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# INHERITANCE OF PLANT HEIGHT IN SIX SUNFLOWER CROSSES

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## Abstract

The genetics of plant height was studied in 6 sunflower (Helianthus annuus L.) crosses. Selections from PI 386316 and PI 386323, the short parents, were crossed with HA 89, HA 124, and HA 301. Plants were grown in the field at Brookings, SD in 1983. PI 386316 and PI 386323 selections were significantly shorter than the other inbred lines with the exception of HA 89. HA 89 averaged 107 cm, which was significantly different from PI 386316 but not PI 386323. The shorter plant height of PI 386316 and PI 386323 selections was due to shorter internode lengths rather than fewer leaves. All $F_1$ were significantly taller than the tallest parent with the exception of PI 386316 x HA 89 which was numerically taller than HA 89 but not significantly. Height of $F_1$ hybrids was reduced by selfing. PI 386316 and PI 386323 crossed with HA 89 plus PI 386323 x HA 301 produced the shortest hybrids averaging 132 cm, 126 cm, and 129 cm, respectively. These same crosses gave the smallest reduction in plant height of $F_2$ family means upon selfing of the $F_1$. The tallest $F_1$ in this study was PI 386316 x HA 301. This cross also had one of the largest reductions in plant height upon selfing of $F_1$. These data suggest that HA 89, PI 386316, and PI 386323 have genes in common which reduce plant height while HA 301 has genes in common with PI 386323 but not PI 386316. Results from Generation Mean Analysis indicated that approximately 57% of the total genetic variation was due to dominance and 30% due to additive gene action. It appears that PI 386316 and PI 36323 will be useful in producing shorter hybrids.

## Introduction

Lodging in sunflower limits production in many parts of the world. Shorter plant height is one means by which lodging can be reduced. Both multigene and single gene control of rather large differences in plant height have been reported in the literature (1, 2, 3, 5, 6, 7). In most studies the $F_1$ hybrid was taller than the tallest parent suggesting that heterosis for plant height is fairly common. However, heterosis for plant height is not always a desirable phenomenon in sunflower. There are at least 2 ways of overcoming the problems of heterosis for plant height. The simplest is to identify a single dominant gene which reduces plant height. The other is to develop hybrids using inbred lines with the same genetic complement controlling plant height thereby reducing heterosis for this trait. This assumes that there is no negative relationship of plant height with seed yield. Under this option, inheritance still needs to be fairly simple, but control by a single dominant gene is not required.

The purpose of this research was to study the genetics of plant height in $F_2$ families of 6 sunflower crosses using parents representing a range in plant height. The 2 shortest parents were selected from PI 386316 and PI 386323. The other parents were single plant progeny of inbred lines HA 89, HA 124 and HA 301.

## Materials and Methods

This study was conducted at Brookings, SD in 1983. Three inbred lines HA 89, HA 124 and HA 301 and selections from PI 386316 and PI 386323 were crossed to produce the various generations needed for this study. The experiment was planted on June 3. A split plot design with two replications was used with crosses as main plots. There were six subplots in each main plot, consisting of two parents, $F_1$, $F_2$, and backcross generations. Only data from the parents, $F_1$ and $F_2$ plants will be reported. Each subplot had a variable number of 7m rows depending on the expected amount of genetic segregation. The parents and $F_1$ hybrids consisted of 1 row plots while the $F_2$ families were planted in 11 row plots. Rows were planted on 76cm centers with hills spaced 23cm within a row. Plots were overseeded and thinned to 1 plant per hill 28 days after planting. Poor stands were observed in some plots due to seed dormancy from greenhouse produced seed and downy mildew (Plasmapara halstedii).

Data were collected on individual plants for plant height and number of leaves. Plant height was measured near maturity and was the distance from the soil surface to the center of the head when held in a vertical position. The number of leaves on a plant were counted after flowering was complete. Counting began with the first leaf above the cotylendary node and stopped with the last leaf below the head. Small leaves attached to the back of the head were not counted. Internode length was calculated by dividing plant height by the number of leaves.

Means, standard deviations, variances and simple correlations were calculated on a single plant basis. Analysis of variance based on means of all plants in a subplot were used to establish levels of significance among generations within a cross and between crosses. Plot means also were used for generation mean analysis and fitted to the genetic model of Mather and Jinks (4) using unweighted multiple regression.

## Results

Means for plant height of the 5 parents are given in Table 1. The shortest parent was PI 386316 with an average height of 86 cm while the tallest was HA 124 at 129cm. The tallest parent, HA 124, and the 2 shortest parents, PI 386316 and PI 386323, had the same internode length. There are 2 reasons for this result. First the stands obtained for HA 124 were particularily thin. Since there was a positive relationship between population density and plant height, (8) plant height of HA 124 probably was underestimated relative to the other lines. Second, HA 124 has significantly more leaves than the other lines. HA 290 and HA 302 were also included in this study. Both were taller than HA 124, and both had fewer leaves per plant (22 and 26 respectively).

Table 1. Means for three agronomic traits of five inbred lines of sunflower grown at Brookings, SD in 1983.

| Parent | No. of Plants | Plant Height (cm) | No. of Leaves | Internode Length (cm) |
|---|---|---|---|---|
| PI 386316 | 77 | 86 d[1] | 28 b | 3.1 c |
| PI 386323 | 46 | 94 cd | 28 b | 3.3 c |
| HA 89 | 56 | 107 bc | 27 b | 4.0 b |
| HA 301 | 27 | 111 b | 24 c | 4.2 ab |
| HA 124 | 12 | 129 a | 37 a | 3.5 c |
| Mean | | 105 | 29 | 3.6 |

[1] Means followed by the same letter are not significantly different based on Waller K-ratio = 100.

Plant height of the 6 hybrids averaged 142cm with the tallest hybrid PI 386316 x HA 301 averaging 157cm while the shortest hybrid, PI 386323 x HA 89 averaged 126cm (Table 2). Heterosis for plant height averaged 138% and ranged from 125% to 159%. All plants were significantly taller than the tallest parent with the exception of PI 386316 x HA 89 which was numerically taller than HA 89 but not significantly (data not shown) taller. It should be noted that PI 386323 x HA 301 was nearly the shortest hybrid with the lowest level of heterosis while the cross between PI 386316 x HA 301 was the tallest hybrid and had the greatest level of heterosis. Crosses with HA 124 also were unique because of the low level of heterosis for the number of leaves per plant compared to the other crosses.

Table 2. Means and levels of heterosis for three agronomic traits in six sunflower hybrids grown at Brookings, SD in 1983.

| $F_1$ Hybrid | No. of Plants | Plant Height | | No. of Leaves | | Internode Length | |
|---|---|---|---|---|---|---|---|
| | | Mean | Heterosis | Mean | Heterosis | Mean | Heterosis |
| 16 x 89 | 12 | 132 | 137 | 31 | 113 | 4.3 | 121 |
| 23 x 89 | 22 | 126 | 125 | 31 | 113 | 4.1 | 112 |
| 16 x 124 | 20 | 155 | 144 | 33 | 102 | 4.7 | 142 |
| 23 x 124 | 25 | 154 | 138 | 34 | 105 | 4.5 | 132 |
| 16 x 301 | 37 | 157 | 159 | 30 | 115 | 5.3 | 120 |
| 23 x 301 | 23 | 129 | 126 | 29 | 112 | 4.5 | 120 |
| Mean | | 142 | 138 | 31 | 10 | 4.6 | 129 |

Percent heterosis = (observed value of $F_1$ hybrid / midparent value) x 100.

There was an 11% reduction in plant height in the $F_2$ population from selfing $F_1$ hybrids (Table 3). Again there was considerable variation in the level of inbreeding depression among the crosses. Those crosses with little heterosis also had little reduction in plant height upon selfing. For example, PI 386323 x HA 124 had 154% heterosis and 18% reduction in the mean of $F_2$ plants PI 386323 x HA 89, had 125% heterosis, and only 4% reduction in plant height. This same general relationship between heterosis in the $F_1$ and inbreeding depression also was apparent for internode length. There was little change in the observed means of the $F_1$ and $F_2$ generations for leaves per plant.

Table 3. Means and percent reduction from selfing $F_1$ plants for three agronomic traits in six sunflower $F_2$ populations grown at Brookings, SD in 1983.

| Population | No. of Plants | Plant Height Mean | Plant Height Reduction | Leaves per Plant Mean | Leaves per Plant Reduction | Internode Length Mean | Internode Length Reduction |
|---|---|---|---|---|---|---|---|
| 16 x 89 | 232 | 122 | 8 | 28 | 10 | 4.4 | - 2 |
| 23 x 89 | 322 | 121 | 4 | 30 | 3 | 4.1 | 0 |
| 16 x 124 | 73 | 132 | 15 | 32 | 3 | 4.2 | 11 |
| 23 x 124 | 183 | 127 | 18 | 34 | 0 | 3.8 | 16 |
| 16 x 301 | 464 | 135 | 14 | 29 | 3 | 4.7 | 11 |
| 23 x 301 | 173 | 117 | 9 | 29 | 0 | 4.1 | 9 |
| Mean | | 126 | 11 | 30 | 3 | 4.2 | 8 |

Variances of generation means for plant height indicated that the dominance source of variation was significant in all six crosses and that the additive component was significant in all crosses except PI 386316 x HA 89 and PI 386323 x HA 124 (Table 4). Using this method detectable genetic variation for leaf number was present in three of the crosses. Dominance was present in crosses with HA 89 while additive variance was significant only in PI 386316 x HA 124. The error term was high in those crosses in which there was no significance. Results of the analysis for internode length was similar to plant height.

Table 4. Analysis of variance of generation means for three agronomic traits in six sunflower crosses grown at Brookings, SD in 1983.

| Population | Plant Height Add | Plant Height Dom | Plant Height Res | Leaf Number Add | Leaf Number Dom | Leaf Number Res | Internode Length Add | Internode Length Dom | Internode Length Res |
|---|---|---|---|---|---|---|---|---|---|
| 16 x 89 | | ** | | | ** | | * | ** | |
| 23 x 89 | * | ** | | | * | | ** | ** | |
| 16 x 124 | ** | ** | | ** | | | | * | |
| 23 x 124 | | ** | | | | | | ** | |
| 16 x 301 | ** | ** | | | | | ** | ** | ** |
| 23 x 301 | ** | ** | * | | | | ** | ** | ** |

Add = Additive, Dom = Dominance, Res = Residual.
 * Significantly different at the 5%.
** Significantly different at the 1%.

Dominance accounted for 57% of the total genetic variation for plant height when averaged over the six crosses (data not shown). The range was from 29% to 73% indicating considerable variation between crosses. Dominance also was the primary source of genetic variation for internode length averaging 51% and ranging from 21% to 90%. The additive source of genetic variation for all three traits was approximately 30%.

## Discussion

The main objective of this research was to study the genetics of plant height in several parents of cultivated sunflower. One of the limitations of this study was that there was not a tall parent by tall parent cross with which to compare. However in a commercial hybrid trial of 49 entries seeded two days earlier, the range in plant height was from 130cm to 178cm with a mean of 155cm. Hybrid 894 averaged 142cm. The 3 shortest hybrids in this study averaged about 130cm, while the 3 taller hybrids averaged approximately 155cm. It appeared that both PI 386316 and PI 386323 germplasm can be used to produce relatively short hybrids. However these hybrids are not shorter than from current USA hybrids.

Not all hybrids with plants selected from PI 385316 and PI 386323 are short. Crosses with HA 124 produced relatively tall hybrids, while crosses with HA 89 were short. PI 386316 x HA 301 was the tallest hybrid in the study while PI 386323 x HA 301 was among the shortest. At least two conclusions can be made from these results. First, there are genes in both HA 89 and HA 301 which reduce plant height. Second, it appears that HA 89, HA 301, PI 386316 and PI 386323 have some common genes which condition a reduced plant height in their hybrids. Crosses of HA 89 with PI 386316 and PI 386323 selections produced the shortest hybrids and experienced the least reduction in plant height upon selfing. This result suggests that these three lines have similar genotypes for the control of plant height. Results of generation mean analysis supported these observations in that both crosses had about the same amount of additive and dominance sources of genetic variation. In crosses with HA 301, it appears that genes controlling height in PI 386316 were not the same as those in PI 386323 because of large differences in the height of these two hybrids.

Another consideration in the use of short hybrids is whether there is a loss in photosynethetic area through the loss of leaves. It appears from our data that the PI 386316 and PI 386323 selections are shorter because of shorter internodes rather than fewer leaves. This characteristic was also evident in their hybrids. HA 124 may be useful for producing genetic material with increased leaf area through increased numbers of leaves.

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