with moderate to low self compatibility may be enhanced when compared with highly self compatible cultivars. Cross pollination by insect pollinators would be favoured in cultivars with moderate to low self compatibility whereas cross pollination would be less likely in a highly self compatible cultivar. The possibility may exist for the yield of commercial crops to be increased by sowing two cultivars with similar maturity but of moderate to low self compatibility rather that one cultivar.

The contribution made by the maternal genotype to heterosis is well established. The study shows that the pollen genotype can make a significant contribution to reproductive heterosis in some traits, particularly oil content per seed.

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T1982GENTS

GENETIC EFFECTS OF DAYS TO FLOWERING IN SUNFLOWER (HELIANTHUS ANNUUS L.) UNDER SHORT DAY REGIME.

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ABSTRACT
Four genotypes of sunflower, Helianthus annuus L., with diverse flowering dates were crossed in a partial diallel. These four parental lines, F2 progeny, F2 progeny from reciprocal crosses, and backcross F1 progeny of these crosses were planted in a randomized complete block design at Molokai, Hawaii, the winter of 1981. The number of days were recorded from the time sunflowers were planted to when 50 percent were in flower. Genetic effects were estimated. Additive effects were statistically significant while dominance, epistasis, and reciprocal effects were all nonsignificant. Estimated heritability coefficient of 39.8 percent was determined indicating moderate success in selecting for different flowering dates.

INTRODUCTION
Information concerning the inheritance of the number of days from planting to flowering in sunflower, Helianthus annuus L., is limited and somewhat conflicting. Unrau (1947) and Putt (1965) reported overdominance in F1 progeny of certain crosses where the F1 progeny flowered earlier than either parent. Kovacik and Skaloud (1978) reported different genetic effects when they divided the period from planting to flowering into two phases: 1) from planting until 'head setting' (presumably budding), and 2) between head setting and florescence (bud to flowering). They found additive genetic effects predominating in phase one and dominant effects predominating in phase two Fick (1978) reported isolated lines from the cultivar 'Volgar' which segregated for early and late flowering plants with early flowering conditioned by a single recessive gene.

Reported estimates of heritability for days to flowering have been quite high. Shabana (1974) reported broad sense heritability of 97.7% and Russell (1953) reported heritability estimated by correlation coefficients of 0.86 and 0.91 between days to flowering of certain inbred lines and their top cross progeny.

This is a preliminary report of a study to define genetic effects and inheritance of days to flowering and of photoperiod on flowering for certain sunflower parental lines and segregating progeny from diallel crosses.

MATERIALS AND METHODS

Four sunflower cultivars with diverse number of days from planting to flowering were crossed in a partial diallel. Two of these cultivars, Corona (early flowering, day-length neutral) and Guayacan (late flowering, day-length neutral) are open-pollinated.

The other two cultivars, HA 89 (mid-flowering, long day responding) and HA 124 (mid-flowering, day-length neutral), are inbred. F_2 progeny, F_2 progeny from reciprocal crosses and backcross, F_1 progeny from these crosses were planted in a randomized complete block design with two replications at Molokai, Hawaii, the winter of 1981. Day-length was approximately 12 hours during the period from planting to flowering at this location. The days from planting to 50 percent flowering were recorded for each plant.

Additive, heterozygous, dominant, and reciprocal effects were estimated using Gardner and Eberhart's analysis one (Gardener and Eberhart, 1966). The following equations define these effects:

$P_I = \mu + a$

$P_{op} = \mu + a + d$

$F_2 = \mu + 1/2 \ (ax + ay) + 1/4 \ (dx + dy) + 1/2 \ h_{xy} + R_{xy}$

$BC1 = \mu + 3/4 \ ax + 1/4 \ ay + 3/8 \ (dx + dy) + 1/4 \ h_{xy} + R_{xy}$

where P_I = inbred parents; P_{op} = open pollinated parents; μ

= mean; a = effects due to homozygous loci (additive effects); d = effects due to heterozygous loci; h = effects due dominance; R = reciprocal effects; F_2 = F_2 progeny; BC1 = backcross F_1 progeny; and x = P_1; and Y = P_2.

The heritability coefficient was estimated using the following relationships (Allard, 1964; Vranceanu et al. 1978).

$$H = \frac{(G^2 + G^2) - G^2}{\frac{G \ \ \ E \ \ \ E}{\frac{G^2 + G^2}{G \ \ \ E}}}$$

where variance among F_2 progeny of crosses of inbred parental lines = $\frac{G^2 + G^2}{G \ \ \ E}$ and variance among plants from

an inbred line = $\frac{G^2}{E}$.

RESULTS AND DISCUSSION

With few exceptions, the average number of days to flowering of segregating progeny were intermediate to their parents (Table 1). The F_2 progeny of Corona /HA124 and the BC1 progeny of Corona/2*HA124 had mean flowering dates later than either parent but not significantly so. The reciprocal of this cross had F_2 and BC1 progeny with mean flowering dates intermediate to the parents. The F_2 progeny of the cross HA124/HA89 had an earlier flowering date, but not significantly different than the early parent.

Table 1. Mean days to flowering for sunflower parental lines, F_2 and backcross F_1 progeny, Molokai, Hawaii, 1981.

male or recurrent parents

female parents	Corona		HA89		HA184		Guayacan	
	Gen[1/]	X	Gen	X	Gen	X	Gen	X
Corona	P_{op}	54.3	F_2	59.4	F_2	61.8	F_2	70.6
			BC1	73.4	BC1	63.4	BC1	68.6
HA89	F_2	64.2	P_1	78.4	F_2	65.2	F_2	72.6
					BC1	61.2	BC1	78.2
HA124	F_2	53.2	F_2	56.0	P_1	58.0		
	BC1	54.6	BC1	63.8				
Guayacan							P_{op}	76.0

CV 7.9%

lsd (P = .01) = 6.4

[1/] Gen = generation

HA89 showed the effects of the short photoperiod and did not flower until an average of 78.4 days after planting (Table 1). This was later than the flowering date of Guayacan. HA124 and Corona flowered within five days of one another under these conditions. Under long-day conditions at Fargo, Corona flowered about 10 days earlier than HA89 and HA124. Guayacan flowered about 10 days later than these two inbreds (Roath, unpublished data).

Short-day responding sunflower have been reported (Dyer et al., 1959); however, we have not been able to identify any specific cultivars with this character. Kinman [3/] (personal communication) identified HA124 as a possible short-day responding cultivar. We classified HA124 as mid-flowering, day-neutral from data obtained in nurseries at Fargo, ND,

and Homestead, FL, (Roath, unpublished data). HA124 at Molokai flowered relatively early (Table 1). We suspect that these conflicting data can be attributed to temperature, with Hawaii being considerably warmer during the flowering initiation period than southern Florida.

Estimates of genetic effects from these parent lines and their F_2 and BC1 progeny indicated that additive gene effects were predominant. All other effects were not statistically significant (Table 2). A heritability coefficient of 39.8 percent was calculated.

[3/] M.L. Kinman, Research Geneticist, ARS, USDA, Texas A.M. University, retired.

Table 2. Mean squares of genetic effects of segregating progeny from crosses of selected sunflower parental lines, Molokai, Hawaii, 1981.

Effects	DF	MS	F
additive (a)	3	296.529	14.388*
heterozygous loci (h)	2	0.160	0.007
dominant (d)	5	25.082	1.090
reciprocal (r)	5	25.700	1.414

* Significant at the 5% level of probability.

Fick attributed the differing results of various attempts to define genetic effects of flowering date to the different parental lines involved (3), and our results support this explanation.

These results suggest that selection for early flowering sunflower lines under short-day conditions would be at least moderately successful. The degree of success would depend on the specific selection of parental lines. Selection for moderate — to late —flowering lines could be more difficult, particularly if one or more of the parental lines responded to long-day photoperiod.

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EPISTATIC GENE ACTION IN SUNFLOWER — A CAUTION TO SUNFLOWER GENETICISTS AND BREEDERS.

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ABSTRACT

The three epistatic types of gene action viz., additive x additive (i), additive x dominance (j) and dominance x dominance (1) are usually involved to a lesser extent than the additive (d) and dominance (h) types of gene action in the inheritance of quantitative characters. But, an investigation into the genetics of 12 quantative characters in sunflower involving seed yield, its components and vegetative characters, by a 10 x 10 diallel analysis (Hayman, 1954) and six generation mean analysis (Jinks and Jones, 1958) of 25 crosses revealed a different trend. For all the characters, the former method indicated epistasis while the latter showed '1' as the most important type of gene action. Though 'h' was next in the order of merit, the other two epistatic components 'i' and 'j' were observed to have been involved to a greater extent than 'd' for seven to eight characters. Thus, it appears safer for the geneticists and breeders meddling with sunflower to make room for epistasis in planning their experiments.

dominance types of gene action in quantitative genetics and consequently the diallel analysis should usually work. This investigation was hence planned to know the applicability of diallel analysis to sunflower. In planning so, care was taken to carry the material forward to further generations to estimate epistasis, in case the diallel analysis were to reveal such a type of gene action.

INTRODUCTION

Even a cursory glance at the sunflower literature reveals a strange fact that though the progress in sunflower breeding has been satisfactory, there is not much information accumulated on the genetics of the crop. There is thus, need in sunflower, for methods of genetic analysis that would provide ample information on genetics in a minimum time possible, so that, any breeding programme could be given a proper orientation in the initial stages itself depending on the genetic architecture of the base material. Diallel analysis which requires only parents and their all possible F_1s is one such method. But it works only under certain assumptions with regard to the genetic constitution of the material under study; one of the important assumptions being 'absence of epistatic gene action'. Theoretically speaking (Falconer, 1975) epistasis is not much involved in comparison with additive and

MATERIALS AND METHODS

Ten inbred lines with wide genetic diversity were crossed in all possible combinations to get the 45 F_1s. For 25 of these 45 F_1s, seeds for the F_2, B_1 and B_2 generations were also obtained by selfing and back crossing. These 25 crosses involved all the ten parents. This experimental material was grown in a randomized block design with three replications.

Observations were recorded on twelve characters viz., number of leaves, leaf length, leaf breadth, petiole length, stem girth, plant height, head diameter, head weight (dry), number of seeds per head, hundred seed weight, seed yield and S/H estimate (proportion of seed yield to head weight) on five randomly selected plants in case of parents and F_1s and on all the plants in case of F_2s, B_1s and B_2s. Measurements of the leaf length, leaf breadth and petiole length were to be recorded after blooming so as to allow maximum growth of the leaves. By then, most of the lower leaves were dried up, hence seventh leaf from the top which had not yet dried in any of the plants was used for recording these three observations.

Analysis of variance (ANOVA) was carried out by the method of Panse and Sukhatme (1961) while the method of Hayman (1954) was followed for diallel analysis. The components of means using the data from six generations i.e., Parent 1 (P_1) Parent 2 (P_2), F_1, F_2, B_1 and B_2 of 25 crosses were estimated by the generation mean method of Jinks and Jones (1958) and Hayman (1958).