Herbicide Influence on Cottonseed Oil Quality

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The influence of registered application rates of diuron, fluometuron, chlorpropham, DCPA, norea, prometryne, and alaclor on cottonseed oil quality from field grown cotton was measured by gas–liquid chromatography. Percentage composition of myristic, palmitic, palmitoleic, stearic, oleic, linoleic, linolenic, and arachidic acids in the soil was not influenced by the herbicide treatments. Seasonal and edaphic variations caused greater changes in cottonseed oil quality than did the herbicides tested.

Nutritional aberrations induced by pesticide applications in current agronomic crop production practices have become a major source of concern to environmentalists. In 1966 a total of 568 million kg of cottonseed (*Gossypium hirsutum* L.) oil was utilized for human consumption (Fats and Oils Situation, 1967). This oil was produced by a crop of which 78% was treated with herbicides (Quantities of Pesticides Used by Farmers in 1966, 1970).

Numerous studies have been reported on the influence of herbicides on: seed germination; plant emergence, growth, and development; photosynthesis; respiration; and yield of various crops. However, there are few data on the influence of herbicides on crop quality.

Increased protein content of wheat (*Triticum* spp. L.) following applications of 2,4-dichlorophenoxyacetic acid (2,4-D) was reported by Erickson *et al.* (1948). A reduction in oil percentage in flax (*Linum* spp. L.) following 2,4-D applications was reported by Tandon (1949). Similar results were reported by Dunham (1951). Ries *et al.* (1967) reported increased protein content of susceptible species following treatment with 2-chloro-4,6-bis(ethylamino)-*s*-triazine (simazine). These reports were from postemergence treatments of field or growth chamber grown plants.

Possible variations in the metabolism of field grown cotton by preemergence applications of herbicides could influence the quality of cottonseed oil used in human food. Therefore, determinations of the influence of several commonly used herbicides on crop quality were undertaken.

METHODS AND MATERIALS

Following cultivation and fertilization practices common to the area, cotton, var. Atlas 67, was planted on Cecil sandy clay loam (Cscl) at Experiment, Ga., and Davidson and Lloyd sandy clay loams (Dscl and Lscl, respectively) at Eatonton, Ga., in 1968 and 1969. A plot sprayer (Futral, 1963) calibrated to deliver 187 l./ha total volume was used to make preemergence applications to plots (2-m × 9.1-m). Common and chemical names and formulations are shown in Table I. Plot design was a randomized block. Plots were maintained uniformly throughout the growing season, hand harvested, and samples were taken for oil analysis. Four replications were utilized in each experiment.

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Cottonseed oil was extracted for 2 min at 6.9 × 10^8 dynes/cm^2 in a Carver press. The methyl esters of the fatty acids were prepared by transesterification with methanol (ACS–absolute) and concentrated H_2SO_4 at 65° C for 4 hr as described by Jellum and Worthington (1966a,b).

Fatty acid methyl esters were separated and quantitated on a gas–liquid chromatograph (Hewlett-Packard Model 5751A) equipped with dual flame-ionization detectors and a digital integrator [Infotronics (CRS-100)]. Chromatographic conditions were: 2.43 m × 4.76 mm i.d. copper columns filled with 70/80 mesh Chromosorb W (AW) (DMCS) carrying 10% w/w stabilized diethyleneglycolsuccinate (DEGS); carrier gas flow was helium at 75 ml/min. Temperatures utilized were: oven, 200° C isothermal, detector, 280° C, and injection port, 250° C. Retention times of the

Table I. Common Name, Chemical Name, and Formulations of Herbicides Used on Cotton Grown at Eatonton and Experiment, Ga., 1968 and 1969

Common name	Chemical name	Formulation
Diuron	3-(3,4-Dichlorophenyl)-1,1-dimethylurea	S[a]
Fluometuron	1,1-Dimethyl-3-(α,α,α-trifluoro-*m*-tolyl)urea	WP[b]
Chlorpropham	Isopropyl-*m*-chlorocarbanilate	EC[c]
DCPA	Dimethyl tetrachloroterephthalate	WP
Norea	3-(Hexahydro-4,7-methanoindan-5-yl)-1,1-dimethylurea	WP
Prometryne	2,4-Bis(isopropylamino)-6-(methylthio)-*s*-triazine	WP
Alaclor	2-Chloro-2′,6′-diethyl-*N*-(methoxymethyl)acetanilide	EC

[a] S = slurry. [b] WP = wettable powder. [c] EC = emulsifiable concentrate.

Table II. Influence of Herbicides on Percentage Composition of Cottonseed Oil

Herbicide	Rate kg/ha	No. of measurements	Myristic S[a]	Palmitic S	Palmitoleic U[b]	Stearic S	Oleic U	Linoleic U	Linolenic U	Arachidonic S	Total saturated S	Total unsaturated U
Diuron	0	28	0.8a[c]	22.7a	0.8a	2.2a	16.1a	57.0a	0.2a	0.1a	25.8a	74.1a
	1.57		0.8a	22.6a	0.7a	2.2a	16.3a	56.9a	0.2a	0.1a	25.8a	74.1a
Fluometuron	0	28	0.8a	22.7a	0.8a	2.2a	16.1a	57.0a	0.2a	0.1a	25.8a	74.1a
	2.24		0.8a	22.5a	0.7a	2.3a	16.3a	56.9a	0.3a	0.1a	25.7a	74.1a
Chlorpropham	0	16	0.9a	23.1a	0.7a	2.2b	16.5a	56.0a	0.2a	0.2a	26.4a	73.4a
	10.01		0.9a	23.3a	0.7a	2.3a	16.8a	55.5a	0.2a	0.2a	26.8a	73.1a
DCPA	0	8	1.0a	23.7a	0.9a	2.2a	16.5a	55.5a	0.1a	0.2a	27.0a	73.0a
	11.20		1.0a	24.0a	0.6a	2.2a	16.9a	55.0a	0.1a	0.1a	27.3a	72.7a
Norea	0	8	1.0a	23.7a	0.9a	2.2b	16.5a	55.5a	0.1a	0.2a	27.0a	73.0a
	2.24		1.0a	23.7a	0.6a	2.3a	16.7a	55.4a	0.1a	0.1a	27.2a	72.8a
Prometryne	0	8	0.9a	23.4a	0.8a	2.2a	15.6a	56.9a	0.1a	0.1a	26.6a	73.4a
	1.79		0.9a	23.0a	0.7a	2.3a	15.9a	56.8a	0.2a	0.2a	26.4a	73.6a
Prometryne	0	8	0.7a	22.5a	0.7a	2.1a	14.5a	59.2a	0.3a	0.0a	25.3a	74.6a
	2.24		0.7a	22.1a	0.6a	2.2a	15.0a	59.0a	0.3a	0.0a	25.0a	74.8a
Alaclor	0	8	1.0a	23.7a	0.9a	2.2b	16.5a	55.5a	0.1a	0.2a	27.0a	73.0a
	2.24		1.0a	23.8a	0.6a	2.4a	16.9a	55.2a	0.1a	0.1a	27.2a	72.8a
Alaclor	0	8	1.0a	23.7a	0.9a	2.2b	16.5a	55.5a	0.1a	0.2a	27.0a	73.0a
	1.68		0.9a	23.8a	0.6a	2.3a	16.8a	55.2a	0.1a	0.2a	27.2a	72.8a
Retention time (min)			1.4	2.3	2.8	4.1	4.7	6.0	7.7	8.1		

[a] S = saturated fatty acid. [b] U = unsaturated fatty acid. [c] Values within a component (*i.e.*, myristic) and one rate herbicide followed by the same letter or letters are not significantly different at the 5% level.

Table III. Influence of Soil Type, Location, and Year on the Percentage Composition of Cottonseed Oil Fatty Acid Constituents

Herbicide	Location	Year	Soil type	Myristic S[a]	Palmitic S	Palmitoleic U[b]	Stearic S	Oleic U	Linoleic U	Linolenic U	Arachidonic S	Total saturated S	Total unsaturated U
Diuron 1	Experiment	1968	C[c]	0.90b[f]	23.54a	0.88a	2.13c	16.49b	55.73c	0.11b	0.18b	26.74b	73.20c
2			C	0.93ab	23.01b	0.63a	2.51a	18.16a	53.89d	0.25ab	0.33a	26.78b	72.93c
4		1969	C	0.76c	22.78b	0.78a	2.10c	14.48d	58.79ab	0.18b	0.04c	25.68c	74.21b
5			C	0.61d	21.75c	0.59a	2.10c	14.90c	59.45a	0.38a	0.00c	24.46d	75.31a
3	Eatonton	1968	D[d]	0.98a	23.86a	0.69a	2.36b	16.91a	54.80c	0.13b	0.28a	27.48a	72.53d
6		1969	D	0.74c	21.98c	0.70a	2.06c	15.88bc	58.46ab	0.16b	0.00c	24.78d	75.20a
7			L[e]	0.75c	21.75c	0.80a	2.06c	16.61b	57.64b	0.26ab	0.00c	24.56d	75.31a
Fluometuron	Experiment	1968	C	0.93ab	23.73a	0.86a	2.15bcd	16.34bc	55.66b	0.10a	0.18b	26.98ab	72.96c
			C	0.89b	22.93b	0.64a	2.51a	17.93a	54.34b	0.25a	0.29a	26.61b	73.15c
		1969	C	0.73d	22.36b	0.71a	2.29abc	14.95c	58.59a	0.25a	0.00c	25.38c	74.50b
			C	0.61e	21.89c	0.56a	2.14bcd	15.08c	59.25d	0.29a	0.00c	24.64cd	75.18ab
	Eatonton	1968	D	0.98a	23.86a	0.69a	2.36ab	16.91ab	54.80b	0.13a	0.28a	27.48a	72.53c
		1969	D	0.79c	22.03c	0.83a	2.09cd	15.80bc	57.91a	0.44a	0.00c	24.90cd	74.98ab
			L	0.75cd	21.59d	0.85a	2.01d	16.31bc	58.03a	0.28a	0.00c	24.35d	75.46a
Chlorpropham	Experiment	1968	C	0.95a	23.69a	0.86a	2.18c	16.68a	55.36b	0.10b	0.18b	26.99a	73.00b
			C	0.98a	23.35a	0.65a	2.49a	17.76a	53.96b	0.28a	0.26a	27.08a	72.65b
		1969	C	0.65b	21.95b	0.58a	2.15c	15.30a	58.81a	0.38a	0.03c	24.78b	75.06a
	Eatonton	1968	D	0.96a	23.94a	0.84a	2.36b	16.94a	54.85b	0.10b	0.28a	27.54a	72.48b
DCPA	Experiment	1968	C	0.93b	23.58a	0.84a	2.09b	16.39a	55.93a	0.09a	0.14a	26.73a	73.24a
	Eatonton		D	0.99a	24.06a	0.66a	2.31a	17.06a	54.55b	0.13a	0.23a	27.59a	72.40a
Norea	Experiment	1968	C	0.93a	23.43a	0.76a	2.18b	16.58a	55.89a	0.08a	0.11b	26.64a	73.30a
	Eatonton		D	0.98a	24.05a	0.69a	2.29a	16.68a	54.96a	0.10a	0.25a	27.58a	72.43a
Prometryne	Eatonton	1968	D	0.98a	23.85a	0.68a	2.34a	16.85a	54.96b	0.11a	0.24a	27.40a	72.60b
1.79	Experiment	1969	C	0.75b	22.59b	0.74a	2.14b	14.68b	58.78a	0.20a	0.04b	25.51b	74.39a
Prometryne	Experiment	1969	C	0.78a	22.69a	0.75a	2.10a	14.41a	59.01a	0.19a	0.01a	25.58a	74.36a
2.24			C	0.63b	21.91b	0.55b	2.16a	15.04a	59.14a	0.38a	0.01a	24.71a	75.10a
Alaclor 2.24	Experiment	1968	C	0.95a	23.66a	0.81a	2.19a	16.35a	55.85a	0.08b	0.11a	26.91a	73.09a
	Eatonton		D	0.96a	23.81a	0.69a	2.36a	17.03a	54.78a	0.15a	0.25a	27.36a	72.64a
Alaclor 1.68	Experiment	1968	C	0.93a	23.66a	0.83a	2.16b	16.40b	55.70a	0.13a	0.15a	26.90a	73.05a
	Eatonton		D	0.96a	23.81a	0.68a	2.34a	16.89a	54.99a	0.13a	0.23a	27.34a	72.68a

[a] S = saturated. [b] U = unsaturated. [c] C = Cecil sandy clay loam. [d] D = Davidson sandy clay loam. [e] L = Lloyd sandy clay loam. [f] Values within a component (*i.e.*, myristic) of a single herbicide (*i.e.*, diuron) followed by the same letter or letters are not significantly different at the 5% level.

fatty acid methyl esters are shown in Table **II**. Quantitation was by normalization. Analysis of variance was performed on the data for each component and means were separated by the Duncan's multiple range test.

RESULTS AND DISCUSSION

Application of the individual herbicides to cotton resulted in four statistically significant changes in cottonseed oil quality (Table II), which were increased concentration of stearic acid from cotton treated with chlorpropham (10 kg/ha), norea (2.24 kg/ha), alaclor (2.24 kg/ha), and alaclor (1.68 kg/ha). Fatty acid composition of the remaining constituents was unaffected by herbicide application.

The practical implications of the four significant differences are questionable. A change of 0.1–0.2% in a component carrying 2.2% of the total fatty acid content may equal *ca.* 10% change in the individual component and still be of little or no practical significance. The Duncan's multiple range test (DMRT) is equal to the Least Significant Difference (LSD) separation of means where two means are considered. But the DMRT is more conservative than the LSD when more than two means are to be separated. Thus, in Table III, any two means of a component fatty acid taken from a herbicide rate that are followed by the same letter or letters are not significantly different at the 5% level. Since both methods of mean separation depend on the standard error of the mean of the analyzed data, the quantity of difference between two means required for the means to be statistically different is a good measure of the variability in the data.

The practical implications of the statistically significant herbicide responses are best demonstrated by the comparison of soil types, locations, and years of planting. In diuron-treated cotton the myristic acid content was significantly different from cotton grown on the same plot area for two successive years. Soil types influenced the myristic acid content of diuron-treated cotton at Experiment, Ga., since cotton grown on Cecil sandy clay loam had 0.90% myristic acid whereas that of the cotton grown on Davidson sandy clay loam was 0.98%. A second plot of cotton grown at Experiment, Ga., on Cecil sandy clay loam had a myristic acid content that was intermediate to the crops grown on two different soils at that location in 1968. Gotton grown on Davidson sandy clay loam further demonstrates the variability of myristic acid content of cottonseed oil from crops grown on the same plot area in two different seasons. Thus, comparison of the variability in cottonseed oil quality after herbicide application indicates that greater changes in cottonseed oil quality were produced by edaphic and environmental factors that were found to be due to the herbicide application.

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Received for review January 4, 1971. Accepted March 18, 1971. Journal Series No. 940 of the University of Georgia Agricultural Experiment Stations, Georgia Station, Experiment, Ga. 30212