Effect of Planting Date and Southern Corn Leaf Blight on the Fatty Acid Composition of Corn Oil[1]

M. D. JELLUM, University of Georgia College of Agriculture Experiment Stations
Georgia Station, Experiment, Ga. 30212

ABSTRACT

Eight commercial corn (*Zea mays* L.) hybrids were planted on each of three different dates in 1969 and 1970. Southern corn leaf blight caused by *Helminthosporium maydis* did not occur in 1969, but a severe disease epidemic occurred in 1970 and greatly reduced yields of susceptible hybrids in the second and third planting dates. Fatty acid composition of oil was determined for each hybrid from each planting date and year. Hybrids were significantly different for all fatty acids in both years. Planting dates had a small influence on only palmitic and stearic acids in 1969, but all fatty acids (except linolenic) were significantly different among planting dates in 1970. One hybrid resistant to infection by leaf blight and one hybrid with intermediate resistance showed identical trends in oil composition among planting dates, as did hybrids susceptible to leaf blight. Therefore, it was concluded that southern corn leaf blight did not influence oil composition. A relationship between temperature (during the period of rapid change in oil content and oil composition) and fatty acid composition of oil could not be established under the field conditions of this study.

An epidemic of southern corn leaf blight caused by the fungus *Helminthosporium maydis* Nisikado and Miyake occurred on corn (*Zea mays* L.) throughout the U.S. in 1970. The epidemic was caused by Race T of the fungus, which was able to infect corn hybrids containing the Texas source of cytoplasmic male sterility (1,2,3). The leaf blight was especially destructive on corn in the southeastern states and on late-planted corn in the midwest corn belt.

The influence of various diseases on the fatty acid composition of corn oil is unknown. Since the quality and use of corn oil is determined by its fatty acid composition, knowledge of the effect of diseases on oil composition is of interest for the industrial utilization of corn affected by various diseases such as leaf blight. In other crops, five virus diseases of hops (*Humulus lupulus*) were reported (4) to have no influence on oil composition; but cowpea chlorotic mottle virus (soybean strain) and tobacco ringspot virus significantly increased stearic and oleic acids and decreased palmitic, linoleic, and linolenic acids of soybean oil (5,6). The tobacco ringspot virus had greater effects on oil composition than did cowpea chlorotic mottle virus.

Jellum and Marion (7) studied oil composition of nine corn hybrids from three planting dates in each of two years. Oil composition was affected in only one year, with the late planting date having corn which had oil lower in stearic and oleic acids

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[2]Pioneer (also Asgrow, Coker, Excel, Funk's, McCurdy, P-A-G, and Speight) is a brand name and the number is the hybrid designation. The use of brand names in this paper is for identification only and does not imply their endorsement or recommendation by the University of Georgia over other hybrids which may have similar characteristics.

and higher in linoleic acid. In other planting-date studies, a late planting date has been associated with a higher degree of unsaturation of rape oil (8) and soybean oil (9,10). In most oilseed crops an increase in temperature during the seed-maturation period will generally result in a lower percentage of unsaturated fatty acids (10,11,12,13).

MATERIALS AND METHODS

Hybrids and Planting Dates

Eight commercial corn hybrids were planted on April 2, April 25, and May 21 in 1969 and on April 8, May 8, and June 16 in 1970. Pioneer[2] 511A, Funk's G-4761, Coker 912, McCurdy 67-14, P-A-G SX99, Pioneer 309B, and Speight D-20 were grown in 1969 and 1970. The other hybrid in 1969 was Excel E-1022A and in 1970 it was Asgrow ATC403W. Hybrids were planted in two-row plots (each row had eight hills with two plants per hill) with four replications. Since these were yield trials, controlled pollinations were not made, and some of the variability in oil composition among replications would be because of the uncontrolled source of the pollen parent (xenia effect). However, it was concluded from a study of the data that the differences among hybrids and planting dates were of greater importance than that owed to xenia effects.

Pioneer 511A had 100% normal cytoplasm and was resistant to infection by *H. maydis* in 1970. Funk's G-4761 was a blend of seed (33% normal cytoplasm and 67% Texas male sterile cytoplasm) and had a mixture of resistant and susceptible plants (intermediate disease reaction). The other six hybrids had 100% T cytoplasm and were susceptible to leaf blight. Leaf blight was not present in 1969, but severely affected the susceptible hybrids in the second and third planting dates in 1970.

Sampling Procedure and Oil Extraction

A representative grain sample of each hybrid was obtained by stripping 2 to 3 kernel rows the length of the ear from 12 to 15 ears per plot in each replication. The grain was ground in a Wiley mill and two sub-samples of 0.2 g. were extracted with petroleum ether (Skellysolve F) and absolute methanol (14). Oil composition reported in this paper represents the total seed lipids and would not be identical to commercial corn oil which is obtained from the germ fraction of the kernel (14). Preparation of samples for GLC analysis has been previously described (14,15).

GLC and Statistical Analysis

The equipment has been described previously (14). Methyl esters were separated on a copper column 7.5 ft. by 1/8 in. packed with 10% stabilized diethylene glycol succinate on 80/100 mesh Chromosorb W AW-DMCS solid support. The column oven was held at 210°C., and the retention time for linolenic acid was about 8 min. with excellent resolution of fatty acids. Column performance and detector response were periodically checked by analyzing a sample of commercial corn oil of known composition.

An analysis of variance was performed on the data for each year. Planting dates were the main plots and hybrids were the subplots. Significant differences among various means were determined by Duncan's Multiple Range Test at the 5% level of significance.

RESULTS AND DISCUSSION

Grain Yield

Grain yields are shown in Table I to indicate the general growing conditions for each of the planting dates in 1969 and 1970. Leaf blight was not present in 1969 and the average yield of all hybrids is shown. In 1970, yield of hybrids with different disease reactions shows the effects of leaf blight on yield. Grain yield is given to show a possible relationship between yield level and oil composition.

Oil Composition

Mean squares are given in Table II to show the sources of variation which were significantly different. Hybrids were different in all fatty acids in both years. Differences among planting dates were obtained for palmitic and stearic acids in 1969 (5% level) and for palmitic, stearic, oleic, linoleic, and arachidic acids in 1970. The hybrid X planting date interaction mean squares were quite small when compared with the other mean squares.

Fatty acid composition of oil from the various hybrids is shown in Table III. An average for all hybrids is given for 1969 since there was little effect of planting date

TABLE I. GRAIN YIELD OF HYBRIDS FROM THREE PLANTING DATES IN 1969 AND 1970

	Planting Date		
	First	Second	Third
	quintals/hectare (bu./A.)		
1969			
Yield of eight hybrids when leaf blight was not present	32.4 (52)	51.6 (82)	47.0 (75)
1970			
Yield of resistant hybrid (Pioneer 511A)	82.7 (132)	85.0 (136)	36.7 (59)
Yield of intermediate hybrid (Funk's G-4761)	69.3 (111)	58.4 (93)	22.8 (36)
Yield of susceptible hybrids (six hybrids)	67.2 (107)	54.0 (86)	7.8 (13)

TABLE II. MEAN SQUARES FROM THE ANALYSIS OF VARIANCE

Source of Variation	d.f.	Fatty Acid 16:0	18.0	18:1	18:2	18:3	20:0
				1969			
Replication	3	0.35	0.010	2.47	0.89	0.005	
Planting date	2	2.33*	0.124*	1.51	4.65	0.018	
Error (a)	6	0.31	0.014	1.69	1.18	0.006	
Hybrid	7	1.48**	0.681**	237.03**	240.91**	0.009**	
Planting date X hybrid	14	0.26	0.016	3.12*	2.68*	0.003	
Error (b)	63	0.14	0.015	1.53	1.37	0.003	
				1970			
Replication	3	0.62	0.045*	0.85	0.10	0.010	0.016
Planting date	2	14.78**	1.311**	59.09**	29.59**	0.003	0.108**
Error (a)	6	0.19	0.005	0.78	0.32	0.005	0.007
Hybrid	7	3.06**	0.209**	254.79**	231.30**	0.010*	0.025**
Planting date X hybrid	14	0.66**	0.024*	4.12**	2.70	0.006	0.003
Error (b)	63	0.20	0.012	1.54	1.61	0.004	0.003

TABLE III. OIL COMPOSITION OF HYBRIDS FROM THREE PLANTING DATES

Hybrid[a]	Dates	Percent Fatty Acid Composition of Oil 16:0	18:0	18:1	18:2	18:3	20:0
				1969			
Average (eight hybrids)	1	15.4a[b]	2.2a	35.0a	46.6a	0.8a	
	2	15.2ab	2.1a	34.6a	47.3a	0.9a	
	3	14.9b	2.0b	35.0a	47.2a	0.9a	
				1970			
Average (eight hybrids)	1	14.8a	2.2a	35.1a	46.3a	0.9a	0.6a
	2	15.1b	1.9b	34.4b	46.9b	0.9a	0.6a
	3	16.1c	1.8c	32.5c	48.2c	0.9a	0.5b
Pioneer 511A	1	14.6	2.1	36.3	45.3	0.9	0.5
	2	14.7	2.0	36.2	45.5	0.9	0.5
	3	15.4	1.7	34.1	47.4	0.8	0.5
Funk's G-4761	1	14.2	2.4	41.4	40.2	0.8	0.6
	2	14.8	2.1	39.9	41.5	0.8	0.6
	3	14.8	2.0	40.4	41.4	0.9	0.5
Asgrow ATC403W	1	14.1	2.3	37.8	44.3	0.8	0.6
	2	14.5	1.9	37.2	44.8	0.9	0.6
	3	16.0	2.0	33.9	46.7	0.9	0.5
Coker 912	1	15.2	2.3	37.2	43.5	0.9	0.7
	2	15.4	1.9	35.8	45.2	0.9	0.7
	3	17.4	1.9	33.1	45.9	0.9	0.6
McCurdy 67-14	1	15.0	2.2	36.5	44.7	0.8	0.6
	2	15.3	1.9	33.9	47.3	0.9	0.6
	3	15.7	1.7	35.1	46.0	0.9	0.5
P-A-G SX99	1	14.9	2.1	25.0	56.2	0.9	0.6
	2	15.7	1.8	26.3	54.6	0.9	0.5
	3	16.5	1.6	22.7	57.6	0.9	0.4
Pioneer 309B	1	14.9	2.0	33.5	47.9	0.9	0.6
	2	15.1	1.7	32.5	49.1	0.9	0.6
	3	16.8	1.6	29.7	50.3	0.9	0.5
Speight D-20	1	15.5	1.9	32.9	48.0	0.9	0.6
	2	15.3	1.8	33.5	47.5	0.9	0.6
	3	16.3	1.7	30.6	50.0	0.9	0.5

[a]Pioneer, Funk's, etc. are brand names and numbers are hybrid designations. Pioneer 511A had normal cytoplasm and was resistant to blight; Funk's G-4761 had a 33/67 blend of N and T cytoplasm; the other hybrids had 100% T cytoplasm and were susceptible to leaf blight.

[b]Duncan's Multiple Range Test. Means of fatty acids within each year followed by a common letter are not significantly different at the 5% level.

and also no leaf blight. Oil composition of each hybrid was similar between the two years and the over-all average was similar (Table III). Oil composition for each hybrid from different planting dates is shown for 1970 when southern corn leaf blight severely affected grain yields of susceptible hybrids. If leaf blight affected oil composition, oil composition of Pioneer 511A (resistant to leaf blight) and Funk's

G-4761 (intermediate disease reaction) should have reacted differently among planting dates when compared with the susceptible hybrids. Pioneer 511A and Funk's G-4761 reacted identically to the other hybrids and the degree of change was similar to susceptible hybrids (Table III). Therefore, the change in oil composition among planting dates was caused by environmental factors rather than by southern corn leaf blight.

The third planting date in 1970 was especially late (June 16), and grain yields of susceptible hybrids were severely affected by leaf blight (Table I). Pioneer 511A was also much reduced in yield, but because of its resistance to leaf blight it was about 5X higher in yield than the susceptible hybrids. This planting date resulted in the greatest deviation in oil composition for all eight hybrids. The results indicate that oil composition under field conditions are affected only under severe environmental stress which will also greatly affect grain yield. Even under these conditions the differences in oil composition among hybrids are of much greater importance than differences caused by environmental factors. Although more differences in oil composition due to planting date were found in this study than in a previous study (7), the results are in general agreement.

All hybrids (except P-A-G SX99) had a relatively low proportion of linoleic acid. P-A-G SX99 probably has more Corn Belt-type germ plasm than the other hybrids and the oil comes closest to that of commercial corn oil (16). The over-all average oil composition of these hybrids agrees with the oil composition found in an extensive survey of foreign and U.S. germ plasm (17).

Temperature and Oil Composition

It was concluded that southern corn leaf blight did not affect oil composition and that differences among planting dates in 1970 were due to environmental factor(s). Preliminary results (M. D. Jellum and D. L. Thompson, unpublished data) with one corn genotype have shown a much higher proportion of linoleic acid in oil from plants grown in a cool environment than plants grown in a warm environment. These preliminary results with corn are similar to results in other crops (10,11,12,13) concerning the relationship between temperature and oil composition.

A rapid increase in total oil content occurs during the third and fourth weeks after pollination (18), and the greatest change in oil composition occurs from about 10 to 24 days after pollination (19). Therefore, the average maximum and minimum temperatures are given in Table IV for the period of 10 to 24 days after

TABLE IV. AVERAGE MAXIMUM AND MINIMUM TEMPERATURE DURING THE PERIOD (10 TO 24 DAYS AFTER POLLINATION) OF RAPID CHANGE IN OIL CONTENT AND COMPOSITION

Year	Planting Date: First		Second		Third	
	Max.	Min.	Max.	Min.	Max.	Min.
1969	91.8	70.7	88.1	69.9	85.2	66.9
1970	88.3	65.5	89.7	70.0	88.9	69.6

pollination for each planting date in 1969 and 1970. Although temperatures during this period were lowest for the third planting date in 1969, little difference was observed in oil composition (Table III). In 1970, lowest temperatures occurred for corn planted April 8 (first planting date). Linoleic acid proportion of oil was lowest in corn from the first planting date and is in contrast to expected results. Temperatures were not greatly different for corn from different planting dates and the data from this field study are inconclusive concerning any relationship between temperature during seed maturation and oil composition.

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