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EXPLOITATION OF SUNFLOWER GERMPLASM FOR DEVELOPING NEW POPULATIONS AND HYBRIDS

H. JAYARAMAIAH, JAYARAME GOWDA, B. N. JAGADEESH, NAGARAJU AND C. HANUMANTHA RAO,
Project Co-ordinating Unit (Sunflower), University of Agricultural Sciences, GKVK, Bangalore 560 065 (Karnataka)

The genetic resources activities have been initiated at the Project Co-ordinating Unit, Bangalore through NBPGR to conserve and supply germplasm to the breeders in the country. Currently around 2000 accessions are conserved in the project. These include open pollinated populations, inbred lines, CMS lines, restorer lines, wild types/species and cytoplasm sources for male sterility. Characterization and evaluation of germplasm accessions has been done in a phased manner. Germplasm accessions of economic importance which can be used in breeding programmes are identified. Two catalogues incorporating characterization and evaluation data have been developed. Good number of populations/hybrids have been developed by different breeders in the country by using parental lines supplied from the unit. Out of these, at least 20-25 populations/hybrids are superior to already recommended hybrids. Present sunflower cultivars have a narrow genetic base. To overcome this, germplasm enhancement for broad genetic base has been initiated in two directions - i) Creation of gene pools using desirable germplasm of diverse geographic origin and ii) Utilization of selected wild species for germplasm introgression to generate wide variability.

Key words: Sunflower, genetic resources, oil content, variability, male sterile lines, gene pool introgression

Sunflower is grown for oil and protein throughout the world. It has genetic variability for adoption in variable climates. The crop is becoming popular in view of its high yield potential and short duration. Germplasm evaluation and utilisation is imperative for improving the productivity of the crop.

MATERIALS AND METHODS

The material consisted of open pollinated populations/hybrid derivatives, CMS lines, B lines, restorer lines, inbred lines, CMS sources (Table 1) which were collected from different countries through NBPGR. The total number of germplasm accessions now conserved at the unit is over 2000.

Table 1. Germplasm accessions conserved in the Project Co-ordinating Unit (Sunflower)

Germplasm types	Numbers
Open pollinated populations/ Hybrid derivatives	1363
CMS lines	43
B lines	60
Restorer lines	56
Inbred lines	232
Wild species	157
CMS sources	3
Total	1914

Over 1700 germplasm accessions were evaluated over years and seasons in a Randomised complete block design/simple lattice/Augmented

block design with two replication under rainfed/protective irrigated conditions. The rows were sown 60 cm apart with a plant to plant spacing of 30 cm. A fertilizer dose of 60:60:40 NPK kg/ha was given. Two to three seeds were sown in each hill to ascertain uniform stand of plants. Thinning was done 20 days after sowing to retain one plant per hill. Recommended crop management practices were followed during the crop growth period, except the plant protection measures in order to facilitate screening for pests and pathogens.

Characterization and evaluation was carried out for various qualitative and quantitative characters as per IBPGR (1989) descriptors for sunflower and were screened for *Alternaria*, rust and downy mildew at Bangalore and at Latur as per Nagaraju, *et al.* (1993) and Patil, *et al.* (1992). In addition to this, the accessions were also screened against temperature moisture stress based on Drought Susceptibility Index (DSI) and Temperature induction response. Two catalogues have been prepared as documents and the lines are conserved (Virupakshappa and Sindagi, 1987; Jayramaiah *et al.*, 1995).

RESULTS AND DISCUSSIONS

The accessions were evaluated for seed yield and yield components, biological yield and oil content. The range values are presented in Table 2. The range with respect to days to flowering was 46-80 days, seed yield 2.09-72.47 (g/plant), oil content 14.88-50.74, biological yield 21.82-178.25 g/plant, plant height 48.28-234.50 CMS, number of leaves 22-59, stem girth 0.99-2.79 cm, head diameter 6.75-20.69 cm, 1000 seed weight 20.40-97.00 g and oil yield per plant 1.73-15.49 g. The promising lines for specific attributes of agronomic importance are listed in the table 2 (Jayaramaiah *et al.*, 1993, 94, 95 a and b).

The accessions were also screened for moisture stress based on drought susceptibility index and temperature induction response (Table 3). Based

Table 2. Genetic resources of breeding importance in sunflower

Character	Range values	Number of accessions
Earliness (Days to flowering)	46-80	C0-1, SS-56, Morden, Acc. No. 1541, 1532, M-787-6-, 1398, M-78-6-1, 1408, 1440
Seed yield/plant (g)	2.09-72.47	Acc.No. 426,422, 439, 435, 430, 437, 129, 75, 131, 61, 88, 179, 1156, 1219, 1275, 1287, 1461, 1460, 1465, 1210, 765, 1179, 916, 1219, 692, 1134, 86, B1, BC-11,687
Oil content (%)	14.88-5074	655, 521, 657, 470, 60, SG502, 581, 87- R, RLC 4-2, 45, BLC 10-4, 15- 6, 1091, 1092, 1225, 1230, 1423, 881, 779, 1058, 901, 1013, 896 1223, 1006.
Biological yield/plant (g)	21.82-178.25	Acc.No.419, 422, 426, 434, 437, 438, 602
Plant height (cm)	48.28/234.50	No.414 (Bekees) HA 291 Acc.No.1478, 1874, N-787-9-2
Leaves/plant (Nos)	22-59	BC- 11, Acc.No.687, 690, 828, 887, 1034, 120, 1222, 1464, 1555
Stem girth (cm)	0.99-2.79	BC-11 Acc.No. 687, 690, 831, 948, 1056, 1147, 1268, 1465, 1563
Head diameter (cm)	6.75-2069	BC- 11, Acc.No.690, 828, 880, 902, 917, 948, 1134, 1268, 1384, 1469, 1563
Test weight (g) (1000 seed weight)	20.40-97.00	IB-24, 86 B3, Acc No. 916, 1179, 1031, 1217, 1219, 1366, 1464 1560
Oil yield/plant (g)	1.73-15.49	BC-11, 89-B, Acc.No. 687, 765, 828, 873, 1134, 1268, 1366, 1402

on DSI values both for seed yield and Total Dry Matter (TDM). EC-68414 was considered to be drought tolerant both under early as well as late stress. The other promising types are EC-68415 and MSFH-17.

Table 3. Drought susceptibility index of the genotypes based on filled seed weight and TDM under early and late stress conditions

Genotypes Acc. No.	Drought susceptibility index			
	Seed yield		TDM	
	Early Stress	Late Stress	Early Stress	Late Stress
BSH-1	1.22	1.21	1.06	0.99
66	1.23	1.38	1.17	1.51
88	1.00	1.03	1.09	0.84
179	0.93	1.14	1.12	1.86
217	1.04	0.21	0.94	0.26
226	0.98	1.20	1.08	1.21
266	1.34	1.24	1.31	1.21
275	0.42	0.00	0.88	0.74
314	1.38	1.69	1.39	1.74
333	1.63	1.67	1.27	1.60
418	1.22	1.43	1.21	0.90
430	0.75	0.67	0.97	0.44
436	0.48	1.13	0.45	1.19
438	0.44	0.90	0.83	0.28
kbsh-1	1.19	1.75	0.95	1.00
872	1.27	1.50	1.33	1.24
154	0.65	1.07	0.79	1.37
37	1.37	1.12	1.29	1.26
EC-68415	0.68	0.35	0.97	1.24
MSFH-8	0.89	1.25	0.80	1.34
Morden	1.35	0.94	0.85	0.70
MSFH-17	0.77	0.86	0.68	0.37
EC-68414	0.72	0.30	0.71	0.38
198	1.02	1.76	0.83	1.16
Drought intensity	0.53	0.42	0.56	0.34

Screening for resistance to different diseases like *Alternaria* leaf spot, downy mildew was carried out and resistant/tolerant lines are listed in Table 4. The promising accession numbers are 5, 7, 14, 284, 353, 832, 886, 889, 1015, 1430, 1440, 1667, 1858, CMS 89 A, 234 B, 341 B, 850 B, RHA 334, 356, 83 R6, 6D-1 (Nagaraju *et al.* 1983, 97).

Table 4. Sunflower germplasm lines resistant/ tolerant to different diseases

Alternaria leaf spot
Acc. Nos. 5, 7, 14, 25, 28, 32, 33, 35, 38, 42, 43, 53, 90, 93, 109, 111, 118, 120, 129, 131, 133, 143, 145, 146, 147, 149, 150, 151, 167, 173, 175, 179, 180, 194, 208, 16, 223, 230, 241, 244, 251, 256, 284, 35, 323, 333, 338, 339, 340, 342, 343, 344, 347, 348, 351, 353, 358, 361, 364, 367, 373, 389, 391, 393, 400, 410, 3423, 426, 430, 431, 438, 444, 446, 450, 451, 456, 690, 702, 765, 776, 785, 798, 810, 829, 832, 848, 860, 873, 875, 880, 881, 886, 887, 889, 892, 901, 905, 912, 914, 916, 918, 931, 1015, 1020, 1029, 1039, 1040, 1052, 1054, 1136, 1139, 1143, 1149, 1153, 1168, 1171, 1174, 1184, 1222, 1223, 1229, 1286, 1381, 1385, 13561391, 1401, 1440, 1424, 1425, 142, 9, 1430, 1431, 1434, 1441, 1442, 1445, 1447, 1467, 1473, 1474, 1483, 1484, 1485, 1589, 1491, 1497, 1510, 1542, 1548, 1559, 1562, 1565, 1581, 1591, 1626, 1631, 1635, 1667, 1717, 1858, 1878, 1888, CMS86A, 86A3, 232A, 291A.300A, 303A, 336A, 341A, 343A, 361A, 597A, 696A, 821A, 822A, 850A, 851A, 62B, 86B, 89B, 219B, 234B, 290B, 302B, 335B, 337B, 341B, 343B, 400N, 850B, 852B, RHA334, 292, 272, 274, 83R6, 3376R, 6D-1
Rust
Acc. Nos. 5, 7, 28, 31, 32, 33, 38, 42, 90, 99, 109, 111, 120, 146, 147, 149, 150, 173, 178, 210, 216, 393, 423, 430, 430, 431, 438, 444, 451, 471, 485, 518, 659, 702, 715, 776, 780, 785, 786, 788, 810, 825, 832, 841, 847, 860, 884, 889, 897, 901, 931, 1009, 1020, 1031, 1052, 1053, 1055, 1058, 1059, 1157, 1167, 1168, 1197, 1215, 1225, 1229, 1232, 1251, 1381, 1440, 1442, 1456, 1473, 1474, 1485, 1489, 1491, 1497, 1500, 1510, 1562, 1626, 1667, 1717, 1858, 1878, CMS 89A, 207B, 234B, 341B, 351B, 850B, RHA 356
Downy mildew
Acc.Nos. 241, 470, 536, 842, 846, 882, 888, 931, 1234, RHA 278, 334, 344, 345, 346, MRHA-1, MRHA-2

Issues noticed in the crop

1. Lack of self fertility
2. Less productivity in seed and oil yield

3. High quality oil and protein type
4. Lack of sufficient breeding materials
5. Narrow genetic base
6. Lines for better biotic and abiotic stress
7. Non utilisation of wild species
8. Identification of good lines for confectionery purpose

Future strategies and action plan

Based on the evaluation strategies an action plan has been initiated on the issues noticed in the crop through utilisation and enhancement of the available germplasm lines.

a) Generating new breeding materials/gene pools

Promising germplasm lines were identified after thorough evaluation and were used to generate new breeding material for breeders. Two gene pools - B and R line composites were generated using promising maintainer and restorer lines respectively. These include lines with high oil content, high self fertility, seed yield and resistance to diseases. The gene pools have been supplied to breeders for developing superior parental lines to be used in heterosis breeding.

b) Development of inbred lines

Inbreeding is in progress to develop inbred lines using the base population, B-line gene pool, R-line gene pool, AEC-68414, EC-68415 and Morden. Based on the quantitative data the promising progenies were advanced by selfing.

c) Development of high olieic acid, high protein and early maturing hybrids

High oleic acid types were identified and crosses were effected to develop high oleic acid hybrid and early maturing hybrids. Four hybrids with oleic acid content, two hybrids for earliness and yield have been identified. (Shekar *et al.*, 1998).

d) Diversification of CMS source:

Only one CMS source (derived from *Helianthus petiolaries* by leclerque) is being used at present in the hybrid development programme carried over use of single cytoplasm result in genetic vulnerability of the hybrids to biotic and abiotic stress. Keeping this in view, research work on diversification of CMS sources have been initiated. Out of six new CMS sources, two new CMS sources - CMS-PF (*H. petiolaris* fallex) and CMS-I (*H. lenticularis*) are being used in this programme. Maintainer and restorer lines have been identified for these sources. The promising maintainer lines have been back crossed to develop lines in the new CMS background for their use in hybrid development programme in future. Using new CMS lines hybrids have been synthesised and are being evaluated.

e) Germplasm enhancement

Currently grown sunflower entries have a narrow genetic base. It is therefore imperative to generate new breeding material having a broad genetic base. The two approaches for germplasm enhancement are (i) creation of gene pools using desirable germplasm of diverse geographic origin for high oleic acid, high self fertility, resistance to pests and diseases, drought tolerance, earliness and other related desirable attributes. Later on developing inbred lines evaluating for GCA, lines into CMS and restorer lines and developing new CMS sources for obtaining better hybrids. (ii) Utilisation of selected wild species for germplasm interogression to generate wide variability - even though this is a long time process sufficient attention has not been diverted in this direction. There is good amount of genetic variability available among wild species especially for resistance to diseases, good agronomic characters, yield, oil, protein, oleic acid content, confectionary and the like. Wild species which could be used in breeding for improvement of different attributes (Seiler, 1992) are presented in Table 5.

Table 5. Potential wild species usefull for different attributes

Sl.No.	Species	Attributes
1.	*Helianthus annuus*	Rust, downy mildew, wilt, brown canker, oleic acid
2.	*H. petiolaris*	Rust, Wilt
3.	*H. praecox* spp. *runvonii*	Rust, Oleic acid
4.	*H. praecox* ssp. *hirsutus*	Rust, downy mildew
5.	*H. argophyllus*	Rust, downy mildew, brown canker, oleic acid, leaf area duration, drought resistant, self incompatibility
6.	*H. grosseserratus*	Downy mildew, wilt
7.	*H. maxximiliani*	Downy mildew, protein, leaf area duration, lowest molecular weight, rubber
8.	*H. nuttallii*	Downy mildew, rust, protein
9.	*H.tuberosus*	Downy mildew, Alternaria, wilt, brown canker, head, starch, sugar, protein & mineral
10.	*H. tementosus*	Wilt
11.	*H. pauciflorus*	Alternaria, wilt, head
12.	*H.niveus* ssp. *canesceus*	Oil (anual and Perrnia)
13.	*H.anomalus*	Oil
14.	*H.petiolaris* ssp. *fallax*	Oil
15.	*H.porteri*	Linolenic acid, protein
16.	*H.debilis cucumerifolius*	Oleic acid
17.	*H.atrorubens*	Wilt,oleic acid, protein
18.	*H.paradoxus*	Protein, salinity
19.	*H.silphioides*	Wilt, Powdery mildew, oleic acid, protein
20.	*H.hirsutus*	Alternaria, powdery mildew, oleic acid
21.	*H.calitronicus*	Powdery mildew
22.	*H.divaricatus*	Head rot
23.	*H.mollis*	Leaf area duration, population/unit area
24.	*Hsalicifolius*	Leaf area duration, oil
25.	*H.radula*	Leaf area duration, rubber
26.	*H.deserticola*	Drought resistant

Table 6. Varieties and hybrids recommended for different states

Sl.No.	Variety/ Hybrid	Year of release	State for which recommended	Remarks
A. VARIETIES				
1.	EC 68414	1972	All India	Suitable also for late sowing
2.	EC-68415	1972	Karnataka	Prone for lodging under high fertility conditions
3.	Morden	1979	All India	Suitable for multiple and mixed cropping systems
4.	Surya	1983	Maharashtra	Striped seed
5.	CO-1	1983	Tamilnadu	Closer spacing of 20 cm × 15 cm to be followed,short duration
6.	CO-2	1986	Tamilnadu	Medium duration
7.	SS-56	1988	Maharashtra	Short duration
8.	GAU SUF-15	1994	Gujarat	Medium duration,tall type
9.	PKVSF-9	1995	Maharashtra	Vidarbha area of Maharashtra
10.	TNAU SUF-7	1996	Tamilnadu	Medium duration
11.	LS-11	1998	Maharashtra	Variety from Latur
B. HYBRIDS				
1.	BSH-1	1980	Karnataka	Resistant to rust and tolerant to Alternaria leaf spot

(*Cont. on next page*)

2.	APSH-11	1987	Andhra Pradesh	Medium duration
3.	LDMRSH-1	1988	Maharashtra	Resistant to downy mildew
4.	LDMRSH-3	1988	Maharashtra	Resistant to downy mildew
5.	KBSH-1	1992	All India	High yielding and high oil content hybrid with wide adaptability
6.	PSFH-67	1993	Punjab	Suitable for spring season
7.	PKVSH-27	1995	Maharashtra	Drought resistant
8.	DSH-1	1998	Karnataka	Recommended for North Karnataka

Hybrids MSFH-1, 8,17, PAC-3425, Advance, SH-3322, PAC-9128, PAC- 8699, PAC-36, PAC-308, Jwalamukhi, Sungene-85, PAC-1091 have been recommended for cultivation from the private sector.

f) Purification of parental lines diagnostic characters of male sterile and restorer lines

The diagnostic characteristics of the parental lines of the hybrids are essential in seed certification for maintenance of genetic purity of the lines to produce high quality seeds. The details of seed production technology has also been developed (Jayaramaiah, 1997).

g) Germplasm supply and accomplishments

Priority has been laid to supply germplasm material to various scientists in the country. Nearly 4000 to 5000 seed samples of different accessions and gene pools, derived materials have been supplied to different indentors. By using these lines supplied by the centre, a number of hybrids and populations have been developed at different locations in the country. Some of the varieties and hybrids released for cultivation are presented in Table 6. In addition 1000 hybrids are in testing stages, whereas 20-30 hybrids are significantly superior to the available commercial hybrids. They are PCSP-47, PCSH-21, PCSH-23 from Project Co-ordinating Unit, Bangalore, KBSH-35, 39, 40, 41, 42 from AICRPO Bangalore, DSH-102 from Dharwad, LSFH-115, 12 from Latur, PSFH-10, 118, 125, 95, 226 from Ludhiana, HSFH-795, HSFH- 792 from Hissar. In addition to this many Private hybrids are also in offing (Jayaramaiah, 1998).

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