Variability Studies in Sunflower Lines Derived through Interspecific Hybridization

GS Mohan[1] and A Seetharam[2*]

[1] *Department of Genetics and Plant Breeding, University of Agricultural Sciences, GKVK, Bangalore-560 065, Karnataka*

[2] *All India Coordinated Crop Improvement Project (Small Millets), University of Agricultural Sciences, GKVK, Bangalore-560 065, Karnataka*

Variability and *per se* performance of 137 interspecific derived sunflower lines along with seven known cultivated sunflower accessions was assessed during the study. Considerable variation for several important agronomic attributes was seen in the interspecific derived lines. High values of phenotypic and genotypic coefficient of variability, and high heritability with high genetic advance were observed for seed yield/plant, oil yield/plant, plant height, head diameter, oil content and test weight indicating the scope for utilization in crop improvement. The study could identify a few superior seed and oil yielding lines with comparable *Alternaria* leaf spot tolerance to the best check.

Key Words: Coefficient of variability, Interspecific hybridization, *Per se* performance

Utilization of related wild species is one of the effective means of introducing new variability to cultivated sunflower. The genus *Helianthus* consists of a large number of wild relatives with 49 species and 19 subspecies. The species show wide variability to many agronomic characters, insect and disease resistance and seed quality factors (Seiler, 1992). Many successful attempts harnessing the variability in wild sunflowers have been recorded. For instance, they have been exploited for obtaining the male sterility and restorer genes into cultivated sunflower. (Leclerq, 1969; Kinman, 1970). More than 55 CMS lines including the extensively utilized male sterile source (introgressed from *Helianthus petiolaris*) in commercial breeding programmes are obtained through interspecific hybridization (Serieys, 1999).

The contribution of wild species in disease and pest resistance breeding has been enormous. Resistant lines to important diseases such as downey mildew, charcoal rot, rust, broomrape, sclerotinia wilt, *Alternaria* leaf spot and pests such as sunflower moth have been developed through interspecific hybridization. Moreover, interspecific hybridization is also employed for transferring the abiotic stress resistance (drought tolerance from *H. argophyllus*; Seiler 1999), yield and oil quality attributes. In the context of their importance, it is imperative that the interspecific derived lines be evaluated for the variability and *per se* performance in order to utilize them in the ongoing breeding programs. This exercise would also help in assessing the efficiency of current methods employed (prebreeding efforts) to derive the interspeicific lines and modifications in prebreeding efforts that needs to be explored.

Material and Methods

The experiment was conducted at the University of Agricultural Sciences, Bangalore and the material comprised 144 accessions that included 137 advanced lines derived from interspecific crosses involving 5 wild species and seven other known sunflower lines as checks for comparison (Table 1). The interspecific lines were either derived by crossing the wild species as females to the cultivated sunflower variety or using available cytoplasmic male sterile lines crossed to a male wild species. The interspecific hybrid was subsequently backcrossed to the cultivated sunflower for four generations. In each backcross generation, the plants with desirable phenotypes were selected within the family rows, discarding branched and pigmented plants. From BC_4F_1 generation, the desirable phenotypes were sibbed and the seeds were bulked. This is continued till BC_4F_4 and the plants were further maintained by sib pollination. In each wild species, only one representative accession of the species was utilized for crossing program.

The lines were sown with the spacing of 60 cm between rows and 30 cm with in a row in 12 x 12 Simple Lattice design in two replications. Each replication consisted of 12 blocks and with in each block 12 lines were sown. The replications, blocks and the lines with in a block were randomized. Each line having 12 plants was grown in a row of 3.6 meters. Two seeds were dibbled in each hill

* *Correspondence: Dr. A Seetharam, Emeritus Professor, AICRP (Small Millets), University of Agricultural Sciences, GKVK, Bangalore-560 065, Karnataka. Telefax: 091 80 23332387 Email: annadanasram@rediffmail.com*

Table 1. Details of pedigree of interspecific derived lines and checks

Pedigree	Generation	No. of cultures	Line no.
Interspecific derived lines			
H. argophyllus X *H. annuus* cv. Morden	BC_4F_4	36	1 to 35,127
H.petiolaris X *H. annuus* cv. Morden	BC_4F_4	34	36 to 65,128 to 130,137
H.annuus (wild) X *H. annuus* cv. Morden	BC_3F_5	18	66 to 80,131 to 132,136
(*H.argophyllus* X *H.annuus*(wild)) X *H. annuus* cv. Morden	BC_3F_4	30	81 to 107,133 to 135
H. annuus cv. CMS234A X *H.debilis*	BC_4F_4	19	108 to 126

Checks	Description
Morden	Open pollinated variety
PAC1091	Three way cross hybrid
KBSH-1	Single cross hybrid
HA 6D-1	Promising restorer line
HA 265	Restorer line
HA 234	Promising inbred
HA 336	Promising inbred

Wild Speices	Source of Important Tratis
H. argophyllus	Resistance to Downy mildew, Rust, *Sclerotinia* wilt
	CMS and fertility restoration, drought tolerance, self compatibility, oil content, Fatty acid composition
H. petiolaris	Resistance to rust, CMS source
H. annus (wild)	Resistance to Downy mildew, rust, *Verticillium* wilt, CMS source, Fertility restoration, Fatty acid composition
H. debilis	Salt tolerance and Fatty acid composition, Ornamental value

to facilitate better emergence and to provide uniform plant stand. The recommended manurial dosage was applied. Thinning was attended on 15th day after sowing to retain one plant per hill. The plants were grown under protective irrigation. All the recommended agronomic practices were followed to facilitate good growth and to raise a successful crop. From each line in each replication 5 competitive plants were tagged at random. Except days to 50 percent flowering, all other observations on quantitative characters were recorded at maturity. Variability and *per se* performance assessment were carried out utilizing these observations. Characterization of accessions based on limited qualitative characters was also attempted.

Results and Discussion

1. Variability

The analysis of variance for 17 characters indicated highly significant differences among the lines. Considerable variation for each character was evident from the wide range thus providing large scope in selecting superior material for use in breeding programs (Table 2). High values (>20%) of Phenotypic and Genotypic Coefficient of Variability (PCV and GCV) were observed for percent autogamy, seed yield/plant, oil yield /plant, plant height, head diameter, number of leaves/plant, number of leaves in upper 1/3rd plant, oil content and test weight. Low GCV and moderate PCV was observed for days to 50 per cent flowering, Percent Disease Index (*Alternaria*), hull content and both low GCV and PCV for days to maturity. Low GCV for *Alternaria* leaf spot was obvious as the lines employed in the study are derived from diploid annual species that are generally susceptible to *Alternaria.* Low GCV for days to 50 per cent flowering and days to maturity indicated limited variability in the material evaluated. However, many interspecific lines showed distinct earliness compared to checks and could form useful material.

High heritability estimates (>60%) were obtained for all characters except percent autogamy, *Alternaria* severity, number of leaves/plant, hull content and seed width. High heritability with high genetic advance (>20%) was observed for characters such as seed yield/plant, oil yield/plant, plant height, stem girth, head diameter, mean number of leaves in upper 1/3rd plant, volume weight, oil content and test weight. None of the characters showed high heritability with low genetic advance.

2. Per se Performance of Interspecific Lines

Comparative performance of interspecific derived lines and checks evaluated in the study is given in the Table 3. Lines 10 and 106 showed superiority even over the hybrid check PAC 1091 for many characters and could be useful genetic stocks. The lines 77, 88 and 5 possessed early maturity. It was observed that the upper limit for oil content in interspecific derived lines was generally less

Table 2. Descriptive statistics of different characters in 144 lines of sunflower

Characters	Min	Max	Mean	SEm(±)	GCV	PCV	h^2(BS)	GA (Percent of mean)
Days to 50 percent flowering	47.80	79.82	57.14	0.44	8.90	9.66	84.78	16.88
Plant height (cm)	52.36	204.88	97.53	2.05	24.44	25.89	89.17	47.55
Stem girth (cm)	0.86	2.77	1.56	0.03	18.13	22.21	66.67	30.50
Head diameter (cm)	4.79	20.54	11.53	0.24	24.20	26.67	82.34	45.23
Days to maturity	67.66	106.48	83.71	0.52	7.21	7.69	87.87	13.92
Alternaria incidence (Percent Disease Index)	48.28	86.50	69.33	0.54	7.67	10.65	51.82	11.37
Mean number of leaves/plant	2.90	25.50	10.79	0.30	27.81	37.19	55.91	42.84
Number of leaves in upper 1/3rd plant	2.73	11.87	5.48	0.12	23.58	29.93	62.08	38.28
Volume weight(g)	16.36	42.69	27.86	0.38	15.43	17.36	79.00	28.25
Hull content (%)	21.30	56.19	33.32	0.43	8.90	19.98	19.85	8.16
Seed length(cm)	0.60	1.25	0.90	0.01	10.24	11.92	73.91	18.14
Seed width(cm)	0.35	0.65	0.46	0.01	11.91	15.37	60.00	19.00
Oil content (%)	11.40	46.20	24.84	0.55	25.43	28.02	82.40	45.41
Test weight (g)	1.57	7.22	3.50	0.09	28.90	32.54	78.87	52.87
Percent autogamy	0.12	93.11	14.72	0.04	38.63	50.99	58.82	3.51
Seed yield /plant(g)	0.16	55.09	10.92	0.78	79.97	90.68	77.77	145.28
Oil yield/plant (g)	0.03	24.83	3.08	0.31	81.58	92.60	81.89	211.88

though range was considerably large. Only two lines (line 10 and 106) were found to be superior to the best check. There was not much improvement for oil content in the interspecific derived lines due to higher number of backcrosses and relatively low oil content of the recurrent parent Morden (23.40 %) which might have restricted the improvement that would otherwise be possible. So it would be prudent to use recurrent parent with high oil content in interspecific hybridization studies.

The lines were also screened for two important diseases of sunflower namely *Alternaria* leaf spot and rust, and the major pest *Heliothis*. However, none of the lines showed less severity of *Alternaria* compared to best check PAC 1091 or KBSH-1. On the other hand, all the interspecific derived lines showed higher tolerance to rust disease. As far as *Heliothis* incidence was concerned, two lines 86 and 87 were having high mean larval load/plant and seemed relatively more susceptible to *Heliothis*.

The interspecific derived lines were scored for six distinguishable qualitative characters such as head inclination, head shape, leaf size, pigmentation, plant type and seed color following IPGRI sunflower descriptor (Table 4). For head inclination, majority of the lines (90) had the most desirable 135° angle and for head shape, majority of the lines (94) had the desirable convex shape head. Intense purple plant pigmentation is not a preferred character in sunflower and with regard to plant type, erect types are preferred over druping ones. The absence of pigmentation was observed in 131 lines and 100 lines with erect plant type were observed in the study.

Conclusions

The magnitude of heritability and genetic advance would influence the effectiveness of selection in breeding programs. It was evident that the two most important characters viz., seed yield and oil yield along with oil content showed high heritability and genetic advance indicating that selection would be effective and the improvement is possible in the interspecific derived lines. Further there is ample scope for selection, as exemplified by high phenotypic and genotypic coefficient of variation. Though many superior lines were identified in the study, for economic traits such as seed yield, oil yield and oil content only one or two lines were superior and few other lines were on par with the best checks. Manjula and Seetharam (2000) evaluated 32 lines (BC_3F_2) derived from the interspecific cross *Helianthus annuus* var. Morden x *Helianthus argophyllus* and observed low to moderate performance for agronomic traits.

While attempting introgression of genes from wild gene pool, one has to resort to backcrossing with the recurrent parent (cultivated species) in order to retrieve the desirable agronomic background. While doing so, one may fail to optimize the blending of genes from wild and

Table 3. Interspecific derived lines identified superior to best checks in hybrids and population / inbreds

Character	Best check		Superior Lines				
	Hybrid	Population/ inbred					
Percent autogamy (+)	PAC1091	R265	70	98	34	127	
	60.2	*91.9*	*91.9*	*85.6*	*83.6*	*81.5*	
Days to maturity (-)	KBSH-1	Morden	77	88	5	105	2
	92	*78*	*68*	*69*	*70*	*71*	*71*
Days to 50 per cent flowering (-)	KBSH-1	Morden	88	77			
	62	*49*	*48*	*48*			
Plant height (cm) (-)	KBSH-1	Morden	77	85	84	88	89
	160.4	*76.8*	*52.4*	*57.5*	*58.1*	*61.2*	*62.0*
Volume weight (g) (+)	KBSH-1	336B	106	10			
	37.8	*37.5*	*42.7*	*42.3*			
Percent hull content (-)	PAC 1091	6D-1	24				
	27.5	*22.50*	*21.3*				
Test weight (g) (+)	PAC1091	Morden	10	45	106	79	
	5.4	*5.2*	*7.2*	*6.3*	*6.2*	*6.1*	
Percent oil content (+)	PAC1091	336B	10	106			
	41.4	*41.1*	*46.2*	*42.1*			
Oil yield/plant (g) (+)	PAC1091	Morden	10	106	130		
	22.7	*4.8*	*24.8*	*17.7*	*15.7*		
Seed Yield/plant (g) (+)	PAC1091	Morden	10	130	106	40	128
	55.1	*18.9*	*53.3*	*43.0*	*42.6*	*31.5*	*27.2*

Values in italics are the actual figures for that character ; + and - indicate the desirable direction of the character

Table 4. Qualitative grouping of 144 lines

Character	Category	# of lines
Head inclination		
	90°	20
	135°	92
	180°	32
Head shape.(Grain side)		
	Concave	4
	Flat	52
	Convex	85
	Highly convex	3
Leaf size		
	Small	2
	Medium	139
	Large	3
Pigmentation		
	Stem, petiole and disc pigmentation	4
	Petiole pigmented	9
	Green	131
Plant type		
	Errect	100
	Non errect	44
Seed colour		
	Grey	12
	Brown	10
	Black	122

cultivated groups leading to greater tilt towards cultivated forms. As a result, the value of interspecific derived lines by way of providing additional advantages in breeding research is reduced. Restricting to BC_1 generation for selecting the superior introgressions and intercrossing amongst them would result in lines with higher heterogeneity and *per se performance.*

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