Table 3.). Some characters were not included in all descriptions and therefore were excluded. Then with the help of the Patima program (developed by G. Stafleu, Computer Centre, Agricultural University, Wageningen) a cluster analysis was carried out to group the 58 European and Russian

accessions. The number of characters was 28, or when omitting the four Körnicke's characters 24. When using only these 24 states a grouping of accessions was obtained which could be better explained than when 28 states were used. The result is given in Table 4. For most accessions there was a clear distribution according to region. When the group was small (see Table 4) accessions of various provenances were included, but when the group was large it appeared that most of the varieties came from the same region. When studying the distribution of the 19 late accessions over the groups of table 4 we observed that 10 of the 11 accessions of group II. sub 2 were late, and 7 of the 9 accessions of group III. sub 2 were late. This also means that the accessions of the other groups were mostly 'early to midseason' accessions. There was only one early accession.

It is interesting to mark that Percival's 'Gelderse' was included into the East European group (Table 4, III.1). This also points to an East European origin of the Gelderse groups (see above).

From this investigation we concluded that a good classification was obtained when the four characters: awns, hairy glumes, red glume and red grains were excluded as discriminators. This means that the general custom to classify varieties according to Körnicke's taxa to compare the varieties with each other, is not a good method.

7. Conclusion

The four Körnicke-characters have often, with or without other characters, been used to classify landraces. Probably it would be better to omit any character with a possible selective (dis)advantage. Characters like gliadins or glutenins are known to be selective neutral unless hitch-hiking plays a role. Similar work with enzymes as is going on with maize (Goodman, 1978; Goodman et al., 1983; Kemble et al., 1983; Stuber & Goodman, 1983; Smith et al., 1984) can be done. Care should be taken to grow the material to be investigated under uniform conditions to reduce environmentally induced variation. Further, when a landrace is grown in a 'non-native' environment, hitherto masked variation may manifest itself. For instance Qualset and Peterson (1978) found two populations in a winter oat landrace when sown in the spring. When identifying allele frequencies of enzymes it is worthwhile to take (parts of) the same organ of similar age and development. Morphological characters can also be used as they develop independent of the environment or if the environment has the same influence, as was shown by Syme and Thompson (1981). They grouped old and modern bred wheat cultivars according to 25 morphological and two physiological characters.

Closely related landraces can be clearly discriminated through the emerging molecular biological methods such as restriction fragment length polymorphisms (for instance Ogihara & Tsunewaki, 1982; Tsunewaki & Ogihara, 1983; Soller & Beckmann, 1983; Tabata et al., 1984; Okita, 1984; Beckmann & Soller, 1986). Although there is no information on any difference of cytoplasm within bread wheat these methods may bring out small differences.

Comparison of the 'parental' landrace and its derivative landrace(s) may show close relationship. In that case the parental landrace still should exist. Parental landraces may have already disappeared at an early time. When the first migration of bread wheat via Turkey to the Balkans and further by the Danube farmers into Europe had taken place, (wheat) farming stopped in Turkey and hence the first Turkish landraces

disappeared (Zeven, 1980). Later other landraces of bread wheat were introduced and grown in Turkey until recent times, whereas those of the Danube farmers were grown in Europe until about the second half of the 19th Century.

When more data about landrace relationships and groups become available it will be possible to draw conclusions on the evolution of each landrace and each landrace group.

The results will not only add information to the history of bread wheat, but also to the history of mankind which continues to depend on this important food crop.

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Table 1 - Lange's classification of 278 plants (see text). (Lange, 1926).

Character	Ear density		
	57* lax	103 moderate	118 dense
bearded	9 (15.1)**	17 (16.6)	15 (12.7)
beardless	48 (84.9)	86 (83.4)	103 (87.3)
hairy glume	11 (19.3)	22 (21.3)	51 (43.2)
smooth glume	46 (80.7)	81 (78.7)	67 (56.8)
red glume	15 (26.3)	37 (35.9)	25 (21.2)
white glume	42 (73.7)	66 (64.1)	93 (78.8)

* number of plants
** (frequency in %)

Table 2 - The sixteen subspecies of bread wheat based on four morphological characters and named by Körnicke (1873)

Character				Körnicke's subspecies
1	2	3	4	
+	+	+	+	turcicum
+	+	+	-	barbarossa
+	+	-	+	meridionale
+	-	+	+	ferrugineum
-	+	+	+	pyrothrix
+	+	-	-	hostianum
+	-	+	-	erythroleucon
-	+	+	-	delfii
+	-	-	+	erythrospermum
-	+	-	+	velutinum
-	-	+	+	milturum
+	-	-	-	graecum
-	+	-	-	leucospermum
-	-	+	-	alborubrum
-	-	-	+	lutescens
-	-	-	-	albidum

1 = awned/awnless +/-
2 = hairy/smooth glume +/-
3 = red/white glume +/-
4 = red/white grain +/-

Table 3 - Characters and states based on Percival (1921)

Character		character states
1 bearded		
2 hairy glume		
3 red glume		
4 red grain		
5 seedling habit	5.1	erect
	5.2	semi-erect
	5.3	prostrate
6 strawlength	6.1	≤100 cm
	6.2	101-120 cm
	6.3	≥121 cm
7 ea length	7.1	≤9 cm
	7.2	9.5-11 cm
	7.3	≥11.5 cm
8 number of spikelets/ear	8.1	≤17.5 cm
	8.2	18-21.5
	8.3	≥22
9 glume length	9.1	≤8 mm
	9.2	8.5-9 mm
	9.3	≥9.5 mm
10 seed quality	10.1	mealy
	10.2	semi-flinty
	10.3	flinty
11 seed size*	11.1	≤77 mm³
	11.2	77.5-90 mm³
	11.3	≥90.5 mm³
12 earliness	12.1	very early
	12.2	early to midseason
	12.3	late

*Percival gave length, width and height of the grains.
We have multiplied his figures to obtain 'grain size

Table 4 - Grouping of 59 land wheat accessions from Europe and Russia as described by Percival (1921)

Group	No. of accessions	Provenance of accession
I.1	10	S. Europe: Italy, Spain, Portugal
I.2	10	S. Europe (5) and elsewhere (5)
II.1	5	not clear
II.2	11	mainly late squarehead accessions
II.3	4	not clear
III.1	9	East Europe
III.2	9	mainly late accessions from West Europe