VARIATION IN AGRONOMIC AND MORPHOLOGICAL CHARACTERISTICS OF SEVERAL POPULATIONS OF WILD ANNUAL SUNFLOWER (*HELIANTHUS ANNUUS* L.)

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INTRODUCTION

Wild annual sunflower (*Helianthus annuus* L.) is the most widely distributed species in the genus *Helianthus*, and it is extremely variable for several agronomic and morphological characteristics. Each population has a potential for contributing germoplasm that is uniquely different from others. Plants from different populations are frequently variable for many characteristics, but the sources of the variation (genetic or environmental) may not be known. One way to obtain information on the origin of morphological variations is by growing a number of populations at a common location (environment) and by determining if there are significant differences among the populations.

Wild annual sunflower grown at a common location has been examined by Beard and Williams (1982), Heiser (1954) and Seiler (1982, 1983). Beard and Williams (1982) examined 177 population accessions at Davis, California, using cluster analysis to group the populations into 20 groups for morphological characteristics and 10 groups for agronomic characteristics. Heiser (1954) evaluated 80 populations of wild *H. annuus* for morphological characteristics, which led him to divide the species into three subspecies and one variety. Later, Heiser et al. (1969) described six forms of non-cultivated sunflower of wild annual sunflower. Heiser (1954) concluded that there is considerable variation in the common wild sunflower, and moreover, that the variation of certain characteristics, with some deviations, is geographic. However, no sharp discontinuities existed in the variation pattern. Seiler (1982; 1983) examined 38 populations of wild annual sunflower for oil and oil quality characteristics. Developmental patterns of oil and fatty acid in wild *H. annuus* follow the trends that exist in modern commercial hybrids, but are of a different magnitude.

Increased knowledge of variation in agronomic and morphological characteristics of wild annual sunflower should lead to greater use in sunflower breeding programs. The objective of this study was to examine several populations of wild annual sunflower grown at a common location for variability of several agronomic and morphological characteristics and to assess their potential for use in sunflower breeding programs.

MATERIALS AND METHODS

Seeds of 90 populations of wild *H. annuus* were planted 19 May 1981 at Bushland, Texas, 35° N Lat and 102° W Long. The collection sites of the populations were scattered over an area from 26 to 46° N Lat and 81 to 122° W Long. Plots were furrow irrigated to maintain maximum plant growth. "Hybrid 894" was planted 19 May 1981 for comparison.

Measurements were made from five plants per plot on the terminal head of the primary stem for flowering date (first anthesis), flowering period (number of weeks), head diameter (includes ray and disk) (cm), disk diameter (cm), ray number, ray length (cm), ray width (cm), bract number, bract length (cm), bract width (cm) and plant height (m). Leaf length (cm) and width (cm) were taken on five largest leaves per plant. Weight per 200 seeds (g), test weight (kg hl^{-1}), oil concentration of the seed (%) and fatty acid concentrations of the oil (palmitic, stearic, oleic and linoleic acids) (%) were determined on dry seed samples from heads of the primary stem. Seeds used for the above analyses were from sibbed-pollinated heads composited into a single sample for each week a population flowered. Composited seed samples from each week were then subsampled twice for analyses. Data were recorded on a plot basis for each population.

Oil concentration was determined using nuclear magnetic resonance (NMR) analysis. Each sample was cleaned to remove empty seeds and dried at 60°C for 24 hours (Gran-

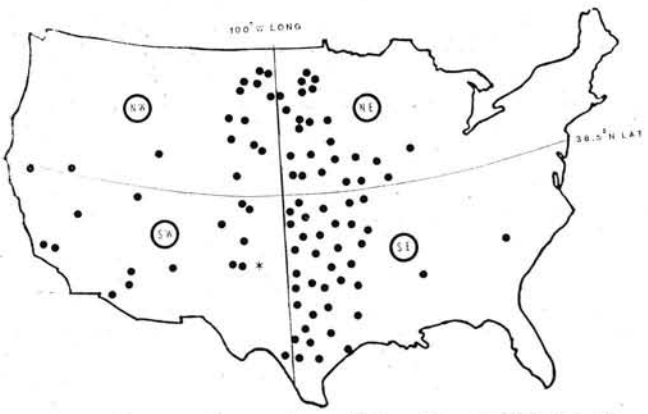

Fig. 1 — Geographic regions of the 90 populations of wild annual sunflower examined
* = Location of Bushland, Texas.

lund and Zimmerman, 1975). Fatty acid composition of solvent-extracted oil using methyl esterification was determined by gasliquid chromotography (GLC) (Christie, 1973).

The 90 populations of wild *H. annuus* were divided into four regions (Fig. 1). The northeast region consisted of populations from greater than 38.5° N Lat and less than 100° W Long. The northwest region consisted of populations from greater than 38.5° N Lat and greater than 100° W Long. The southeast region consisted of populations from less than 38.5° N Lat and less than 100° W Long. The southwest region consisted of populations less than 38.5° N Lat and greater than 100° W Long.

RESULTS AND DISCUSSION

Mean values and ranges for agronomic and morphological characteristics of the 90 populations from four generalized regions of the United States are given in Tables 1 and 2.

AGRONOMIC CHARACTERISTICS

1. WEIGHT PER 200 SEEDS

Weight per 200 seeds averaged over all populations was 1.3 g and ranged from 6 to 3.0 g (Table 1). Commercial Hybrid 894 had a 200 seed weight of 7.5 g (Table 1). Variation of means from the four regions was very small, but considerable variation still existed within a region, as evidenced by the range of values. Some of the variation may be accounted for by the strong influence that number of seeds/head has on seed weight. Wild *H. annuus* is multiple-headed and heads which flower early are larger and have more seeds than heads which flower later in the season.

2. TEST WEIGHT

Test weight averaged over all populations was 43.4 kg hl^{-1} and ranged from 23.5 to 60.6 kg hl^{-1} (Table 1). Test Hybrid 894 was 43.3 kg hl^{-1}. There was not a significant difference in test weight among the regions, but considerable variation was still present within a region. Part of the variation in test weight may be accounted for by the number of weeks a population flowered. In a previous study (Seiler, 1983), average weight per seed decreased with the later flowering dates, indicating that the seeds were smaller.

3. FLOWERING DATE

The average initial flowering date for all populations was 30 July (71 days after planting). The earliest populations began flowering on 3 July (40 days after planting), and the

Table 1

Agronomic characteristics for 90 populations of wild annual sunflower from widely separated geographic regions when grown at a common location

Regional origin	Number of populations	Wt/200 seeds (g)	Test weight kg hl^{-1}	Flowering date	Flowering period	Oil %	Palmitic acid %	Stearic acid %	Oleic acid %	Linoleic acid %
Northeast [1]	24	1.3* .9—2.4**	44.0 25.9—60.6	714 703—724	9 5—12	25.3 15.7—30.1	5.5 2.3—7.6	2.8 2.1—3.8	26.3 20.1—32.5	64.6 59.8—69.8
Northwest [2]	14	1.3 .8—1.7	45.0 31.0—58.3	720 703—731	7 4—15	25.1 19.6—29.6	5.0 4.0—6.2	2.7 1.3—4.6	26.0 17.8—31.3	65.8 58.3—72.8
Southeast [3]	37	1.2 .6—2.4	41.5 29.7—58.5	803 703—822	10 5—13	23.5 14.5—29.9	5.6 4.2—7.0	3.3 2.3—5.0	23.3 16.2—31.2	66.8 57.3—74.5
Southwest [4]	15	1.2 .8—3.0	43.1 23.5—56.9	822 710—822	9 4—12	21.2 13.8—25.9	5.8 4.2—6.6	3.5 2.2—4.7	23.0 14.7—33.1	66.9 56.6—73.3
Overall mean	90	1.3 .6—3.0	43.4 23.5—60.6	730 703—822	9 4—15	23.8 13.8—30.1	5.5 2.3—7.6	3.1 1.3—5.0	24.7 14.7—33.1	66.1 56.6—74.5
Hybrid 894	1	7.5 7.4—7.6	45.1 44.1—46.1	721 —	1 —	44.5 44.0—45.0	5.9 4.5—6.3	4.0 3.8—4.2	37.1 36.1—38.1	50.9 50.0—52.0

* Mean
** Range
[1] Northeast = > 38.5° N Lat and < 100° W Long
[2] Northwest = > 38.5° N Lat and > 100° W Long
[3] Southeast = < 38.5° N Lat and < 100° W Long
[4] Southwest = < 38.5° N Lat and > 100° W Long

latest populations began flowering on 22 August (90 days after planting) (Table 1). The initial flowering date of several populations was influenced by their regional origins. The northeast populations flowered first followed by the northwest populations. Southeast populations began to flower about 2 weeks later, with the southwest flowering 2 weeks after the southeast populations. There appears to be considerable variation in the initial and continuation of flowering that could be selected for in sunflower breeding programs.

4. FLOWERING PERIOD

The average flowering period for a population was nine weeks, but ranged from 4 to 15 weeks (Table 1). Sunflowers from the southern regions flowered for an average of one and a half weeks longer than sunflowers from the northern regions. Each region had some populations that flowered over the full range of flowering dates. Flowering differences among populations indicate that the development of sunflower maturity groups may be possible.

5. SEED OIL CONCENTRATION

The average seed oil concentration for all populations was 23.8% and ranged from 13.8 to 30.1% (Table 1). These values were close to those previously reported by Seiler (1983) and Thompson et al. (1981). Seeds from the northern populations averaged slightly higher in oil (25.2%) than seeds from southern populations (22.3%). The northeast populations had the highest average oil concentration (25.3%), while the southwest populations had the lowest (21.2%). Oil concentration from seeds of wild populations was low compared with oil concentration of Hybrid 894 seed (44.5%). Oil concentration may have been lower than would normally be encountered, because in this study the seed sample per plot was a composite of seed from all weeks a population flowered. Composited samples contained seeds from heads which flowered earlier and had a lower oil concentration than seeds from heads flowering later.

6. PALMITIC AND STEARIC ACIDS

In the wild *H. annuus* populations examined, palmitic and stearic acid concentration averaged 5.5 and 3.1%, respectively (Table 1) and ranged from 2.3 to 7.6% for palmitic and from 1.3 to 5.0% for stearic acid. Palmitic acid did not vary much among regions, but each region still had considerable variation. Stearic acid appeared to have a greater regional variation, being slightly higher in seed originating in the southwest region (3.5%) than seed originating from the northwest region (2.7%).

7. OLEIC AND LINOLEIC ACIDS

Oleic acid concentration averaged 24.7% while linoleic acid averaged 66.1% (Table 1). Oleic acid ranged from 14.7 to 33.1%, while linoleic acid ranged from 56.6 to 74.5%. The seed from northern populations of wild *H. annuus* averaged 3% higher oleic acid than seed from southern populations. Linoleic acid averaged about 2% less in seed from plants originating in the southern regions than seed from plants originating in the northern regions. This would be expected because of the high negative correlation ($r = -0.96$) between oleic and linoleic acid (Seiler, 1983). The higher oleic acid in the seed from northern populations may be accounted for by the earlier flowering of the populations. In a previous report, Seiler (1983) showed that earlier flowering heads had higher concentrations of oleic acid and a lower concentration of linoleic acid. Growing plants originating from seed from different regions at a common location appears to reduce the variation in both these acids. It also shows that the variation is not as great as that observed in a commercial hybrid when grown at a common location (Unger, 1980). Wild *H. annuus* appears to have adequate variation for both these acids and could be used in a sunflower breeding program.

MORPHOLOGICAL CHARACTERISTICS

1. HEAD AND DISK DIAMETER

Head diameter averaged 9.2 cm and ranged from 5.7 to 13.4 cm (Table 2). Disk diameter averaged 3.1 cm and ranged from 1.7 to 5.7 cm. Head diameter was larger, averaging 9.5 cm in plants originating from southern populations, than plants originating from northern populations (8.9 cm). The southwest region had the largest head diameter (9.8 cm), while the northwest region had the smallest head diameter (8.8 cm). However, the disk diameter was about the same in plants from both the northern and southern regions, indicating that the ray petals are longer in the southern populations. Hybrid 894 had a head diameter of 25.8 cm and a disk diameter of 14.5 cm. Head diameter can be used to identify possible hybridization with cultivated sunflower. No populations examined appeared to have intermediate values, indicating no probable hybridization with cultivated sunflower.

2. RAY PETAL LENGTH, WIDTH, AND NUMBER

Ray petal length averaged 3.4 cm and ranged from 1.8 to 5.2 cm (Table 2). Ray petal width averaged 1.1 cm and ranged from .7 to 1.8 cm.

Table 2

Morphological characteristics for 90 populations of wild annual sunflower from widely separated geographic regions when grown at a common location

Regional origin	Number of populations	Head diameter (cm)	Disk diameter (cm)	Ray number	Ray length (cm)	Ray width (cm)	Bract number	Bract length (cm)	Bract width (cm)	Leaf length (cm)	Leaf width (cm)	Plant height (m)
North-east [1]	24	9.0*	3.1	21.0	3.3	1.1	28.0	2.1	.9	16.4	14.0	1.5
		8.0—13.1**	2.2—5.7	14.0—32.0	2.1—5.2	.7—1.8	18.0—36.0	1.5—4.0	.7—1.8	9.5—28.6	8.5—25.2	.9—2.4
North-west [2]	14	8.8	3.1	21.0	3.2	1.0	30.0	2.1	.9	17.3	14.4	1.7
		6.4—11.8	2.2—4.6	16.0—34.0	1.8—4.3	1.1—1.4	21.0—38.0	1.5—3.8	.6—1.1	7.2—28.0	5.1—24.0	.9—2.3
South-east [3]	37	9.2	3.0	21.0	3.5	1.1	29.0	1.9	.8	20.0	17.4	1.9
		5.7—13.1	1.7—4.5	13.0—39.0	2.0—5.1	1.1—1.6	19.0—41.0	1.1—2.8	.5—1.1	10.0—35.1	6.2—33.6	.8—3.4
South-west [4]	15	9.8	3.3	22.0	3.7	1.1	32.0	2.0	.9	20.5	18.2	2.0
		6.8—13.4	2.2—5.5	16.0—33.0	2.4—5.2	.8—1.7	25.0—44.0	1.3—3.1	.5—1.2	8.5—31.0	6.5—29.0	1.2—3.2
Overall mean	90	9.2	3.1	21.0	3.4	1.1	30.0	2.0	.9	19.1	16.2	1.8
		5.7—13.4	1.7—5.7	13.0—39.0	1.8—5.2	.7—1.8	18.0—44.0	1.1—3.8	.5—1.8	7.2—35.1	5.1—33.6	.8—3.4
Hybrid 894	1	25.8	14.5	45.0	7.4	1.9	66.0	5.6	2.6	21.8	21.5	1.4
		22.5—29.0	12.0—17.0	40.0—50.0	7.0—8.0	1.7—2.0	61.0—71.0	4.9—6.3	2.0—3.0	19.0—24.0	18.0—26.0	1.0—1.5

* Average
** Range
[1] Northeast = > 38.5° N Lat and < 100° W Long
[2] Northwest = > 38.5° N Lat and > 100° W Long
[3] Southeast = < 38.5° N Lat and < 100° W Long
[4] Southwest = < 38.5° N Lat and > 100° W Long

Ray petal number averaged 21 rays per head and ranged from 13 to 39. Ray petal length and width are similar to those reported by Beard and Williams (1982). The highest number of ray petals (39) in wild annual sunflower comes close to the commercial Hybrid 894 which had 45 ray petals.

3. BRACT LENGTH, WIDTH AND NUMBER

Bract length and width averaged 2.0 cm and .9 cm, respectively (Table 2). Bract length ranged from 1.1 to 3.8 cm and bract width ranged from 5 to 1.8 cm. Bract number averaged 30, ranging from 18 to 44. Bract size (length and width) can also be used as an indicator of hybridization with cultivated sunflower. Some of the populations examined approach the bract length and width of Hybrid 894, indicating possible hybridization and introgression with cultivated sunflower at some point in time. The genetic background of the wild populations was not examined in the present study.

4. LEAF LENGTH AND WIDTH

Average leaf length and width of the largest leaves was 19.1 and 16.2 cm, respectively (Table 2). Leaf length ranged from 7.2 to 35.1 cm and leaf width ranged from 5.1 to 33.6 cm. Leaf length and width of Hybrid 894 were quite comparable to populations from the southern regions. The northern populations tended to have shorted and narrower leaves. However, leaf size and shape are known to be environmentally modified (Heiser, 1954). There still appears to be adequate variation in leaf size for selection in a sunflower breeding program.

5. PLANT HEIGHT

Plant height averaged 1.8 m and ranged from .8 to 3.8 m (Table 2). These measurements were within the range given by Heiser et al. (1969). Hybrid 894 averaged 1.4 m. Most wild populations would be considered too tall for hybrid perental lines. Heiser (1954) indicated that there is a relationship among plant height, disk diameter and flowering date. Therofore, selection for plant height may result in changes in some of the other characteristics.

CONCLUSIONS

Considerable natural variation is still present when wild annual sunflowers from widely separated geographical populations are grown at a common location. Of the nine agronomic characteristics examined in this study, adequate variation in test weight, flowering date, flowering period, seed oil concentration and fatty acid composition of oil indicates their potential use in hybrid sunflower breeding programs.

The 12 morphological characteristics of populations of wild *H. annuus* from widely separated regions examined at a common location also had considerable variation. Potentially useful characteristics for a hybrid breeding program might be leaf size, which was comparable to Hybrid 894, and plant height of some of the shorter populations.

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LA VARIATION DES POPULATIONS ANNUELLES SAUVAGES DE TOURNESOL *(HELIANTHUS ANNUUS* L.) CONCERNANT LES CARACTÉRISTIQUES AGRONOMIQUES ET MORPHOLOGIQUES

Résumé

L'auteur a collecté 90 populations annuelles sauvages de tournesol *(H. annuus)* dans une zone très large des États-Unis étendue entre 26—46° latitude de nord et 81—122° longitude de l'ouest. L'étude de cette collection a été effectuée à Bushland, Texas, en 1981.

On a observé une variation naturelle considérable de ces populations de tournesol sauvage provenant de zones géographiques très différentes, lorsqu'elles ont été cultivées dans une localité commune. Parmi les 9 caractéristiques agronomiques examinées, une variation adéquate pour les programmes d'amélioration ont présenté le poids hectolitrique, la date de floraison, la période de floraison, la teneur en huile des graines et la composition en acides gras de l'huile. En ce qui concerne les caractéristiques morphologiques, la grandeur de la feuille et la tige courte ont été considérées comme des variations utiles pour l'amélioration du tournesol.

VARIACIÓN DE UNAS POBLACIONES DE GIRASOL ANUAL SALVAJE *(HELIANTHUS ANNUUS* L.) EN CUANTO A ALGUNAS CARACTERÍSTICAS AGRONÓMICAS Y MORFOLÓGICAS

Resúmen

Se han colectado 90 poblaciones de girasol anual salvaje *(H. annuus)* de una zona muy rica de los Estados Unidos, comprendida entre 26—46° latitud norte y 81—122° longitud oeste. El estudio de esta colección se efectuó en Bushland, Texas, en el ano 1981.

Se notó una considerable variación natural de estas poblaciones de girasol salvaje proviniente de zonas geográficas muy diferentes, cuando están elevadas en una localidad común. De las 9 características agronómicas examinadas, una variación adecuada para los programas de mejora presentaron el peso hectolítrico, la fecha del florecimiento, el período de florecimiento, el contenido en aceite de las semillas y la composición de los ácidos grasos de aceite.

En cuanto a las características morfológicas el tamaño de la hoja y el tallo bajo se consideraron útiles para la mejora.