

# Rediscovery of Indian dwarf wheat (*Triticum aestivum* L. ssp. *sphaerococcum* (Perc.) MK.) an ancient crop of the Indian subcontinent

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**Abstract** Indian dwarf wheat (*Triticum aestivum* L. ssp. *sphaerococcum* (Perc.) Mac Key, synonym: *T. sphaerococcum* Perc.) is endemic to southern Pakistan and northwestern India. It was one of the main winter crops grown by ancient Indian cultures. However, it disappeared from the record during the early twentieth century, especially after the Green Revolution brought modern wheat varieties into India and Pakistan. Whether or not Indian dwarf wheat is presently cultivated has been unclear. Here we report

on the rediscovery of the cultivation of this wheat in northern Karnataka and southern Maharashtra in India. Molecular genetic analysis of the chloroplast DNA of the two specimens collected at location 3 revealed that both samples have a unique haplotype that is specific to Indian dwarf wheat. We found this wheat at three locations in 2010, but at only one of the three locations in 2011. Therefore, the future survival of this subspecies is uncertain. Further ethnobotanical research is urgently needed to conserve this unique genetic resource for the future.

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**Keywords** Chloroplast DNA · Field survey · Indian dwarf wheat · Indian subcontinent · Indus civilization · Relict cultivation · *Triticum aestivum* ssp. *sphaerococcum*

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The development and spread of agriculture in the Indian subcontinent has a complex history that can be traced back to Neolithic times. During this long period, agricultural practices have been transformed by the introduction and adaptation (or evolution) of domesticated plants and animals from Southwest Asia, Africa, Southeast Asia, and the New World. In the Indus civilization that emerged around 2600 B.C. in South Asia, people practiced a two-season crop strategy (Weber 1999, 2010; Fuller 2002). The *rabi* crops were sown in autumn. They depended on winter rain and irrigation for growth, and were harvested in spring. Wheat was one of the major *rabi*

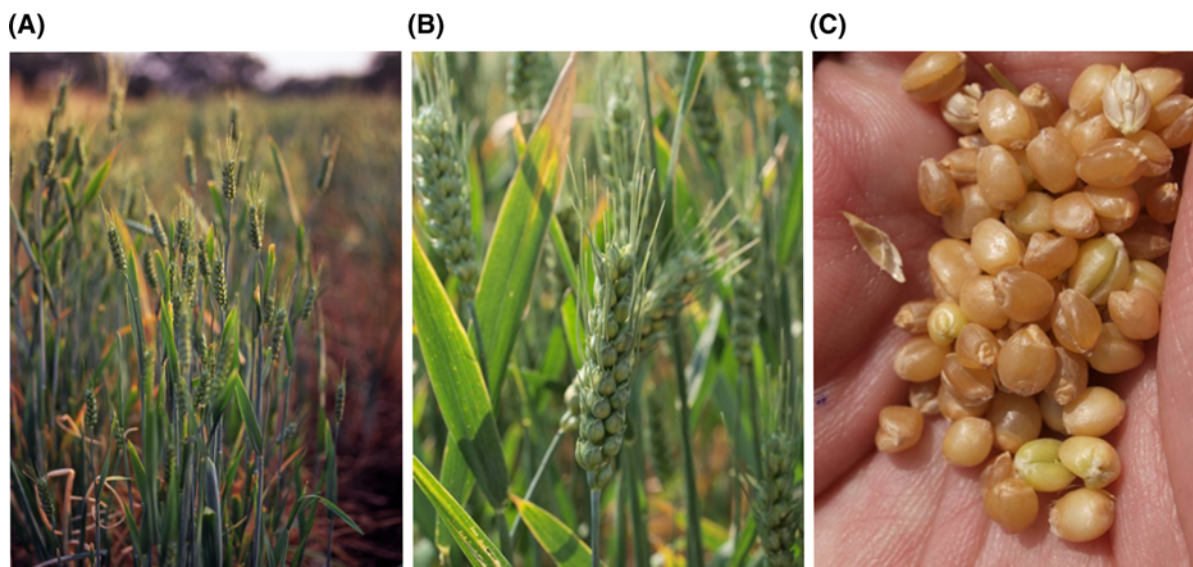
crops originally introduced from the Southwest Asia. The *kharif* crops were grown in summer; they depended on summer monsoon rains and were harvested in autumn.

Indian dwarf wheat or shot wheat, *Triticum aestivum* L. ssp. *sphaerococcum* (Percival) Mac Key (synonym: *T. sphaerococcum* Percival), was described by Percival (1921) as a wheat subspecies endemic to southern Pakistan and northwestern India. According to Percival (1921), this landrace flowers early, is resistant to yellow rust, and moderately resistant to drought. It is distinguished from other wheat subspecies by the following characteristics: its semidwarf stature and characteristic erect and rigid appearance (60–70 cm), stout and short culm, small ears, and semispherical grains (Fig. 1). These characteristics are controlled by the pleiotropic effects of a unique gene, *s*, which is located on chromosome 3D (Sears 1947). The molecular basis of the function of this gene is unknown. However, the *Rht* gene of the Green Revolution (Hedden 2003 for review) does not contribute to the semi-dwarf phenotype in Indian dwarf wheat. This suggests that people in ancient India might have utilized their own dwarfing gene thousands of years before the Green Revolution.

The presence of this wheat has been reported at archaeological sites throughout South Asia from the

Kashmir Valley to the Deccan Plateau and east to the Ganga Valley (Kajare 1991; Lone et al. 1993). However, there is some controversy regarding the identification of archaeological remains of wheat species on the basis of carbonized grains alone (Fuller 2001, 2002, 2006). For example, Tenberg (1999) studied rachises from archaeological remains and reported the presence of hexaploid wheat in Miri Qalat, S.W. Pakistan (4000–2000 B.C.). However, she did not mention Indian dwarf wheat. In addition, a distinctly small-grained free-threshing wheat was identified in Kohla, Nepal (12th century A.D.) (Asouti and Fuller 2009). These observations suggest that either Indian dwarf wheat was much more widespread and ecologically diversified in prehistory than in recent history, or that there were additional small-and-round-grained wheat varieties. In order to investigate this further, it will be necessary to develop accurate methods, such as DNA markers, for the characterization of wheat varieties in archaeological remains.

Nevertheless, a number of reports suggested that Indian dwarf wheat was one of the main winter crops in the ancient South Asian cultures. At Mehrgarh on the west margin of the Indus Plain, Indian dwarf wheat-like remains were reported together with a naked barley, einkorn wheat, and emmer wheat



**Fig. 1** Indian dwarf wheat (*Triticum aestivum* ssp. *sphaerococcum*) found in Masavinala, Karnataka, India. **A** Indian dwarf wheat in the field, **B** ears, and **C** grains

(Costantini 1984; Meadow 1996). Archaeological remains of Indian dwarf wheat have been recovered from Early Harappan, Mature Harappan, Late Harappan and early historical sites (Weber 1999; Vishnu-Mittre and Savithri 1982; Kulshrestha 1985; Pokharia et al. 2009; Pokharia et al. 2011). This subspecies was probably grown in the northwestern regions of the Indian subcontinent, including Sind, Punjab, Rajasthan, and Saurashtra, during the period 2400–1750 B.C. Subsequently, its cultivation diffused south to Madhya Pradesh and Maharashtra during the period 1600 B.C.–100 A.D. (Vishnu-Mittle 1974; Hutchinson et al. 1976). In modern times, Indian dwarf wheat was grown mainly in the western district of the Punjab, and to a lesser extent in the Central Provinces (now Madhya Pradesh in India) and the United Provinces (now Uttar Pradesh in India). It was suited to these regions in part because of its drought tolerance (Howard and Howard 1910; Ellerton 1939; Hutchinson et al. 1976). However, in the early twentieth century its cultivation rapidly declined because the grain had no export value owing to its small size, and it could therefore only be used for local consumption (Howard and Howard 1910; Ellerton 1939). Later, the Green Revolution, beginning in the 1960s, brought modern semi-dwarf wheat varieties into India and Pakistan, and landraces including Indian dwarf wheat were mostly wiped out. It has been unclear whether Indian dwarf wheat is still cultivated.

As a part of the Indus Project conducted by the Research Institute for Humanity and Nature (RIHN) in Kyoto, Japan, we have been surveying locally grown crops in India, especially the wheat landraces, to reconstruct the daily life in the ancient Indus civilization. Here we report on the present cultivation of Indian dwarf wheat, which we rediscovered during a field survey in the states of Karnataka and Maharashtra in India.

Figure 2 shows the route of the field research in February 2010. In this survey, we found Indian dwarf wheat being cultivated at three locations (Table 1). Location 1 was at the village of Masavinala, about 30 km southeast of Bijapur in northern Karnataka; location 2 was at Motevadi, about 30 km northwest of Bijapur in southern Maharashtra; and location 3 was at Gulgunjnal, about 2 km southeast of Motevadi in southern Maharashtra. We examined the chloroplast DNA of the two specimens collected at location 3 and

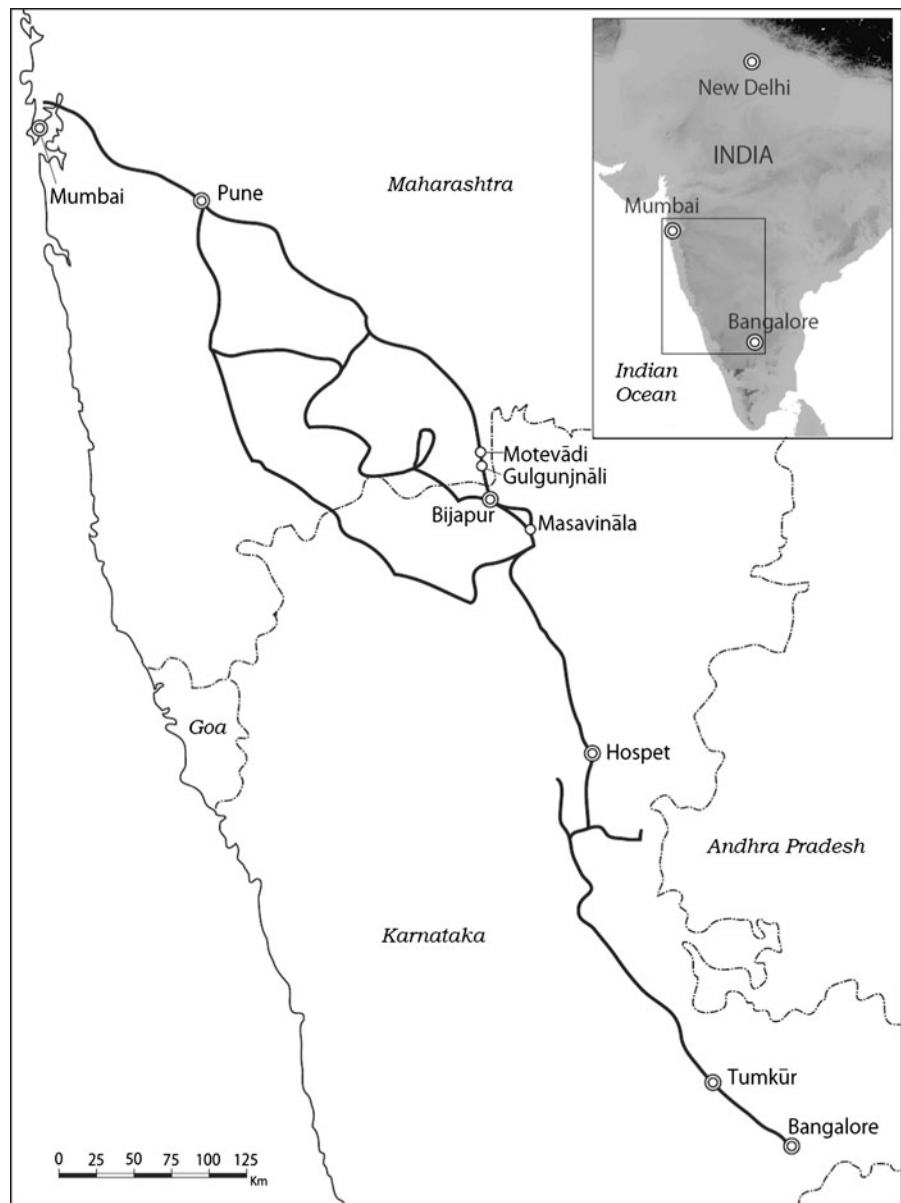
found that both samples have a unique plastotype that is specific to Indian dwarf wheat (Table S1 and Table S2). As shown in the Supplementary results, our present study revealed that chloroplast DNA markers might be useful for identifying Indian dwarf wheat. This could be a valuable tool for investigating archaeological remains, provided DNA of good quality can be recovered.

The farmers called the Indian dwarf wheat “gunḍu-godi” in Karnataka and “boḷ-gahū” in Maharashtra. This wheat is sown between early November and early December, and is harvested in middle to late March (Table 1). Therefore, Indian dwarf wheat matures very early compared with other wheat varieties. At all three locations, its cultivation was limited in scale, and each field was less than 1,000 m<sup>2</sup>. At all three locations the fields were irrigated once each week using motor pumps. The local farmers reported that this wheat is disease tolerant and easy to grow, and that they preferred the white color of the flour and the light taste of breads made from it. The Indian dwarf wheat is used only for home consumption. It is used to prepare traditional daily foods including chapati, roti, and uppuma, and ritual foods.

As part of the survey we interviewed grain dealers, and found only one dealer, at Neharu Market in Bijapur, Karnataka, who knew of this wheat. However, he has not seen it in recent years. He reported that the price of Indian dwarf wheat was lower than those of other varieties when he traded it in the past (Table S3). This is in contrast with a record from the late nineteenth century (Powell 1868 cited by Singh 1946), indicating that the price of Indian dwarf wheat was higher than those of durum wheat (*T. turgidum* L. ssp. *durum* (Desf.) Husn.) and bread wheat (*T. aestivum* L. ssp. *aestivum*). This suggests that Indian dwarf wheat lost its market value some time ago.

In March 2011 we carried out another field survey in northern Karnataka and southern Maharashtra (Fig. 2), but no additional cultivation sites were found. Only one grain dealer, in Mhasvad, Maharashtra (about 130 km northwest of Bijapur), knew of this variety, but she reported that she has not seen it in a long time. Furthermore, the farmers at locations 2 and 3 (see Table 1) had stopped growing Indian dwarf wheat in 2011. They have recently begun growing cash crops, such as a modern variety of cotton, after harvesting the wheat. Although Indian dwarf wheat

**Fig. 2** The regions and routes surveyed in February 2010 and March 2011 in Karnataka and Maharashtra in India



**Table 1** Locations where cultivation of Indian dwarf wheat rediscovered, its local names, and growing seasons

Location no.	Village	Local name	Sowing	Harvesting
1	Masavināla, Karnataka, ~30 km southeast of Bijapur	ḡuḡḡu-godi	Early November	Middle March
2	Motevadi, Maharashtra, ~30 km northwest of Bijapur	boḡ-gahū	Early December	Late March
3	Gulgunjnāl, Maharashtra, ~2 km southeast of Motevadi	boḡ-gahū	November	Middle March

matures very early, it is harvested about 2 weeks later than a variety of durum wheat. This later harvesting time causes delays in planting the cash crops.

Therefore, the cultivation of the ancient wheat does not appear to fit well with the recent change from traditional to commercialized agriculture.

We report here that the wheat grown by ancient Indian farmers continues to survive in a few locations in India. However, it now faces extinction due to the rapid modernization of agriculture practices. Indian dwarf wheat has a number of characteristics that make it a valuable genetic resource at a time of reduced diversity in our modern cropping systems. Further ethnobotanical research is urgently needed if we are to understand the traditional human-crop relationships involving this ancient wheat. It is critical that steps be taken to conserve this unique genetic resource for the future.

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