ASSOCIATION OF SEED YIELD AND SEED OIL CONTENT WITH OTHER PLANT AND SEED CHARACTERISTICS IN HELIANTHUS ANNUUS L.[1]

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Summary

Correlation and regression analyses were used to determine the association of seed yield and seed oil content with other quantitative traits in sunflowers (Helianthus annuus L.). A random sample of 436 plants was selected from a field planted with different open pollinated varieties and inbred lines of sunflowers. Multiple regression coefficients, using seed yield and oil content as dependent variables, as well as correlation coefficients between each of the two variables was estimated. Seed oil content was positively correlated with plant height and embryo percentage, but negatively correlated with head diameter, stem circumference, seed yield, and seed size. Plants with larger heads produced more seeds with larger achene size and lower oil content. Taller plants had thicker stems with higher number of leaves, and had larger heads which produced more seeds with higher oil and embryo percentages. A non-significant negative correlation was observed between seed protein and oil content.

Introduction

The major goals in improving sunflowers are to increase seed yield and oil content. Both of these two traits have low heritability and some information on the relation between these two characters and other plant or seed characteristics will be helpful to breeders in their breeding programs. Some useful information has already been obtained by different investigators. Ross (4) studied the relationship between seed yield and oil content with some morphological characters of sunflowers and found positive correlation between oil content and plant height and seed yield. Putt (3). on the other hand using inbred lines, did not find definite associations between oil content and seed yield, plant height, stem and head diameter, days to maturity, seed size and test weight. Association between oil content and other characters of plant height, days to flower, leaf area, vigor rating and rust rating was reported when Russel (5) studied the data obtained from some inbred lines and their top cross hybrids. Burns (1) using data obtained on single plants selected from two different cultivars, found high correlation between head size and seed yield. He concluded that yield estimates based on head size could be more accurate than actual seed weight in experimental plots which have considerable bird damage.

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Association of oil content with other plant and seed characteristics was studied by Fick et al (2) using the data obtained from high-oil Russian derived germplasm. They found positive correlation between seed oil content and days to 50% flowering, plant height and test weight but no significant relationship between oil content and seed yield and seed weight.

This paper reports the results of regression analyses of seed yield and oil content with several other plant and seed characters and correlation analyses between several different quantitative characters in sunflowers.

Materials and Methods

The data were obtained by measuring single plants selected from sunflower experiments grown at College of Agriculture's Experimental Field, Karaj, Iran in Spring 1976. Different open pollinated cultivars such as Record, Peredovik, NSP61, Luch, Armavirce, Zaria, Nosavsky, Majak, Chernianka, some inbred lines in the S_3 through S_{10} generation of inbreeding and a few mixed populations were planted with an average of approximately 60,000 plant/ha. The entries represented a wide range of variation for plant and seed characteristics. A random sample of 500 plants was selected and labeled before flowering and the heads were covered after full seed setting to prevent bird damage. Heads were harvested and threshed separately. Measurements were taken on plant height, stem circumference, number of leaves, head diameter, seed yield, 200-seed weight, embryo percentage, oil and protein content of the seeds as follows:

1. Plant height and head diameter were measured after plants had reached full maturity.

2. Stem circumference and number of leaves were determined when plants were in full seed setting before full maturity.

3. Seed yield was obtained by threshing the head of a single plant.

4. 200-seed weight was obtained from a random sample of 200 seeds taken from the total seed pool of each plant.

5. Embryo percentage was determined for 5 grams of seeds taken from each harvested head.

6. Two seed samples of 3 grams each were taken from each of the harvested heads and used to determine the oil content using a nuclear magnetic response analyzer. The average oil percentage of these two samples was then used as the oil percentage for the seeds under study.

7. Protein percentage was determined by the Kjeldahl method using a 3 gram seed sample.

A complete data set including plant height, stem circumference, number of leaves, head diameter, seed yield, 200-seed weight embryo and oil percentages was obtained for 436 plants. However, protein percentage was determined for only 147 randomly selected plants from the 436 plant sample.

The data set for the eight characters on the 436 plants was used to estimate simple correlation coefficients between characters as well as to determine the multiple regression statistics for seed yield or oil percentage as dependent variables. A stepwise regression program was used to estimate the coefficients in a first order linear regression model where no interaction terms between variables were included. Separate analyses were made using the data obtained from plants with higher oil content (oil percentage $\geq$ 38) and plants which had less than 38 percent oil in their seeds.

Correlations of protein percentage with other traits were determined using the data obtained for the 147 plant sample.

Results and Discussion

The means and standard errors for different traits are shown in Table 1.

TABLE 1. Means and Standard Errors of Nine Quantitative Characters Measured on Single Plants of Sunflower.

Character	Plants With Oil Content $\geq$ 38 N = 350		Plants With Oil Content $>$ 38 N = 86		Total N = 436	
	$\bar{x}$	Sx	$\bar{x}$	Sx	$\bar{x}$	Sx
Plant height (cm)	174.0	31.0	165.0	41.0	173.0	34.0
Head diameter (cm)	16.5	3.9	20.5	5.5	17.3	4.5
No. of Leaves	31.8	4.9	33.7	7.9	32.2	5.7
Stem circumference (cm)	6.5	1.3	7.9	2.1	6.8	1.6
Seed yield (gr)	48.3	30.9	60.9	44.8	50.8	34.4
200-seed weight (gr)	12.3	3.6	14.0	4.0	12.6	3.7
Embryo percentage	72.0	5.0	68.0	6.1	71.6	5.6
Oil percentage	44.6	3.7	33.6	3.4	42.4	5.6
Protein percentage[1]	--	--	--	--	18.1	1.8

[1] Measured only for 147 plants.

Plants selected from different sources showed a wide range of variation for all characters especially for plant height, head diameter and seed yield. Some differences were observed when the mean of plants with lower percentage of oil were compared with the means obtained for plants with higher oil content. The observed differences are partly due to the presence of some short stemmed cultivars such as Chernianka and Armavirce as compared to the tall and high-oil cultivars, Record and Peredovik. However, estimates of correlation coefficients indicate that part of the differences could be accounted for by the relationship between oil content with other characters.

Correlation coefficients and multiple regressions are presented in Tables 2-4. Among the 436 plants, plant height was positively correlated with all

other characters except seed size. Taller plants produced more seed with higher percent of oil. Also they were thicker and had more leaves with larger heads. Positive correlations between plant height and characters such as stem circumference between plant height and oil percentage could possibly be due to the presence of some short-stemmed, low-oil and long-stemmed, high-oil cultivars in the material studied. However, the relationships did not change when the data for these two groups were analyzed separately. Head diameter was positively correlated with number of leaves, stem circumferences, seed yield and size of the seeds and negatively correlated with embryo percentage and oil content. Plants with larger heads produced more seeds with heavier achenes, but with lower embryo percent and oil content. Seed size was positively correlated with head diameter, stem circumference, seed yield and embryo percentage and negatively correlated with oil content. Smaller seeds were higher in oil content which is in agreement with the results obtained by other investigators (3, 5, 2).

Oil percentage was positively correlated with plant height and embryo percentage and negatively correlated with head diameter, stem circumference, seed yield and 200-seed weight.

Some differences in the results were observed when data obtained from plants with lower oil content and data from high-oil plants were analyzed separately. These differences were as follows:

1. Positive correlation between plant height and embryo percentage was not significant and negative correlations were not observed between seed yield and oil percentage. The correlation between embryo percentage and seed size was positive for the total data set and for the data set obtained on high oil plants but negative for plants with lower oil content.

2. There was no negative correlation between head diameter and embryo percentage or between oil percentage and seed size for high-oil plants only.

3. Significant positive correlation was observed between number of leaves and percent of oil and between stem circumference and embryo percentage for the plants with higher oil content.

The regression equations obtained using oil percentage and seed yield as independent variables are shown in Tables 2-4. Some differences in order of variables and their significance were observed when the data for low-oil and high-oil plants were analyzed separately (Tables 2-4). On the average, only 40% of the variation in oil percentage and 70% of the variation in seed yield was contributed by the variables in this study.

The data obtained from the 147 randomly selected plants were used to estimate the correlations between protein content with other traits. The results are shown in Table 5. Protein content was positively correlated with embryo percentage and 200-seed weight. A negative correlation between oil and protein content was observed but was not significant. No definite relation was observed between protein content and other traits studied.

TABLE 2. Correlation Coefficients Between Eight Quantitative Characters Obtained from 436 Sunflower Plants.

Variables	X_1	X_2	X_3	X_4	X_5	X_6	X_7
X_1 Plant height							
X_2 Head diameter	.131**						
X_3 No. of leaves	.538**	.236**					
X_4 Stem circumference	.284**	.810**	.320**				
X_5 Seed yield	.286**	.768**	.235**	.731**			
X_6 200-seed weight	.071	.576**	-.054	.541**	.601**		
X_7 Embryo %	.121*	-.108*	-.087	-.084	.026	.129**	
X_8 Oil %	.265**	-.340**	-.007	-.325**	-.098*	-.233*	.393**

*, ** Significant at the 5% and 1% probability levels, respectively.

Stepwise Regression Equations

a. Y = Oil percentage

$Y = 27.3 + .31X_7 - .25X_2 + .05X_1 = 1.21X_4 + .06X_5 - .06X_6 = .08X_3$

$R^2 = .40$ S.E. = 4.4

b. Y = Seed yield

$Y = -134 + 3.7X_2 + .42X_6 + .09X_1 + 1.1X_8 + 5.3X_4$

$R^2 = .70$ S.E. = 19.1

TABLE 3. Correlation Coefficients Between Eight Quantitative Characters Obtained From 86 Sunflower Plants. Oil % 38.

Variables	X_1	X_2	X_3	X_4	X_5	X_6	X_7
X_1 Plant height							
X_2 Head diameter	.223*						
X_3 No. of leaves	.678**	.161					
X_4 Stem circumfer.	.379**	.848**	.352**				
X_5 Seed yield	.404**	.807**	.297**	.819**			
X_6 200-seed weight	.060	.535**	-.047	.461**	.458**		
X_7 Embryo %	.124	-.225*	.068	-.251*	-.194	-.225*	
X_8 Oil %	.336**	-.166	.197	-.110	.016	-.280*	.425**

*, ** Significant at the 5% and 1% probability levels, respectively.

Stepwise Regression Equations

a. Y = Oil percentage

$Y = 23.1 + .18X_7 + .03X_1 - .04X_6 + .03X_5$

$R^2 = .35$ S.E. = 2.9

b. Y = Seed yield

$Y = -135 + 7.9X_4 + 3.5X_2 + .15X_1 + 1.7X_8$

$R^2 = .75$ S.E. = 23.3

TABLE 4. Correlation Coefficients Between Eight Quantitative Characters Obtained From 350 Sunflower Plants. Oil % 38.

Variables	X_1	X_2	X_3	X_4	X_5	X_6	X_7
X_1 Plant height							
X_2 Head diameter	.166**						
X_3 No. of leaves	.510**	.230**					
X_4 Stem circumfer.	.337**	.750**	.257**				
X_5 Seed Yield	.265**	.758**	.178**	.687**			
X_6 200-seed weight	.109*	.566**	-.104	.551**	.649**		
X_7 Embryo %	.075	.102	-.102	.173**	.194**	.347**	
X_8 Oil %	.265**	-.108*	.139**	-.084	.025	-.103	.183**

*, ** Significant at the 5% and 1% probability levels, respectively.

Stepwise Regression Equations

a. Y = Oil percentage

$Y = 32.7 + .03X_1 + .59X_4 = .17X_7 + .04X_6 + .03X_5$

$R^2 = .18$ S.E. = 3.4

b. Y = Seed yield

$Y = -118 + 3.73X_2 + .53X_6 + .07X_1 + .86X_8 + 3.5X_4$

$R^2 = .68$ S.E. = 17.7

TABLE 5. Correlation Coefficients Between Protein Content and Other Quantitative Characters Obtained from 147 Sunflower Plants.

Character	r	Character	r
Plant height	-.09	Seed yield	.18*
Stem circumference	.26**	200-seed wt.	.27**
No. of leaves	-.05	Embryo %	.21**
Head diameter	.15*	Oil %	-.13

*, ** Significant at the 5% and 1% probability levels, respectively.

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