

# Single Cross Hybrid:

## A Potential Technology for Boosting Maize Production

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THE rediscovery of Mendel's law and the concept of pure line selection have set the pace for science based development of new cultivars especially in self pollinated crops. The extension of the pure line theory concept to a highly cross pollinated crop, i.e. maize by Shull and East in 1908 led to development of new concept of single cross hybrid, i.e. a cross between two pure lines. Initially Shull and East envisaged and proposed the potentiality of single cross hybrid in breaking the yield barriers. However, due to poor yielding ability of pure lines (inbred lines in cross pollinated crops like maize) the concept of single cross hybrid could not be practiced in true spirit and took the back seat. In the mean time Jones (1918) proposed the concept of double cross hybrid (a cross between two single cross hybrids) to overcome the bottleneck of poor yielding ability of inbred lines. The double cross hybrids were relatively low yielders as compared to single cross hybrids but concept was accepted immediately due to its practicability.

### Maize Research and Development

After independence the survey revealed that the productivity of maize was very low as compared to advanced countries like USA. The Government of India, with the objective to enhance the productivity of maize, imported several hybrids from USA and Caribbean region during early 1950's and introduced the identified promising hybrids for commercial cultivation after multi-location testing. However, such effort could not make any significant impact on enhancing the productivity, because the parental lines of such introduced hybrids were of temperate region and could not acclimatise to tropical Indian climate and the hybrid seed production faced many difficulties. Further, these hybrids were of long duration and failed to find a place in cropping systems of India.

Attempts were made to exploit double cross hybrids (DCHs) but these could not become popular because of inherent operational difficulties. The DCH seed production requires 7 isolation and

faces several research challenges, with respect to identification of four parents and their combining ability. On research front, the development of multi-parent hybrids was also very slow mainly because identification of best possible inbred combinations to produce elite double/double top crosses was time consuming and lengthy process. The above problems prevented commercialization of DCH technology in India. Instead following USA in adoption of an easy, most potential and acceptable technology of SCH rather India shifted to further most complicated technology of composite breeding as a strategy to mitigate the seed availability issue and facilitate Indian farmers based on the theory of to save and use their own seeds year after year, like self pollinated crop. This is in contrast to the almost same period where in most desert crop like pearl millet the concept of hybrid gained research importance and its adoption dominated in the farmers' field and is continued with highest acreage under hybrid cultivation today. The aggressive composite

*The double cross hybrids increased the average yield of maize in United States of America (USA). The pursuit for new methods and techniques for bridging the knowledge gap continued and several methods were proposed and practiced like recurrent selection, population improvement, top cross hybrids, three-way cross hybrid etc. Finally, it was realized that the concept of single cross hybrid was the most simple to implement among all. Therefore, efforts were initiated to overcome the bottleneck of poor inbred lines by exchanging and sharing the source material among maize researchers/institutes in the USA helped in developing the productive inbred lines and by 1960 the single cross hybrids started replacing the double cross due to their highest yield potential. The major reason for their success came from the development of productive inbred lines and their involvement in SCH development.*

breeding continued from 1967. India has released 73 composites and 29 multi-parent hybrids (1967-2000). The productivity of maize for 20 years, i.e. 1967-1987 was remained 1.1 t/ha with no yield improvement. The reason for stagnation was due to cultivation of landraces/contaminated landraces/composites and segregating populations of multi-parent hybrids. As multi-parent and composites could not make any impact, the focus shifted to SCH.

The shift of focus from double cross hybrids on to composites has led to stagnation in maize productivity. The parallel situation can be drawn from USA that its maize productivity did not cross 2.0 t/ha during the 70 years (1865-1935) period of OPV, in spite of favourable conditions for maize which includes long duration, high fertile soils, assured irrigation/rains and mild climatic conditions. The scenario of maize productivity in USA has changed significantly after it started shifting from OPVs to DCH and then taken on to single cross hybrid cultivation during 1960's. The maize research in USA concentrated on single cross hybrids and achieved 100% area of maize under single cross hybrids in 30 years (1960-1990). However, in India 1990's to early 2000's can be considered as era of great revival after slump period of around 20 years. India's productivity increased from ~500 kg/ha to ~1.0 t/ha in 32 years from 1951-89, which was an era of predominantly composites/landraces cultivation. During this period (1951-1989), 33 composite were released which constitutes about 75% share of the total released variety of the country. However, after 1989 the impetus on single cross hybrid has started but remained predominantly composite breeding until early 2000's. In the transition period from composites to single cross hybrids, the cultivation of double cross hybrid started increasing due to liberalized seed policy. The private sector introduced many double cross hybrids on to the farmers field especially in irrigated belts particularly in Southern Indian belt of the country and simultaneously the productivity was

also increased from ~ 1 t/ha to ~2 t/ha during the span of around 15 years.

The focussed research on single cross hybrid was started from 2006 onwards. During 2006-2010, as many as 26 single cross hybrids and 8 composites were released. In addition, 14 double/three-way crosses were also released from private sector. The average maize productivity during this period (2006-2013) was around 2.5 t/ha with CAGR of 4.0 % as compared to 1.4 % during 1997-2006.

The achievement was remarkable despite ~80% maize area under rainfed and low input condition. In contrast to increase in maize productivity the maize area under irrigation has increased only marginally from ~11% during the time of independence (1950-51) to ~30% to date (2012-13). However despite all these facts, the maize productivity in India was low (2.5 t/ha) as compared to world average productivity (~5 t/ha).

#### Single Cross Hybrids for Water Scarcity Areas in *Rabi* Season

In the peninsular India, until recently the major crop in both *kharif* and *rabi* season was the rice, but the indiscriminate extension of rice area beyond the prescribed command area in both season has led to over exploitation of ground water thus leading water scarcity particularly in *rabi* season. The fag end of *rabi* rice used to face with water scarcity in

major *rabi* rice growing region like Guntur district of Andhra Pradesh, Raichur in Karnataka and few pockets in Tamil Nadu. The farmers of these areas found single cross hybrid maize as best alternative over *rabi* rice because of its low water requirement, high yield potential, and its higher profitability. The maize productivity in Andhra Pradesh is one among the highest and is almost double the national average. This major increase was achieved due to adoption of nearly 100% area under single cross hybrids.

#### Hybrids for Conservation Agriculture

The rice follow zero tillage maize in India has become a success story. The state of Andhra Pradesh especially the district of Guntur has become the model for the whole country. The Zero-till technique along with SCH has brought maize revolution in the Andhra Pradesh and the area under rice follow maize is gradually spreading in certain districts of Tamil Nadu (Coimbatore) and Karnataka (Raichur) as well. Zero till maize advances the sowing time, saves water and fuel, reduces cost of cultivation, improves farm profitability thus an environment friendly technique. The zero-tillage technique also improves soil health by providing an opportunity to increase soil organic matter and, also reduces soil erosion. Presently in Andhra Pradesh alone the zero-till maize production has crossed two



Conservation Agriculture Practices

lakh hectare area and it is increasing at very faster rate to the neighbouring states. The current productivity in zero-till SCH cultivation belt is close to 9 t/ha which is more than per day productivity of USA. The single cross hybrid seed also allows mechanical sowing thus helping for farm mechanization.

### Hybrids for Farm Mechanization

Maize being purely row crop having non-tillering plant type provides an opportunity for the mechanized sowing, pesticide, fertilizer application and inter-cultivation operations. The placement of fertilizer near root zone under conservation agriculture practice is a challenge, which drives mechanization of maize cultivation. Single cross hybrid being uniform with respect to maturity, height and ear placement is best suited for mechanized harvesting/combine harvesting. Thus, single cross hybrid maize is a solution crop for the labour shortage, timely operation, reducing post harvest losses and promotion of farm mechanization in Indian agriculture.

### Hybrids for Crop Diversification

In some parts of the country, the rising temperature is affecting the wheat crop profitability but the rising temperature during winter is good for maize and is an alternative / possible solution for wheat farmers. The best quality hybrid seed production of maize with high profitability can be taken during *rabi* season. The favourable temperature in the *rabi* season in states like West Bengal, Odisha, parts of Rajasthan, Gujarat, Chhattisgarh, Jharkhand

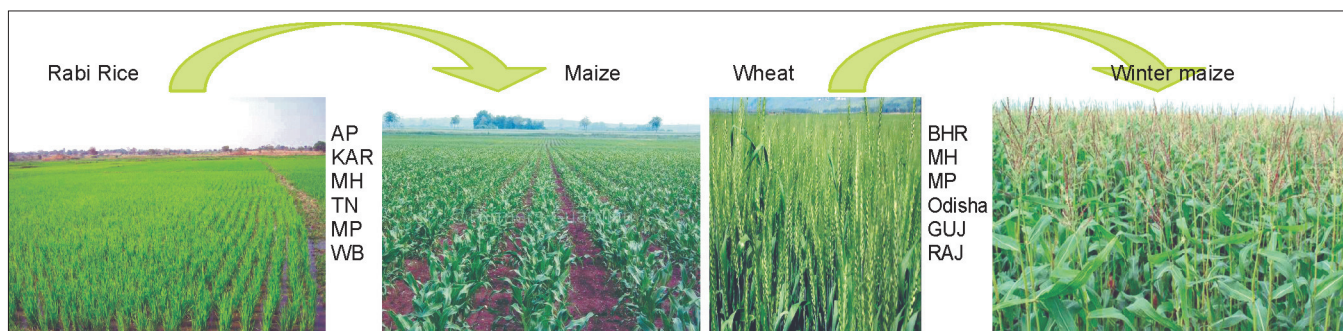
Madhya Pradesh, Bihar and Eastern UP offers a great potential for maize hybrid seed production and commercial cultivation. The areas under hybrid seed production as well as under commercial cultivation are increasing very fast in these areas. The possible alternative sites for hybrid seed production have been identified in these states. The remunerative seed production in these states will cater the needs of the states as well as have potential for export to neighbouring states and countries. The success story of West Bengal and Rajasthan in QPM hybrid seed production can be replicated in other parts of the country as well. The hybrid seed produced in West Bengal is being exported to North-Eastern states and other parts of the country. Further, the cultivation of spring maize after harvest of potato and sugarcane has become reality in some of the states *viz.*, Punjab, Haryana, western UP, lower valley of Uttarakhand, Bihar, Gujarat, Madhya Pradesh, Odisha, and emerged as an alternative profitable crop replacing summer rice and other non-remunerative and more water requiring crop thus becoming a main driving force for crop diversification.

### Hybrids for Crop Intensification

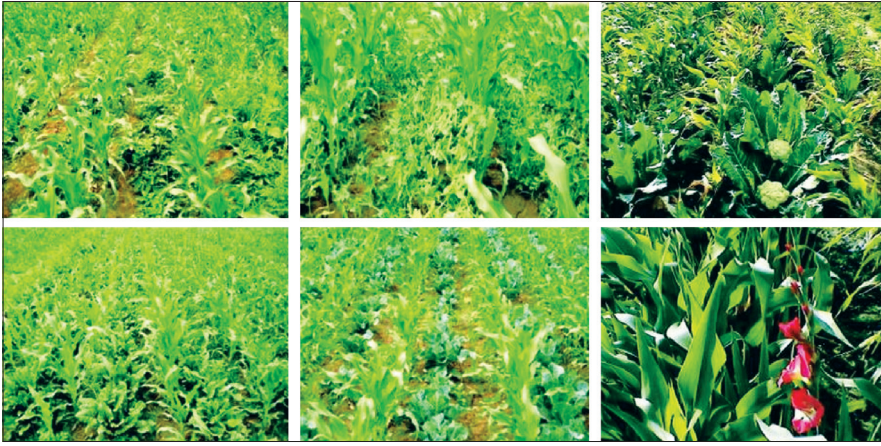
Maize is one of the most versatile crop with different kinds like sweet corn, baby corn, popcorn, QPM etc. The sweet corn and baby corn being harvested at green stage before completing their life cycle provides an excellent opportunity to take up 3-4 crops per year thus enhancing the crop horizontal intensification percentage. Because the sweet corn and baby corn can be harvested within 60-90 days therefore, they can

be fitted to any cropping system which provides a window of 60-90 days. The late maturing single cross hybrids which grow relatively at slow rate can accommodate many short duration intercrops for vertical crop intensification especially during winter season. Inter cropping with high value vegetables (broccoli, green pea, potato, root beet, Cole group, garlic, onion, lettuce group etc.) and flowers (gladiolus, *genda*) crops with winter maize provide minimum additional income from Rs. 5,000 – 10,000 per hectares depending upon the crop and prevailing market price. Some of the legume inter crop improve the soil health. The intercropping of the high value vegetable and flower crops like sugar beet, broccoli, gladiolus with baby corn and sweet corn leads to sometime rupees Rs. 50,000/ha more monetary return.

Intercropping of *kharif* maize with mungbean, urdbean, soybean and cowpea give additional income to the farmers and provides avenues to increase production of pulses and oilseeds in the country and cover the risk due to mono-crop cultivation. By growing these short duration maize crops farmers can get regular income during lean period, which ensures livelihood security. Thus, Intercrop with maize is a solution for enhancing production of pulses, oilseeds, vegetables and flowers that will reduce the import dependency and bring overall prosperity in the country. However, intercropping may not provide an opportunity to mechanized cultivation of maize but it do provide an opportunity for additional income to farmers with small holding thus, substantiating the fact that maize is the versatile crop as



Crop diversification in India



Baby corn intercropping with potato, pea, cauliflower, cabbage, sugarbeet and gladiolus

it can be grown by both small and large holding farmers.

### SCH Impact on Hybrid Seed Production and Seed Industry

The SCH technology has not yet been able to penetrate across all the states, mainly because of non-availability of hybrid seed. It can be correlated with the stagnation and very slow increase in maize productivity of some of the states like Bihar, Gujarat, Rajasthan, Odisha, Uttar Pradesh, Madhya Pradesh, Jharkhand, Chhattisgarh and Uttarakhand where the area under maize is quite large but the productivity very low as compared to national average. In fact these are the states which cover more than 50% of area and have yields level lower than national average (<2.4 t/ha). Recently some of the states like Rajasthan and Odisha where there is low productivity of maize, the state government has intervened through subsidised distribution of hybrid maize seed. The efforts are also on in states like Punjab, Uttar Pradesh, Gujarat and NE States to replace either upland rice or wheat with maize because SCH technology has lot of potential to achieve the

objective. Public Private Partnership (PPP) through memorandum of understanding (MoU) for public bred maize hybrid seed production and marketing has already been taking place.

The Government of India is already making an effort to find a suitable alternative in Punjab, Haryana and western UP to replace *kharif* rice with maize because higher productivity of single cross hybrids can compete with rice. If area under SCH increased in above mentioned states then we can double maize production and productivity in these states with the help of available hybrids. The demand for SCH seed is increasing day by day; at present only 30-35% of hybrid seed demand is being met by production agencies existed in the country. Therefore, the major challenge is to make availability of quality single cross hybrid seed at the doorsteps of farmer of these states, as seed is the basic input, which has the tremendous potential to increase the productivity. So, SCH seed production can revive the seed industry of the country. The SCH hybrid seed production can provide employment to the agricultural

graduates' as well as rural masses. There is need to devise effective mechanisms of public private partnership (PPP) to meet the SCH hybrid seed demand across the country.

### SUMMARY

The growing demand for single cross hybrid seed is an opportunity for seed industry growth. India has already developed strong network of seed production agencies like NSC, SFCI, NGOs, and Private Seed Companies supported by several crop specific research institutions established under ICAR, SAUs. The favourable government policies also in place therefore the task of availability of sufficient quantity of quality seed to farmers does not seem difficult to achieve. The hybrid seed production is largely (~90%) concentrated in Andhra Pradesh and and there is 100% area under hybrid is the state that is why AP has highest productivity in the country. There is need to replicate the model of Andhra Pradesh across different states of the country. Therefore, several alternative seed production sites *viz.*, E. India: WB - Midnapur, Krishna Nagar, Bihar - Muzaffarpur, Begusarai, Somastipur etc (*rabi*); W. India: Gujarat-Panch mahal, Dahud, Rajasthan-Banswara, Dungarpur (*rabi*); C. India: MP - Chindwada, Indore, Ratlam, Jabalpur, Hinday, Chhattisgarh - Chhattisgarh, Raipur (*rabi*); S. India: MH - Aurangabad, Ahmednagar, KA - Bellary, Raichur, Shimoga (*rabi*); N. India: E.UP in *rabi*, UK in Spring, J&K - Jammu, Himachal - Unna were also identified to achieve the availability of hybrid seed at local places.

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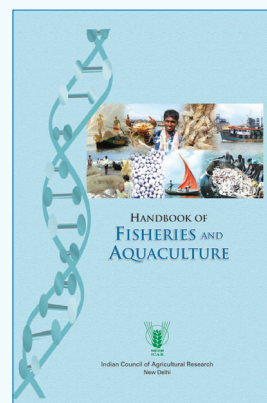
### FEW FACTS

- Corn is called maize by most countries, this comes from the Spanish word 'maiz'.
- Corn is a cereal crop that is part of the grass family.
- An ear or cob of corn is actually part of the flower and an individual kernel is a seed.
- On average an ear of corn has 800 kernels in 16 rows.
- Corn will always have an even number of rows on each cob.
- Corn is now a completely domesticated plant so you're unlikely to find it growing in the wild.

## Handbook of Fisheries and Aquaculture

Fisheries is a sunrise sector with varied resources and potentials. The sector engages 14 million people at the primary level and is earning over Rs. 10,000 crore annually through exports. Fish consumption has shown a continuous increasing trend assuming greater importance in the context of 'Health Foods'. It is expected that the fish requirement by 2025 would be of the order of 16 million tonnes, of which at least 12 million tonnes would need to come from the inland sector and aquaculture is expected to provide over 10 million tonnes. The domestic market for fish and fishery products is also growing rapidly and necessary models and quality control protocols in this regard need to be developed.

In 2006, the Indian Council of Agricultural Research brought out the First Edition of 'Handbook of Fisheries and Aquaculture'. The present revised edition comprises 42 updates and six new chapters, viz. Fish physiology; Aquaculture engineering; Fisheries development in India; Fisheries cooperatives; Demand and supply of fish; and Climate change-impact and mitigation. The Handbook would be of great value to students, researchers, planners, farmers, young entrepreneurs and all stakeholders in fisheries and aquaculture.



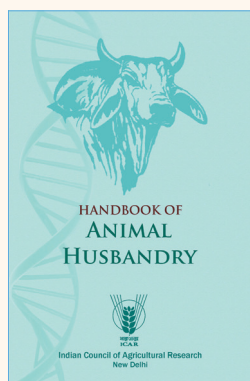
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## HANDBOOK OF ANIMAL HUSBANDRY



Livestock sector has created a significant impact on equity in terms of employment and poverty alleviation. After staple crops, livestock sector is the second most important contributor to the agricultural economy. The producer prices of meat, eggs and milk, in India appear to be highly competitive as the domestic producer prices of these products are quite low compared to the ex-farm gate prices of major exporters in the world markets. A knowledge resource is essential to harness the potential of animal production. The Indian Council of Agricultural Research brought out first edition of *Handbook of Animal Husbandry* in 1962 for serving the end-users ranging from livestock owners to academicians. This is the Fourth revised and enlarged edition of *Handbook of Animal Husbandry* which includes 48 chapters under nine sections, such as Animal Genetics and Breeding; Animal Nutrition and Feed Technologies; Animal Management; Animal Reproduction; Animal Health Management; Animal Biotechnology; Animal Products, Technology and Machineries; Economics and Trade of Livestock and Poultry Enterprise; and Social Sciences. It has 19 new chapters like Impact of Biotechnology, Nanotechnology: Applications in Animal Sciences; Carbon Trading: Mechanisms and Opportunities in Livestock Sector; Intellectual Property Rights Regime; Indigenous Technical Knowledge etc.; and old chapters were revised holistically. The fourth revised and enlarged edition of *Handbook of Animal Husbandry* will prove useful to the students, teachers, livestock/poultry farmers, and to especially those who visualize the economic growth of country with the support of livestock sector.

### TECHNICAL SPECIFICATIONS

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