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INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS

Key descriptors for fonio millets

INTERNATIONAL YEAR OF MILLETS 2023

Key descriptors for
fonio millets

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and
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
on behalf of
THE INTERNATIONAL TREATY ON PLANT GENETIC RESOURCES
FOR FOOD AND AGRICULTURE

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The ICAR-Indian Institute of Millets Research (ICAR-IIMR) is a premier agricultural research institute engaged in basic and strategic research on millets under the Indian Council of Agricultural Research (ICAR). The institute's vision is to transform subsistence farming of millets into a globally competitive climate resilient nutri-cereal enterprise through value addition to meet food, feed, fodder, nutrition, and bio-fuel requirements of the country for equitable prosperity.

The ICAR-National Bureau of Plant Genetic Resources (ICAR-NBPGR) is the node in India for undertaking various programmes and activities related to plant genetic resources (PGR) management for its conservation and utilization in crop improvement. The Bureau also works under the delegated powers of Plant Quarantine Order 2003 for quarantine of germplasm, including transgenic material introduced from abroad or exported for research purposes. ICAR-NBPGR carries out research, education and service activities in managing PGR.

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a pioneering, international non-profit scientific research for development organization, specializing in improving dryland farming and agri-food systems. The Institute was established as an international organization in 1972, by a Memorandum of Agreement between the Consultative Group on International Agricultural Research and the Government of India. ICRISAT works with global partners to develop innovative science-backed solutions to overcoming hunger, malnutrition, poverty, and environmental degradation on behalf of the 2.1 billion people who reside in the drylands of Asia, sub-Saharan Africa, and beyond.

The objectives of the FAO International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) are the conservation and sustainable use of all plant genetic resources for food and agriculture (PGRFA) and the fair and equitable sharing of the benefits arising out of their use, in harmony with the Convention on Biological Diversity (CBD), for sustainable agriculture and food security.

Articles 5 and 6 of the ITPGRFA guide countries in promoting the conservation and sustainable use of PGRFA. An essential component of Article 5 – Conservation, Exploration, Collection, Characterization, Evaluation and Documentation of PGRFA – is the characterization and evaluation of crops and their potentially useful traits needed to develop new crop varieties. Article 5 also highlights the importance of adopting a complementary approach between *in situ* and *ex situ* conservation.

The ITPGRFA also stresses, through Article 17 on the Global Information System, the importance of collecting and making publicly available information on scientific, technical and environmental matters related to PGRFA.

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Cover Photo: Fonio and wild fonio grains

Credit: © Jean Francois Cruz (CIRAD)

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CONTENTS

PREFACE

The *Key descriptors for fonio millets* consist of an initial minimum set of characterization and evaluation descriptors for *Digitaria exilis* Stapf and *Digitaria iburua* Stapf of the family Poaceae. This strategic set aims at facilitating access to and utilization of these species and it does not exclude the addition of other descriptors later.

This work has been done jointly with the ICAR-Indian Institute of Millets Research (ICAR-IIMR), the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the ICAR-National Bureau of Plant Genetic Resources (ICAR-NBPGR) and the FAO International Treaty on Plant Genetic Resources for Food and Agriculture. The descriptor list is based on a draft list of descriptors for fonio developed by Dr Raymond Vodohuè and a group of scientists. Subsequently, internet searches were carried out looking for the most updated information on relevant characteristics and traits. The original list was afterwards integrated with evaluation traits. Special attention was given to the inclusion of descriptors relevant to germplasm utilization, including nutritional traits and biotic and abiotic stresses of particular importance in the context of emerging adverse weather events, which are expected to intensify under current and future climate challenges.

The key set of access and utilization descriptors was defined through an online survey, in which 28 experts from 23 different organizations and universities from 16 countries participated. The results of the survey were subsequently validated in consultation with a Core Advisory Group (see "Contributors") led by ICAR-IIMR, ICAR-NBPGR and ICRISAT.

The strategic set of data standards is designed to facilitate access to and utilization of plant genetic resources for food and agriculture. Together with passport information (Alercia, A. *et al.* 2015), descriptors are critical to the effective sharing of characterization and evaluation data and to the efficient use of plant genetic resources for food and agriculture.

INTRODUCTION

Fonio millets belong to the plant family Poaceae and are important cereal crops of West Africa, having cultural, nutritional, and economic significance. There are two cultivated species of fonio millets, *Digitaria exilis* Stapf, referred to as white fonio, and *D. iburua* Stapf, known as black fonio.

Fonio is also recognized by various names such as acha (for white fonio), and iburu (for black fonio), among other commonly used names. Among these two species, white fonio is predominantly cultivated. These millets are grown in various West African countries including Benin, Burkina Faso, Côte d'Ivoire, the Gambia, Guinea, Guinea-Bissau, Mali, the Niger, Nigeria and Senegal.

The favourable attributes such as fast-growing, high adaptation to poor soils, remarkable drought tolerance, and nutritional superiority over other cereals make fonio a promising staple crop for household food security among rural dwellers in West Africa.

A sizeable morphological variability exists among fonio landraces, including maturity duration, plant height, grain size, and number of racemes, among others. Late maturing landraces are cultivated for higher yield, while landraces with short duration are grown for ensuring food security during periods of scarcity. Fonio millets serve multiple purposes, being utilized as food and fodder, and in brewing processes. They are also used to develop healthy or special foods like acha-bread, biscuits, cookies, sourdough, and traditional drinks.

This descriptor list follows the international standardized documentation system for the characterization and study of genetic resources as promoted by Bioversity International (2007). It is expected that it will support studies focusing on the genetic and morphological diversity of fonio millets and its wild and weedy relatives, as well as those on conservation, domestication and use.

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FONIO MILLETS DESCRIPTORS

Descriptors are used for studying diversity in key characteristics of accessions within a species. They should be used when they are useful to users, either collection curators for the management and maintenance of their germplasm material or to all other users of plant genetic resources for promoting their sustainable use.

As far as possible, environmentally stable descriptors should be selected but some important plant traits show genotype × environment (G×E) interaction. Rather than avoiding these traits, such as plant height, yield and nutritive value, it is suggested that comparisons between accessions should be made using representative data generated with the same methodology from plantings on the same date in the same site and season. It is also advised to use standard local checks and appropriate experimental design while performing characterization and evaluation to compare data generated over time. Additionally, date of sowing, soil types and climatic variables such as temperature, rainfall, daylength, etc. could support data interpretation across years.

To this end, highly discriminating descriptors are listed below to facilitate selection of those accessions best suited to user's needs and highlighted throughout the text along with their relevant definition.

MINIMUM SET OF CHARACTERIZATION AND EVALUATION DESCRIPTORS

Number	Descriptor name
1.	Plant growth habit
2.	Plant height (cm)
4.	Number of basal tillers
5.	Number of racemes per panicle
10.	Inflorescence colour
12.	Panicle compactness
14.	Days to 50% flowering
16.	Caryopsis (seed) shape
17.	Seed colour
18.	1000-Seed weight (g)
19.	Seed shattering (%)
20.	Easiness to dehusking
21.	Biomass yield per plant (g)
25.	Grain crude protein content (%)
26.	Grain carbohydrate content (%)
30.	Susceptibility to drought
31.	Susceptibility to salinity

32.	Susceptibility to soil acidity
35.	*Chilo partellus* (Stem borer)
36.	*Striga hermonthica* (Striga)

CHARACTERIZATION

Record quantitative traits on five randomly selected plants or plant parts and report as a mean, with standard deviation, unless otherwise specified. For qualitative descriptors (habit, shape, colour etc.) record the predominant visual assessment of a single observation on group of plants on plot basis. For all colour descriptors the use of the Royal Horticultural Society (RHS) Colour Chart codes is recommended. If these are not available, the colour codes listed may be used. Choose plants or plant parts from the middle of the row to avoid boarder effects for all the traits.

1. Plant growth habit

Record the growth habit on plot basis at flowering.

1 Erect
2 Prostrate
3 Spreading

2. Plant height (cm)

Record the height of main tillers on five randomly selected plants from the ground level to the tip of inflorescence at physiological maturity.

3. Number of nodes per culm

Record the average number of nodes per culm of main tillers on five randomly selected plants at maturity.

1 Low (2-3)
2 Medium (4-5)
3 High (> 5)

4. Number of basal tillers

Record the average number of basal tillers at ground level or from the basal nodes on five randomly selected plants at maturity.

5. Number of racemes per panicle

Record the average number of racemes on the main panicle of five randomly selected plants at maturity.

0 No branching
1 Low branching (1-2 racemes)
2 Medium branching (3-4 racemes)
3 Strong branching (> 4 racemes)

6. Leaf colour

Record the predominant leaf colour observed on three leaves from five randomly selected plants in a plot, at vegetative stage.

1 Light green
2 Dark green
3 Purplish
99 Other (specify in the Notes descriptor)

7. Blade pubescence of leaf

Record the blade pubescence of three leaves from main tillers of five randomly selected plants in a plot, at flowering.

0 Absent
3 Sparse
7 Dense

8. Leaf senescence

Record the level of leaf senescence assessed as a visual observation on a plot basis, at physiological maturity.

1 Leaves almost green
2 Leaves moderately green
3 Leaves almost dry
4 Leaves completely dry

9. Peduncle length (cm)

Measure from the topmost node of main tiller to the base of the inflorescence of five randomly selected plants, at flowering.

10. Inflorescence colour

Record the predominant colour of inflorescence at physiological maturity.

1 White
2 Green
3 Red
4 Purplish
99 Other (specify in the Notes descriptor)

11. Panicle exsertion

Record the extent to which the panicle is exserted above the flag leaf sheath of five randomly selected main tillers at physiological maturity.

1 Enclosed (panicle is partly or entirely enclosed within the leaf sheath of the flag leaf blade)
2 Partly exserted (panicle base is slightly beneath the collar of the flag leaf blade)
3 Just exserted (panicle base coincides with the collar of the flag leaf blade)
4 Moderately well exserted (panicle base is above the collar of the flag leaf blade)
5 Well exserted (panicle base appears well above the collar of the flag leaf blade)

12. Panicle compactness

Record compactness of the panicles at physiological maturity.

3 Loose
5 Intermediate
7 Compact

13. Raceme length (cm)

Record the length of main axis of raceme from the base to the tip. Average of five randomly selected racemes at physiological maturity.

14. Days to 50% flowering

Record the number of days from sowing until 50% of plants (main tillers) have begun to flower.

1 Very early (≤60 days)
2 Early (60 to 70 days)
3 Medium (70 - 80 days)
4 Late (80-90 days)
5 Very late (>90 days)

15. Spikelet arrangement on the raceme

Record the arrangement of spikelets on the raceme.

1 Alternate
2 Opposite
99 Other (specify in the Notes descriptor)

16. Caryopsis (seed) shape

Record the shape of seeds visually assessed as a single observation on a small seed lot.

1 Round
2 Oblong
3 Ellipsoid
99 Other (specify in the Notes descriptor)

17. Seed colour

Record the predominant seed colour visually assessed as a single observation on a small seed lot.

1 White
2 Pale yellow
3 Brown
4 Black
99 Other (specify in the Notes descriptor)

18. 1000-Seed weight (g DW)

Record the weight of 1000 seeds dried to about 11-12% moisture content.

EVALUATION

All evaluation descriptors are environmentally influenced, and therefore care needs to be taken when collecting evaluation data. To present reliable and reproducible information about characters that have significant G×E interaction, it is encouraged that measurements for these descriptors are taken from a carefully managed trial. The planting date, agronomic treatments, environmental conditions, season, age of plants and physiological stage at the time of measurement and plant treatments after harvest should be the same for all accessions and be described and documented in the trial. All nutritional traits reported should be from comparable samples using analyses done according to standard accredited methods from the same laboratory.

19. Seed shattering (%)

Record the percentage of spikelets remaining on racemes at full maturity. Observed as the extent to which seeds have shattered from the panicle.

1 <10
2 10-30
3 >30

20. Easiness to dehusking

Record the ease with which the grains can be dehusked by rubbing between the fingers in a small seed lot.

3 Easy
7 Difficult

21. Biomass yield per plant (g DW)

Record the average dry weight of 10 plants randomly selected.

22. Harvest index

Record the grain to total biomass (dry weight) ratio.

23. Grain hardness

Measure using a Grain Hardness Meter. Otherwise, the scale below can be used.

3 Soft endosperm
7 Hard endosperm

24. Grain lipid content (%)

Record the percentage of lipids content from seed samples randomly collected from the plot.

25. Grain crude protein content (%)

Record the percentage of crude protein content from seed samples randomly collected from the plot.

26. Grain carbohydrate content (%)

Record the percentage of carbohydrate content from seed samples randomly collected from the plot.

27. Grain calcium content (mg/100g)

Record the calcium content from seed samples randomly collected from the plot.

28. Grain iron content (mg/100g)

Record the iron content from seed samples randomly collected from the plot.

29. Grain zinc content (mg/100g)

Record the zinc content from seed samples randomly collected from the plot.

ABIOTIC STRESS SUSCEPTIBILITY

Scored as percentage survival from a specific trial to induce stress, under conditions which are clearly specified. Drought trials are often performed under greenhouse conditions or rain-out shelters. These are coded on a susceptibility scale from 1 to 9:

3 Low
5 Intermediate
7 High

30. Susceptibility to drought

31. Susceptibility to salinity

32. Susceptibility to soil acidity

33. Susceptibility to cold

34. Susceptibility to soil alkalinity

BIOTIC STRESS SUSCEPTIBILITY

Scored as percentage infection from a specific trial to induce disease or insect infestation, under natural/artificial inoculation conditions to be specified. In each case, it is important to state the origin of the infestation or infection, i.e., natural, field inoculation, laboratory. Record such information in descriptor 42. Notes. These are coded on a susceptibility scale from 1 to 9:

3 Low
5 Intermediate
7 High

Causal organism	Common name
35. *Chilo partellus*	Stem borer
36. *Striga hermonthica*	Striga
37. *Puccinia oahuensis*	Rust
38. *Atherigona* spp.	Shoot fly
39. *Sogatella furcifera*	White-backed plant hopper
40. *Meloidogyne incognita* *Meloidogyne javanica*	Root-knot nematode
41. *Curvularia* sp.	Leaf spot

42. NOTES

Specify here any other additional information. Add any additional traits (e.g., plant pigmentation, spikelet density) that are important to describe the diversity among accessions within these species.

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