PERSPECTIVE AND CHALLENGES TO DEVELOP HIGH YIELDING, DISEASE RESISTANT AND OIL QUALITY SUNFLOWER HYBRIDS IN INDIA

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INTRODUCTION

Sunflower (*Helianthus annuus* L.) is the third important oilseed crop in the world after soybean and groundnut. It is grown over an area of 25.6 m ha with a production of 44.8 m. tons and average productivity of1749 kg/ha in the world. Due to its wide adaptability, it is grown in all the continents. Important sunflower growing countries are Argentina, CIS countries, France, Spain, USA, China and India. China, France, Turkey are the highest yielding countries with an average yield of >2 tonnes/ha as against the lowest yielding countries like Kazakistan, Myanmar and India with <1 tonne per ha. Russia and Ukraine have largest share of about 50% in total sunflower production in the world. The crop has become an important oilseed crop in India covering an area of 0.55 m ha with a production of 0.41 m tons with the average yield of 752 kg/ha.(Annon.2014). In India the cultivation of sunflower is confined to southern states of Karnataka, Tamil Nadu, Maharashtra and Andhra Pradesh. During the last 20 years, the crop has made a dent in nontraditional areas in the northern states of Punjab, Haryana and Uttar Pradesh, in Spring/zaid season. The productivity of sunflower in these states is highest (2111 Kg/ha) in the country.

HISTORICAL DEVELOPMENT

Breeding in sunflower began around 1912 in the former Soviet Union and the most successful early breeding programme was that of V.S.Pustovoit. The concerted efforts for four decades resulted in increasing oil content from about 30 to 52%. High oil sunflower varieties, such as Peredovik, Armavirskiy 3497, Mayak,VNIIMK 8931, VNIIMK 6540 and Smena developed by V.S.Pustovoit and his associates enabled the spread of sunflower crop not only in Soviet Union but also to other continents. In the 1940s, Putt in Canada developed shorter, early maturing cultivars (Miller,1992). Resistance to rust was incorporated from wild species. Breeding programs were started about the same time in Argentina and several other countries. In the USA, Kinman began breeding programme around 1950, intensive breeding programmes were pursued in several countries around the world, as a result of which sunflower is now grown over a large area in many countries.

Development of hybrids in maize and other crops stimulated sunflower breeders to work towards developing hybrids in sunflower. Kinman in USA, Putt in Canada and several other workers started a hybrid production scheme taking advantage of self-incompatibility system in the crop (Fick, 1978). Although a high per cent of hybrid seed could be obtained on the female line, the % seed set varied with the lines and environmental conditions. Evolving hybrids using genetic male-sterility was developed by Vranceanu (1974) in Romania. Male-fertility (MS ms) was linked with red anthocyanin pigmentation enabling rouging of fertile plants in the female line in the seed production plots. Hybrid seed production cost was high in view of the labour requirement to remove fertile plants.

The landmark in the development of commercial sunflower hybrids was the discovery of cytoplasmic male-sterility by Leclercq (1969) in the progeny of a cross between Helianthus petiolaris Nutt and cultivated sunflower. The system was stable as evidenced by sterility obtained in the progeny of male-sterile plants crossed with fertile cultivated sunflower plants. Genes for genetic restoration of

fertility were found in the wild species by Kinman (1970). Subsequently, Leclercq (1971), Enns et al. (1970) and Vranceanu and Stoenescu (1971) also reported fertility restoring genes. First commercial hybrids based on cytaoplasmic male-sterility were made available in1972 in the USA. Subsequently, the cultivation of sunflower hybrids spread to all parts of the world.

Development of Hybrid Sunflower in India

The value of hybrids and heterosis breeding was recognized with the inception of AICRP on sunflower in 1972-73. Experimental hybrids were developed at Bangalore in 1974-75 using 4 CMS lines(CMS 2, CMS 124, CMS 204 and CMS 234) and 2 restorer lines (RHA 266 and RHA 274) introduced from the USA. All the hybrids were distinctly superior to the check variety EC 68415 both in seed and oil yield .Thus, the first sunflower hybrid BSH-1 (CMS 234A X RHA 274) was released for commercial cultivation in 1980(Seetharam et.al. 1980).Since then the hybrid base has been further widened in the country through extension of heterosis breeding work to other research centres. Many hybrids have been developed by different Public and private Institutes/universities (Table 1).

HETEROSIS STUDIES

Heterosis studies carried out in sunflower have been presented for inter-line, inter-varietal and top cross hybrids involving genetic and cytoplasmic male sterility. Kovacic (1960) in a study of inter varietal crosses observed superior response with an increase in seed yield. But only few lines exceeded the parents in oil content. However, F_1s were more vigorous and flowered earlier than the parents. Popov and Lazarav (1963) developed inbred lines from high yielding varieties and reported that single cross and top cross hybrids surpassed their parents in oil content and seed yield. Some inter-varietal hybrids exceeding their parents in seed yield were also obtained. Schuster (1964) observed heterosis for seed yield to the extent of 70%, heterosis for plant height to an extent of 47% and heterosis for head diameter was upto 60 percent.

Leclercq (1971) observed heterosis to an extent of 12-40% over standard variety Peredovik. Shuravina (1972) found that 16 out of 24 hybrids exhibited heterosis over tester parent to an extent of 39% and 20% for seed weight and seed yield, respectively. In another study, 14 out of 18 hybrids showed heterosis upto 90% for seed weight and 40% for seed yield. However, ten hybrids had reduced hull per cent and three exhibited heterosis upto 4.8% for oil content. Kloczowskii (1972) observed heterosis upto 90 to 160% for seed yield in the F_1, but in F_2 achene yields and oil content were dropped by 20 and 4%, respectively. Fick and Zimmer (1976) reported an increase in yield upto 31% over Peredovik in hybrids. Hybrids were also found to have higher oil content. Kloczowskii (1975) reported heterotic effect upto 43% for achene yield in inerline hybrids while in line x variety hybrids it was18%. In a diallel crosses between short and tall varieties.. The highest yielders were obtained by crossing short lines, families and varieties with variety Cernyanka-66. Skoric (1977) observed that four single cross hybrids yielded 25 to 30% higher seed yield, earlier, shorter and more resistant to diseases than Peredovik and Vniimk-8931. The hybrids had approximately three % higher oil content.

Seetharam *et al*. (1977) while studying the performance of hybrids produced by four cytoplasmic male sterile and two fertility restorer lines observed a significant positive heterosis for days to flower, plant height, head size, test weight, oil content and seed yield. But heterosis was not significant for stem girth and number of leaves. BSH-1 and BSH-2 were considered as best hybrids which surpassed the check variety EC-68415 by 30% in seed yield. In a study of single, double and three way cross hybrids. Shrinivasa (1982) observed a significant heterosis for plant height, stem girth, head diameter and yield per plant in all nine crosses, heterosis for oil content was significant only over the mid parental valve and was negative for 100 achene weight.While evaluating100 F1 involving 20 inbred lines and 5 pollen parents, Choudhary and Anand (1984)observed 62.3% heterosis for 1000-seed weight, 62.8% for seed yield,

64.6% for head diameter, 23.2% for oil content and negative heterosis of 7.7% for days to flowering over better parent.

Singh *et al.* (1984) in a study on performance of variety x inbred crosses observed heterosis for yield to an extent of 47-206%. The studies of Shivaraju (1984) on ten F_1 hybrids indicated an average heterosis to an extent of 175% for seed yield, 129% for number of filled seeds, 39%for head diameter, 22% for stem girth and 7% for oil content. Majority of the hybrids showed negative heterosis for days to 50% flowering and days to maturity.

Among the 49 hybrids studied, Reddy *et al*. (1985) recorded heterobeltiosis for achene yield and oil percentage in 46 and 41 hybrids, respectively. In eight hybrids, heterobeltiosis for achene yield exceeded 100% while in ten, heterobeltiosis for oilyieldwas10%. Giriraj *et al*. (1986) by crossing five CMS lines with two restorers observed average heterosis of -8% for days to flowering and 192% for achene yield per plant. Low heterosis was exhibited for oil content and number of leaves. In a study of 18 hybrids. Wali (1987) observed that heterosis varied considerably for yield and its component characters. The highest heterosis of 259% and 363% over mid-parent was observed for seed yield per plant in summer and kharif seasons, respectively. Heterosis was high and positive for leaf area index,100 seed weight, head diameter and number of filled seeds per plant while it was negative for days to flowering over both mid-parental and better parental value.

Fernandez et al. (1989) crossed lines breeding true for oil with high oleic acid (at least 85%) with standard lines having an oleic acid content of 30%. They analyzed the oil of F_1 seed and showed that high oleic acid content was a dominant trait and had maternal influences. Dedio (1993) observed heterosis for kernel oil content as well as achene oil content. In a comparative study of single cross and three-way cross hybrids, Naresh (1993) indicated that more number of three-way cross hybrids have manifested significant positive average heterosis for all the characters studied except days to 50% flowering and seed filling. The average heterosis registered for seed yield ranged upto 128%.

Disease resistance:

Sunflower (*Helianthus annuus* L.), is prone to attack by several pests and diseases (Mayee, 1997).
Several diseases are known to cause yield loss in sunflower. In India the important diseases are: alternaria leaf spot caused by *Alternaria helianthi*; rust caused by *Puccinia helianthi*; downy mildew caused by *Plasmopora helstedii* and various root and stem rots caused by *Sclerotium sp.* and *Rhizoctonia sp*. But little information is available about genetic control of disease resistance. Wild species of sunflower are known to harbor genes for resistance against diseases.

Sunflower Necrosis Disease:

Sunflower cultivation was seriously affected in India by an unusual necrosis disease caused by Sunflower necrosis virus (SNV). It was first observed in Karnataka state in 1997 and in the subsequent years it spread to other states viz., Tamil Nadu, Andhra Pradesh and Maharashtra with the average disease incidence up to 50%.Necrosis appears on the part of leaf lamina near the mid rib resulting in twisting of leaf and then extends through one side of the lamina to the petiole and stem and finally terminate to the shoot of the plant leading to partial paralytic symptoms . Necrosis at bud formation stage leads to partial twisting of the capitulum .Thrips suspected to act as a vector in transmission of this disease. No resistance source has been reported so far. However, through management this disease can be controlled Sunflower necrosis virus disease (SNVD) became a major threat to the successful cultivation of all the sunflower hybrids and varieties and devastating the crop since 1998. Significant reductions in terms of total crop loss up to 90% were reported due to early infection in the farmers' fields (Bhat et al., 2001; Ramaiah et al., 2001a; Lavanya et al., 2005). This has resulted in the substantial loss of sunflower production to 0.733 M tones in 2000–2001 in comparison to 2.0 M tones in 1998–1999 (Bhat et al., 2002a; Jain et al., 2003). According to Ravi et al. (2001) SNV belongs to the ilarvirus sub group I and is related to tobacco streak virus (TSV) as the former shared 90% amino acid sequence identity with the latter. It has been

reported that the SNV is a single stranded circular RNA virus with isometric virions; the sunflower ilarvirus was related to TSV on the basis of coat protein gene sequence (Prasada Rao et al., 2000; Bhat et al., 2002b). Initially, Jain et al. (2000) reported that the SNV was associated with tospovirus, but later it was confirmed that the ilarvirus, antigenically related to TSV was associated with SNVD (Jain et al., 2003). A disease similar in nature to SNVD has been reported in the Netherlands (Dijkstra, 1983) and Australia (Brunt et al., 1996). Thrips mediated SNV transmission has already been reported in sunflower (Jain et al., 2003; Lokesh et al., 2005). Notably, a groundnut (Arachis hypogaea L.) isolate of TSV was transmitted by a thrip, Frankliniella schultzei Trybom (Reddy et al., 2002). Although ilarvirus is transmitted through seeds (van Regenmortel et al., 2000), there is no report confirming the transmission of SNV through seeds in sunflower. Limited attempts were made for the management of SNVD using border crops and insecticides mainly to control the SNV carrier, thrips (Jain et al., 2000, 2003; Ramaiah et al., 2001b). Apart from vector control, no effective control measures are available for the management of SNVD. Therefore, the majority of the farmers depend only on chemical control of the insect to minimize the virus spread, despite the fact pesticides can be hazardous to the environment and public health. In this scenario, biological control, an eco-friendly disease control. strategy is worth testing as a supplement or an alternative to chemical control. Application of biocontrol agents (BCAs) is an important strategy in crop protection against plant pathogens. The most important control to this disease is to develop sunflower hybrids which show resistance to this virus.

Alternaria leaf spot:

It is a common disease in many countries but causes more damage in India. Only field resistance has been reported in cultivated sunflowers and no information is available on the inheritance of resistance to this disease.

Rust:

Rust is one of the most destructive diseases of sunflower in the world and can appear throughout the plant growth. Racial differentiation exists in this fungus. So far, four races and the corresponding resistant genes have been identified. Resistance to rust found commonly among wild species of *Helianthus* has been successfully incorporated into commercial cultivars. In India, although rust is of a common occurrence, the race pattern is not known.However, resistant source for local races have been identified and incorporated in the hybrids under cultivation.

Downy mildew:

At present, downy mildew is more serious under temperate conditions than in tropics. Its occurrence in India was reported in Maharashtra in 1984 (Mayee and Patil, 1986). The pathogen shows wide variation with many races and corresponding resistant genes in the host. Resistance to each race was found to be controlled by a single dominant gene. Apart from major genes several modifiers are also known to influence resistance. The resistance to the disease appears to be rare in cultivated annuals but more common in wild perennials. One of the popular restorer lines, RHA 27A, has the P12 gene for resistance to races 2and 3.

Wilt: Resistance to wilt is present in both cultivated and wild sunflowers. The
available information indicates that resistance is both simple and complex depending upon the material involved in the study.

This disease was reported first time in India during 1997 in Bagepally area of Kolar distt. in Karnataka and also in Rangareddy distt. of A.P.This disease was also reported in Parts of Maharastra and TamilNadu.

High Oil Quality hybrids:

Oil percentage and fatty acid profile is an important trait to develop high quality hybrids of sunflower. Several environmental factors also influence oil percentage as well as fatty acid composition. Low temperature at seed development stage increases the linoleic component and decreases the other fatty acids whereas it is reverse under high temperature conditions (Sheoran *et. al*, 2014.) For this purpose breeder must go for selection of inbred lines which shows high oil content and fatty acid profile and

emphasis should be laid on the stable lines so that the hybrids with high yield and high oil quality trait could be developed.

Perspective

Sunflower has become a crop of major economic importance worldwide. It is cultivated mainly as an edible oil seed crop. As a source of edible vegetable oil, it is one of the important oil seed crops in the world. Sunflower has made a significant dent in a number of tropical and temperate countries because of the following desirable features including wide adaptability of the crop enabling its cultivation in different agro-climatic regions and soil types. Being day neutral, the crop can be grown in different seasons. Being a short duration crop, it can fit into various multiple cropping systems. Ideal crop for contingency cropping plans. The versatile nature of crop and its increasing contribution to oilseeds production calls for concerted efforts to evolve hybrids with higher productivity. To achieve quantum jumps in the productivity levels among the large areas of Asia, Africa and other countries, production of quality hybrid seed is required. Further to keep pace of the new challenges, broadening the genetic base of male sterile as well as restorer lines, development of superior hybrids and supply of genetically pure hybrid seeds to commercially exploit maximum heterosis assumes greater importance. The gains in productivity of sunflower crops have been achieved primarily through exploitation of available genetic variability Conventional breeding coupled with modern tools such as biotechnology should now be the primary focus in crop improvement programs. Heterosis breeding should be the major focus in this crop. To facilitate better exploitation of the available gene pools and overcome the production constraints, research emphasis needs to be on (i) augmentation/ identification of trait specific germplasm; (ii) prebreeding and genetic enhancement; (iii) allele mining, (iv) functional genomics, proteomics, metabolomics, and interactomics; (v) marker assisted breeding and gene pyramiding; and (vi) trait improvement through genetic engineering.

SELECTED LITERATURE:

Chidambaram, S. and N. Sundaram. (1990). Heterosis in varietal crosses in sunflower. *Madras Agricultural Journal* **77**: 517-519.

Choudhary, S.K. and I.J. Anand (1984). Heterosis and inbreeding depression in sunflower. *Crop Improvement* **11**: 15-19.

Cruz, Q. and R.Dela (1986). Heterosis and combining abiity for yield and yield components in sunflower. *Philippines Journal of Crop Science* **11**: 171-174.

Dedio, W. (1992). Performance comparison of single and three-way crosses in sunflower. *Canadian Journal of Plant Science* **72**: 431-444.

Enns, H., D.G.Domell, J.A. Hocs and W.O.Chubb (1970). Sunflower research a progress report. *In: Proceedings of 4th International Sunflower Conference*. Tennessee, pp. 162-167.

Fernandez Martinez J., A.Mimenez, J. Demingoez, J.M. Garcia, R. Garces and M. Mancha (1989). Genetic analysis of high oleic acid content in cultivated sunflower (H*elianthus annuus*).*Euphtica* **41**: 39-51.

Fick, G.N. (1978). Breeding and Genetics, In: *Sunflower science and technology* (Ed) J.F. Carter. The American Society of Agronomy, Madison, USA.pp. 279-338.

Giriraj, K., N. Shivaraju and S.R. Hiremath (1986). Studies on heterosis and inbreeding depression in selected CMS combinations of sunflower. *Journal of Oilseeds Research* **3**: 67-72.

Ibrahim (1985). Studies on heterosis and path coefficient analysis in sunflower (H*elianthus annuus* L.).M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Bangalore.

Kinman, M.L. (1970). New developments in the USDA and state experiment station, sunflower breeding programme. Proceedings of Fourth International Sunflower Conference, Memphis Tennesse 181-183.

Kovacik, A. and V.Skalous (1975). The influence of inbreeding and sib crossing on the characters of productivity in sunflower (Helianthus annuus L.). In: Proceedings of 6th International Sunflower Conference, Buicharest, Romania. psp. 435-438.

Miller, J.F. (1992). Sunflower. In: Principles of cultivar development. Vol. 2 Fehr. W.R. (ed.). Macmillan Pub.Co. 626-669.

Putt, E.D. (1940). Observation on morphological characters and flowering process in sunflower (*Helianthus annuus* L.). *Scientific Agriculture* **21**: 167-169.

Putt, E.D. (1941). Investigations of breeding technique for the sunflower (*Helianthus annuus* L.). *Scientific Agriculture* **21**: 689-702.

Putt, E.D. (1966). Heterosis, combining ability and predicted synthetics from a diallel cross in sunflower (*Helianthus annuus* L.). *Canadian Journal of Plant Science* **46**: 59-67.

Reddy, P.S., M.V. Reddy, M. Lawrence and N.D.R.K. Sharma (1985). Heterobeltiosis for seed yield and oil content in sunflower (*Helianthus annuus* L.). *Indian Journal of Genetics and Plant Breeding* **45**: 166-170.

Seetharam, A. (1984). BSH-1 sunflower hybrid for stable and high yields. *Current Research* **13**: 49-50.

Seetharam, A. and A.R.Satyanarayana (1983). Method of hybrid seed production in sunflower (*Helianthus annuus* L.). I. Effect of parental ratios and methods of pollination on hybrid seed yield and its attributes. *Seed Research* **11**: 1-7.

Seetharam, A. and K.Virupakshappa (1993). Present status and future directions of sunflower breeding in India. In: National seminar on oilseeds research and development in India: Status and strategies, Extended Summaries. ISOR, DOR, Hyderabad. pp. 13-15.

Sheoran, R.K.; Chander, S. and Niwas, R. (2014) Climatic effect on oil quality and its correlation in sunflower (*Helianthus annuus* L.) "In: Cutting Edge Science and Technologies for Food, Environment and Health" Eds: R.K. Behl, A.R. Asif, and W. Merbach. Agrobios (International) pp 75-79

Sheriff, N.M., R. Appadurai and M.Rangaswamy (1985). Heterosis in varietal crosses of sunflower. *Madras Agricultural Journal* **72**: 6-8.

Shivaraju, N. (1984). Heterosis, inbreeding depression, correlation and path coefficient analysis in selected cross combinations of sunflower (*Helianthus annuus* L.). M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Bangalore.

Shrinivasa, K. (1982). Inheritance of fertility restoration and oil content in sunflower (*Helianthus annuus* L.). *Thesis Abst.,* **8**: 70-71.

Singh, S.B., K.S.Labana and D.S.Virk (1984). Heterosis in variety x inbred crosses of sunflower. *Crop Improvement* **11**: 35-38.

Skoric, D. (1977). Production of economic values of new sunflower hybrids. *Sunflower Newsletter* **1**: 5-8.

Skoric, D. (1992). Achievements and future directions of sunflower breeding. *Field Crop Research* **30**: 231-270.

Unrau, J. and W.J.White (1944). The yield and other characters of inbred lines and single crosses of sunflower. *Scientific Agriculture* **24**: 516-528.

Virupakshappa, K. (1993). Heterosis breeding in sunflower: Historical development, present status and future perspectives. In: Hybrid research and development. Pub. Indian Society of Seed Technology, IARI, New Delhi. pp. 81-91.

Virupakshappa, K. (1996). Sunflower. In: 50 years of crop science research in India (Eds: R.S.Parods and K.L.Chadha), ICAR, New Delhi .pp. 352-365.

Virupakshappa, K. (1997). Evaluation of single and three way hybrids and economics of their seed production in sunflower. In: Proc. Intn. Symp. Genetics and Exploitation of Heterosis in crops, CIMMYT, Mexico.

Vranceanu, V. (1970). Advances in sunflower breeding in Romania. In: Proceedings of 4th International Sunflower Conference (Tennesse). pp. 136-148.

Wali, M.C. (9187). Line x tester analysis of estimating combining ability in sunflower (*Helianthus annuus* L.). M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Bangalore.