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INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS

Key descriptors for foxtail millet

INTERNATIONAL YEAR OF MILLETS 2023

Key descriptors for **foxtail millet**

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ICAR-NATIONAL BUREAU OF PLANT GENETIC RESOURCES,
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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: *Setaria italica* fruit

Credit: © ICRISAT/M. Vetriventhan

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PREFACE

The *Key descriptors for foxtail millet* consist of an initial minimum set of characterization and evaluation descriptors for *Setaria italica* and *Setaria pumila* 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 list was based on the *Descriptors for* Setaria italica *and* Setaria pumila (IBPGR, 1985). Subsequently, internet searches were carried out looking for the most updated information on relevant characteristics and traits. The original list was subsequently integrated with evaluation traits. Special attention was given to the inclusion of descriptors relevant to germplasm utilization 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 29 experts from 20 different organizations and universities from 13 countries participated. Survey results 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 *et al.* 2015, 2018, 2022), 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

Foxtail millet (*Setaria italica* (L.) P. Beauv.) is one of the oldest cereals, and its domestication in China dates to over 10 000 years ago. It then spread to India and Europe and became a cereal cultivated throughout Eurasia in arid and semi-arid regions.[1]

Foxtail millet is a member of the family Poaceae. The genus *Setaria* comprises several subgenera, with over 100 species distributed worldwide. Many species are weedy and distributed widely in warm areas throughout the world. *Setaria italica* is believed to be domesticated from the weed – green foxtail, *Setaria viridis*. Both *S. viridis* and *S. italica* have emerged as new biological and genomic models for studying C_4 photosynthesis and many other traits relating to the productivity of crops and bioenergy grasses.

Foxtail millet is an important crop of dryland agriculture, a potential climate-resilient grain, and a nutrient-dense crop for food security and nutrition. It is valued as a crop of short duration maturing in 60 to 100 days, resistant to drought and salinity, and less prone to insect pests and diseases. It can be successfully cultivated in areas with low precipitation, and altitudes from sea level up to 2000 m above mean sea level.

Foxtail millet grain is used for human consumption and as feed for poultry and cage birds. The husked grain is used as food in Asia, south-eastern Europe and Africa. The grain may be cooked and eaten like rice. It can be ground and made into unleavened or leavened bread by mixing it with wheat flour. The flour is also used to prepare cakes, noodles, porridges and puddings. It is considered a nutritious food with high protein content and is often recommended for older people and pregnant women. It is recognised as diabetic food as it releases glucose steadily to the bloodstream because of its high dietary fibre content. In Europe and the United States, foxtail millet is primarily grown as bird feed. It is also a critical fodder crop in the United States of America. In Europe it is grown for hay and silage.

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 this publication will support studies focusing on genetic and morphological diversity of foxtail millet and its wild and weedy relatives, as well those on conservation, domestication and use.

[1] doi.org/10.1073/pnas.0900158106

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FOXTAIL AND YELLOW 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 x environment (GxE) interaction. Rather than avoiding these important use traits, such as plant height, yield and nutritive value, it is suggested that comparisons between accessions should only be made using representative data generated with the same methodology from plantings on the same date in the same site and season. To this end, highly discriminating descriptors are listed below to facilitate selection of those 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.	Days to 50% flowering
3.	Plant height (cm)
4.	Number of basal tillers
5.	Plant pigmentation
8.	Blade length of flag leaf (cm)
12.	Peduncle length (cm)
14.	Inflorescence length (cm)
15.	Inflorescence width (cm)
16.	Inflorescence lobes size
17.	Panicle growth habit (in relation to stem)
18.	Panicle branching
20.	Inflorescence compactness
21.	Inflorescence shape
22.	Seed colour
23.	Seed shape
24.	1000-Seed weight (g)
25.	Shattering of inflorescence (%)
26.	Grain yield per plant (g)
27.	Straw yield per plant (g)
29.	Grain crude protein content (%)
33.	*Pyricularia setariae* (Blast disease)
34.	*Uromyces setariae* (Rust)

35. *Ustilago crameri* (Smut)
36. *Sclerospora graminicola* (Downy mildew)
37. *Atherigona* spp. (Shoot flies)
38. *Sesamia inferens* (Stem borer, pink stem borer)
42. Susceptibility to high temperature
43. Susceptibility to drought
44. Susceptibility to high soil moisture

CHARACTERIZATION

Measure/count each descriptor 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) record the predominant visual assessment of a single observaton 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.

1. Plant growth habit

Record the growth habit on plot basis at flowering/heading stage.

1 Erect
2 Erect geniculate
3 Decumbent
4 Prostrate

2. Days to 50% flowering

Record number of days from sowing until 50% of plants (main tillers) have begun to flower/anthesis on plot basis.

3. Plant height (cm)

Record the height of main tillers of five randomly selected plants from ground level to tip of inflorescence at physiological maturity. In case of decumbent or prostrate, length of flowering culm from rooted base at physiological maturity.

4. Number of basal tillers

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

5. Plant pigmentation

Record the pigmentation on five randomly selected plants at flowering.

0 Not–pigmented or green
1 Pigmented
2 Deep purple

6. Culm branches

Record the number of culm branches on the main stem of five randomly selected plants at physiological maturity.

0 Absent
3 Few
7 Many

7. Leaf colour

Record the predominant colour assessed as a single observation on group of plants on plot basis from main tillers at vegetative stage.

1 Light green
2 Green
3 Yellow
4 Purple
5 Dark purple
99 Other (specify in the descriptor Notes)

8. Blade length of flag leaf (cm)

Record leaf blade length from ligule to tip of flag leaf on main tillers of five randomly selected plants at flowering.

9. Blade width of flag leaf (cm)

Record leaf blade width at the widest point of flag leaf on main tillers of five randomly selected plants at flowering.

10. Sheath length of flag leaf (cm)

Record leaf sheath length from node to ligule on main tillers of five randomly selected plants at flowering.

11. Leaf senescense

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

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

12. Peduncle length (cm)

Record length of peduncle from top most node of main tiller to base of inflorescence on five randomly selected plants at maturity.

13. Peduncle exsertion (cm)

Record length of the exposed portion of the peduncle from the flag leaf sheath up to the base of the inflorescence on main tillers of five randomly selected plants at maturity.

14. Inflorescence length (cm)

Record length of inflorescence from lowest branch to tip of last branch on main tillers of five randomly selected plants at physiological maturity.

15. Inflorescence width (cm)

Record the width of widest part of inflorescence on main tillers of five randomly selected plants at physiological maturity.

16. Inflorescence lobes size

Record the size of lobes on the inflorescence of five randomly selected plants at physiological maturity.

0 Absent
3 Small
5 Medium
7 Large

17. Panicle growth habit (in relation to stem)

Record the growth habit on plot basis at flowering.

1 Erect
2 Semi-erect
3 Horizontal
4 Drooping

18. Panicle branching

Record the branching of panicle on five randomly selected plants at distal end of panicle at physiological maturity.

0 Absent
1 Present

19. Inflorescence bristles length

Record the length of bristles assesed as visual observation at the middle of the inflorescence on five randomly selected plants at flowering stage.

3 Short (<4mm)
5 Medium (4-8 mm)
7 Long (>8mm)

20. Inflorescence compactness

Record the arrangement of lobes and compactness of inflorescence on five randomly selected plants at physiological maturity.

3 Loose
5 Medium
7 Compact

21. Inflorescence shape

Record the predominant shape observed on five randomly selected plants at physiological maturity.

1 Oblong
2 Ovate
3 Elliptic
4 Obovate

22. Seed colour

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

1 White
2 Yellow
3 Orange
4 Brown
5 Red
6 Black
99 Other (specify in the descriptor Notes)

23. Seed shape

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

1 Round
2 Elliptical
3 Oval
4 Ovate

24. 1000-Seed weight (g)

Record weight of 1000 seeds after drying the seeds at 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 GxE 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.

25. Shattering of inflorescence (%)

Record percentage of spikelets remaining on racemes at full maturity from five plants selected at random.

3 Low
5 Medium
7 High

26. Grain yield per plant (g)

Record the average grain yield of five plants randomly selected.

27. Straw yield per plant (g)

Record the average straw yield of five plants randomly selected.

28. Grain carbohydrate content (%)

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

29. Grain crude protein content (%)

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

30. Grain dietary fibre content (%)

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

31. Grain calcium content (mg/100g)

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

32. Seed starch type

Record starch type on seed samples randomly collected from the plot.

0 Non waxy
1 Waxy

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 46. NOTES. These are coded on a susceptibility scale from 1 to 9:

3 Low
5 Intermediate
7 High

Causal organism	Common name
33. *Pyricularia setariae*	**Blast disease**
34. *Uromyces setariae*	**Rust**
35. *Ustilago crameri*	**Smut**
36. *Sclerospora graminicola*	**Downy mildew**
37. *Atherigona* spp.	**Shoot flies**

Record percentage deadhearts at 21 days after seedling emergence (Screening under timely/late sowing condition to be specified).

38. *Sesamia inferens*	**Stem borer, pink stem borer**

Record percentage deadhearts at vegetative stage/white earheads at maturity.

39. *Helminthosporium* spp.	**Leaf spot**
40. *Spodoptera frugiperda*	**Fall army worm**
41. *Chilo partellus*	**Spotted stem borer**

Record percentage deadhearts at vegetative stage/white earheads at maturity.

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.

42. Susceptibility to high temperature

43. Susceptibility to drought

44. Susceptibility to high soil moisture

45. Susceptibility to low temperature

46. NOTES

Specify here any other additional information. Add any additional traits that are important to describe the diversity among accessions within this species.

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