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Corresponding Author
Ganapati Mukri
e-mail: ganapati4121@gmail.com

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White Maize (*Zea mays* L.): An Emerging Option for Crop Diversification and Nutritional Security

Ganapati Mukri[1*], Chandu Singh[1], K. Bhojaraja Naik[2], V. R. Yalamalle[1] and Subhash Babu[1]

Abstract

Maize is the third most important cereal after wheat and rice and the major chunk of maize production is used as poultry and animal feed in India. But for direct human consumption white maize is preferred. Hence, from the human nutritional point of view, there is a need to improve the nutritional value of white maize. Genetically both yellow and white maize is the same except for genes coding the β-carotene, which imparts a golden yellow color to the maize. The white maize breeding program started during the 1960s, resulting in the release of 'Ganga safed 2', which is still popular among farmers. The future breeding prospects and the role of quality protein maize (QPM) in nutrition and value additions are very important aspects.

1. Introduction

Maize (*Zea mays*) is one of the oldest and most dynamic crop species, which has gained popularity, due to its applications in diverse dishes. The literal meaning of its name (*Zea*-sustaining life and *mays*-life giver) rightly says its potential of sustaining both the human and animal populations of the world (Mukri et al., 2020). In India, it is the third most important crop after wheat and rice. Maize is consumed as a staple food in the eastern and western parts of India in general and in Assam, Bihar, Gujarat, Rajasthan, Madhya Pradesh, and Himachal Pradesh in particular (Kaul et al., 2012). White maize is mostly preferred over yellow maize for direct human consumption as a staple food. White maize is similar to yellow maize in all nutritional aspects except that white maize has recessive alleles of the β carotene gene, which is responsible for white endosperm color.

The area and production scenario of white maize are not readily available due to the lack of a separate record of white maize as a

Author's Address
[1]ICAR-Indian Agricultural Research Institute, Pusa New Delhi (110 012), India
[2]ICAR-Indian Institute of Seed Science, Mau, Uttar Pradesh (275 103), India

separate commodity. But it is estimated that > 90% of the white maize produced is directly utilized for human consumption in India (Mukri et al., 2013). The *roti-making* quality of white maize is far better than yellow maize and it does not give any additional flavor as that of yellow maize, for culinary preparations. The flour of white maize can be mixed with any other flour and a variety of dishes with improved nutritional value can be prepared. So, it is considered the best option to increase the value of snack preparations made up of rice, wheat, and gram flour.

2. History of White Maize Improvement in India

The maize improvement research focuses entirely on the development of populations, composites, and hybrids in yellow maize and very little attention has been paid to the development of white maize varieties/hybrids, however, due to the growing domestic requirements, some of the institutes were exclusively working on the improvement of white maize in India. In India, crop improvement work on white maize started during the 1960s. The 'Ganga Safed 2', a double top cross hybrid, was the first white maize hybrid released in 1963 by the Directorate of Maize Research, New Delhi. It is a widely adapted, medium maturing hybrid; very popular in white maize growing regions of Uttar Pradesh, Bihar, and Rajasthan. It is resistant to foliar diseases and most resistant to bacterial rot having a yielding ability of 4.5–5.0 t ha^{-1}. Since then a series of white maize composites and hybrids were released from different institutions and they are tabulated as follows.

Table 1: White maize composite/hybrid released after 'Ganga safed 2'

Sl. No.	Name	Type of variety	Year of release	Developing centre	Salient feature
1.	Sonari (Shweta)	Composite	1980	Pant Nagar	Early
2.	African Tall	Composite	1982	Kolhapur	Suitable for fodder
3.	Chandan Safed Makka 2	Composite	1982	Chindwada	Flint, Medium maturity
4.	Gujarat Makai-1	Composite	1988	Godhra	Early maturity
5.	J 1006	Composite	1992	PAU, Ludhiana	Suitable for fodder
6.	Rajendra Hybrid Makka-2	Hybrid	1996	Dholi	Late maturity
7.	Dewaki	Composite	1996	Dholi	Semi dent, resistant to TLB, fusarium wilt, Fuccinia sorgai
8.	Mahidhawal	Composite	1996	Banswara	Late, Semi dent, moderately resistant to stem borer and DM
9.	JM-8	Composite	1997	Chindwada	Flint, grain filling up to the tip end and highly resistant to MLB
10.	JH-12	Composite	1999	Chindwada	Semi-flint, tolerance to TLB and MLB
11.	Gujarat Makai-3	Composite	1999	Godhra	Early
12.	Aravali Makka	Composite	2001	MPUAT, Udaipur	Early maturity, Flint
13.	Gujarat Makai-4	Composite	2001	Godhra	Flint, tolerance to R. herculea, MLB, BSDM and CLS
14.	Shaktiman-1	Hybrid	2001	Dholi, Bihar	Tolerant to TLB, BSLB and stem borer
15.	Gujarat Makai-6	Composite	2002	Godhra	Early, tolerant to MLB and BSDM
16.	Narmada Moti	Composite	2002	Godhra	Extra early, moderate tolerance to C. partellus. Resistant to MLB and TLB
17.	Pratap Hybrid Maize-1	Hybrid	2004	MPUAT, Udaipur	Extra early, white semi flint, moderately resistant to C. partellus
18.	Shaktiman-2	Hybrid	2004	Dholi, Bihar	Late maturity, resistant to MLB

Table: Continue...

Sl. No.	Name	Type of variety	Year of release	Developing centre	Salient feature
19.	HM-5	Hybrid	2005	CCSHAU, Uchani	Dent, medium tall, tolerance to frost
20.	Pratap Makka-3	Composite	2005	MPUAT, Udaipur	Early, semi flint, moderately resistant to stem borer, BSDM, BSLB, ESR, PFSR, MLB and TLB
21.	Pratap Makka-4	Composite	2006	MPUAT, Udaipur	Semi flint, moderately resistant to stem borer
22.	Pratap Makka-5	Composite	2006	MPUAT, Udaipur	Medium maturity
23.	Pratap makka chari	Composite	2009	MPUAT, Udaipur	Suitable for fodder
24.	YM-9905 (Shatak)	Composite	2011	PDKV, Nagpur	Late and semi flint
25	GAWMH-2	Hybrid	2012	Godhra	Flint, Early
26	GAYMH-1	Hybrid	2013	Godhra	Flint, Early
27	HM-12	Hybrid	2013	CCSHAU, Uchani	Medium, semi dent

3. QPM in White Maize

Breeding for improved protein quality in maize began in the mid-1960 with the discovery of mutants, such as *opaque-2*, that produce enhanced levels of lysine and tryptophan, the two limiting amino acids in maize endosperm proteins. Quality Protein Maize (QPM) contains, in general, 55% more tryptophan, 30% more lysine, and 38% less leucine than that of normal maize. Besides protein quality, QPM Maize is also high in biological value, which refers to the proportion of absorbed protein from food that incorporated into the proteins of the organism's body. In yellow maize, several hybrids have been released with improved protein quality. Whereas, in white maize also two important hybrids, Shaktiman 1 and Shaktiman 2 were released for general cultivation in Bihar state to mitigate hidden hunger. The detailed consumer preference studies for white maize will further boost the white maize improvement program in India. There is no dearth of availability of the germplasm for white maize improvement (Mukri et al., 2018).

4. Fodder Variety in White Maize

To meet the increased feed and fodder demand from the livestock sector, maize becomes a potential option to answer the growing needs of this sector. Fodder research in maize is gaining importance because of its improved nutritional quality, better palatability, and absence of anti-nutritional components. One of the outcomes of forage research in white maize is African tall, a composite variety, which was released in 1982 from the Kolhapur center. Another two composite *viz*., J 1006 and Pratap Makka Chari 6 which were released from PAU, Ludhiana, and MPUA&T Udaipur respectively, are suitable for fodder purposes.

Figure 1: Cob and grains of white maize

5. Conclusion

Maize is a versatile crop, which consumes fewer resources compared to paddy. White maize has several industrial applications in the preparation of baby food, corn sugar, and industrial starch. White maize also has a low glycemic index and high fiber content, there is an increasing consumer preference for white maize. The white QPM maize floor has the potential to replace or partly replace other cereals in packaged and processed foods, further strengthening the nutritional security of India.

6. Future Research Thrust

White maize is preferred over yellow maize for direct human consumption in the form of roti. The majority of the genetic materials used in the white maize improvement are temperate in origin. There is an immense scope for breeder to breed for tropically adapted white maize germplasm to enhance the productivity. The genetic and nutritional quality enhancement of white maize followed

by an efficient hybrid breeding programme should be the strategy for sustained improvement of white maize in India.

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