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Breeding for Quality Protein Maize (QPM)

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improvement of protein quality mechanism of o2 mutant and problem associated with o2mutant, breeding, genetics and molecular approach that could used to get e cient QPM cultivars [5-7].

To review the quality traits, measurements and possible breeding methods to improve protein quality of maize.

L w

Maize kernel mainly consists of three parts: pericarp (6%), embryo (12%) and endosperm (82%). e pericarp is the outer covering of the kernel that protects and preserves the nutrient value inside of it. A thin, suberized nucellar membrane acquired from the outer epidermal wall of the nucellus persists as a continuous covering between the aleurone and the pericarp [8]. e embryo is located in one face of the basal part of the kernel. A mature embryo is comprised by the embryo axis and the scutellum. Both the embryo and endosperm contain proteins but the germ proteins are superior in quality as well as quantity. Most of the volume and weight of the kernel is accomplished by the endosperm. It can be divided into three parts: starchy endosperm, aleurone layer, and the basal transfer layer. e aleurone layer is the outer most layers secreted by specialized cells, rich in hydrolytic enzymes. Starch-rich endosperm is present within the aleurone layer having vitreous and starchy regions [9-12].

e zein proteins form insoluble accretions which are acquired in a vitreous region called protein bodies in the lumen of rough endoplasmic reticulum and it is densely packed between starch grains towards maturity (Gibbon, and Larkins, 2005). Zeins are the prolamins of maize grain which are soluble in an alcohol having one major class (α-zeins) and three minor classes (β, γ, and δ). ese four types constitute about 50-70% of maize endosperm and are essentially rich in glutamine, leucine and proline and poor in lysine and tryptophan (Nelson,.1969) [13,14].

Higher proportion of leucine (18.7%), phenylalanine (5.2%) isoleucine (3.8%), valine (3.6%) and tyrosine (3.5%) are normally present in zein fraction, while other essential amino acids such as threonine (3%), histidine and cysteine (1%), methionine (0.9%), lysine (0.1%) are in smaller amounts and is signi cantly de cient in tryptophan as it is devoid from the major prolamin fraction (α-zeins) of maize kernel. Non-zeins include other proteins such as globulins (3%), glutelins (34%) and albumins (3%). e nonzein protein fraction is balanced and rich in lysine and tryptophan (Vasal,.2002) [55-17] (Figure 1).

Malnutrition is a persistent problem in Africa, especially in rural isoleu647 Tmn, andicaarc esstare(sBio-f pheT(*enz),e a wall)Tjnd)Td oblem in

adverse pleiotropic e ects. So, researchers use two genetic systems by exploiting double-mutant combinations and. Simultaneous use of

al. 2002), provided to Dr. Edwin Mertz seeds of opaque-2 maize to be included in his group's systematic e ort to identify maize accessions with improved protein quality (Paes and Bicudo, 1994). Soon a er the discovery of the nutritional bene ts of the o2 mutation, it began to be incorporated into many breeding programs worldwide, with a major emphasis on conversion of normal endosperm populations and inbred lines to o2 versions through a direct backcross approach (Prasanna et al., 2001). However, enthusiasm over the direct use of the o2 mutation in breeding programs soon subsided a er the discovery of serious negative secondary (pleiotropic) e ects of this mutation [44]. e so endosperm of o2 genotypes initially caused up to a 25% yield loss due to the lower density of the opaque grains, as well as increased susceptibility to fungal ear rots and storage pests (Vasal, 2000). e so endosperm texture also is not acceptable to many in the developing world who are accustomed to harder grain types. Such negative secondary e ects severely limited practical use of the mutation in the eld. Fortunately, during the process of converting normal maize populations to o2 versions, partially harden do sperm (i.e. vitreous) or modi ed grains had been observed by many researchers including breeders at CIMMYT in Mexico. Separation of such grains when encountered began as early as 1969 by Dr. John Lindquist (Vasal, 2000). Besides, the rst published report highlighting the importance of such grain modi cation in reducing the negative pleiotropic e ects of the o2 mutation was published in 1969 (Paezet al., 1969). Selection for hard endosperm modi cation was rapidly incorporated into o2 breeding schemes. Occurring at the beginning QPM breeding e orts at CIMMYT focused on conversion of a range of sub-tropical and tropical lowland adapted, normal endo-sperm populations to o2 versions through a backcross-recurrent selection procedures, with a focus of accumulating the hard endosperm phenotype, maintaining protein quality and increasing yield and resistance to ear rot (Villegas et al. 1992). e improved populations were released for direct use in the eld as open pollinated varieties (OPV's), or individual plants were self-pollinated to for mind red lines used in hybrid formation. Similar programs with sustained breeding of QPM also continued at the University of KwaZulu-Natal (previously University of Natal), South Africa and the Crow's Hybrid Seed Company at Milford, Illinois USA (Prasanna etal., 2001) [45].

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ere is a need of marker-assisted selection because of mainly three reasons:

Å each backcross generation needs to be selfed to identify the opaque-2 recessive gene and a minimum of six backcross generations are required to recover satisfactory levels of recurrent parent genome

Å To maintain the homozygous opaque-2 gene, multiple modi ers must be selected.

Å Rigorous biochemical tests to ensure enhanced lysine and tryptophan levels in the selected materials in each breeding generation require. A er the sequencing of the maize genome has been completed, a large number of the market system are now available that are associated with o2and endosperm modi cation phenotype (Singh,et al. 2017). A convenient utilization of such markers will greatly enhance the e cacy of selection for improvement of grain protein in maize furthermore reduce the cost and time. Both foreground MAS and background MAS can be e ciently utilized for selecting o2phenotypemoreoverassuring maximum recovery of the recurrent parent. MAS used for development of QPM parental lines and developed QPM hybrid in less than half the time required through conventional breeding (Singh, et al. 2017). Various markers are used to introgress o2gene into elite maize inbred lines by rapid backcross conversion programme. ey found that using a marker for QPM and endosperm modi cation can enormously improve the selection e ciency for isolating fully modi ed kernels in QPM background (Singh,et al. 2017) [46].

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QPM could have an impact in areas where maize constitutes a large proportion of the diet, especially as a source of protein, and where children and lactating mothers, su er protein de ciency. with the discovery of opaque-2 mutation. is natural recessive mutation causes alteration in amino acid composition and opaque phenotype of endosperm by regulation of speci c zein genes and combined use of the o2 gene and genetic modi ers. Modi ed marker assisted back cross breeding used to develop QPM versions of normal maize inbreeds with desirable endosperm characteristics and seed yield. ese QPM introgression lines may be united to develop QPM hybrids. ere may be increasing use of molecular genetic tools in QPM research in the future.

References

1. Akalu G, Tafesse S, Gunaratna NS, De Groote H (2010) The effectiveness of quality protein maize in improving the nutritional status of young children in the Ethiopian Highlands. Food Nutr. Bull 31: 418-430.
2. Bass HW, Webster C, Roberts JK, Boston RS (1992) A maize ribosome-inactivating protein is controlled by the transcriptional activator opaque-2. The Plant Cell 4: 225-234.
3. Bjarnason M, Vasal SK (1992) Breeding of quality protein maize (QPM). Plant breeding reviews 9: 181-216.
4. Bjarnason M, Vasal SK (1992) Breeding for quality protein maize. Plant Breed. Rev 9: 181-216.
5. Prasanna BM, Vasal SK, Kassahun B, Singh NN (2001) Quality protein maize. Curr Sci 81: 1308-1319.
6. Bressani R (1991) Protein quality of high-lysine maize for humans. Cereal Foods World 36: 806-811.
7. Brochetto-Braga MR, Leite A, Arruda P (1992) Partial purifcation and characterization of lysineketoglutarate reductase in normal and opaque-2 maize endosperms. Plant Physiology 98: 1139-1147.
8. Coleman CE, Clore AM, Ranch JP, Higgins R, Lopes MA, et al. (1997) Expression of a mutant α-zein creates the foury2 phenotype in transgenic maize. Proceedings of the National Academy of Sciences 94: 7094-7097.
9. De Groote H, Gunaratna N, Ergano K, Friesen D (2010) Extension and adoption of biofortifed crop: Quality protein maize in East Africa. In Proceedings of the African Agricultural Economics Association Meetings, Cape Town, South Africa 19-23.
10. Dereje B, Mosisa W, Hadji T, Wonde A, MandefroN, et al. (2001) On-Farm Evaluation of CIMMYT'S Quality Protein Maize Varieties in Ethiopia. Seventh Eastern and Southern Africa Regional Maize Conference held in Nairobi Kenya 77-79.
11. Dudley JW, Lambert RJ (2004) 100 Generations of selection for oil and protein in corn. Plant Breeding Review 24: 79-110.
12. Emerson RA, Beadle GW, Fraser AC (1935) A Summary of Linkage Studies in Maize; Cornell University Agricultural Experiment Station Memoirs. Ithaca NY USA 180: 1-80.
13. Gibbon BC, Larkins BA (2005) Molecular genetic approaches to developing quality protein maize. Trends in Genetics 21: 227-233.
14. Gibbon BC, BA Larkins (2005) Molecular genetics Approaches to develop quality protein maize.
15. Gunaratna NS, De Groote H, Nestel P, Pixley KV, Mccabe GP, et al. (2010) A meta-analysis of community-based studies on quality protein maize. Food Policy 35: 202-210.
16. Hartings H, Maddaloni M, Lazzaroni N, Di Fonzo N, Motto M, et al. (1989)

The o2 gene which regulates zein deposition in maize endosperm encodes a protein with structural homologies to transcriptional activators. The EMBO journal 8: 2795-2801.

17. Ignjatovic-Micic D, Kostadinovic M, Stankovic G, Markovic K, Vancetovic J (2013) Biochemical and agronomic performance of quality protein maize hybrids adapted to temperate regions. Maydica 58: 311-317.

18. Koutsika-Sotiriou M (1999) Hybrid seed production in maize. In Basra AS (Ed.)