

## Foxtail millet (*Setaria italica* (L.) P. Beauv.) in Mazandaran/Northern Iran

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**Abstract** Foxtail millet, *Setaria italica* is still cultivated in Mazandaran (N-Iran). It is used for the preparation of local food and for feeding cage-birds. The cultivated race is convar. *moharia*, formerly widely grown from Europe to SW Asia. The newly found material allows conclusion with respect to evolution and distribution of this old crop.

**Keywords** Foxtail millet · Iran · *Setaria italica* · Underutilized crops

*Setaria italica* was included in the original treatment of Flora Iranica (Bor 1970) citing a few localities. In his additions, Scholz (1981) refers to this species, based on a herbarium specimen of Gauba: “In valle fluvii Calus, 500 m, 8.10.1937, Cult.”.

Material from this area was, again, collected in 2004 (Khoshbakht 2005). Foxtail millet, formerly a famous crop of Persia (Körnicke 1885), and for a long time a traditional cereal in Mazandaran,

has become a very rare and underutilized crop as defined by Hammer et al. (2001).

The species, locally named “Gavras italiaei; Gours” was formerly used in a wide range of local cuisines. The grains were boiled like rice, cooked into porridge, or after grinding baked into flat bread. Today we found a few accessions mostly grown for cage-birds and poultry.

A determination of the material on the basis of herbarium specimens and a cultivation experiment in the greenhouse of University of Kassel in Witzenhausen, Germany, (Fig. 1) came to the result that the material belongs to the following race (in agreement with Scholz 1981):

*Setaria italica* (L.) P. Beauv. convar. *moharia* (Alef.) Koern. in Handb. Getreideb. 1, 1885, 272 (sub *Panicum italicum*) ex Mansf. in Züchter 22 (1952) 311. – *Panicum italicum* L. var. *moharia* Alef., Landw. Flora 1866, 315; *Setaria italica* ssp. *colchica* Maisaya et Gorgidze in Soobšč. A. N. Gruz. SSR 119, 1985, 589, nom. inval.

Short description (see also Mansfeld 1952; Clayton 1980): Annual; stems upright, (25–) 50–140 cm, up to 1 cm thick, unbranched or branched in the lower part. Leaves 20–40 cm × 6–30 mm; ligula ending in a row of hairs. Panicle 4–30 cm long, 1.5–3 mm thick, ellipsoid to cylindrical, the rachis villous; bristles 2–16 mm, 2–5 per cluster of spikelets, antrorsely scabridulous, yellowish to black, mostly longer than the spikelet; upper glume 2/3 as long to almost as long as

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**Fig. 1** *Setaria italica* convar. *moharia*. (a) collected seeds from Mazandaran (Northern Iran); (b) cultivated plant in greenhouse, Witzhausen; (c) mature spike (photo: K. Khoshtakht)



the spikelet. Spikelet 2–3 mm, green, mature yellow, red or brown. Upper lemma smooth, disarticulating from the rest of the spikelet at maturity. Stigma yellowish. Spikelets not disarticulating at maturity, only the grain, enclosed by the glumae, becomes free.

Convar. *moharia* is the more primitive race, with a tendency towards cross pollination (Körnicke 1885), closely related to the wild progenitor *S. viridis* (L.) P. Beauv.

It can be differentiated from convar. *italica* by looser panicles, shorter panicle branches and smaller grains. The flower glumes are smooth and shining, easily disarticulating together with the mature caryopsis from the persisting lower glumes (see also Tzvelev 1976; Scholz 1981). This race is mostly 50–100 cm tall, with 5–52 (ave. 9) culms per plant. They have small (5–20 cm long), erect or slightly nodding panicles with short (1–3 cm long) fascicle branches on which the spikelets are arranged in clusters (Prasada Rao et al. 1987; de Wet et al. 1979). The setae are well

developed. Differing from weedy variants by having spikelets that persist after maturity, aiding harvest.

This is one of the two major entities of *S. italica* (convar. *italica* and convar. *moharia* (Alef.) Koern. ex Mansf.) “races” according to Prasada Rao et al. (1987). Convar. *moharia* predominated the traditional agriculture from Europe. It was found, e.g. in the last fields of slash-and-burn cultivation in Slovakia (Kühn and Hammer 1979). Its distribution in the eastern part of the area of the species remained unclear. Körnicke (1885) provided a very detailed description and found the most eastern proveniences from Hungary (p. 276). This was confirmed also by Metzger (1841). Generally SW Asia was considered as the area of distribution of this race (Prasada Rao et al. 1987). As the growing area of convar. *moharia* is still declining, it was possibly one of the last opportunities for indicating the former large distribution area of this race.

Because of its typical geographical definition, Scholz (1981) considered this race as a subspecies<sup>1</sup>.

The hypothesis of a multiple origin of foxtail millet is supported by archeological, morphological, and molecular evidence (Pernès 1985; Sakamoto 1987, Li et al. 1995; Fukunaga et al. 2002; Darmency 2005).

Two main centers of origin are considered—China, where it has been domesticated already about 8,000 years ago (Li and Wu 1996) and where is still an important center of variation (Kawase and Sakamoto 1984; Jusuf and Pernès 1985, Baik et al. 1986; Nguen and Pernès 1985; Gao and Chen 1988; Li et al. 1995; Li et al. 1996) and—SW Asian center (Vavilov 1926, 2nd millennium BC in central Europe, late Bronze Age—Greece, Zohary and Hopf 1988)—along the Alps it was cultivated since 5,000 years (Hammer et al. 1999).

The wild progenitor *Setaria viridis* (L.) P. Beauv. has a very wide distribution including large parts of Eurasia and North Africa. *Setaria viridis* var. *major* (Gaud.) Posp. is usually seen as an introgression product of the wild *Setaria viridis* with cultivated races, it is characterized by larger panicles than the wild species and belongs to the weedy races.

Formerly the hypothesis was proposed that there is an evolutionary continuum starting with *Setaria viridis* (L.) P. Beauv. – *S. viridis* var. *major* (Gaud.) Prosp., *S. viridis* ssp. *pycnocomum* (Steud.) Tzvel. – *S. italica* (L.) P. Beauv. convar. *moharia* (Alef.) Mansf. – *S. italica* var. *media* (Koern.) Scheibe – *S. italica* convar. *italica* (convar. *maxima* (Alef.) Koern. ex Mansf.) (see Werth 1937 emend. Scheibe 1943; Williams and Schreiber 1976).

Now a more dynamic model has been proposed (Table 1). The newly collected material allows the following conclusions and discussions:

(1) Distribution of *Setaria italica* convar. *moharia*.

Iran is an important area for the production of foxtail millet since classical times (see Körnicke 1885). Now the area of distribution of this race

includes northern Iran indicating possible connections to the East via Afghanistan (Vavilov and Bukinich 1929) where the race was exclusively found, and the Hindukush, which has been characterized as a refuge area (Scheibe 1943). To the west there is an interruption in the distribution in the neighbouring Caucasus where only convar. *italica* is cultivated (Dekaprevich and Kasparian 1928; Maissurian 1929), i.e. eastern domesticate!?

Further to the west the convar. *moharia* can be, again, found. An important area of cultivation has been Hungary. Germany belongs to the traditional growing areas of *Setaria germanica* (Mill.) P. Beauv. (see Hoops 1905). As convar. *moharia* cultivation continues to decrease, it becomes more and more difficult to define the traditional growing area.

(2) As the wild progenitor unanimously *S. viridis* is discussed. This species is also occasionally cultivated (Fritsch 2001), mainly as a fodder crop, but also for the grains as observed by Scheibe (1943) in Hindukush. This cultivated race of *S. viridis*, grown in the Parun-valley of Hindukush, had a thousand-grain-weight of 0.24 g. As compared to convar. *indica* (2.78–3.26 g) and convar. *italica* (3–4 g) (Scheibe 1943).

The hypothesis that *S. viridis* ssp. *pachystachys* (Franch. et Savat.) Masam. et Jang, with its main distribution in China or Japan gave rise to convar. *italica* and ssp. *viridis* with a very large but generally more western distribution is the progenitor of convar. *moharia* is still under discussion.

*Setaria viridis* and *S. italica* easily introgress (see Table 1). But usually the introgression products are derived from crosses of convar. *italica* and *S. viridis* (as in the cases of *S. ketzchovellii* Menabde et Eritsian and *S. gigantea* (Franch. et Savat.) Makino, see also Takahashi and Hoshino 1934; Harlan 1965; Tzvelev 1976).

One of the reasons may be that *S. viridis* and *S. italica* convar. *moharia* are rather similar and introgression products between them are difficult to recognize. Introgressions between convar. *italica* and convar. *moharia* have been postulated based on observations in Hindukush (Scheibe 1943). They resulted in a stable new race with character states in between both parents (*S. italica* ssp. *media* (Koern.) Scheibe).

<sup>1</sup> *Setaria italica* subsp. *moharia* (Alef.) Scholz in Willdenowia 36 (2006) 663

**Table 1** Possible relationship among wild, weedy, crop and feral forms in the *Setaria italica*/*S. viridis* group (after Darmency 2005)

Species	Process	Resulting Type	Conclusion	Likelihood
<i>S. viridis</i>	Selection by man	<i>S. italica</i>	Domestication	High
<i>S. italica</i>	Seed lost at harvest	<i>S. italica</i>	Volunteerism	Very low
<i>S. italica</i>	Back mutation	<i>S. viridis</i> ssp. <i>pycnocoma</i>	Endoferality	Hyper rare
<i>S. viridis</i>	Genetic variability	<i>S. viridis</i> ssp. <i>pycnocoma</i>	Mimicry	Possible
<i>S. italica</i> and <i>S. viridis</i>	Interspecific gene flow	<i>S. viridis</i> ssp. <i>pycnocoma</i>	Exoferality	High

*Setaria italica* subsp. *mohari* (Alef.) Scholz in Willdenowia 36(2006) 663

(3) A refugial area for *Setaria italica* was found in the valley of Hindukush (Scheibe 1943). This area has been also rich in diversity of foxtail millet. Today such diversity centers also in the mountains are vanishing because of the decline of traditional agriculture in many parts of the world. They are becoming poor refugial areas as in the case of *S. italica* convar. *moharia* in the Albourz mountains of Iran. Increasing efforts are necessary for the collection of such rare races not only as a genetic resource but also as possible missing link for constructing of evolutionary pathways in crop plants. Still most data in literature focus on *S. italica* convar. *italica* whereas the forage grass convar. *moharia*, though it was and sometimes still is cultivated as a grain crop, received only limited attention (see Darmency and Pernès 1987; Till-Bottrand et al. 1992; Darmency 2005).

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