National Symposium
on
Hybrid Technology for Enhancing Crop Productivity

Concept Note

Background and Rationale

Global food insecurity concerns have lately been rising on account of economic inequality, poverty, climate change, economic slowdown and political conflicts. The shocks of COVID-19 epidemic in 2019-20, and Russia-Ukraine and Israel-Palestine war going on since early 2022 and 2023, respectively, have greatly intensified these concerns by severely disrupting the global food supply chain. These developments are threatening food security having implications on achieving sustainable development goals (SDG), especially to reduce poverty and ending hunger, including all forms of malnutrition by 2030. According to the Food and Agricultural Organization of the United Nations (FAO), the global population is estimated to reach 8.19 billion by 2025 and around 8.55 billion by the end of 2030. Further, the food and nutritional needs globally are increasing due to overall economic development and changing food habits. This would require greater emphasis on improving productivity and production of diversified foods with better nutritional quality.

Among various possible options, hybrid technology has greater potential for genetic enhancement of traits such as yield, nutritional quality, resistance/tolerance to biotic/abiotic stresses, adaptation to climate change etc. Hybrid technology aided further by the deployment of marker-assisted selection, genetic engineering, genome/gene editing, precise phenotyping, doubled haploid (DH) technology *etc*., can help greatly to address our future food and nutritional needs of burgeoning population.

The cultivation of hybrids in maize started on a large scale in 1930s in the USA. Because of its superiority over open pollinated varieties, hybrids spread fast across the world after the second world war. In India, the first systematic hybrid breeding program also started in maize in 1957 with the initiation of an All-India Coordinated Maize Improvement Project under the auspices of Indian Council of Agricultural Research (ICAR). As a result, large number of double cross and double topcross hybrids were released for general cultivation. Later, realizing that single cross hybrids have greater yield potential, the maize breeding program was reoriented in 1980s under a special hybrid breeding program for nine crops including maize. As a result, the first single cross maize hybrid was released in 1995, followed by many others. These hybrids, beside those introduced by multinational seed companies, helped in area increase (now 10 mha), productivity (from 1.0 to now 3.5 t/ha) and production (37.5 mt) of maize in the last two decades with annual growth rate of > 4.0 per cent in last two decades.

In fact, India is known to have bred the world's first commercial hybrids of sorghum (1964), grain pearl millet (1965), castor (1968), cotton (1970), pigeonpea (1991) and safflower (1997). India also made great strides in hybrid breeding in other crops, such as rice, safflower, tomato, cauliflower, cabbage, muskmelon, watermelon, brinjal, chilly, *etc*. Hybrid pearl millet and *kharif* sorghum initially created an impact but then had a setback due to incidence of downy mildew and grain mold, respectively. However, the plant breeders did overcome these by developing new hybrids with having good resistance/tolerance incorporated for both biotic and abiotic stresses.

With the implementation of the 'New Seed Policy' in 1988, and subsequently enactment of Protection of Plant Varieties and Farmers Rights Act (PPV&FRA) in 2001 by the Government of India, permitted bulk import of quality hybrid seeds and strengthened intellectual property rights (IPRs). With these policy measures, the adoption of hybrids of different crops got real impetus leading to faster growth of both public and private seed sectors.

Challenges and Opportunities

Hybrid breeding allows exploitation of heterosis by bringing together desirable genes in heterozygous state resulting in significant genetic enhancement along with germplasm enhancement through recurrent selection to develop source populations for inbred-lines derivation. But it is more difficult task than other breeding options, namely, pure line, composite/synthetic, and clonal breeding, since it involves inbreeding, inbred evaluation for performance *per se* and combining ability, and evaluation of yield and other traits' superiority. Thus, hybrid breeding requires access to wider germplasm, trained human resource and greater financial support.

On the other hand, it is also a fact that most crops, in which hybrid technology has made an impact, are mainly grown in rainfed conditions reflecting hybrids' inherent buffering capacity besides higher potential performance. Hence, it is worth discussing the tangible benefits, future options and current constraints for harnessing the potential benefits of hybrid technology in the national interest and more so for the economic benefit to our smallholder farmers.

Major factors that affect the success of a hybrid program, relative to a pure line breeding program, include: (i) mating system, including possibility and ease of control pollination, (ii) availability/development of heterotic pools, (iii) degree of heterosis, (iv) ease and cost of hybrid seed production, and (v) the quantity of seed requirement for sowing per unit area.

In the current era of genomics, new opportunities are emerging which can accelerate hybrid breeding. The new genomic tools do enable precision as well as faster cultivar development genomic selection, genome editing and reducing the testcross as well as phenotypic evaluation requirements. DH technology and speed breeding/off-season nursery also shorten the duration of inbred line and hybrid development, particularly the former.

Maize is not only the first but also the most successful example of utilization of heterosis in crops to enhance the agricultural production. The introduction of single-cross hybrid cultivars has resulted in the expansion of area from 6.61 mha in 2000-01 to 10.04 mha in 2022-23 and increase in production from 12.04 mt to 34.61 mt and productivity from 1.82 t/ha to 3.44 t/ha during the same period. In spite of adopting single-cross hybrid cultivars, there is still not only wide variation in maize productivity in the country but also substantial gap between average productivity at the global level (5.75 t/ha) *versus* that in India (3.44 t/ha).

Hybrid rice technology is an extremely promising option for boosting productivity approximately by 15-20 per cent over that of rice varieties. Over the decades of rigorous research, Dr Yuan Long Ping, father of hybrid rice, was the first to develop male sterility that enabled him to exploit heterosis in rice in 1975 in China. In fact, through hybrid rice technology, covering almost 50per cent area (about 15.0 mha), China has been harvesting 15 million tons of extra rice per year since last four decades. On the contrary, we in India, in collaboration with International Rice Research Institute (IRRI), initiated systematic hybrid rice research in 1989 and thus, became the second country to cultivate hybrid rice commercially. Yet, the area covered in the last three decades has not yet exceeded 2.0 mha. The encouraging fact, however, is that area so far covered is mostly the rainfed upland rice in eastern India, reflecting again superiority of hybrid technology under water stress environment. Like in China, hybrid rice technology in India, has not yet made significant impact in irrigated ecosystems. It would require extensive investment and full-time commitment of researchers to develop appropriate rice hybrids and economically viable hybrid seed production technology involving public and private seed agencies. The latter would also require a close collaboration between the two sectors. A mutually acceptable model of collaboration needs to be developed in India.

It is by now well established that hybrid technology can increase productivity significantly and the farmers are happy to embrace this technology, However, maximum potential of hybrid technology is yet to be realized in various foodgrains and vegetable crops as area under hybrid varieties is varying considerably. It is almost 12 mha (94%) in cotton, 0.46 mha (78%) in sunflower, 5.6 mha (60%) in maize, 2.84 mha (40%) in pearl millet, and 1.5 mha (28%) in sorghum. This obviously reflects that there is great opportunity to harness the potential of hybrid technology by adopting a well-planned R & D strategy at the national level.

About the National Symposium

Hybrid technology in crops offers an opportunity to increase productivity by 15-20 per cent over the varieties. To expand the adoption of hybrid cultivars in crops, a 3-day "**National Symposium on Hybrid Technology for Enhanced Crop Productivity"** will be organized by the Trust for Advancement of Agricultural Sciences (TAAS) in collaboration with Indian Council of Agricultural Research (ICAR) and CGIAR Institutes namely, International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), International Maize, Wheat Improvement Centre (CIMMYT), International Rice Research Institute (IRRI), and Indian Society of Plant Genetic Resources (ISPGR), with the support of Federation of Seed Industry of India (FSII), Maharashtra Hybrid Seed Company (MAHYCO), Rasi Seeds (P) Ltd. and Bayer Crop Science Limited, in AP Shinde Symposium Hall at National Agriculture Science Complex (NASC), Pusa Campus, New Delhi, from **2-4 December 2024**. at the National Agriculture Science Complex (NASC), Pusa Campus, New Delhi, from 2-4 December 2024. Around 300 stakeholders including researchers, policymakers, representative of CG centres and private sector are expected to participate. The aim of the Symposium is to discuss and suggest a way forward for scaling hybrid technology in crops, mainly rice, maize, cotton, pearl millet, sorghum, sunflower, pigeonpea, castor and some selected vegetable crops.

Objectives

- To understand the current status of hybrid research in various crops
- To discuss current scientific and policy constraints in scaling hybrid breeding and seed production for increased productivity

- To foster closer public-private partnership for promoting hybrid breeding and seed production
- To develop strategies and 'Way Forward' for accelerating adoption of hybrid technology on a large scale in the national interest

Expected Outcomes

- The constraints for scaling hybrid breeding technology identified
- Application of molecular and other tools for accelerating hybrid breeding technology in major crops assessed
- The expected economic and social benefits of adopting hybrid technology in crops well understood
- Strategy for strengthening public-private partnership for hybrid breeding and seed production developed
- Enabling policies for strengthening hybrid R & D for improving crop productivity and production suggested

Organizers

- Trust for Advancement of Agricultural Sciences (TAAS), New Delhi
- Indian Council of Agricultural Research (ICAR), New Delhi
- International Crop Research Institute for Semi-Arid Tropics (ICRISAT), India
- International Maize and Wheat Improvement Centre (CIMMYT), Mexico
- International Rice Research Institute (IRRI), Philippines
- Indian Society of Plant Genetic Resources (ISPGR), New Delhi

Participants

About 300 participants representing researchers/breeders from ICAR and State Agricultural Universities (SAUs), CG Centers, policymakers, private seed sector, farmer seed producers are expected to attend the Symposium.

Date: 2-4 December 2024

Place: NASC, Pusa Campus, New Delhi