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Relationship between Groat-Oil Content and Grain Yield of Oats *(Avena sativa* L.)[1]

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ABSTRACT

Raising the energy content of oat (*Avena sativa* L.) groats by increasing their oil percentage could improve the economic value of oats as a feed grain and as a source of culinary oil. Relative importance of genotype x environment interaction for groat-oil content and grain yield and the correlations of groat-oil content with yield and maturity were evaluated for ten cultivars grown at three Iowa locations for two years. Cultivar x location mean squares were significant for both traits, but they were much smaller, relative to cultivar mean squares, for groat-oil content than for grain yield. Ranking of oat cultivars for groat-oil content was similar in all environments. Groat-oil content was positively correlated with grain yield in both years (r = 0.62* and 0.63*) and had a negative but nonsignificant correlation coefficient with maturity (r = −0.28 and −0.48). These relationships are favorable for the development of high-yielding, high groat-oil content cultivars.

INDEX DESCRIPTORS: grain quality, genotype x environment interaction

Researchers in Canada and the United States of America have suggested that high groat-oil content would augment the value of the oat (*Avena sativa* L.) crop (Brown et al., 1966; Klinck, 1967; Brown and Craddock, 1972; de la Roche et al., 1977; Forsberg *et al.*, 1974). Oats are highest in kernel oil content among the cereals (Weber, 1973; Price and Parsons, 1975), but the low energy content of the hull restricts the use of oats as a feed grain (Hutchinson and Martin, 1955; Brown and Craddock, 1972). In feeding trials in Manitoba, "high-oil" oats (9%) were similar to barly (*Hordeum vulgare* L.) in feeding value for swine (Stothers, 1977).

Frey and Hammond (1975) calculated that an oat cultivar with 17% groat-oil content and present levels of groat protein and grain yield would be competitive for oil extraction. According to Hammond (1982), extraction of oil from oats with 10% groat oil would add $2.34 net to the value of 100 kg (approximately $0.34 per bushel) of oat grain (about 20%).

The agricultural value of high-oil oats is dependent upon their grain yield as well as upon groat-oil percentage, but few researchers have examined the relationship between these traits. Stuke (1960) noted that high values for groat-oil content and grain yield occurred together in some European cultivars. Other investigators found either independence or a positive association between groat-oil content and grain yield (Forsberg *et al.*, 1974; Gullord, 1980). Youngs and Forsberg (1979) mentioned that 'Dal', 'Wright', 'Mo-0205', 'Lyon', and 'Lodi' were cultivars with good yielding ability and high levels of groat-oil content.

The primary objective of this study was to ascertain the relationship between groat-oil content and grain yield. This information is pertinent to undertaking a breeding program to achieve a high level of groat-oil content in agronomically suitable cultivars.

MATERIALS AND METHODS

Grain yield and groat-oil content were determined in each of two years for several *A. sativa* cultivars adapted to the Midwestern USA. In 1978, the cultivars were 'Richland', 'Garland', 'Bates', 'Otee', 'CI9273', 'Spear', 'Chief', 'Grundy', 'Clintford', and 'Multiline M73', and in 1981, 'Noble', 'Lang', and 'Iowa X' were substituted for CI9273, Bates, and Clintford. Seed lots were obtained from three replicates at each of four locations (Ames, Nashua, Kanawha, and Sutherland, Iowa in 1978 and Nashua, Kanawha, Sutherland, and Washington, Iowa in 1981) of the Iowa Oat Variety Tests. The experiments were conducted in randomized block designs with cultural practices, including fertilizer application, as recommended for high productivity in the region. A plot consisted of four rows, each 2.5 m long, and spaced 30.5 cm apart. All plots were hand-weeded, and the experiments were free of disease and insect damage.

Days to heading was recorded for a plot when 50% of the panicles were fully emerged. The two center rows of a plot were harvested when mature, threshed, and used to estimate grain yield. A 4-g sample of groats from each plot was used for analysis by the NMR method (Conway and Earle, 1963) to determine oil content. Groat-oil content is expressed as a percent of total kernel dry weight.

Data for yield per plot and for groat-oil content were used to compute analyses of variance for estimation of cultivar, location, and cultivar x location (i.e., genotype x environment) effects. Data were not transformed for the analysis of variance. Phenotypic correlations between the two traits were calculated within locations and pooled across locations by using "z" transformations (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Mean squares for cultivars x locations interaction were significant for both groat-oil content and grain yield in both years (Table 1). The cultivars x years source of variation for groat-oil content for the seven cultivars common to both years was highly significant (Table 2), whereas the cultivars mean square over years was not.

The relationship between groat-oil content and grain yield in the oat samples ranged from independence to significantly positive (Table 3). Yield at Nashua in 1981 was severely reduced by heavy rainfall on several occasions and this may have affected the correlation coefficient for groat-oil content with grain yield at that location. Correlation coefficients of groat-oil content with heading date were negative but not significantly different from zero in both years. Although the cultivar x location mean squares were significant for groat-oil content in both years, they were much smaller relative to the cultivar mean squares than were those for grain yield. Therefore, groat-oil content of the cultivars was determined largely by genetic effects. Our results corroborate those observed by Hutchinson and Martin (1955) for British and by Baker and McKenzie (1972) for Canadian cultivars.

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Table 1. Analyses of variance for groat-oil content and grain yield for 10 oat cultivars grown at four locations in two years in Iowa.

Source of variation	Degrees of freedom	Mean squares			
		Groat oil (%)		Grain yield (g/plot)	
		1978	1981	1978	1981
Locations	3	4.46**	0.61	33,044**	340,384**
Cultivars	9	15.22**	4.91**	20,086**	3,561
Cultivars x locations	27	0.09*	0.30**	5,774**	7,904**
Error	72	0.05	0.12	3,098	2,819

*, ** Significant at the 0.05 and 0.01 levels of probability, respectively.

Environment modified groat-oil content of oats to a lesser extent than it modified grain yield, so the ranking of cultivars across locations was much more consistent for groat-oil content than for grain yield. These results suggest that measurement of groat-oil content of an oat genotype in one environment should give a reliable indication of its relative rank for this trait in other environments.

The cultivars that we evaluated were highly selected for grain yield but unselected for groat-oil content. Therefore, they may represent a random sample of genotypes for groat-oil content. The highest-yielding cultivars had the highest groat-oil content (expressed on a kernel bases; see materials and methods) in both years (Bates in 1978 and Lang and Iowa X in 1981), and the lowest-yielding cultivars had the lowest groat-oil content (Richland in 1978 and Garland in 1981). Cultivars with the highest yield and highest groat-oil content were early in maturity.

The positive correlation between groat-oil content and grain yield in these cultivars and the smaller, nonsignificant negative correlation coefficients for groat-oil content and maturity are favorable for development of high-yielding, early-maturing, high groat-oil content cultivars for the Midwestern United States. However, the correlations obtained in this study should be applied with caution in planning selection for yield and groat-oil content in segregating oat populations. This study included a set of cultivars in which genes for yield and groat-oil content are not in gametic-phase equilibrium (Falconer, 1981); therefore, it is possible that chance association of alleles for high yield and high groat-oil content occurs in certain of these cultivars. Such a chance association of the two traits would be unrepresentative of the situation to be expected in selfed progeny of biparental crosses, because only true linkage and pleiotropy will affect trait association in biparental progenies. Sufficient agreement exists, however, between these results and previous observations to suggest that these relationships apply generally within *A. sativa.*

Table 2. Analysis of variance for groat-oil content for seven oat cultivars grown for two years at three locations in Iowa.

Source of variation	Degrees of freedom	Mean square
Years	1	0.50
Cultivars	6	0.33
Cultivars x years	6	1.41**
Error	41	0.13

** Significant at the 0.01 level of probability.

Table 3. Correlations between groat-oil content and grain yield of oats in Iowa.

Location	Year	
	1978	1981
Ames	0.44	—
Kanawha	0.04	0.14
Nashua	0.68*	0.45
Sutherland	0.53	0.23
Washington	—	0.62*
Over locations	0.62*	0.63*

* Significantly different from zero at the 0.01 level of probability.

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REFERENCES

BAKER, R. J., and R. I. H. McKENZIE. 1972. Heritability of oil content in oats, *Avena sativa* L. Crop Sci. 12:201-202.

BROWN, C. M., and J. C. CRADDOCK. 1972. Oil content and groat weight of entries in the world oat collection. Crop Sci. 12:514-515.

BROWN, C. M., D. E. ALEXANDER, and S. G. CARMER. 1966. Variation in oil content and its relation to other characters in oats (*Avena sativa* L.). Crop Sci. 6:190-191.

CONWAY, T. F., and F. R. EARLE. 1963. Nuclear magnetic resonance for determining oil content of seeds. J. Am. Oil Chem. Soc. 40:265-268.

de la ROCHE, I. A., V. D. BURROWS, and R. I. H. McKENZIE. 1977. Variation in lipid composition among strains of oats. Crop Sci. 17:145-148.

FALCONER, D. S. 1981. Quantitative genetics. Longman, Inc., New York. 340p.

FORSBERG, R. A., V. L. YOUNGS, and H. L. SHANDS. 1974. Correlations among chemical and agronomic characteristics in certain oat cultivars and selections. Crop Sci. 14:221-224.

FREY, K. J., and E. G. HAMMOND. 1975. Genetics, characteristics, and utilization of oil in caryopses of oat species. J. Am. Oil. Chem. Soc. 52:358-362.

GULLORD, M. 1980. Oil and protein content and its relation to other characters in oats (*Avena* sp.). Acta Agric. Scand. 30:216-218.

HAMMOND, E. G. 1982. Oat lipids. *In* E. Barnes (ed.) Lipids in cereal technology. Academic Press, New York. In press.

HUTCHINSON, J. B., and H. F. MARTIN. 1955. The chemical composition of oats. I. The oil and free fatty acid content of oats and groats. J. Agric. Sci. (Camb.) 45:411-418.

KLINCK, H. R. 1967. Some aspects of quality in cereals. Cereal News. Can. Dep. Agric. Res. Bull. 12:3-9.

PRICE, P. B., and J. G. PARSONS. 1975. Lipids of seven cereal grains. J. Am. Oil Chem. Soc. 52:490-493.

STEEL, R. G. D., and J. H. TORRIE. 1980. Principles and procedures of statistics. 2nd ed. McGraw-Hill Book Company, New York.

STOTHERS, S. C. 1977. High fat oats for finishing pigs. Can. Inst. Food Sci. Tech. Joint Conf. 14-18 Aug. Guelph, Ontario, Canada.

STUKE, H. 1960. Untersuchungen über den Rohfettgehalt des Hafers. Z. Pflanzenzücht. 42:147-189.

WEBER, E. J. 1973. Structure and function of cereal components as related to their potential industrial utilization. IV. Lipids. *In.* Y. Pomeranz (ed.) Industrial uses of cereals. Am. Assoc. Cereal Chem., St. Paul, Minn.

YOUNGS, V. L., and R. A. FORSBERG. 1979. Protein-oil relationships in oats. Crop Sci. 19:798-802.