The Ancient "Khapli" Wheat: Is it Under–utilized?

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Three species of wheat, namely *Triticum vulgare* Host. Syn. *T. aestivum* L. (bread wheat), *Triticum durum* Desf. (macaroni or durum wheat) and *Triticum dicoccum* Schub. L. Syn. *T. dicoccon* Schrank. (emmer or Khapli wheat), are grown commercially in the Indian subcontinent since historic times. They are all of the spring type, i.e., they are planted in spring and harvested in mid or late summer. Khapli wheat, as *T. dicoccum* is known in India, was one of the first cereals to be domesticated in the "fertile crescent". Ancient sources inform us that there was a wide variety of different kind loaves of breads with coarse texture and loaves with a fine consistency. Kernel hardness is one of the most important factors influencing the flour texture since crushing is more difficult for grains with hard endosperm. Emmer and durum wheats are all hard, but their hardness is variable. Moreover, emmer is hulled wheat, which means that husks enclose the grain. During threshing, the outer chaff does not release the grain. When a spike of hulled wheat is threshed, it breaks up into its component spikelets, each consisting of tough glumes attached to a rachis segment (Nesbitt and Samuel, 1996) (Fig. 1).

Another wheat species with somewhat round kernels, *T. sphaerococcum* Mihi. that was cultivated in the Punjab during the Indus Valley civilization (2600–1900BCE), has now almost vanished. According to eminent Swiss botanist, A P De Candolle, wheat originated in the valley of Euphrates and Tigris rivers and spread from there to China, Egypt and other parts of the world (De Candolle, 1886). Some investigators believe that wheat probably originated in South West Asia, specially Syria and Palestine. According to Russian botanist and plant explorer NI Vavilov, the origin of durum wheat was probably in the region of Abyssinia (the modern times Ethiopia and Eritrea), whereas the whole group of soft wheat including bread wheat probably originated in the region of the Indus Valley, South–Western Afghanistan, and the southern parts of mountainous Bokhara (Vavilov, 1992). The Aryans brought wheat grains to India and possibly this crop spread from its place of origin to European countries in the opposite direction as well. The importance of hulled wheat in past societies is hardly reflected in their current status as a minor and ever–declining crop grown in isolated and marginal areas in the

world (Nesbitt and Samuel, 1996). Today, in India, it is traditionally cultivated on a limited scale in Karnataka, southern Maharashtra, Saurashtra region of coastal Gujarat, parts of Tamil Nadu, and Andhra Pradesh (Fig. 2).

Emmer wheat was largely cultivated during seven millennia in the Middle–East, Central and West Asia, and Europe. It has since been largely replaced by hull–less species and exists now only as a minor crop, with the exception of some countries and like India, Ethiopia and Yemen, where its grain is used for preparing traditional or specialty foods (Zaharieva *et al.*, 2010). The earliest evidence of cultivation of Khapli wheat comes from the Neolithic archaeological site of Mehrgarh (6000–5000 BCE). However, archaeological findings from Kunal in Haryana, Kanishkapura in Kashmir, Harappan settlement of Rohira in Punjab also show evidence of Khapli cultivation (Damania, 2007). It is speculated that Khapli wheat came to Kashmir from the Middle–East through Persia and Afghanistan and to southern India by sea from north eastern Africa (Luo *et al.*, 2007). Today Khapli wheat forms only 1% of all wheat grown in India.

Potential genes for disease resistance in Khapli wheat

Khapli emmer is resistant to those cultures of *Erysiphe graminis* f. sp. *tritici* with which it has been inoculated. 'Yuma' durum grown in Arizona in the US, which had Khapli as one parent, is resistant to the same *E. graminis tritici* cultures. Both Khapli and Yuma are tetraploids (Briggle, 1966). A dominant gene for resistance to the powdery mildew fungus, herein designated as Pm4, has been transferred from Khapli into the genetic background of the hexaploid bread wheat variety

Figure 1. Spikeltes of Khapli wheat (*Triticum dicoccum*) with persistent glumes

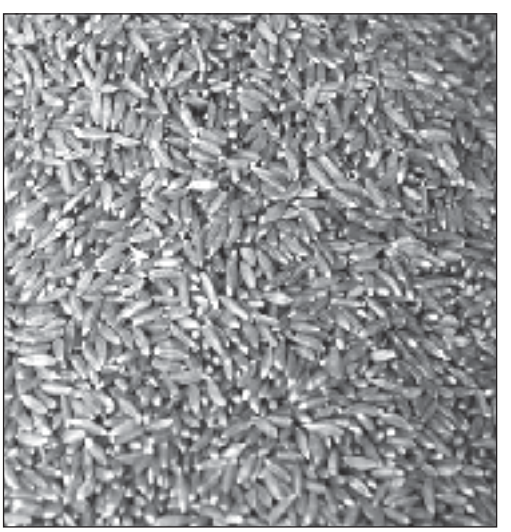

Figure 2. Grains of Khapli wheat

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'Chancellor'. The new line of Chancellor (Khapli × Chancellor) is homozygous for resistance and appears identical to Chancellor in morphological characters. A dominant gene for resistance to *E. graminis tritici* has also been transferred from Yuma into Chancellor. Present evidence indicates that this gene is identical with that in Chancellor from Khapli. The gene from Khapli (Pm4) has been shown to be at a locus different from Pm1, Pm2, and Pm3.

Medicinal value of Khapli wheat

Khapli is found to have curative properties for treating diabetes and cardiovascular diseases. Its capacity to lower blood glucose and lipid levels and high temperature stress tolerance compared to other cultivated species has enabled biologists to identify its therapeutic value. The name "Khapli" was given to this variety of T. dicoccum because the glume or the husk remains tightly adhered to the grain even after harvest and is only separated by pounding. It is sown

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traditionally on black cotton soil in November and harvested in March (Anon, 1905). This species besides possessing high yield potential of 42 to 45 q/ ha is also found to confer resistance to biotic and abiotic stresses. As a result of systematic research effort, the world's first semi–dwarf dicoccum variety–DDK–1001 was released in 1996. The other varieties released by the University of Agricultural Sciences at Dharwad include DDK–1009, DDK–1025 and DDK –1029. Khapli wheat is grown on a limited scale in an area of 0.2 million hectare with an approximate production of 0.5 million tons. Due to hard and vitreous nature of its grains, the milling quality of Emmer wheat is quite superior, especially for semolina preparation which takes less time for cooking with more cooking tolerance.

Breeding of Khapli wheat in India

In India, a new high yielding, disease resistant semi–dwarf wheat variety of *T. dicoccum*, HW 1098 (called 'Nilgiri –Khapli') was released by the Central Sub–committee on Crop Standards and Notifications in 2013. The released variety

is targeted towards Khapli growing zones in India under timely sown irrigated conditions. It has mean grain yield of 45.53 q/ha with maximum yield potential of 47.8 q/ha recording relatively lesser yield loss under late sown conditions when compared to checks. The variety has shown high degree of adult plant resistance against all the three kinds of rust infections under field conditions. The Supporting Research and Technology (SRT) data indicated resistance response to all the pathotypes of brown stem rust and to all yellow rust pathotypes except race 78S84 (mixed reaction). The HW 1098 quality is at par with that of NP 200, a traditional dicoccum variety with high protein (16.5%), higher grain weight (46.5g), sedimentation value (29.0ml) and higher β–carotene (3.39ppm) as well as an ideal plant height (85cm).

A great deal of work is also being done on Chaplin wheat at the Indian Agricultural Research Institute (IARI), New Delhi. For example, in a joint effort at the IARI's Regional Station at Wellington in the Nil

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iris, a well–planned improvement strategy was implemented to develop a semi–dwarf, high yielding, disease resistant *dicoccum* wheat variety in the form of HW 1098 designated as "Nilgiri–Khapli" (Sivasamy *et al.*, 2014). The variety has shown high degree of adult plant resistance against all three rusts under field conditions. Here I would like to second the thoughts expressed by D Clouston (Director of Agriculture, Central Provinces and Berar) in his Presidential Address to the Agricultural Section of the Seventh Indian Science Congress held at Nagpur, 1920 (just after WWI which ended in 1918). I quote– "The great task of reconstruction which lies before us is well worth all the energy and brains we can put into it; for the development of her (India's) agriculture depends not only on the prosperity of many millions of

agriculturists, but to a great extent the lot of those engaged in other industries dependent on agriculture. Increased production will help to banish famine and poverty from the land, and to bring us near the realization of our hope, namely, to make India a garden ringing with cheerful and contented life, with smiling fields and food in plenty" (Clouston, 1920).

Ethnic uses of Khapli wheat and on–farm observation

The Bohri sub–sect of Muslims is famous for their rich and varied food such as "Biryani". Their "Khichdi" dish, in particular, uses Khapli wheat exclusively. The husk of Khapli retains all the goodness of fiber. Evidence of large scale clinical and epidemiological studies implies that diet in whole grains may have a protective role in reducing the risk of coronary heart diseases as well as type 2 diabetes, age–related eye diseases such as macular degeneration, and certain types of cancers (Arzani, 2011). Products of this variety are softer, tasty, and have high satiety value. These nutritional and functional qualities make emmer wheat more suitable than durum wheat for the manufacture of dense foods and other local semolina products and are also more suitable as therapeutic food. In fact, some Italian farmers used to grow *Triticum monococum* (Einkorn) and *T. dicoccum* (Khapli or Faro) wheat. These wheats were known to be grown since Roman times, i.e., as far back as 200 BCE and were thought to have disappeared (Perrino and Hammer, 1982).

In an often quoted case of farmer–based conservation of obsolete crop varieties, the above two obsolete forms were found to be growing in the mountain villages of Castelfranco and Miscano in the Benevento province of central Italy and in the village of Monteleone di Puglia in the Foggia province of Southern Italy (Qualset *et al*., 1997). When this author visited the village of Castelfranco, the farmer readily showed samples of the wheat crops which had persistent glumes. When asked how he used the wheat, the farmer confessed that he purchased bread from the bakery in the village but used the Khapli type wheat as a supplementary diet for his swine herd, and also as poultry feed. When asked whether their children will continue to grow the monococcum and dicoccum wheats, the farmer and his wife replied that their children had gone away to big cities as there were not many jobs in the village. They will not return to the farm.

However, in recent years, the cultivation of Khapli type wheats has received a boost in Italy and elsewhere in central Europe because of the high demand for "farro", the flour obtained from milling hulled wheat grains, which was discovered to prevent colon cancer due to its high fiber content when compared to flour from other wheats (Preedy *et al*., 2011). At first only health food boutique shops used to carry this flour and grain, but due to demand it is now available also in super markets. In India too, consumers should ask for Khapli flour and biscuits and other pastries made from Khapli flour. However, from my

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experience it is not yet easily available in the normal shops where we buy provisions.

Conclusions

The danger of genetic erosion in wild and primitive forms of wheat and the associated likely consequences for agriculture, especially in the light of climate change phenomenon, reinforces the need for exploitation of the unrealized potential of ancestral species such as Khapli wheat. Khapli wheats are rich in total sugar and dietary fiber contents. Rich source of dietary fibers and low carbohydrate digestibility are the contributing factors for lowering blood glucose and hence they not only have nutritive value but also possess medicinal properties (Bhuvanesswari *et al*., 2004). Semolina of Khapli wheat varieties have higher protein and ash contents than durum and bread wheat, whereas fat and total carbohydrate contents were lower as compared to modern durum wheat varieties (Patil and Yenagi, 2002). The protein content of Khapli is intermediate between the wild emmer and the cultivated durum wheat which has the lowest (Damania, 2008). Full compatibility in crosses makes the transfer of Khapli genes to durum wheat fairly straightforward. Increasing interest in natural and organic products has led to the 'rediscovery' of dicoccum wheats, not only for their nutritional and health properties but also because it is amenable to low input technology. Finally, Khapli wheat's superiority for tolerance to biotic and abiotic stresses such as pests, atmospheric and ground pollution, cold, heat, and salinity could help subsistence farmers sustainably manage harsh growing conditions without relying solely on mechanization, chemical fertilizers, pesticides, or modern technologies. It's nutritional and cancer preventive properties should be made widely known and its consumption encouraged.

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