NB : les références des livre sont indiquées à la fin du document

11
Characterisation and evaluation of okra

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Introduction

Okra (*Abelmoschus esculentus*) is an important vegetable crop throughout the tropics and subtropics. Its genetic resources, including related cultivated and wild *Abelmoschus* species, were the subject of joint IBPGR/ORSTOM projects,which resulted in a status report largely based on available literature (Charrier, 1983, 1984). For details on taxonomy, geography, cytology, inter- and intra-specific crossability, etc, reference should also be made to this report. The species nomenclature used in this paper is summarised in Table 11.1.

The world collection of okra

The composition of the joint ORSTOM/IBPGR okra collection based in Côte d'Ivoire, is shown in Table 11.2. There are 2,283 accessions. Clearly, the African continent (with 2,029 accessions) and West Africa in particular (with 1,769) is far more heavily represented than other continents and countries. Wild and cultivated species, other than *A. esculentus*, from Asia are absent in the collection and require collecting in the next few years.

Worldwide, cultivated okra is largely species *A. esculentus*, but *A. manihot* and *A. moschatus* may be grown as well (see Table 11.1). A major discovery was an undescribed cultivated species, collected mainly in Côte d'Ivoire (Siemonsma, 1982*a*, 1982*b*). Hamon & Yapo (1986) detail further the distribution of this latter species which we refer to here as 'West African taxon' (WAT), after its present known area of distribution.

Figs. 11.1 and 2 map the sampling sites for *A. esculentus* and WAT. These figures, covering West Africa and part of Central Africa show each species separately to emphasise the differences in cultivation areas throughout the four major climatic zones. From north to south these are:

desert (village or oasis cultivation), Sahelian (north of latitude 12°N), savannah (between latitudes 8 °N and 12 °N) and rain forest climatic zones.

A. esculentus (Fig. 11.1) is primarily distributed throughout the intermediate savannah zone between the rain forest and the arid Sahel. The species is less frequently found in the rain forest zone but is, on the other hand fairly well represented in the Sahel zone. With one exception, the WAT (Fig. 11.2) does not occur in the Sahelian zone since it has a long life-cycle and usually requires abundant, continuous rainfall. The eastern boundary of its distribution is difficult to determine due to lack of samples from Central Africa. At present, the most distant sampling sites are in Cameroon. Since a natural interspecific hybrid of the two cultivated species occurs in the central part of Sudan, WAT is possibly more widely distributed than currently known.

Information on the collection

Table 11.2 summarises the coverage of passport data in the ORSTOM/IBPGR okra collection. It is comparatively well documented (cf. Peeters & Williams, 1984). Elevation data are missing because they are not very important in West Africa. Local names are listed frequently but not systematically translated and therefore often unusable. Missing passport data largely relates to material obtained from other genebanks before 1981.

Samples acquired from multi-crop collecting missions fail to list the number of fruits, fruit characteristics, and comments on local traditions indicating crop associations. This produces a major data gap. Further information can be obtained from local names when they are systematically collected and translated. Fig. 11.3 has been prepared on the basis of a translation of local names from the Togo/Benin collecting mission (Hamon & Charrier, 1983). The relative frequencies are shown in decreasing order of importance from top to bottom. Asterisks represent the most commonly used characteristic for a given category. Interest focuses primarily on the harvest period. Contrast between early varieties (*A. esculentus*) and late varieties (WAT) is the most usual distinction. The date of planting and the length of plant cycle are secondary.

It is not unusual to identify a variety by colour or shape of the fruit, comparing the fruit with a part of some familiar animal (e.g. antelope horn, agouti cheek, rat tail) or of a human being.

Names describing plant characteristics (height, leaf type, etc) are less frequent, and tend to be used by ethnic groups who already know a great

Table 11.1. *Nomenclature of* Abelmoschus *species used in this paper*[1]

Species	Chromosome number	Cultivated/wild
1. *A. moschatus*		
1a) *A. moschatus* subsp. *moschatus* var. *moschatus*	72	±Cultivated
1b) *A. moschatus* subsp. *moschatus* var. *betulifolius*	?	Wild
1c) *A. moschatus* subsp. *biakensis*	?	Wild
1d) *A. moschatus* subsp. *tuberosus*	38	Wild
2. *A. manihot*		
2a) *A. manihot* subsp. *manihot*	60–68	Cultivated
2b) *A. manihot* subsp. *tetraphyllus* var. *tetraphyllus*	130–8	Wild
2c) *A. manihot* subsp. *tetraphyllus* var. *pungens*	138	Wild
3. *A. esculentus*	66–144	Cultivated
4. *A. ficulneus*	72–8	Wild
5. *A. crinitus*	?	Wild
6. *A. angulosus*	38	Wild
7. West African Taxon (WAT)	185–98	Cultivated
8. *A. tuberculatus*	58	Wild

[1] Species 1 to 6 following van Borssum-Waalkes (1966)
West African Taxon described by Chevalier (1940), Siemonsma (1982*a*, 1982*b*) and Hamon & Yapo (1986)
A. tuberculatus described by Pal *et al.* (1952) in India only

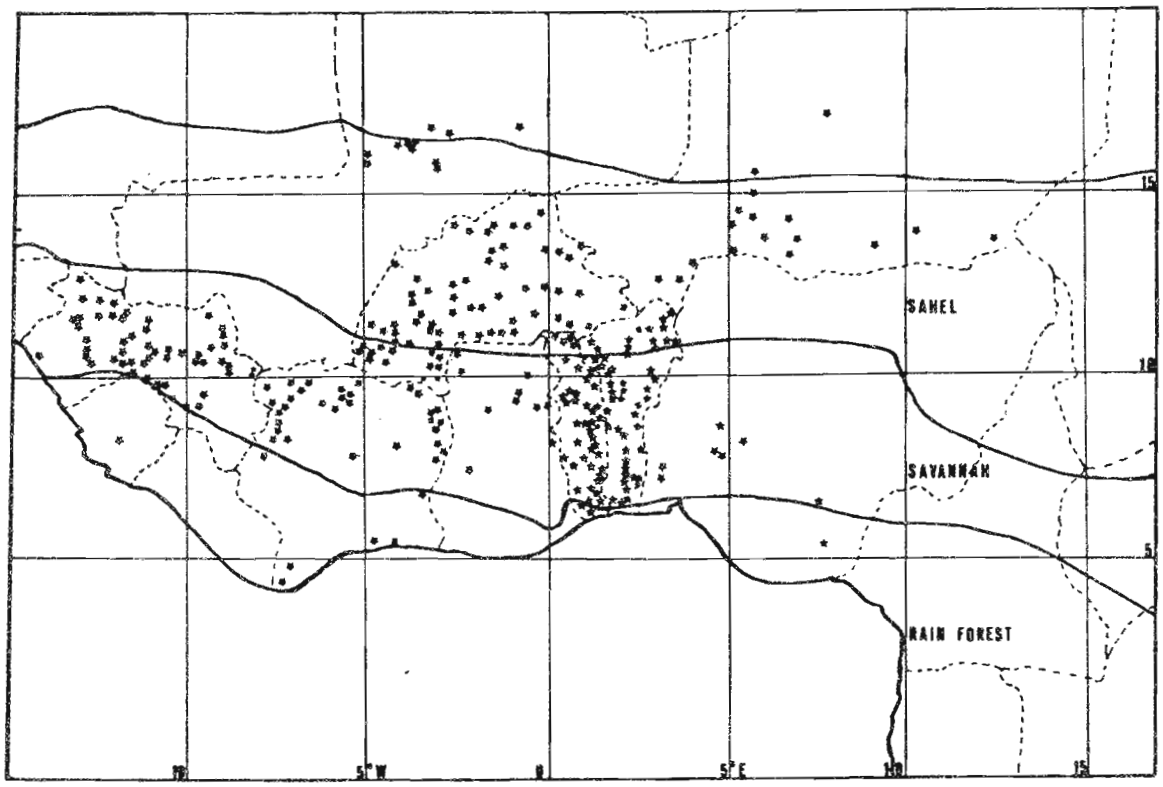
Table 11.2. *Current status of okra 'world collection' at ORSTOM, Centre d'Adiopodoume, Côte d'Ivoire*[1]

Region/Country	Number of samples[2]						
	Abelmoschus esculentus (1)	West African Taxon (2)	Hybrids (1) × (2)	Mixed samples (1) + (2)	*Abelmoschus moschatus*	Total	Samples received, but no germination
West Africa							
– Benin	213	64	6	2	12	297	26
– Burkina Faso	144	30	2			176	4
– Cameroon		23				23	
– Congo		1				1	
– Côte d'Ivoire	88	244			1	333	5
– Ghana	24	23				47	21
– Guinée Conakry	97	94	1	4		196	8
– Liberia		5				5	1
– Mali	19					19	4
– Niger	31					31	
– Nigeria	49	24		1		74	25
– Togo	206	165	8		6	385	86
– Zaire	2					2	
North Africa							
– Algeria	1					1	
– Egypt	35					35	
East Africa							
– Sudan	128		1	1		130	
Southern Africa							
– Zambia	24					24	
– Zimbabwe	70					70	10
America							
– Cuba	3					3	
– Guatemala	2					2	
– Mexico	1					1	
– Peru	2					2	
Mediterranean							
– Turkey	116					116	
– Yugoslavia	13					13	
Middle-East							
– Afghanistan	8					8	
– Iran	16					16	
– Pakistan	7					7	
– Saudi Arabia	1					1	
– Syria	4					4	
Asia							
– China (Taiwan)	4					4	
– India	61					61	
– Philippines	6					6	
Totals	1375	673	18	8	19	2093	190

[1] The majority of the accessions in this collection have been obtained from IBPGR and/or ORSTOM germplasm collecting missions (largely multi-crop) carried out during the period 1980–5.

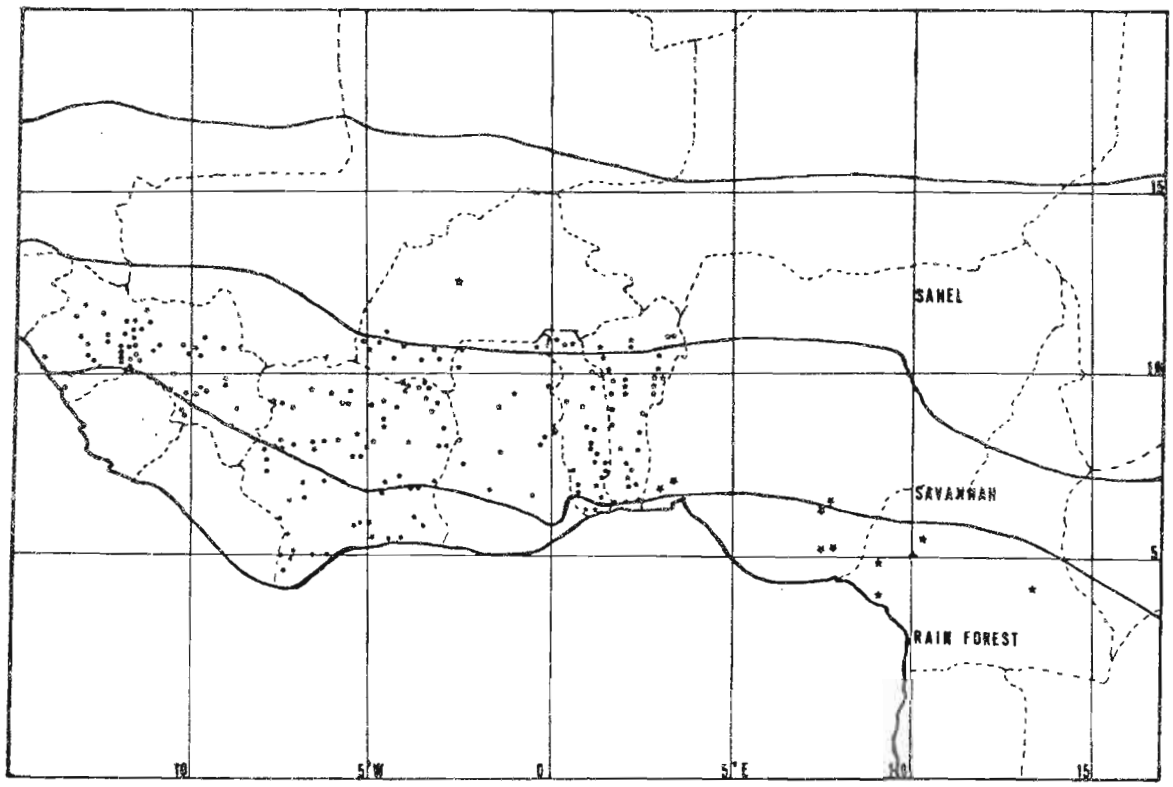
[2] No information on country of origin available for *A. manihot* (3 accessions) and *A. moschatus* (1 accession); the collection also includes 10 standard international cultivars

Fig. 11.1 Geographical distribution of *A. esculentus* in West Africa



* Sampling sites of A. esculentus collected in West Africa

Fig. 11.2. Geographical distribution of the West African Taxon (WAT)



* Sampling sites of WAT collected in West Africa

deal about the plant. Where a collecting mission finds such names it should ask very detailed questions.

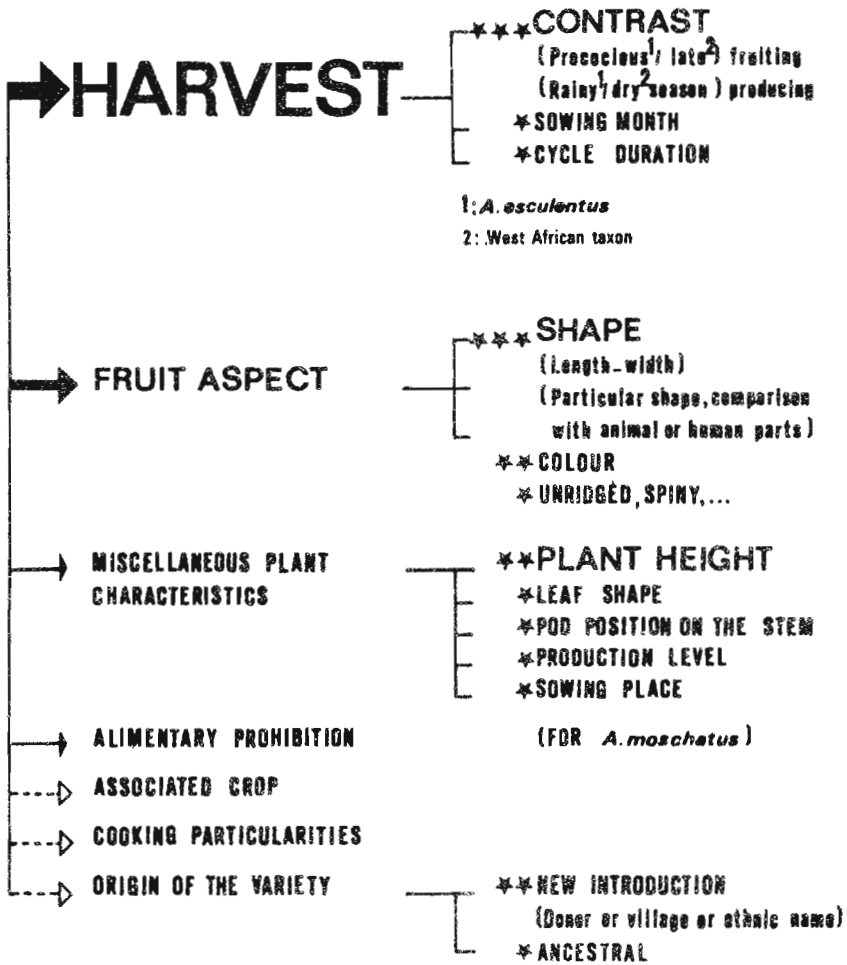
Very occasionally, a local name may refer to some aspect of the plant's provenance, culinary properties or some associated crop. Only *A. moschatus* names refer to food taboos.

Characterisation and evaluation

Materials and methods

The full okra collection was multiplied initially at the ORSTOM Station in Adiopodoumé (lower Côte d'Ivoire). Twenty plants were planted

Fig. 11.3. Recognition of the West African okra landraces based on the translation of the vernacular names



in rows, with the control varieties Clemson Spineless (international *A. esculentus* cv.) and WAT (primitive cv. ORS 520) were planted every twenty rows. Fungal pathogens, insect pests and nematodes were controlled chemically. However, leaf curl virus, transmitted by a whitefly, *Bemissia tabacci*, is very prevalent during the first six months, peaking between February and June. It is impossible to obtain an *A. esculentus* plant at that time which will top 50 cm by the end of its cycle. All parts of the plant are deformed, inflorescences poor and seeds malformed.

Descriptors used in the characterisation and evaluation fall into three categories: (i) quantitative, (ii) qualitative and (iii) enzymatic. In general the published IBPGR/ORSTOM descriptor list (Charrier, 1983, 1984) was used, but for the qualitative descriptors more descriptor states were used.

Quantitative descriptors: Plant morphology and development were characterized by plant height, number of internodes, stem diameter and branching. Measurements were taken systematically between 80 and 100 days after planting, coinciding with the end of the growing cycle of the Clemson Spineless control cultivar. For very long-cycle plants, mainly WAT accessions, a second series of measurements was made two or three months later.

The day of first flower opening, the height at first flowering and first fruiting, and the number of internodes were also noted for each plant. Fruit-setting parameters (average total number of fruits per plant and distribution along the main stem and branches) and fruit characteristics (length, width, number of ridges) and seeds (weight of one thousand seeds) were also noted.

Table 11.3. *Proportion of missing passport data in ORSTOM/IBPGR okra collection*

Passport descriptors	Percentage unknown
Collecting organisation	11
Collector	20
Collector's number	20
Country of origin	0.2
Town/Province	30
Latitude	33
Longitude	33
Altitude	99
Vernacular names	60

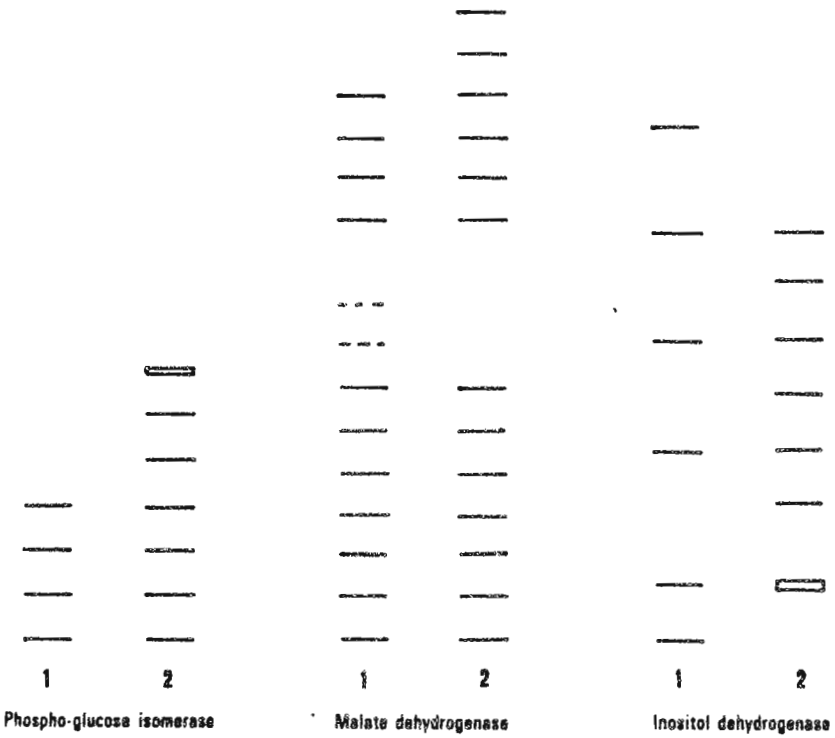
Qualitative descriptors: There are three main types of qualitative descriptors: colour, shape and other features. The specific descriptors were the colour of the main stem, the petal base, the leaf petiole, the veins, the lamina and the fruit (unripe); the shape of the leaves; and the position of the fruit on the main stem. These descriptors tend to be highly subjective.

Enzymatic descriptors: Isoenzymatic electrophoresis can provide a description virtually unaffected by the environment and fairly easy to determine.

Electrophoresis has been carried out with starch gel according to Second & Trouslot (1980). For okra, eleven systems could be used, in decreasing order of resolution:

Excellent: Alcohol dehydrogenase (Adh), phospho-glucose-isomerase (Pgi), phosphoglucomutase (Pgm), inositol

Fig. 11.4. Electrophoretic discriminating patterns of the two main okra cultivated species



1: *A. esculentus* – 2: West African taxon

dehydrogenase (Idh), 6. phosphogluconic acid dehydrogenase (6. Pgd).

Good: Shikimic dehydrogenase (SKdh), Glutamate oxalo-acetate transaminase (GOT).

Fair to poor: Esterase, acid phosphatase, peroxidase, catalase.

Within the cultivated species (*A. esculentus* and WAT) enzymatic variability hardly exists. The electrophoretic patterns of both species are distinct (Fig. 11.4), and hence the method can be used for species identification (Hamon & Yapo, 1986).

Problems encountered during characterisation and evaluation

(i) Species identification

Species identification prior to planting is essential to proper organisation of the work, and passport data on this descriptor are often incorrect. Species identification can be made on fruits at the time of collection (whole fruits are the most common method of okra preservation).

Fig. 11.5 shows the main types of fruit found: fruit types 1 to 5 WAT; fruit types 6 to 10 *A. esculentus*; fruit type 11 the control cultivar Clemson Spineless.

Fig. 11.5. Main okra fruit types: 1–5 West African Taxon, 6–10 *A. esculentus*, 11 Clemson Spineless

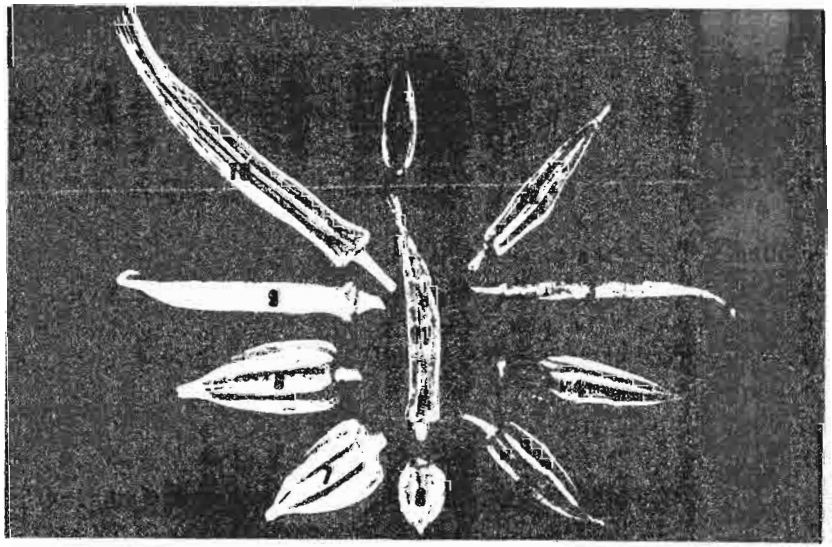


Table 11.4. *Okra accessions' level of heterogeneity*

Country of origin	Number of cases	Intraspecific heterogeneity				Interspecific heterogeneity				Total
		ESC	%	WAT	%	M1	%	M2	%	
Benin	255	181	15.4	65	7.7	8	3.1	1	0.4	16.4
Burkina Faso	131	102	32.3	25	8.0	4	3.0	—	—	29.7
Cameroon	23	—	—	23	0.0	—	—	—	—	—
Ghana	45	23	8.6	21	14.2	1	2.2	—	—	13.3
Guinea	181	81	18.5	95	9.4	4	2.0	1	0.5	16.0
Ivory Coast	21	—	—	21	0.0	—	—	—	—	—
Liberia	4	—	—	3	—	—	—	—	—	—
Mali	17	17	—	3	—	—	—	—	—	—
Nigeria	22	18	11.1	4	0.0	—	—	—	—	9.1
Sudan	35	34	32.3	—	—	1	2.8	—	—	34.3
Togo	352	172	19.4	163	27.6	15	4.2	2	0.6	25.5
Zambia	6	6	20.0	—	—	—	—	—	—	—
Zimbabwe	59	59	10.1	—	—	—	—	—	—	—
Total	1130									20.1

M1: The two species are found in the same sample
M2: As M1 but with the hybrids between them
ESC: *A. esculentus*
WAT: West African Taxon

Direct identification by seed sampling is impossible for both species, but electrophoresis of single seeds can quickly distinguish between the two species. The zymograms in Fig. 11.4 are invariant within each of the two species and different between them. Some samples were found to be mixtures of the two species (Table 11.4). The species can also be identified from the seedling, but this requires expertise and is not conclusive. Species identification by morphological criteria is definitive only on the basis of flower characteristics (number and shape of epicalyx segments). This is effective, but it does have the drawback that it occurs late in the sequence of the trial.

(*ii*) *Seed germination*

The problem of poor germination was the most disturbing factor in establishing trials. Limited numbers of seeds, low rate of germination, pest attacks and other damage produced trial imbalance for a fairly large number of accessions.

(*iii*) *Heterogeneity*

Okra, owing to its floral structure and the absence of self-incompatibility, produces much of its progeny through selfing. However, cross-pollination is frequently mentioned in the literature. The extent of outcrossing varies according to the variety, the cropping season, and the location (Chandra and Bhatnagar, 1975; Martin, 1983; Tanda, 1985), ranging from 0 to 60 per cent. There is a close correlation between cross-pollination and the presence or absence of insects. With strict pest control, contamination is severely restricted. But this is not the case in the traditional agricultural setting where pesticide treatments are non-existent. The continuous flowering and the special constraints of the evaluation procedure make both systematic bagging and isolation impossible. There is, therefore, a certain risk factor.

Table 11.4 lists heterogeneity rates for species and provenances studied in 1984–5. There are three major types of heterogeneity:

1. Interspecific heterogeneity. This is due to mixing of seeds of two distinct species during collecting;
2. Intraspecific heterogeneity refers to accessions which are mixed or segregating. This can result from crossing or from mixing of fruits by the donor or collector. One possibility might be to identify a whole fruit as an accession, but this would cause an enormous increase in the number of accessions. Table 11.4 shows that 18 per cent of WAT and 22

per cent of *A. esculentus* accessions fall into this category;
(3) Partial intraspecific heterogeneity refers to heterogeneity for only one or two traits.

An accession which is homogeneous is a rare occurrence in a plant which is reproduced by seeds and is not strictly autogamous.

Results

(i) Uni-variate analysis

Quantitative descriptors. Table 11.5 lists the statistics of quantitative descriptors for the two species. There are marked inter-species similarities and dissimilarities for particular descriptors. Discriminant analysis (See page 189), clearly brings out the differences between the two species.

Table 11.5. *Statistical parameters observed on data recorded as quantitative descriptors*

Descriptors	Min.	Max.	Mean	SD	CV	
Plant height	16	137	64.2	24.1	37.5	ESC
	24	144	67.7	22.6	33.4	WAT
Number of internodes	5.0	24.0	9.6	1.3	13.5	ESC
	8.2	28.8	19.0	4.2	22.1	WAT
Stem	6.0	32.0	15.3	4.6	30.4	ESC
Diameter at base	10.0	36.0	20.3	4.5	22.4	WAT
Number of branches	0.0	14.0	1.8	0.36	20.0	ESC
per plant	1.0	22.4	8.6	3.9	45.3	WAT
First flowering day	34.0	89.0	47.3	5.7	12.1	ESC
	48.0	101.0	67.4	10.3	15.2	WAT
First fruit producing	4.2	19.5	7.1	2.0	28.4	ESC
node	5.6	27.0	12.7	4.5	35.1	WAT
First flowering node	3.0	19.4	6.9	0.8	11.5	ESC
	4.8	36.0	11.8	2.7	22.9	WAT
Flowering amplitude	13.0	59.0	17.5	9.7	55.6	ESC
	8.0	210.0	34.5	25.0	74.7	WAT
Fruit length at maturity	5.0	30.0	14.4	5.6	39.1	ESC
	5.0	17.0	10.2	2.3	22.3	WAT
Fruit diameter at	0.7	4.8	2.1	0.7	35.1	ESC
maturity	1.2	—	2.5	0.5	21.7	WAT

Min. = Minimum value Max. = Maximum value Mean = Mean value
SD = Standard deviation CV = Coefficient of variation
ESC = *A. esculentus* WAT = West African Taxon

Qualitative descriptors: The main markers are:

Species specific traits:

– Specific to *A. esculentus*:
Bronze (7) stem colour, fruit colour (14), sea green being characteristic of Sudan accessions; darker colour of fruit ridges.

– Specific to WAT:
Colour of floral spot always internal; blackish green fruit colour, fruits slightly or very pendulous; fruits may be prickly; seeds may have a reddish fuzz;

Difference of frequencies:
Differences of frequencies basically concern three plant aspects. The following are most common in *A. esculentus*:
green stems, petioles, fruits
entire leaves, no clearly marked lobes
shorter branches.

(ii) Bi-variate analysis

Correlations among quantitative variables. Correlations between quantitative variables were calculated. The strongest and most persistent correlations are between early flowering and first flowering and fruiting nodes; next, between the first fruiting node and plant structure (stem diameter, number of internodes and number of branches). An unexpected relationship involves the weight of 1,000 seeds which is lower for fruits set at a node high on the stem.

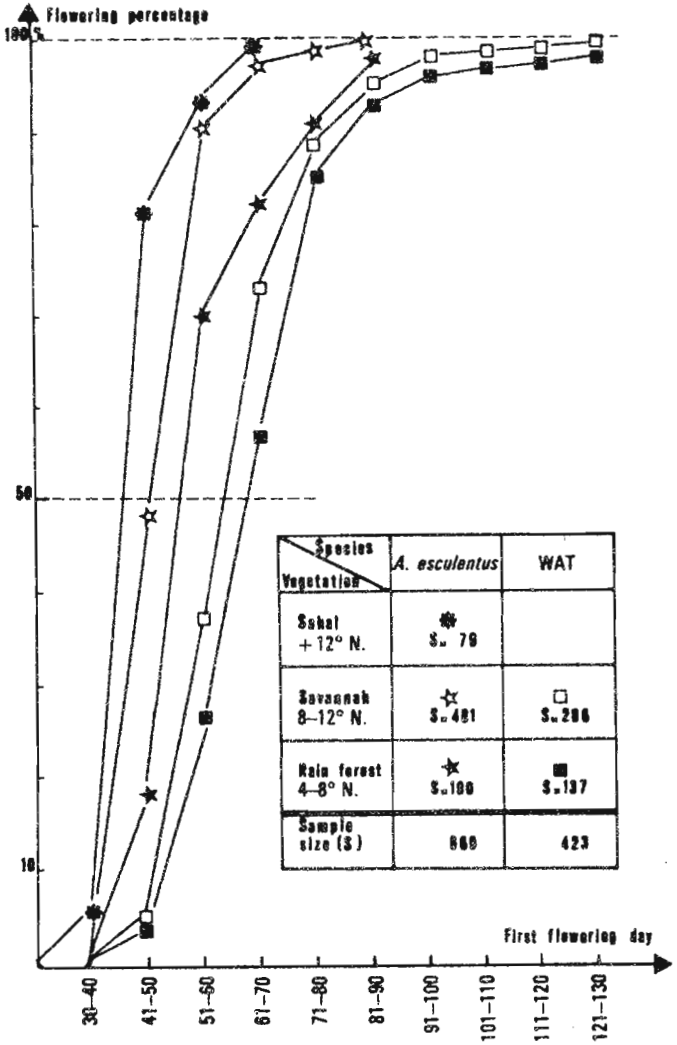
In *A. esculentus*, plant height is closely correlated with flowering and fruiting parameters and structure. This is much less or not at all true of the WAT; height is postively correlated with total seed and fruit production at 80 days. This last descriptor is itself correlated with total fruit production. It can also be seen that the close correlation between fruiting on the stems and on the branches of *A. esculentus* disappears in the WAT.

It is evident that the distribution of quantitative and qualitative variables and their correlations vary between species. Some correlations are not constant between accessions, even within the same species.

Relations between early flowering and latitude of sampling site. Fig. 11.6 depicts early flowering as a series of cumulative frequencies whilst also showing the environmental zone of the sampling site for both species. We have grouped the data in accordance with climatic zones as schematised in Figs. 11.1 and 2. Fig. 11.6 shows that precocity increases as one moves from humid to more arid zones. It also shows that *A. esculentus* flowers earlier that WAT at the same latitude.

Under the evaluation conditions in lower Côte d'Ivoire, the WAT accessions from Cameroon exhibited major flowering problems; some accessions had grown two metres in one year after planting without putting forth a single flower. This was also true to a lesser extent for some accessions at less than 7° from the equator. Generally speaking, early flowering in both species means less development – smaller size, shortened cycle and, for the WAT, fewer branches.

Fig. 11.6. Flowering behaviour of West African okras



(iii) Multivariate analysis

Comparison between the USDA and Côte d'Ivoire collections. Factor analysis was carried out on the collection available in 1982. In Fig. 11.7 the scatter diagram represents 45 per cent of the total variability. All variables were involved in the analysis, but the only ones represented in the figure are those which actually contributed to the axes.

A clear contrast between the two cultivated species is apparent along horizontal axis 1. Vertical axis 2 shows intraspecific variability, particularly in colouration, seed production, fruit width and branching. It shows clearly the contrast between the USDA *A. esculentus* accessions and those from Côte d'Ivoire. The Côte d'Ivoire accessions are much more polymorphic.

Fig. 11.3 shows the varietal recognition methods as deduced from translating the local names of the samples collected. There is a strong similarity between the local names and the factorial variables. This shows that careful attention should be given to peasant systems of variety classification.

Geographic distribution of A. esculentus *variability.* The Côte d'Ivoire *A. esculentus* collection is much more variable than the USDA collection. To understand such differences, a prior comparative analysis of several countries is needed. Principal component analysis of the quantitative variables was undertaken, and Fig. 11.8 shows the scatter diagram containing 50 per cent of the total variability. The countries included are Benin, Burkina Faso, Guinea, Mali, Sudan, Togo, Zambia and Zimbabwe. Only the limits of variability encountered for each country are shown.

A big difference in balloon size is immediately apparent between Togo and Benin with peak variability, and Mali with the smallest balloon. Axis 1 contrasts two types of plants; one early, small and unbranched with heavy seeds, and the other much hardier. It is interesting to note that Axis 2, fruit production, is independent of the okra type and that the most productive plants come from Sudan or Burkina Faso.

Comparison of A. esculentus *and WAT.* The discriminant analysis using quantitative variables, fulfils two major objectives. The first is a test classification of individuals into pre-defined groups according to a selected criterion. The second is to establish a classification of variables in descending order of discrimination, in order to select a minimum number which will suffice.

A comparison was made between the two cultivated species. First, all quantitative variables were compared and, next, only the three most discriminant variables (number of internodes, plant height and total plant

Fig. 11.7. Factor analysis on the Ivorian and USDA okra collections

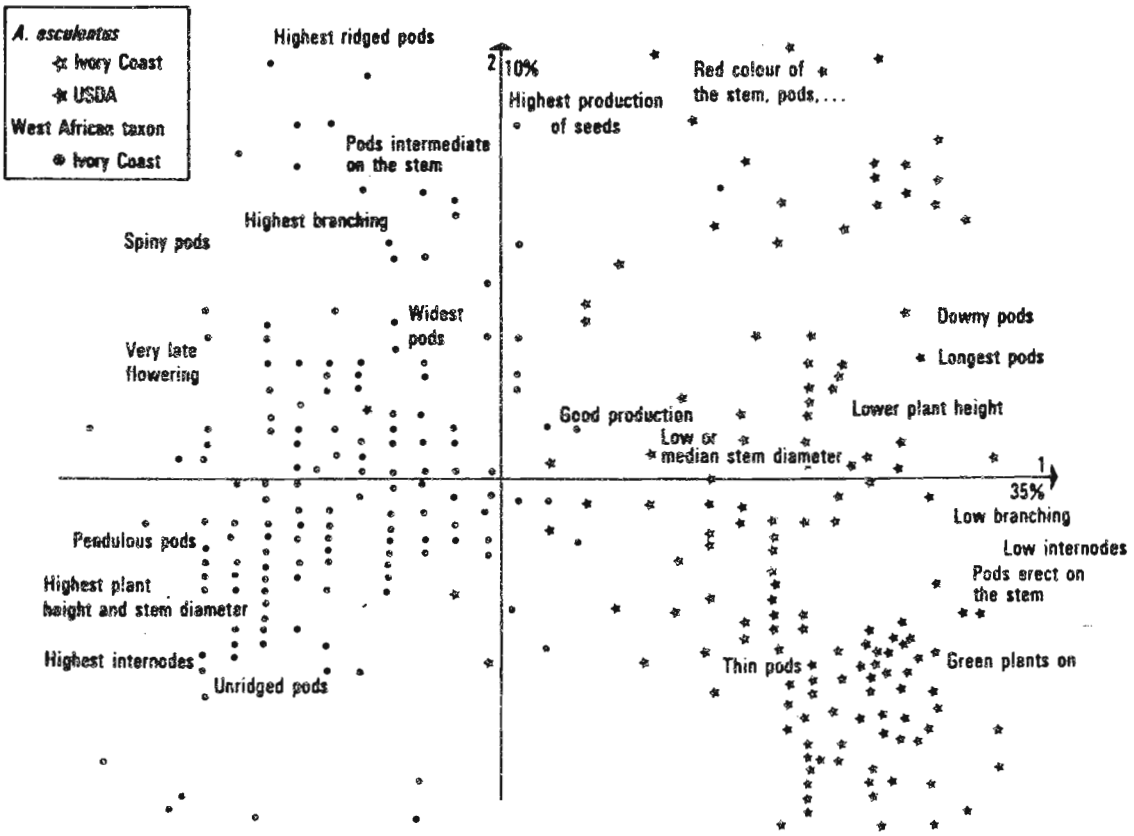
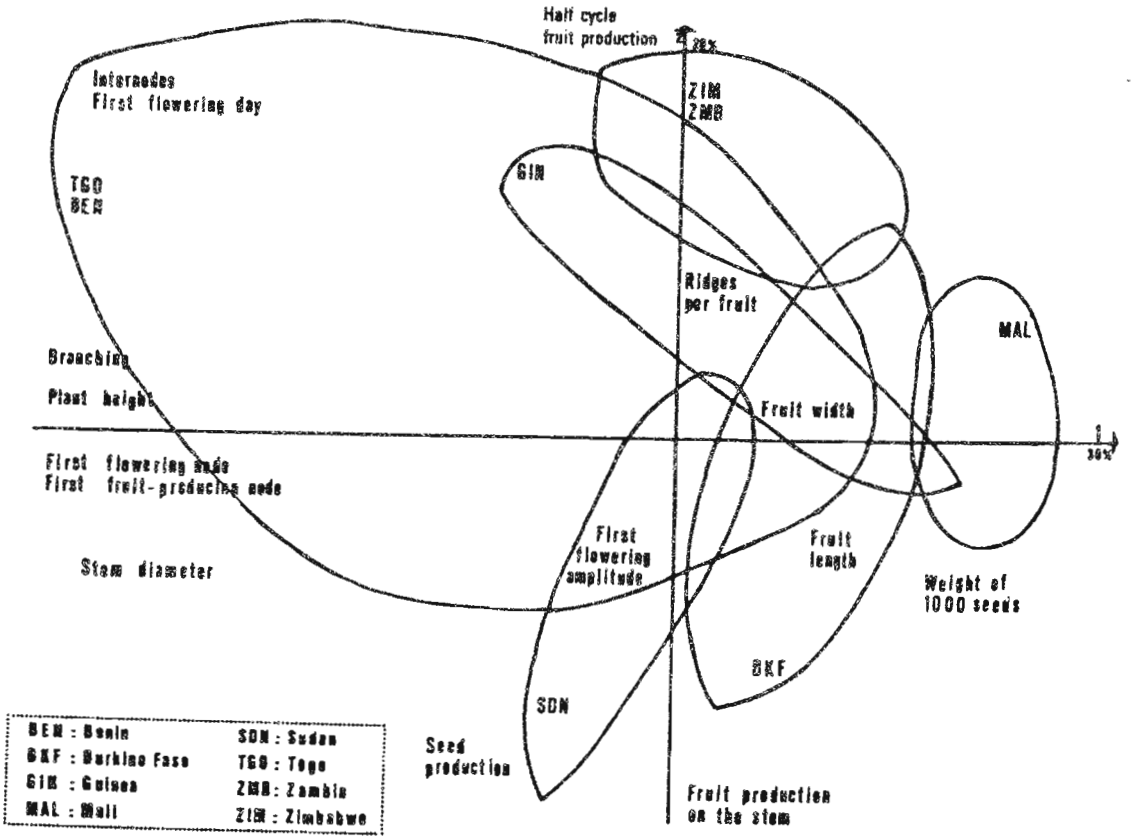


Fig. 11.8. Principal component analysis on *A. esculentus* introductions



fruit production) were selected. The percentage of properly classified variables was determined for each. The results are found in Table 11.6.

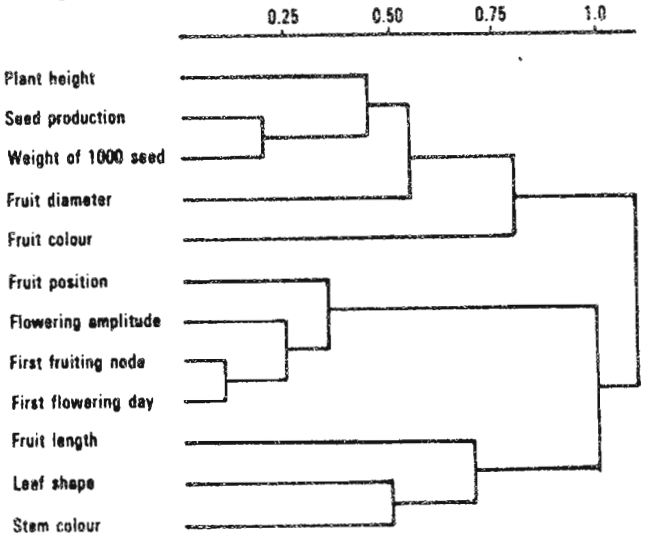
As can be seen, the margin of error is usually small and the estimation with the three variables produces quite comparable results. There is a difference of 0.4 per cent for *A. esculentus* and 5.4 per cent for the WAT.

Table 11.6. *Discriminant analysis between the two cultivated okra species in West Africa*

		Predicted group membership	
Actual group	Number of cases	ESC	WAT
ANALYSIS 1: Whole quantitative descriptors			
A. esculentus	591	99.3%	0.7%
West African Taxon	310	5.5%	94.5%
Per cent of 'grouped' cases correcly classified: 97.67%			
ANALYSIS 2: Maximum of steps equal 3			
A. esculentus	702	98.9%	1.1%
West African Taxon	422	10.9%	89.1%
Per cent of 'grouped' cases correctly classified: 95.20%			

ESC: *A. esculentus*
WAT: West African Taxon

Fig. 11.9. Euclidian distances (variance criteria) between okra descriptors



The slight differences can be explained by specific adaptations or perhaps by introgression from the other species. This is an extremely useful method which can be applied to different kinds of groups such as: plant type, geographic origin, etc.

Regrouping individuals and/or variables. Hierarchical clustering methods allow data to be classified by descriptors or by individuals. In Fig. 11.9 a classification scheme is presented for 12 descriptors, on the basis of factor analysis. Descriptors which are very strictly correlated, fruiting or colour of the petiole and stem, have not been taken into consideration.

This classification shows that the choice of descriptor depends on the required level of precision in describing variability. At the Euclidian distance level of 0.80 three distinct groups can be distinguished (Fig. 11.9). Already at this level one can see a grouping of descriptors translating the variability encountered. A choice at random of one variable in each group would already provide a strong indication of available variability. A choice at level 0.30, which appears acceptable in our situation, would allow the elimination of four descriptors.

Establishment of core collection

The principal ideas behind the concept of the 'core' collection are described in Frankel & Brown (1984); see also chapter by Brown in this volume. The need to reduce collections does not appear directly at the level of the base collection which is multiplied at least once and conserved in its entirety. However, considering the lack of data on many genetic resources collections, and the extremely costly and time-consuming characterisation and evaluation of large collections, there is an obvious need for reduction (Peeters & Williams, 1984; van Sloten, 1987).

With regard to the okra collection, it was decided in 1983 to establish such a core collection (from 200 to 300 accessions). This number was not selected in terms of percentage of the entire collection, but rather in accordance with the following objectives:

1. to have a manageable collection scaled down to the needs of the breeder and/or other user; and
2. to include the widest possible range of variability.

Towards the end of 1985, an okra core collection of 189 accessions was established on the basis of representative variability as described by passport, characterisation and evaluation data, but also including rare types. This core collection has already been distributed to several countries for further evaluation.

In this connection it should be noted that there are relatively few okra

breeding programmes in the world and therefore limited opportunities for gene introductions, i.e. the transfer of specific genes in breeding programmes. There is, however, enormous scope for using the core collection in adaptation trials in a large number of different environments (direct plant introduction).

Conclusions

On the basis of the experience gained in the evaluation of the ORSTOM/IBPGR okra collection, we are attempting an overview of the problems, of the methods of characterisation and evaluation, and possible solutions which may have application in other crop plants.

The quality of the information obtained at the collecting site is an extremely important factor. It goes without saying that information on geographic co-ordinates is an absolute necessity. It is possible to improve the level of information during collecting by observing the following:

1. restrict the mission to one or a very limited number of species;
2. take sufficient time to become familiar with the local conditions and customs;
3. request a systematic translation of local names;
4. ensure the involvement of women farmers.

The cultivation system used is an important source of information, which becomes more important when the crop has a long tradition in the particular country. One can therefore not expect to obtain the same quality of information in all areas, but one should know how to profit most from information available. We have seen that the graphical representation of the variability by means of factorial analysis corresponds closely to the farming systems used and the latter therefore provide a certain orientation in the choice of morphological descriptors.

The choice of descriptors is the second critical stage. Isozyme descriptors are now being used more and more. Their use eliminates the environmental influences, the necessity for large areas for cultivation, and the method is fairly simple. The authors agree with Crawford (1985) who underlines the limitations of the use of such markers and considers the electrophoretic information as complementary to standard characterisation. Morphological descriptors are important, since they are of most interest to the agronomist and breeder. Morphological polymorphism is not necessarily associated nor correlated with enzymatic polymorphism. Davis & Gilmartin (1985) emphasize that substantial morphological variation could be associated with only minor enzymatic changes. At the same time, adaptation plays an important role in the differentiation of ecotypes. We

have observed the disappearance of the WAT from arid zones and a decrease in variability in areas where cultural practices have become restrictive.

The reduction in the number of descriptors can be obtained through multivariate analysis. A step-wise approach consists of running a principal component factor analysis which projects the variability in a limited dimension. Then a clustering analysis is done which will be later tested by a discriminant analysis. In this approach the choice made by the researcher leads to a deliberate, but controlled loss of information.

An effective reduction of a collection, on the understanding that the original collection still needs to be conserved, is a crucial problem. In okra, a collection reduced to 200–400 well-described accessions is likely to be of a size which can be properly used.

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The use of plant genetic resources

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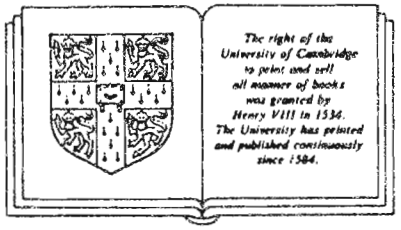

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Preface

There can be little doubt that plant breeders have now a greater range of genetic diversity available to them than ever before. Moreover, it is available to breeders anywhere in the world, subject to some technical constraints. This is due to the co-operation of national and international institutions in an international network promoted and co-ordinated by the International Board for Plant Genetic Resources (IBPGR). Each of the important crops or groups of crops, including all the major and many minor ones, is represented in one or more facilities which act as 'base collections' charged with responsibility for long-term conservation of the genetic resources of one or more crops. Associated 'active collections' provide the link with the users of collections.

Needless to say, the usefulness of collections to plant breeders and other users, including evolutionists, plant pathologists, taxonomists and other experimental biologists, depends in the first instance on the extent to which they are geographically and ecologically representative and on the presence of genes of particular interest to plant breeders. Collections have been enriched by greatly increased collecting activities in recent years, many of which were stimulated or organised by IBPGR. Indeed, collections of many more crops are a great deal more comprehensive than ever before.

Then why are they not used by breeders to a greater extent than they appear to be? Various reasons have been suggested. Breeders tend to use breeding materials with which they are familiar and which are reasonably adapted to their environment, as against alien materials requiring a lengthy programme of pre-adaptation. Further, users require information on collections to be presented in a manner that will allow them to identify accessions of potential use in their projects. This process involves the description, or 'characterisation', of the material, and its 'evaluation' for

characteristics of particular concern to plant breeders. Both characterisation and evaluation have been defined by IBPGR and descriptor lists for many crops have been published. The work involved in these operations is considerable, in many instances exceeding the capacity of national collections which are close – hence most relevant to users.

This book explores the factors that are likely to limit or to facilitate the utilisation of plant germplasm. It grew out of a workshop convened by the IBPGR Programme Committee at St Mathieu de Treviers, near Montpellier, France, 9–12 September 1986.

The book has six parts: in the first part three users representing public and private plant breeders and experimental biologists define the role of collections and suggest ways to enhance their usefulness. The second part presents three case histories of collections and discusses limitations to effective use and how they could be remedied. Large collections are contrasted in the third part with the recently proposed representative core collections. A chapter on smaller collections in Europe shows how the association of national collections stimulates collaboration between breeders and genebank managers. The fourth part describes the evaluation system in three widely differing collections. There follows an assessment of the state of management in germplasm collections, and a discussion of the principles of characterisation and evaluation and of the roles of curators, specialists in relevant fields, and plant breeders. With the higher priority now accorded to wild crop relatives, the fifth part examines how collections are to be broadened and made more representative by the inclusion of crop-related species. The final section outlines recently developed techniques which are beginning to open up new approaches in all areas of genetic resources work.

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