Fatty Acid Composition, Mineral Content, and Flavor Quality of Southern Runner Peanuts Treated With Herbicides and Fungicides[1]

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ABSTRACT

The application of herbicides and fungicides (chemical compounds used to control weed and fungal pests, respectively) generally improve peanut yield and grade, however their effect on peanut composition and flavor quality is not well documented. The effects of herbicides or fungicides and their combinations on mineral content, fatty acid composition and flavor quality of Southern Runner peanut were investigated. Fungicide application [chlorothalonil (C) and diniconazole (D)] alone or in combination, improved the yield. Application of most herbicides or fungicides or their combination decreased the long chain saturated fatty acid, eicosenoic acid (20:1), acetone, methyl pyrrole and hexanal content while increasing pyrazine content. Application of imazquin (I) and most of the combinations increased magnesium (Mg) while decreased zinc (Zn) content. Application of benefin (B), metolachor (M), alachlor (A), (B+V), (M+C), and (M+D) increased the oleic linoleic acid (O/L) ratio which should improve the stability of the peanuts. Application of (B+V+A) decreased the flavor intensity of the roasted peanuts. Application of pesticides affected fatty acid composition and flavor quality of Southern Runner peanuts.

Key Words: *Arachis hypogaea L.*, herbicides, fungicides, fatty acids, minerals, flavor.

Herbicides and fungicides are chemical compounds used to control weed and fungal pests, respectively. Weeds seriously reduce the yield of peanuts through competition for light and nutrients. Weeds also interfere with efficient harvesting. Mechanical weed removal is extremely difficult. Once weeds establish themselves in the row, efficient mechanical removal is impossible and hand weeding is difficult and prohibitive in cost. Therefore, peanut growers rely on herbicides to aid them in controlling weed pests (4). Similarly, peanut growers use fungicides to supplement host plant resistances to various fungal diseases affecting the crop.

Peanuts are a good source for potassium, phosphorus and magnesium (5). Oleic (18:1) and linoleic (18:2) acids represent 80% of the fatty acid composition of peanut oil (1). The nutritional value, stability and the quality of peanuts depend partially on the fatty acid composition of its oil. Nutritionally, a high linoleic acid content is desirable because it is an essential fatty acid and produces a hypocholestolemic effect (9). Fats containing high level of oleic acid may be beneficial in lowering blood cholesterol level (6). High linoleic acid decreases the shelf-life while high oleic/linoleic acid (O/L) ratio indicates a more stable peanut with longer shelf-life. Application of the foliar fungicides Benlate and Bravo to the peanut cultivar, Argentine, decreased the percentage of stearic acid (18:0) and increased the percentage of linoleic acid significantly. These fungicides when applied to Florigiant Peanut (virginia type) increased the 18:0 and 18:1 while decreasing palmitic acid (16:0) and 18:2 (16). Herbicides had only slight effect on oleic and linoleic acid content (7). Application of 1-amino-4-sulphonate ß-naphthol (growth regulator) to the peanut germplasm line C-501 decreased 18:1 and increased 18:2 and oil content (12).

The application of herbicides and fungicides generally improve peanut yield and grade, however the effect of these compounds on peanut composition and flavor is not well documented. The objectives of this experiment were to investigate the effect of a few herbicides and fungicides on the mineral content, fatty acid composition and to determine if these compounds have any effect on the flavor quality of Southern Runner peanuts.

Materials and Method

Peanuts, *Arachis hypogaea L.* cv Southern Runner were planted on the University of Georgia research farm near Tifton. The soil type was a Tifton loamy sand (fine-loamy, siliceous, thermic Plinthic Paleudults) with a pH of 6.2. In the year prior to this experiment, corn was planted. The only pesticide used was atrazine.

Herbicides and fungicides application rates, dates and combination

[1] Mention of a product name given for information and should not be considered an endorsement to the exclusion of like product.

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Table 1. Herbicides and fungicides applied to Southern Runner peanuts.

Treatment #	Common name	Rate applied (lbs/acre)	Dates applied
1	Control	-	-
2	Benefin (B)	1.5	5-30
3	Vernolate (V)	2.6	5-30
4	Metolachlor (M)	2.0	5-30 + 7-7
5	Chlorothalonil (C)*	1.25	7-7 + 8-4 + 8-13 + 9-1 + 9-15
6	Paraquat (P)	0.125	7-7
7	Alachlor (A)	3.0	7-7
8	Diniconazole (D)*	0.125	7-7 + 8-4 + 8-18 + 9-1 + 9-15
9	Chlorimuron ethyl (CE)	0.0156	7-7 + 7-21
10	Imazquin (I)	0.0628	5-30 + 7-21
11	B+V	(as applied in 2 & 3 above)	
12	B+V+A	(as applied in 2,3 & 7 above)	
13	B+V+A+C	(as applied in 2,3,7 & 5 above)	
14	M+C	(as applied in 4 & 5 above)	
15	M+P	(as applied in 4 & 6 above)	
16	M+P+C	(as applied in 4,6 & 5 above)	
17	M+D	(as applied in 4 & 8 above)	
18	M+D+C	(as applied in 4,8 & 5 above)	

* Fungicides while other chemicals are herbicides.
Peanuts were planted on May, 30.

treatments reflect use pattern for these materials (Table 1). The disease resistant cultivar Southern Runner was chosen to minimize the confounding effect of disease on the plants not receiving fungicide treatment. All plots were mechanically cultivated and hand hoed to reduce possible confounding effects of weeds.

Rainfall was supplemented by irrigation to provide plants with adequate moisture to prevent water stress. All treatments were harvested at optimum maturity [approximately 135 days after planting (DAP)], as predicted by the hull-scrape technique. At harvest, plants were inverted, cured in the sun until achieving a moisture content of 20% (3 days). Pods were then harvested by hand, and cured with forced warm (35 C) air until kernel moisture reached 10%. Pod weights were recorded and then the peanuts were shelled and placed in cold storage (-10 C) until used for chemical analysis or sensory evaluation.

Fatty acids

Moisture determination, oil extraction and transesterification of fatty acids to their methyl esters were done according to AOAC, methods (2). Fatty acid methyl esters were separated using a Varian Model 3700 Gas Chromatograph (Varian Associates, Inc. Palo Alto, California) equipped with a (180x0.64x0.02 cm) glass column packed with GP 5% DEGS-PS on Supelcoport (100/20 mesh) (Supelco, Inc. Bellefonte, PA). Column temperature was programmed from 70 C (held for 5 min.) to 190 C (held for 25 min.) at 10 C/min. The flame ionization detector temperature was 250 C and the injector temperature was 220 C. The carrier gas (nitrogen) flow rate was 20 mL/min. Varian CDS 111 integrator was used to record the retention time and peak area of fatty acids. Standard methyl ester fatty acids mixtures (All Tech Associates Inc. Applied Science Lab. Deerfield, IL) were used to identify the fatty acids.

Mineral analysis

Samples were ground in a Sovall Omni-mixer (Ivan Sovall Inc., Newtown, Connecticut) at the highest speed for 45 seconds, dry ashed at 450 c for 4 hrs. and extracted with 10 mL plant buffer (100 mL HCL + 300 mL H_2NO_4 + 20 mL of 1000 ppm molybdenum) /liter. A Mark II Jarrel-Ash 965 Inductively Coupled Argon Plasma (ICAP) Plasma Emission Spectrometer was used for mineral analysis.

Peanut seed size

One hundred peanut kernels were selected randomly and weighed to determine the average kernel size.

Flavor analysis

Sensory analysis

For sensory evaluation, the raw peanuts were roasted in an oven equipped with a rotating stainless steel basket. The oven was preheated for 30 min to an average temperature of 177 C then 300 g of the raw peanuts were roasted for 25 min. After roasting, the peanuts were cooled to room temperature and the testa were removed by hand. Samples were ground by an Oster blender for 2 min. The peanuts were roasted to a Hunter L-value of 50 ± 1. A sample size of 2.0 g from each ground peanut sample was presented to each panelist to evaluate the roasted flavor intensity. Each sample was compared to a reference standard roasted in our lab from USDA Fancy hand picked virginia peanut (Ever-fresh product, Inc. Erlanger, KY).

Roasted flavor intensity was determined by 25 panelists from the Food Science Dept. using a 150-mm line scale with anchor of reference at 60 mm (8, 14). Evaluation was done at two different sessions and green light was used to mask differences in color.

Gas chromatography

A 0.5 g subsample of ground roasted peanut was placed between glass wool plugs in a glass sample tube (11.0 cm long, 7.0 mm OD, and 4.0 mm ID) (11). The sample tube was placed in the inlet of Varian model 3700 gas chromatograph at 140 C. The volatile compounds were stripped with nitrogen for 30 min onto the top of the GC column packed with Porapak P (Supelco, Inc. Bellefonte, PA). The sample tube was then removed and replaced with an empty tube and the GC column temperature programmed from 50 C (held for 2 min.) to 200 C (held for 25 min.) at 4 C/min. The flame ionization detector temperature was 250 C and the injector temperature was 140 C. The carrier gas (nitrogen) flow rate was 20 mL/min. A Varian CDS 111 integrator was used to record the retention time and peak area. Standards were used to identify the flavor compounds.

Data from all experiments were statistically analyzed. The LSD values and Duncan's multiple range test were calculated when the F-test showed significant differences among treatment means. All tests were conducted at the P = 0.05 level (15).

Results and Discussion

Each treatment was harvested to achieved the best yield and maturity distribution possible. However, maturity distribution differences between treatments were present. Even with the improved disease resistance of Southern Runner, the fungicide treatments [chlorothalonil (C) and diniconazole(D)] applied alone or in combination, improved yield and resulted in a crop with a more uniform maturity distribution. The herbicides had a little impact on yield and maturity with the exception of paraquat and its combination which stressed the plant and resulted in a crop with low yield and slightly less mature seeds (Table 2).

Application of herbicides, fungicides and their combination

Table 2. The effect of herbicides and fungicides on Southern Runner peanut yields.

Treatment	Yield Kg ha^{-1}
Control	2140
Benefin (B)	2320
Vernolate (V)	2210
Metolachlor (M)	2510
Chlorothalonil (C)*	3100
Paraquat (P)	1640
Alachlor (A)	2130
Diniconazole (D)*	3920
Chlorimuron ethyl (CE)	2300
Imazquin (I)	2300
B+V	2340
B+V+A	2210
B+V+A+C	2870
M+C	2840
M+P	1480
M+P+C	1810
M+D	3990
M+D+C	3340
LSD (0.05)	510

* Indicate a fungicide others are herbicides

decreased the long chain saturated fatty acids [arachidic acid (20:0), behenic acid (22:0), and lignoceric acid (24:0)] and eicosenoic acid (20:1) content while increased stearic acid (18:0) content significantly (Tables 3 & 4). Application of imazquin (I) increased palmitic acid (16:0) significantly (Table 3). Oleic to linoleic ratio (O/L) is used as a stability indicator. Peanuts with higher (O/L) ratios indicate better stability and therefore longer shelf life (3). Application of benefin (B), metolachlor (M), alachlor (A), (B+V), and (M+C), (M+D) increased oleic acid (18:1) content and (O/L) ratio significantly while application of (I) and (B+V+A) decreased them (Tables 3 & 4).

Treating peanuts with (I) increased magnesium (Mg) content while decreased zinc (Zn) content significantly. Application of M, D, CE, and I increased sodium (Na) content while application of B and V decreased it significantly. Application of P and A increased phosphorus while application of D decreased potassium (K) content (Table 5). Treating peanut with all combinations increased (Mg) content and decreased Zn content. Application of (M+P) and (M+P+C) increased phosphorus content while (M+D) decreased it. Application of (M+D+C) decreased K content while (M+C) decreased Na content significantly. Application of all (M) combination and (B+V) increased aluminum (Al) content. Application of (B+V), (M+P+C), and (M+D+C) increased copper (Cu) while (B+A+V+C) decreased it (Table 6).

Treating peanuts with herbicides, fungicides and their combinations except (P) did not affect peanut kernel size significantly. Treating peanuts with (B+V+A) decreased the roasted flavor intensity significantly while (P) and (V) treatments seemed to increase the flavor intensity slightly although the difference was not statistically significant (Table 7).

Ethanol, acetone, methyl pyrrole are correlated with abusive drying, musty aftertaste, and musty flavor respectively (17). Application of D and (M+D+C) increased ethanol content which made peanuts sensitive to the curing condition while A, CE, (M+P+C), and all B combinations decreased it significantly. Application of V, M, I, all the combinations decreased acetone content significantly. Treating peanut with C, A, and D increased methyl pyrrole content significantly while CE and all combination except (B+V+A+C) and (M+P) decreased it significantly. Hexanal content is associated with beany flavor (17). Treating peanuts with all combinations and all pesticides except C and A decreased hexanal content significantly. Pyrazines are important for roasted peanut flavor since they are associated

Table 3. Effect of herbicides and fungicides on fatty acid composition of Southern Runner peanuts.

	Fatty acid composition (%)								
Treatment	16:0	18:0	20:0	22:0	24:0	18:1	18:2	20:1	O/L
Control	11.2b*	ND	2.2a	5.2a	2.6a	50.2b	26.5ab	2.1a	1.90b
Benefin (B)	11.0b	1.5b	1.6c	4.2b	2.1b	53.2a	24.6b	1.8b	2.16a
Vernolate (V)	11.3b	3.1a	1.7c	3.9b	1.9b	50.8b	25.8ab	1.8b	1.98ab
Metolachlor (M)	11.2b	2.9a	1.7c	2.7c	1.8b	52.8a	25.5b	1.6c	2.08a
Chlorothalonil (C)	10.9b	2.7a	1.6c	4.2b	2.2b	50.6b	26.2ab	1.7bc	1.93b
Paraquat (P)	11.1b	2.7a	1.8bc	5.1a	2.7a	48.0bc	26.9ab	1.9b	1.79c
Alachlor (A)	10.9b	1.4b	1.7c	4.5b	2.2b	53.0a	24.7b	1.8b	2.15a
Diniconazole (D)	11.1b	2.7a	1.6c	3.9b	1.9b	50.1b	27.1a	1.7bc	1.85bc
Chlorimuron ethyl (CE)	11.5b	2.6a	1.5c	3.0c	1.2c	51.0ab	27.8a	1.5c	1.85bc
Imazquin (I)	13.7a	1.7b	2.0ab	4.7ab	2.1b	47.5c	26.3ab	2.1a	1.81c

* Means within the same column followed by the same letter are not significantly different at 0.05% level of probability using Duncan multiple range test (n=4).
ND (Not detected)

Table 4. Effect of herbicides and fungicides combinations on fatty acid composition of Southern. x

Runner peanuts

	Fatty acid composition (%)								
Treatment	16:0	18:0	20:0	22:0	24:0	18:1	18:2	20:1	O/L
Control	11.2a*	ND	2.2a	5.2a	2.6a	50.2b	26.5ab	2.1a	1.90b
Benefin (B)	11.0a	1.5b	1.6b	4.2b	2.1ab	53.2a	24.6b	1.8b	2.16a
B+V	11.1a	1.3b	1.4b	3.5b	1.6b	54.2a	25.4ab	1.6bc	2.14a
B+V+A	11.7a	2.8a	1.5b	3.9b	1.7b	49.8b	27.1a	1.6bc	1.84c
B+V+A+C	11.8a	1.7b	1.7b	5.6a	2.6a	48.2c	26.6ab	1.9ab	1.82c
Metolachlor (M)	11.2a	2.9a	1.7b	2.7c	1.8b	52.8a	25.5ab	1.6bc	2.08a
M+C	10.7a	ND	1.7b	4.3b	2.0b	53.7a	25.8ab	1.8b	2.11a
M+P	10.9a	ND	1.7b	3.9b	1.9b	53.7a	26.5ab	1.6bc	2.03ab
M+P+C	10.7a	1.2b	1.6b	4.9ab	2.7a	50.3b	27.1a	1.7bc	1.86b
M+D	10.4b	ND	1.5b	3.9b	1.8b	56.1a	24.9b	1.5c	2.26a
M+D+C	10.6a	1.2b	1.5b	4.1b	2.1ab	52.3ab	26.6a	1.6bc	1.97ab

* Means within the same column followed by the same letter are not significantly different at 0.05% level of probability using Duncan multiple range test (n=4).
ND (Not detected)

with roasted nutty character (13).

Application of B, V, M, P, B+V+A increased pyrazine content significantly which could improve the roasted flavor quality (Tables 8 & 9).

Conclusion

Application of fungicides alone or in combination increased Southern Runner peanuts yield significantly. Treating peanuts with herbicides, fungicides and their combination affected the fatty acid composition and decreased hexanal content, but did not affect the roasted flavor intensity. Treating peanuts with P had the highest pyrazine content and the lowest hexanal content. Application of B, (B+V), M, (M+C), (M+D) and A may improve peanut stability by increasing the (O/L) ratio.

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Table 5. Effect of herbicides and fungicides on mineral content of Southern Runner peanuts.

	Element (ppm)										
Treatment	Ca	K	Mg	P	AL	Cu	Fe	Mn	Na	Zn	
Control		450a*	6203a	2453b	3805b	40.0a	7.1b	24.3a	17.4a	30.2b	28.9ab
Benefin (B)		522a	5939a	2348b	3683b	38.6a	6.5b	19.8b	17.4a	20.4c	25.7bc
Verolate (V)		495a	6199a	2427b	3879b	35.5b	6.2b	22.5a	17.9a	12.1c	28.7ab
Metolachlor (M)		465a	6047a	2402b	3823b	39.9a	6.6b	22.2a	17.1a	44.6a	28.2ab
Chlorothalonil (C)		489a	5932a	2464b	3795b	40.2a	6.8b	22.2a	17.8a	38.4ab	26.6b
Paraquat (P)		479a	6043a	2443b	4020a	40.2a	8.2ab	26.6a	17.2a	31.0b	29.4a
Alachlor (A)		543a	6178a	2468b	4073a	41.7a	7.6ab	25.8a	17.5a	39.3ab	30.4a
Dinicoazole (D)		559a	5780b	2453b	3695b	40.0a	7.1b	23.4a	17.4a	47.4a	27.4b
Chlorimuron ethyl (CE)		563a	6240a	2405b	3822b	40.5a	9.1a	23.9a	19.2a	40.9a	29.0a
Imazquin (I)		506a	5898a	2682a	3761b	42.4a	7.1b	23.4a	16.3a	43.9a	24.5c

* Means within the same column followed by the same letter are not significantly different at 0.05% level of probability using Duncan multiple range test (n=4).

Table 6. Effect of herbicides and fungicides combinations on mineral content of Southern Runner peanuts.

Treatment	Element (ppm)									
	Ca	K	Mg	P	AL	Cu	Fe	Mn	Na	Zn
Control	450a*	6203a	2453b	3805b	40.0b	7.1b	24.3a	17.4a	30.2b	28.9a
Benefin (B)	522a	5939a	2348b	3683b	38.6b	6.5b	19.8b	17.4a	20.4c	25.7b
B+V	524a	6155a	2726a	3787b	43.6a	9.2a	23.9a	18.2a	28.1b	25.9b
B+V+A	529a	5847a	2623a	3785b	41.3ab	7.5b	24.3a	17.0a	33.0b	26.9ab
B+V+A+C	542a	5754b	2829a	3828b	42.2ab	5.9c	23.9a	18.1a	27.1b	25.3b
Metolachlor (M)	465a	6047a	2402b	3823b	39.9b	6.9b	22.2a	17.1a	44.6a	28.2a
M+C	671a	5817a	2794a	3737b	44.6a	8.7ab	24.6a	17.6a	23.9c	25.7b
M+P	446a	6250a	2673a	4119a	43.0a	8.9ab	25.3a	17.3a	31.5b	27.0ab
M+P+C	526a	6039a	2789a	4078a	45.3a	10.0a	26.4a	18.6a	37.9ab	27.8a
M+D	536a	6006a	2676a	3488c	43.4a	7.1b	23.7a	16.8a	35.3ab	26.0b
M+D+C	592a	5583b	2778a	3777b	45.6a	9.5a	23.6a	17.4a	29.0b	25.6b

* Means within the same column followed by the same letter are not significantly different at 0.05% level of probability using Duncan multiple range test (n=4).

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Table 7. Effect of herbicides and fungicides on size and flavor intensity of Southern Runner peanuts.

Treatment$	Size@	Flavor intensity#
Control	54.2a*	6.36a
Benefin (B)	56.5a	5.92ab
Vernolate (V)	55.5a	6.52a
Metolachor (M)	56.9a	6.00ab
Chlorothalonil (C)	55.2a	6.32a
Paraquat (P)	51.2b	6.72a
Alachlor (A)	56.0a	5.92ab
Chlorimuron ethyl (CE)	55.3a	5.76ab
B+V	55.4a	6.16a
B+V+A	57.0a	5.16b
B+V+A+C	56.9a	5.80ab
M+C	56.9a	5.96ab
M+P	52.3ab	6.04a
M+P+C	52.2ab	5.92ab

@ Weight of 100 seed (n=4).
\# (n=25)
* Means within the same column followed by the same letter are not significantly different at 0.05% level of probability using Duncan's multiple range test.
$ Not all treatments reported since D and I have not received EPA registeration for this use at the time experiment was conducted.

Table 8. Effect of herbicides on flavor compounds of Southern Runner peanuts.

Treatment	Flavor compound (peak area = count x 10^{-4})				
	Ethanol	Acetone	Methyl-pyrrole	Hexanal	Pyrazine
Control	1.13b*	15.44a	3.44bc	9.75a	0.09d
Benefin (B)	0.66cd	14.31a	1.55c	2.95c	6.61ab
Vernolate (V)	0.36cd	4.32c	2.23c	0.43d	4.05ab
Metolachlor (M)	1.24b	3.72c	2.19c	1.62cd	5.12ab
Chlorothalonil (C)	2.50ab	10.02ab	2.61b	7.62ab	1.05c
Paraquat (P)	1.63b	16.65a	2.19c	ND	9.8a
Alachlor (A)	0.89c	15.54a	7.02a	10.32a	0.76cd
Diniconazole (D)	3.76a	11.94ab	4.16b	6.49b	0.99c
Chlorimuron ethyl (CE)	ND	6.38bc	0.43d	2.60c	0.00d
Imazquin (I)	1.53b	8.93b	3.13c	5.32b	0.73cd

* Means within the same column followed by the same letter are not significantly different at 0.05% level of probability using Duncan multiple range test (n=4).
ND (Not detected)

Table 9. Effect of herbicide combinations on flavor compounds of Southern Runner peanuts.

Treatment	Flavor compound (peak area = count x 10^{-4})				
	Ethanol	Acetone	Methyl-pyrrole	Hexanal	Pyrazine
Control	1.13b*	15.44a	3.44a	9.75a	0.09c
Benefin (B)	0.66bc	14.32a	1.55c	2.95c	6.61a
B+V	ND	7.64b	1.92c	3.70c	0.73bc
B+V+A	ND	12.66ab	2.69b	6.73b	5.2a
B+V+A+C	ND	8.40b	4.90a	6.93b	0.62bc
Metolachlor (M)	1.24ab	3.72c	2.19bc	1.61c	5.12a
M+C	1.05b	5.86c	1.96c	2.92c	0.05c
M+P	1.34ab	4.13c	3.14a	3.13c	1.38b
M+P+C	ND	5.18c	1.66c	3.61c	0.75bc
M+D	0.43bc	5.83c	1.53c	3.24c	1.02b
M+D+C	2.27a	7.17b	2.06bc	4.58b	1.03b

* Means within the same column followed by the same letter are not significantly different at 0.05% level of pribability using Duncan multiple range test (n=4).
ND (Not detected)

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