

ROLE OF LANDMARK SINGLE-CROSS HYBRIDS OF 1990s IN THE REORIENTATION OF INDIAN MAIZE BREEDING PROGRAMME

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Maize, recognized as 'queen of cereals' with its ability to adapt to diverse agro-ecologies (from 58°N to 55°S latitude) and the highest genetic yield potential among the cereals, has emerged as a multi-utility industrial crop. In India, maize is the third most important food crop after rice and wheat and contributes nearly 9 % in the national food basket. This is the crop in which the first All-India Coordinated Research Project was started under the auspices of the Indian Council of Agricultural Research in 1957. Under this project, the Indian maize breeding programme achieved several historic milestones, most notably the development of single cross hybrids. These hybrids marked a turning point in Indian maize breeding, with single cross hybrid breeding taking over the multi-parent hybrid and composite breeding approaches.

Maize (*Zea mays* L.) is the first crop in which heterosis was commercially utilized through the cultivation of hybrid cultivars and it is considered as a landmark achievement in plant breeding. Shull (1909) gave the "pure-line method of corn breeding" and proposed development of single-cross hybrids (a hybrid of two inbred parents). However, maize breeders encountered some practical difficulties in adopting the pure-line method, the most important being non-availability of vigorous high yielding inbred parents. To overcome the limitations, Jones (1918) suggested the use of double-cross hybrids, i.e., a hybrid of two single crosses (hybrid having four inbred parents). The first commercial planting of double cross hybrid was done in 1921 in the USA. The adoption was initially quite slow, but starting in the mid-1930s, it gained momentum and the area under double crosses in the USA increased rapidly.

Among various types of hybrids, single crosses have the maximal expression of heterosis and, therefore, the highest performance potential besides having extreme uniformity. Due to this, the cultivation of single crosses started in late 1950s and early 60s. These are now occupying practically all the maize acreage in the USA and many other countries. While hybrid maize was a great success in developed countries, its performance

varied greatly in most developing countries.

In India, maize breeding programme was greatly strengthened in 1957 with the establishment of All-India Coordinated Research Project (AICRP) on maize (initially named All-India Coordinated Maize Breeding Scheme which was expanded in 1963 by including disciplines other than breeding) under the auspices of Indian Council of Agricultural Research (ICAR). Prior to that, some scattered efforts were going on in Punjab, Bengal, Uttar Pradesh and Maharashtra up to mid-1940s (NCA, 1973 and Dhillon *et al.*, 2006). In 1945, ICAR financed ad-hoc schemes in New Delhi, Punjab (Lyallpur/Jalandhar), Uttar Pradesh (Almora and Kanpur), Bombay (Arbhavi and Dohad), Bihar (Sabour and Pusa) and Andhra Pradesh (Himayat Nagar) to develop maize hybrids. A three-way hybrid (single cross x inbred) was developed at Arbhavi in 1950 for Gokak canal area of Mysore in erstwhile Bombay state. Further, a double cross hybrid, Punjab Hybrid 1, having all parental lines derived from indigenous germplasm, was given for cultivation in Punjab in 1956 (Negi and Bahans, 1957). Though, these hybrids had about 20 per cent yield superiority, yet these failed to gain popularity, mainly because of limitations associated with seed and cultivation practices of the hybrids. In early 1950s, a number of commercial hybrids were introduced from the USA, Australia and other countries. Some hybrids showed marked superiority (30 to 50 per cent) over local varieties but these were not accepted by the farmers because of their unattractive grain type, late maturity, susceptibility to the diseases, poor inbred lines and above all, lack of seed industry.

In the Maize-AICRP, initially focus was solely on hybrid breeding. A large number of germplasm including inbred lines were introduced particularly from the USA, Mexico, Colombia and other Latin American countries, and locals were also collected. Large-scale hybrid breeding programme was initiated. Starting in 1961, a number of double-cross and double top-cross hybrids (single cross x open pollinating population) were released. Realizing the difficulties associated with seed production and giving due importance to maize cultivation in low-input agriculture, focus was shifted to composite breeding soon after the release of initial sets of hybrids in early 1960s (composites are open

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pollinating cultivars typically developed by recurrent selection in a base population developed by bulking together seed of a number of phenotypically selected genotypes) breeding. Six composites were released in 1967, and many others later on (Dhillon *et al.*, 2006).

In view of the experiences at global level, national breeding programme was again re-oriented in late 1980s with a focus on single cross and other simple hybrids. First three-way hybrid, Trishulata, developed by Andhra Pradesh Agricultural University, Hyderabad, was released in 1991. Further, first single cross hybrid 'Paras' developed by Punjab Agricultural University (PAU), Ludhiana, was released in 1995 for cultivation in Punjab (Dhillon *et al.*, 1995) which gave a new orientation to maize breeding programme in the country. Due to their exceptional yield potential and remarkable uniformity, a multitude of single-cross hybrids have been subsequently introduced. Currently, these single-cross hybrids dominate a significant portion of the cultivation during the winter/spring season across the nation. Additionally, they predominate in various states during the monsoon season, including Tamil Nadu, Andhra Pradesh, Telangana, Punjab, West Bengal, Haryana, Karnataka, Madhya Pradesh, Odisha, and Chhattisgarh.

The female parent LM 5 and male parent LM 6 inbred lines had been derived from each of the two heterotic pools namely, Tuxpeno and *Makki Safed* pools, respectively, developed by PAU. A large number of material went into the development of these pools that include indigenous and exotic germplasm from International Maize and Wheat improvement Center (CIMMYT) in Mexico, the USA, Thailand etc. (Dhillon *et al.*, 1997). Hybrid Paras was a high yielding and lodging resistant hybrid. On the average of 14 breeding trials conducted during 1992 to 1994 in Punjab state, Paras

yielded 6649 kg/ha in comparison to 4936 kg/ha of hybrid Sartaj and 4921 kg/ha of composite Parbhat and recorded its superiority of about 35% over these checks. In coordinated trials conducted throughout the country at 15 locations, Paras yielded 6632 kg/ha against 5651 kg/ha of hybrid Ganga 11, the superiority of Paras being 17% (Dhillon *et al.*, 1995). It expectedly showed high uniformity for plant and ear characters as compared to the previously released hybrids in the country. Paras had well developed root system and strong stem. The plants remained green even at the time of maturity. These traits imparted high degree of lodging resistance to this hybrid. The plants were relatively tall with average ear placement and semi-erect leaves. Ears were very long but thin. The grains were bold, orange-yellow and flint (Fig. 1). It recorded 58 days for silking and 95 days for maturity.

Later, PAU developed short duration single cross hybrid Parkash, which was released for cultivation in Punjab state in 1997 (Dhillon *et al.*, 1998) and throughout the country in 1998. It was recommended for cultivation under both rainfed and irrigated conditions. In between, six other single cross hybrids (Rajendra Makka 2 in 1996; DMH 1, COH 3, Him 129, and Pusa Early Hybrid 1 and 2 in 1997) were released by different research institutes (Kaul *et al.*, 2010).

The inbred parents of hybrid Parkash were CM 139 and CM 140. CM 139 was derived from a cross of composite Tarun and Makki Safed 1 Yellow. Tarun was an early maturing composite developed by GB Pant Agricultural University of Agriculture and Technology, Pantnagar and released for cultivation in 1978 in Uttar Pradesh and in Indo-Gangetic plains except Rajasthan in 1982. Makki Safed 1 Yellow was a yellow version in Makki Safed 1, an improved version of a Punjab local which was released for general cultivation in Punjab in



Fig. 1 Cobs of maize hybrid Paras



Fig. 2 Cobs of maize hybrid Parkash

1973. CM 140 was derived from J 617, an improved version of a local collected from Punjab.

In 47 irrigated trials, Parkash yielded 4631 kg/ha against 3689 kg/ha of composite Kesari with superiority of 25% and in 41 trials under rainfed conditions, it yielded 4623 kg/ha in comparison to 3653 kg/ha of composite Megha with superiority of 26% in Punjab. In all India coordinated trials conducted throughout the country, Parkash showed 21% superiority over the composite Kiran under both irrigated (13 trials) as well as rainfed (9 trials) conditions (Dhillon *et al.*, 1998). The plants had medium height and ear placement. The leaves were semi-erect, dark green and medium in size. The root system was well developed. The tassel was medium in size. The ears were uniform and long with slight blank tips. Grains were attractive orange flint (Fig. 2). The plants took about 50 days to mid-silk and 82 days to husk brown stage. The plants stayed green at maturity. It recorded short anthesis-silking interval which is an indicator of drought tolerance.

Hybrid Parkash was also recommended for babycorn production. It gave on an average 1750 kg/ha of dehusked ears of pale yellow colour in 2-3 pickings. After first picking of babycobs, Parkash showed tendency of prolificacy with 2-3 cobs/plant for second or/and third picking. The mean babycob length and girth were 7.2 and 1.14 cm, respectively. As Parkash possessed stay-green trait, maize stalks provided good green fodder after picking the babycorn.

Parkash was the first hybrid to be cultivated for babycorn production when Field Fresh Foods, Inc. set up at Ladhowal, Ludhiana in second half of 1990s. Starting in 1998, it was also cultivated in district Sonapat of Haryana. It will, therefore, not be an exaggeration to claim that Parkash laid the foundation of babycorn cultivation in North-West India.

Authors' contribution

Conceptualization of research note (BSD); Analysis of data and interpretation (BSD); Preparation of manuscript (BSD and SS)

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