VARIABILITY IN DECORTICATION OF SUNFLOWER ACHENES AND CORRELATIONS WITH ASSOCIATED ACHENE CHARACTERS.

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Abstract

Seventy sunflower genotypes consisting of inbred, hybrid and open-pollinated varieties were dehulled by a rotor mill. The analysis of variance for decortication demonstrated a significant difference in ease of dehulling among different sunflower genotypes. Achene characters of size, oil percentage, color, wax percentage of the hull and percent hull were studied to determine their interrelationships and to establish the relative importance of each as they affected decortication. Correlation coefficients were calculated for all possible combinations of achene characters. The correlation between decortication and color was not significant. Decortication was negatively correlated with oil and wax percentage ($r = -0.54$ and -0.56, respectively) and positively correlated with percent hull and achene size ($r = 0.42$ and 0.57, respectively), when all 70 genotypes were considered together. None of these characters were significantly correlated with decortication in the nonoilseed genotypes, and hull percent was not significantly correlated with decortication in the oilseed genotypes. Path coefficients were used to analyze multiple correlation coefficients from the best multiple regression model and to establish the relative importance of variables as they affected decortication. Achene size was the most important character in the oilseed genotypes. Oil and wax percentage were shown to have less important effects on decortication. The negative correlation between oil percentage and decortication may pose a problem for the oilseed sunflower breeder.

Introduction

Selection for high oil percent in sunflower (Helianthus annuus L.) has resulted in smaller seed with a lower hull percent and may have resulted in inadvertent selection for seed which is more difficult to decorticate. Partial decortication results in increased wear on machines, and poorer quality meal (Ashes and Peck, 1978).

Little research has been conducted on dehulling sunflower, or on the effect of various seed characters on decortication. Morrison et al., 1981, suggested that hull wax content affected the amount of force required to break sunflower hulls. Dedio, 1982, found a negative correlation between hull and decortication percentages.

This research was conducted to determine the variability among several sunflower genotypes in ease of decortication and the association of decortication and the achene characters of seed size and color, and oil, wax and hull percentages.

Materials and Methods

Seventy sunflower genotypes were classified for decortication percent, whole seed oil percent, hull wax percent, hull percent, seed size, and seed color. Thirteen of these cultivars were supplied by Northrup King Company [1/] and the remainder were from the USDA collection at North Dakota State University. These genotypes included both oilseed and nonoilseed hybrids, inbreds (i.e. both B-lines and R-lines) and open-pollinated lines, grown in 1978 through 1980. Table 1 lists these lines and their type.

Seed size was classified into four groups by the following:

1 = seed through 4.8 mm round-holed screen
2 = seed over 4.8 mm and through 5.6 mm round-holed screen
3 = seed over 5.6 mm and through 6.4 mm round-holed screen
4 = seed over 6.4 mm round-holed screen

Seed color was divided into five groups as follows:

1 = white
2 = gray with white stripes
3 = black with white stripes
4 = black with gray stripes
5 = black

Hull percent was determined by dividing gram weight of the hulls by gram weight of the kernels plus the hulls.

The wax percent of the hulls was determined by a modified Morrison method (Morrison et al., 1975). Two grams of hulls was processed and two replications of each sample evaluated where possible. Hulls were ground in a blender. Fifty-five ml of boiling hexane was added to two grams of ground hulls. This solution was then boiled for 15 minutes. Hulls were removed by suction filtration. The liquid containing the wax was placed in a preweighed planchet and the remaining hexane was boiled off. The planchet was reweighed, and the amount of wax determined by subtracting the initial weight of the planchet from the weight of the planchet containing the wax. This weight was then divided by the weight of the hulls to determine the percent wax in the hulls.

A scaled down model of a commercial rotor mill supplied by California Pellet Mill Company of Crawfordville, Illinois,[1/] was used for this study. Ten replications each of 10, 30 and 50 gram samples of seed from Hybrid 894 were decorticated and variances of each calculated to determine the least variable sample size to use for the study. The 10 gram sample was determined to be most reliable.

A completely randomized design was used to determine statistical differences between decortication and wax percentage of different genotypes.

Simple correlations were calculated between decortication and the various associated seed characters, as well as among the seed characters. The best one, two, three, four and five variable multiple regression models were determined. Path coefficient analysis on all 70 genotypes and upon the oilseed and nonoilseed genotypes separately was utilized to clarify the relationships between decortication and variables contained in this model (Dewey and Lu, 1959, and Thompson, 1980).

1/ Mention of U.S. commerical companies or their products are not an endorsement for those companies or their products by USDA-ARS.

Results and Discussion

Highly signficant differences were found for wax and decortication percentages among the different genotypes (Table 1). Coefficients of determination were found to be 0.99 and 0.98 for wax and decortication. Thus, the vast majority of the variation for both of these traits was due to differences among genotypes. Table 1 presents percent decortication and associated traits for the seventy cultivars. As observations on seed characters other than decortication and wax percentage were non-replicated, no statistical inferences were drawn for differences among genotypes for these characters.

Table 2 shows correlation coefficients between decortication and four of the seed characters studied. Decortication had a significant positive correlation with percent hull and with seed size, and a significant negative correlation with percent wax in the hull and with percent whole seed oil when all 70 genotypes were considered together. A negative correlation between decortication and seed color was non-significant.

The four variable multiple regression model showed that seed size, wax percent, oil percent, and percent hull directly affected decortication, and that 51 percent of the variation in the model was due to the effect of these variables.

Path coefficients show the direct and indirect effects of these four variables on decortication (Table 2). In the cases of seed size and wax and oil percentages, the direct effects are similar to those found by simple correlations. Indirect effects of these associated characters strengthen the direct effect of the individual character. The direct effect of hull percentage on decortication was negative. However, the combined indirect effects from the other three variables resulted in the expected overall positive correlation of hull percentage with decortication.

When the nonoilseed and oilseed genotypes were considered as separate groups, none of the variables were significantly correlated with decortication for the nonoilseed group, and percent hull was not significantly correlated in the oilseed genotypes.

These data indicate that ease of decortication in these nonoilseed sunflower genotypes is independent of the seed characteristics studied. Thus, selection for decortication in nonoilseed sunflower should not be complicated by the effects of these other seed characters. Progress in selection for ease of decortication will depend upon heritability of this character, which is yet to be determined.

The situation in oilseed genotypes is more complicated because three of the characters studied directly affected decortication. The significant negative correlation between oil percent and decortication indicates that breeders may have some problems selecting high oil, easily decorticated lines. However, examination of the data in Table 1 shows that eight genotypes with oil percent over 40 had decortication percentages over 90. Thus selection for high oil and easily decorticated genotypes should be possible.

The effects of hull percent on decortication are unclear. We found mixed reactions in direct and indirect affects of hull percent on decortication, while Dedio, 1982, found a negative correlation between hull percent and decortication. No explanation for these divergent results is apparent. Much work on these interactions is needed.

Conclusion

1. Genotypes differed significantly for decortication and wax percentages.

2. Decortication in oilseed genotypes was negatively correlated with wax and oil percentage and positively correlated with seed size.

3. The effect of hull percent on decortication is unclear.

4. Seed color was not significantly correlated with decortication.

5. Despite these complex relationships, it may be possible to select for genotypes with high oil and high percent decortication.

6. These seed characters do not significantly affect decortication in the nonoilseed genotypes studied.

7. More work needs to be done on the interactions among these characters and their heritabilities.

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Table 1. Mean dehulled percentage for achenes and values for associated achene traits for 70 sunflower genotypes.

Line	Type[a]	Decortication %	Hull %	Wax %	Size[b]	Color[c]	Oil %
5-4836	NO-IB	100	51	.30	4	3	26
IF 4123	NO-IB	100	50	.44	4	2	26
IF 4209	NO-IB	100	50	.42	3	1	29
803489	NO-OP	100	49	.32	3	4	29
803328	NO-OP	100	53	.28	4	2	25
5-4830	NO-IB	99	42	.47	3	4	30
Hybrid 924	NO-HB	99	48	.41	4	3	31
803344	OS-RL	99	60	.23	4	3	45
803485	NO-OP	99	66	.22	4	2	19
804051	OS-RL	98	32	.80	3	5	43
802312	OS-BL	98	27	.67	3	4	43
780235	OS-BL	98	32	.55	3	5	42
780218	OS-BL	98	28	.53	3	4	38
803378	OS-OP	98	34	.84	3	5	40
803488	NO-OP	97	44	.31	2	3	33
803460	NO-OP	97	42	.29	2	2	29
I35	OS-BL	96	27	.68	2	4	45
803320	NO-OP	96	42	.27	2	2	29
803379	NO-OP	96	35	.57	3	4	36
780233	OS-BL	96	31	.90	2	1	33
IF 5198	NO-IB	95	45	.31	2	2	23
IF5199	NO-IB	95	52	.53	3	4	28
803319	NO-OP	95	38	.27	3	2	35
803311	NO-OP	94	51	.35	3	1	25
IF 5196	NO-IB	93	38	.52	2	2	25
IF 4348	NO-IB	93	33	.51	2	4	38
803364	NO-OP	92	33	1.73	2	4	32
803315	NO-OP	92	42	.27	2	2	26
803515	NO-OP	91	33	.53	2	2	35
780223	OS-BL	90	39	.34	2	4	43
780440	OS-BL	90	24	.84	2	4	42
IF 5235	OS-IB	89	30	.46	2	4	41
780468	OS-BL	89	25	1.38	2	4	46
804039	OS-RL	88	29	.69	2	1	43
780086	OS-BL	88	28	.45	2	5	41
5-4802	NO-IB	87	42	.45	2	3	30
I33	OS-BL	87	24	.63	2	4	45
802206	OS-BL	86	27	2.17	2	4	49
803310	NO-OP	86	47	.40	2	2	27
780422	OS-BL	85	25	.81	2	4	49
792281	OS-BL	80	28	.60	2	4	40
802310	OS-BL	80	30	.56	2	5	35
IF 5200	NO-IB	79	36	.37	2	2	32
803316	NO-BL	79	44	.26	1	2	32
780424	OS-BL	78	24	.89	2	4	51
IF 5234	OS-IB	77	30	.53	2	4	41
802202	OS-BL	77	28	2.33	2	4	53
Hybrid 884	NO-HB	77	46	.50	3	2	31
IF 4215	NO-IB	74	39	.37	1	1	28
Hybrid 903	OS-HB	74	27	1.27	2	5	48
I31	OS-BL	71	24	1.19	2	4	44
Hybrid 883	NO-HB	70	47	.37	2	2	29
802169	OS-BL	68	30	.72	2	4	41
Hybrid 894	OS-HB	64	27	3.27	2	4	56
780144	OS-BL	64	23	2.39	2	4	53
780220	OS-OP	57	30	.71	2	5	48
804035	OS-RL	56	24	3.01	3	4	49
802175	OS-BL	54	30	1.53	2	4	48
780454	OS-BL	53	28	.98	2	4	46
780094	OS-BL	50	27	1.34	2	5	48
780225	NO-OP	49	35	.96	2	4	30
804003	OS-RL	43	20	1.16	1	5	48
780156	OS-BL	42	31	1.62	2	4	49
803345	NO-OP	41	43	.39	4	2	33
804034	OS-RL	40	20	1.09	1	4	51
804007	OS-RL	40	26	.89	1	5	49
804012	OS-RL	31	35	1.41	1	5	39
780160	OS-BL	24	36	1.10	1	5	49
804035	OS-RL	22	26	3.71	1	2	49
804057	OS-RL	17	32	1.44	1	3	49
$\bar{X}$		79	35	0.86	2	-	42
SE		3	-	0.08	-	-	-
CV %		3.79	-	6.88	-	-	-
F		186.6**	-	113.0**	-	-	-

a NO = nonoilseed, OS = oilseed, IB = inbred, HB = hybrid, OP = open-pollinated, BL = B-line, RL = R-line.

b = Achenes through a 4.8 mm screen, 2 = achenes over a 4.8 mm screen and through a 5.6 mm screen, 3 = achenes over a 5.6 mm screen and through a 6.4 mm screen, 4 = achenes over a 6.4 mm screen.

c = white, 2 = gray with white stripes, 3 = black with white stripes, 4 = black with gray stripes, 5 = black.

** Significant at the one percent level of probability.

Table 2. Simple correlations and path coefficient analysis between decortication and associated achene characters.

Character	Combined group	Nonoilseed	Oilseed
	path coeff.	path coeff.	path coeff.
Seed size			
direct effect	0.511	0.104	0.734
indirect from wax	0.109	0.001	0.007
indirect from oil	0.175	0.002	0.005
indirect from hull	-0.227	0.008	-0.131
Simple correlation	0.568**	0.115 NS	0.615**
Wax percent			
direct effect	-0.334	-0.008	-0.296
indirect from seed size	-0.167	-0.002	-0.185
indirect from oil	-0.266	-0.002	-0.119
indirect from hull	0.209	-0.006	0.009
Simple correlation	-0.558**	-0.018 NS	-0.591**
Oil percent			
direct effect	-0.215	-0.008	-0.201
indirect from seed size	-0.214	-0.002	-0.202
indirect from wax	-0.417	-0.002	-0.175
indirect from hull	0.306	-0.100	0.008
Simple correlation	-0.540**	-0.112 NS	-0.570**
Hull percent			
direct effect	-0.387	0.138	-0.296
indirect from seed	0.299	0.006	0.324
indirect from wax	0.180	0.004	0.009
indirect from oil	0.329	0.006	0.005
Simple correlation	0.421**	0.154 NS	0.042 NS

** Significant at 0.01 level of probability.