COCOA DESCRIPTORS, THEIR STATES AND MODUS OPERANDI

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RESUMEN

Para estandarizar la descripción de los clones y poblaciones de cacao, se presenta una lista de descriptores y sus respectivas clases. También se dan instrucciones cortas para su uso, incluyendo el tamaño de la muestra mínima para las características cuantitativas.

SUMMARY

In order to standardize the description of cocoa clones and populations, an extensive list of descriptors with their respective states is presented. Short instructions are given for their use, including the minimum sample size for the quantitative characteristics.

INTRODUCTION

The reasons to compile an extensive list of cocoa descriptors are many. First of all is the standardization of the descriptive terminology to permit an exchange of information between scientists working with cocoa genetic resources. Secondly, to facilitate an inventory of what is available worldwide in existing cocoa collections and, consequently, determine what valuable accessions should be duplicated. Thirdly, to facilitate the breeder in selecting better material, not present in his breeding programmes. Fourthly, the methods of computer-assisted data processing need information about individual accessions related to descriptors (descriptive terms, in general of plant characteristics) and their states (gradation in the expression of a descriptor). This

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ensures a quick and adequate transfer of the collected data into machine-readable form, and its efficient storage and retieval. Fifthly, to enable efficient management and maintenance of the collection. Since the latter is not uniformly handled, an additional set of descriptors should be developed locally. This set should also include descriptors for germplasm distribution and use. A final but important aspect is that the development and standardization of crop specific descriptors is the basis for a systematic description of germplasm collections. Chang (1) listed some of the advantages of such a systematic description:

a) characterization of cultivars or breeding lines of national and international interest;

b) differentiation between accessions with identical or similar names;

c) identification of accessions with desired characteristics;

d) classification of cultivars based on reliable data;

e) development of interrelationships between characteristics and also between geographical groups of cultivars; and

f) estimation of the variation available within the collection.

The majority of the descriptors presented here are based on an unpublished revision of the literature which is cited at the end of this article, and an evaluation of the selected descriptors in the Genetic Resources Project at CATIE, Costa Rica.

Methodology

In so far as the descriptors are not self-explanatory, short instructions or comments are given to facilitate their use and to make them unequivocal. The mean and standard deviation of the measured sample should be given for quantitative characteristics. The minimum sample size, 'r' is indicated after descriptors of quantitative characteristics. These have been calculated in a preliminary study so that the sample mean would fall within five percent of the population mean ninety five times in a hundred; using the formula:

$$r \geq 0.16 \left[\frac{(S)\ (100)}{\bar{x}} \right]^2$$

in which r represents the minimum sample size, and 0.16 a constant, S the standard deviation and $\bar{x}$ the mean of a sample. In the case that the calculated minimum sample size is very high, for practical reasons, a much lower value is recommended.

In the same preliminary study differences for fruit and flower characteristics between trees of the same clone, grown at the same sites, did not reach statistical significance. Thus the fruits and flowers of all the trees of one clone can be used and mixed without indicating the tree number. In spite of this, it is recommended to study fruits and flowers of several trees of one clone to ensure the determination of possible mixtures within an accession.

If a particular accession represents a population, the ranges of the phenotypic expression of the characteristics should be given, if possible, with a note on the frequency distribution.

Three types of descriptor states will be found. The first type is an open one, such as 'accession number' or 'leaf length, in centimeters'. The second type consists of fixed state descriptors which do not have a continuous expression. These are arbitrarily coded, generally commencing with '1'. Examples of this type are 'population state', 'collecting source' and 'leaf base shape'. If the descriptor states of characteristics with a continuous expression are classified, the third type, a scale from 1 to 9 is used. Class '1' always represents the lowest, smallest, etc. expression, and '9' the highest, greatest, etc. In general, only some classes of the whole scale are given, e.g. 3 = weak, 5 = intermediate and 7 = vigorous from the scale, ranking from 1 = very weak to 9 = very vigorous, for the descriptor 'vigour'. This does not imply that those not mentioned cannot be used. The presence of an unclassified characteristic is indicated by a '+'. When the expression of a characteristic is not measured, or the information is lacking, a dash '-' should be used.

Some of the descriptors are marked with 'optional'. Further investigation is needed on the correct use and classification of their states.

Instruments and apparatus indispensable for a systematic description are: stereo microscope (for flower characteristics), magnifying glass, different sizes of Vernier calipers, tweezers, dissecting needles, scalpels and glycerine. A camera can be very useful for the recording and determination of shapes, and colour patterns.

To increase the information content of data gathered under determined environmental conditions, the use of at least one world-wide accepted standard clone is strongly recommended. The results of the description of this (or these) clone(s) should be used to adjust the classes of these descriptors, if necessary, whose expressions are strongly influenced by the environment. For purpose of comparison, detailed information on the climatic and soil conditions of the germplasm collection site should be added to the descriptive data.

LIST OF DESCRIPTORS

1. ACCESSION IDENTIFIER

This identifier is recorded when an accession enters a genetic resources centre or germplasm collection. It consists of three descriptors: the first is a unique number, and the second and third the country and locality of the genetic resources centre or collection, respectively. The combination of these three descriptors is unique world-wide.

1.1 ACCESSION NUMBER

This is a number intended to serve as a unique identifier for each accession. This number once assigned to an accession, can never be reassigned, even when an accession becomes extinct.

1.2 COUNTRY GENETIC RESOURCES CENTRE

If the complete name is not used, one of the following abbreviations should be given:

ANG =	Angola	HON =	Honduras
BEL =	Belize	IND =	India
BOL =	Bolivia	JAM =	Jamaica
BRZ =	Brazil	MAI =	Malawi
CAM =	Cameroon	MAL =	Malaysia
CAR =	other Caribbean Islands	MEX =	Mexico
CDR =	Congo	NIC =	Nicaragua
CIV =	Ivory Coast	NIG =	Nigeria
CLB =	Colombia	OCA =	other Oceania
CRI =	Costa Rica	PAN =	Panama
CUB =	Cuba	PER =	Peru
DOM =	Dominican Republic	PNG =	Papua New Guinea
ECD =	Ecuador	PRI =	Puerto Rico
EGU =	Equatorial Guinea	RIN =	Rep. of Indonesia
ELS =	El Salvador	STP =	St. Tomé & Principe
GHA =	Ghana	SUR =	Surinam
GRE =	Grenada	TRT =	Trinidad & Tobago
GUA =	Guatemala	USA =	United States of America
GUI =	Guiana		
HAI =	Haiti	VEN =	Venezuela

2. NOMENCLATURE

Since all the descriptors refer to cocoa (*Theobroma cacao* L.) the genus and species name can be disregarded. The clonal name and its synonyms are very important for the identification of cocoa cultivars.

2.1 ITEM NAME

The current name for clone, cultivar, population, etc., given by the 'original' experimental station. They are generally alpha-numeric or alphabetic identifiers.

2.2 SYNONYMS

These include any previous identification other than the current name; collection number, newly assigned station name or number and/or vernacular names are frequently used as identifier.

3. ORIGINATION

A set of data that specifies the genetic origin of the accession, including the techniques used in breeding work.

3.1 POPULATION STATE

The 'breeding' state of a population from where an accession was taken can be: 1) spontaneous - a population not cultivated and which is unexploited by man; 2) primitive, but cultivated - the original, spontaneous population is unknown; 3) derived - the original population from which it derived is known. This group includes all types of breeding material. The codes are expressed as:

1 = spontaneous
2 = primitive cultivated
3 = derived

3.2 DESCENT

A code representing the way an accession derived from an ancestral population. This can be by natural or open pollination or by artificial pollination.

1 = natural pollination
2 = artificial pollination

3.3 BREEDING METHOD

A coded specification describing the way in which the artificial pollination was conducted in a breeding programme, expressed as:

1 = selfing (S)
2 = hybridization (F)
3 = backcross (BC)

3.4 GENERATION

The actual generation of an accession in a breeding programme. The generation number should be preceded by a corresponding abbreviation given in 3.3. A 'S' for material obtained by selfing, a 'F' for hybrids and a 'BC' for backcrosses.

3.5 PEDIGREE

A register recording a line of ancestors. As much information as possible should be given; even when the male parent is unknown, information on the female can be very useful.

4. GEOGRAPHICAL ORIGIN

A set of data which specifies the geographic origin and precise site from where a certain accession was collected, selected or bred.

4.1 COUNTRY

The full name or an abbreviation - as given under 1.2 - for the country in which a particular germplasm accession was collected, selected or bred.

4.2 POLITICAL SUBDIVISION

The name representing the political or administrative subdivision of the country in which a particular accession was collected. Examples are the names of a state, province, county, etc.

4.3 LOCALITY

The specific name of the town, village or, if relevant, area in which the germplasm accession was collected. If necessary a short description of the exact site should be given, for instance 10 km north of....., along river..... . An alternative is the geographical coordinates of the collection site.

4.4 COLLECTING SOURCE

Self-explanatory. In case '4' is used as code, this should be specified.

1 = natural habitat
2 = farm
3 = experimental station
4 = other

4.5 NAME OF SOURCE

The name or owner of farm, experimental station or 'other' should be given.

5. DONOR IDENTIFIER

A set of data which identifies the donor of an accession.

5.1 DONOR NAME

The name of the person or institution responsible for donating germplasm to a collector.

5.2 DONOR NUMBER

A number or an alpha-numeric identifier assigned to an accession by the donor.

6. TAXONOMIC AND MORPHOLOGICAL DATA

Data of plant characteristics which are mainly collected for the characterization and identification of a population or clone, and usually not directly related to the yield of the crop. However, relevant information for breeders is also included.

6.1 PLANT CHARACTERISTICS

Data which describe the vegetative parts of the cocoa tree.

6.1.1 Architecture

An average observation of several trees of a clone or a population should be given. The observations can be made by estimating the angle between two main branches or the angles between the main branches and the trunk. If the angle(s) is $\leq 90°$, the type is called erect; between 91 and 135°, intermediate; and $\geq 136°$, pendulus. The states are coded as follows:

1 = erect
2 = intermediate
3 = pendulus

6.1.2 Branch Formation

A division is made in the formation of a single main branch, and three or more branches (= verticillate), per ramification.

1 = single
2 = intermediate
3 = verticillate

6.1.3 Vigour

Code refers to the general appearance of an accession, and should be based on observations of several trees.

3 = weak
5 = intermediate
7 = vigorous

6.2 LEAF CHARACTERISTICS

6.2.1 Leaf Shape

Numeric data are used to describe leaf shape. The minimal sample size for these descriptors has to be calculated; the mean and standard deviation should be given.

6.2.1.1 Length, in cm (L), $\bar{x}$ and S

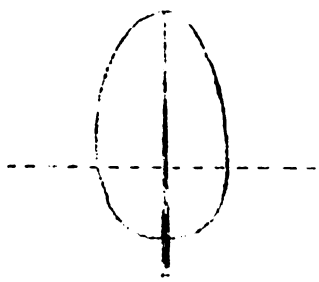
6.2.1.2 Width at widest point, in cm (W), $\bar{x}$ and S

6.2.1.3 Length/width ratio (L/W), $\bar{x}$ and S (r = 15)*

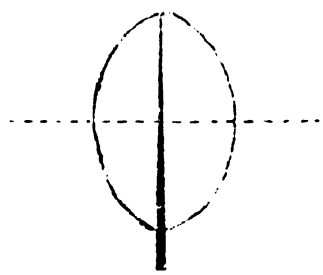
6.2.1.4 Length from base to widest point, in cm (LBW) $\bar{x}$ and S

6.2.1.5 Ratio length/length base to widest point (L/LBW), $\bar{x}$ and S

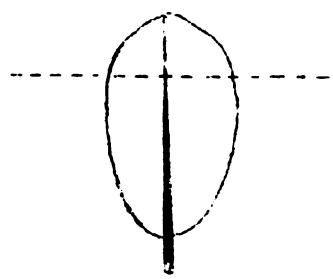
3 = ratio L/LBW < 2, shape is ovate
5 = ratio L/LBW = 2, shape is elliptic
7 = ratio L/LBW > 2, shape is obovate



ovate



elliptic



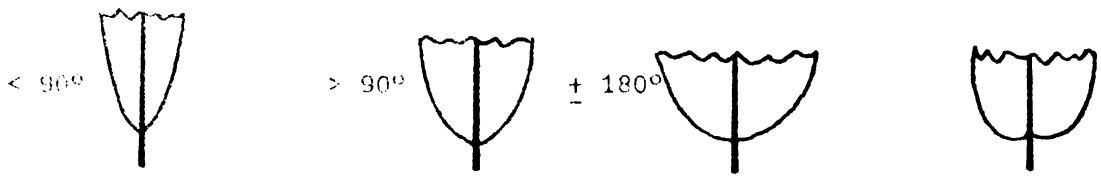
obovate

* Recommended minimum sample size.

6.2.2 Leaf base

The shape of base can be expressed in terms of the angle which the margins form with the petiole at its point of insertion. If this angle $\leq 90°$, the leaf base is acute; $> 90°$ obtuse and $\pm 180°$, rounded. If leaf base is embayed in a sinus whose sides are straight or convex, cordate is used. This observation should be based on several mature leaves of a tree and the codes are expressed as:

1 = acute
2 = obtuse
3 = rounded
4 = cordate

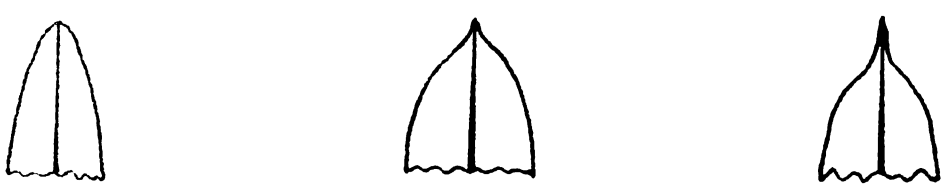


Acute Obtuse Rounded Cordate

6.2.3 Leaf Apex

The shape of that portion of leaf which is bounded by approximately the upper 25% of leaf margin. If the angle of the margins is $\leq 90°$, both with straight and convex margins, the apex is acute. If the tip is acute, with margins markedly concave, the apex is acuminate. The tip can be short or long. This observation should be based on several leaves of a tree.

1 = acute
2 = short acuminate
3 = long acuminate



Acute Short acuminate Long acuminate

6.2.4 Leaf Petiole

Petioles of some clones have noticeable thickenings or pulvini, others do not have them.

1 = without pulvini
2 = with pulvini

6.2.5 Leaf Texture

If the appearance of mature leaves is opaque, like writing paper, the term chartaceous is used; when leathery, thick and stiff, the leaves are coriaceous. In case of 'other' observations, this should be noted.

1 = chartaceous
2 = coriaceous
3 = other

6.2.6 Young Leaf Colour

Data which describe the absence or presence of anthocyanin in a young flush.

6.2.6.1 Anthocyanin absent

3 = light green
5 = intermediate
7 = intense green

6.2.6.2 Anthocyanin present

3 = light red
5 = intermediate
7 = intense red

6.3 FLOWERING CHARACTERISTICS

The flowering habit of cultivars can be described in terms of:

6.3.1 **Flowering Intensity (optional)**

The total number of flowers per cushion and the number of cushions per tree are involved in this descriptor.

6.3.2 Flowering Pattern (optional)

The distribution of the flowering activity during the year; it may be continuous or with one or more peaks per year.

6.4 FLOWER CHARACTERISTICS

Data are taken from two, three or four recently opened flowers of five trees.

6.4.1 Peduncle Colour

Because there is much variation within trees, depending on position, only three classes are divided.

1 = green
2 = green with red
3 = red

6.4.2 Anthocyanin in Outer Sepal

Several flowers of different trees should be observed:

0 = absent
3 = slight
5 = intermediate
7 = intense

6.4.3 Sepal Length, in mm., $\bar{x}$ and S (r = 20)

6.4.4 Sepal Width at Widest Point, in mm, $\bar{x}$ and S (r = 20)

6.4.5 Sepal Length/Width Ratio, $\bar{x}$ and S (r = 20)

The minimal sample size calculated is greater, but 20 is used since 20 sepals are measured.

6.4.6 Orientation Sepal

Several flowers should be observed due to variation. Only two classes are distinguished, reflexed with sepals bent backward, and others more or less horizontal;

1 = horizontal
2 = reflexed

6.4.7 Length Petal Ligule, in mm, $\bar{x}$ and S (r = 20)

Distance between point of insertion of isthmus in hood and apex of ligule.

6.4.8 Width Petal Ligule at Widest Point, in mm, $\bar{x}$ and S (r = 20)

6.4.9 Petal Ligule Length/Width Ratio, $\bar{x}$ and S (r = 20)

6.4.10 Anthocyanin in Petal Ligule

0 = absent
1 = present

6.4.11 Anthocyanin in Stamen Filament

0 = absent
3 = light
5 = intermediate
7 = intense

6.4.12 Staminode Length, in mm, $\bar{x}$ and S (r = 10)

6.4.13 Anthocyanin in Staminode

0 = absent
3 = light
5 = intermediate
7 = intense

6.4.14 Ovary Length, in mm, $\bar{x}$ and S (r = 15)

6.4.15 Ovary Width at Widest Point, in mm, $\bar{x}$ and S (r = 10)

6.4.16 Anthocyanin in Upper Part of Ovary

0 = absent
3 = light
5 = intermediate
7 = intense

6.4.17 Anthocyanin in Lower Part of Ovary

0 = absent
3 = light
5 = intermediate
7 = intense

6.4.18 Maximum Ovule Number per Ovary (r = 5)

Since the ovary has five loculi, some 40, 45, 50, or more will generally be found, with only slight deviations. At least five ovaries should be counted completely.

6.4.19 Anther Disposition

In some clones anthers are missing and in others the anthers are not covered by the hood as in the cultivar 'P-11', which should be noted behind 'other'.

0 = anthers absent
3 = normal
7 = other

6.4.20 Style Length, in mm, $\bar{x}$ and S (r = 10)

6.4.21 Anthocyanin in Lower Half of Style

0 = absent
3 = light
5 = intermediate
7 = intense

6.4.22 Self-compatibility

0 = absent
1 = present

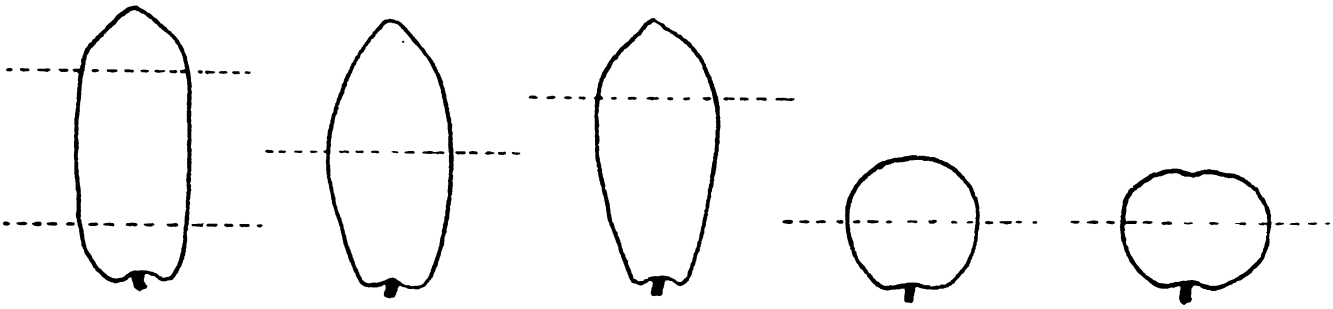
6.5 FRUIT CHARACTERISTICS

Qualitative and quantitative characteristics of unripe and ripe cocoa fruits or pods are described here.

6.5.1 Fruit Shape

Coded information, based on several observations of mature fruits. For oblong fruits, the margins of the middle part of the fruit are parallel or nearly so with the long axis. If the axis of the greatest width is perpendicular to the approximate midpoint of the fruit axis and the margins are convex, the shape is elliptic. If the axis of greatest width inserts the long axis of the fruit apical to the midpoint, the shape is obovate. More or less round fruits are called orbicular and if the fruit width exceeds the length, oblate.

1 = oblong
2 = elliptic
3 = obovate
4 = orbicular
5 = oblate



oblong elliptic obovate orbicular oblate

6.5.2 Basal Constriction

The code representing the constriction or 'bottle neck' of the basal part of the fruit, is expressed as:

0 = absent
3 = slight
5 = intermediate
7 = strong

0 3 5 7

6.5.3 Apex Form

The code representing the form of the apical part of the fruit, is expressed as:

1 = attenuate
2 = acute
3 = obtuse
4 = rounded
5 = mammelate

attenuate acute obtuse rounded mammelate

6.5.4 Fruit Length, in cm, $\bar{x}$ and S (r = 35)

6.5.5 Fruit Width at Widest Part, in cm, $\bar{x}$ and S (r = 35)

6.5.6 Fruit Length/Width Ratio, $\bar{x}$ and S (r = 35)

6.5.7 Distance Base to Widest Part, in cm, $\bar{x}$ and S (r = 20)

6.5.8 Length/Distance Base to Widest Part Ratio, $\bar{x}$ and S (r = 10)

6.5.9 Weight of Whole Fruit in g, $\bar{x}$ and S (r = 35, although the calculated sample size is much higher)

6.5.10 Fruit Surface Rugosity

This code refers to the visual observation of the absence or presence of small protuberances on fruit surface

0 = absent
3 = slight
5 = intermediate
7 = intense

6.5.11 Ridge Pair Appearance

A code for the degree of separation of a pair of ridges. Extremes are fused pairs (e.g.'Pentagona') and equidistant ones (e.g. 'Laranja')

0 = fused
3 = slightly separated
5 = intermediate
7 = well separated
9 = equidistant

6.5.12 Primary Furrow Depth

A code for the depth of the furrow between a pair of ridges, is expressed as:

3 = superficial
5 = intermediate
7 = deep

6.5.13 Fruit Wall Thickness

Fruit wall is defined as comprising both the exocarp and mesocarp. The endocarp should be removed.

6.5.13.1 Ridge, in mm, $\bar{x}$ and S (r = 35, calculated sample size higher than recommended)

6.5.13.2 Primary Furrow, in mm, $\bar{x}$ and S (r = 35, calculated sample size higher than recommended)

6.5.13.3 Secondary Furrow, in mm, $\bar{x}$ and S (r = 35, calculated sample size higher than recommended)

The furrow within a pair of ridges is defined as secondary furrow.

6.5.14 Mesocarp Hardiness

A code representing the hardiness of mesocarp of fruits at least four months old. An objective method of measurement is recommended.

3 = soft
5 = intermediate
7 = hard

6.5.15 Basic Surface Colour

Only green exist as basic colour in unripe fruits, although the intensity can vary

3 = light
5 = intermediate
7 = dark

6.5.16 Anthocyanin Intensity in Ridges

The intensity of anthocyanin in the ridges of unripe fruits can be expressed as:

0 = absent
3 = light
5 = intermediate
7 = intense

6.5.17 Anthocyanin Intensity in Primary Furrows

The intensity of anthocyanin in the primary furrows of unripe fruits can be expressed as:

0 = absent
3 = light
5 = intermediate
7 = intense

6.5.18 Anthocyanin in Ripe Fruits

The code representing the absence (= yellow fruit) or presence in different intensities of the anthocyanin in ripe fruits can be expressed as:

0 = absent
3 = light
5 = intermediate
7 = intense

6.5.19 Period to Maturity

The days from pollination to maturity of fruit varies amongst other factors with the elevation, or variation in temperature. Less than 150 days is coded as short, 151-170 days as intermediate and more than 171 days as long.

3 = short
5 = intermediate
7 = long

6.6 SEED CHARACTERISTICS

Data are generally taken from peeled seeds.

6.6.1 Dry Peeled Seed Weight, in g, $\bar{x}$ and S (r = 20)

Of 20 pods, 5 seeds each are weighed

6.6.2 Seed Length, in mm, $\bar{x}$ and S (r = 10)

Five peeled seeds from each of 10 pods are used.

6.6.3 Seed Width, in mm, $\bar{x}$ and S (r = 10)

Sample as 6.6.2

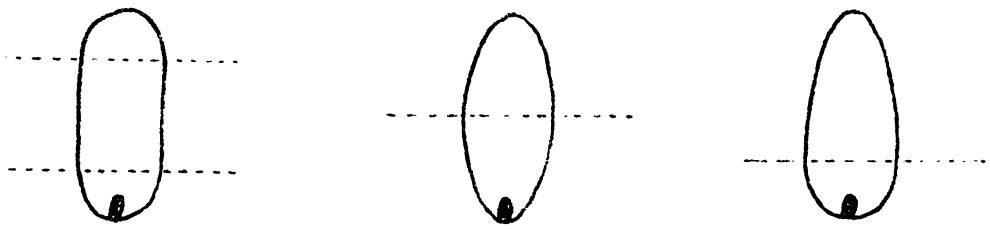
6.6.4 Seed Thickness, in mm, $\bar{x}$ and S (r = 10)

Sample as 6.6.2

6.6.5 Seed Form in Longitudinal Section

Although the form of peeled seeds can vary highly within a pod, the average form should be selected by using several seeds per pod with the embryo as the reference point. Codes are used for the three distinguished classes:

1 = oblong
2 = elliptic
3 = ovate



oblong elliptic ovate

6.6.6 Cotyledon Colour, as a percentage (r = 10)

Since the cotyledon colour depends also on the genotype of the male parent, controlled crosses, either selfing or a test cross, should be used to determine the coloration of the seeds in a useful way. The code representing the colour or combination of colours (e.g. spotted) of the cotyledon is marked by giving the percentage of a certain colour class from the whole.

1 = white
2 = grayish-white
3 = light purple
4 = intermediate purple
5 = dark purple
6 = spotted

6.6.7 Pulp Colour

The code representing the colour of fresh pulp is expressed as:

1 = white
2 = yellow

6.6.8 Fat Content of Cotyledons, as a percentage (r = 3)

Only pods resulting from selfing or crosses with a standard clone should be used.

Content should be determined with a standard method (e.g. Soxhlet, 3) and expressed as a percentage of the fresh seed weight.

7. DISEASE AND PEST REACTION DATA

Data of the reaction to particular organisms are recorded during evaluation at the site where the collection is maintained. Because of the variation in races of pathogens from country to country and even between locations, careful registration of reaction pattern and, if available, the

source of information should be ensured. This category can be divided in subgroups: reaction to fungi, bacteria, viruses, nematodes, insects, etc. In the following, only an example is given. Each germplasm centre should decide which are the locally important diseases and pests.

7.1 REACTION TO FUNGI

This code describes the degree of reaction of an accession to a particular fungal pathogen, recorded by the reaction of a plant organ infected, and expressed as:

1 = very susceptible
3 = moderately susceptible
5 = moderately resistant
7 = very resistant
9 = extremely resistant

7.1.1 *Phytophthora palmivora*
7.1.2 *Crinipellis perniciosus*
7.1.3 etc..

7.2 REACTION TO BACTERIA

7.3 etc..

Acknowledgments

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