Peanut Response to Naturally-Derived Herbicides Used in Organic Crop Production

W. Carroll Johnson, III, Benjamin G. Mullinix, Jr., and Mark A. Boudreau[1]

ABSTRACT

Weed-free irrigated trials were conducted in 2004 and 2005 to quantify phytotoxic effects of herbicides with the potential to be used in organic peanut production. Clove oil and citric plus acetic acid were each applied at vegetative emergence of peanut (VE), two weeks after VE (2 wk), four weeks after VE (4 wk), sequentially VE/2 wk, sequentially VE/4 wk, sequentially VE/2 wk/4 wk, and a nontreated control. Clove oil was more injurious (maximum of 28% visual injury) than citric plus acetic acid (maximum of 4% visual injury), with significant injury occurring with clove oil applied at 4-wk or sequentially. Citric plus acetic acid caused minimal peanut injury. There were no consistent effects of clove oil on peanut yield, although sequential applications of clove oil tended to reduce peanut yield. Peanut yield was not affected by citric plus acetic acid.

Key Words: *Arachis hypogaea* L., acetic acid, citric acid, clove oil, OMRI herbicides, organic weed control.

There is interest in growing certified organic peanut in the southeastern U. S. to support increasing demand for organic peanut food products (Culbreath, 2005). Weed management is universally considered to be the major limiting factor in organic crop production (Organic Farming Research Foundation, 2001) and this is the case with organic peanut. Weed management in organic cropping systems is conceptually based on the same principles of weed management in conventional crop production; an integration of crop rotations, cultural practices, mechanical controls, and herbicides. However, the only herbicides allowed for use in certified organic crop production are those approved by the Organic Materials Resource Institute (OMRI; Box 11558; Eugene, OR 97440). In general terms, OMRI certification ensures that growers can use the herbicide, without compromising their organic crop production certification. While OMRI herbicides are approved to be used in certified organic crop production, such approval does not consider weed control efficacy, crop injury, or cost.

Essential oils are aromatic, volatile oils extracted from plants and have been shown to have herbicidal properties and potential weed management uses in organic cropping systems (Chase *et al.*, 2004; Tworkoski, 2002). Similarly, some organic acids have herbicidal properties and, if derived from organic sources, may offer potential for weed control in organic cropping systems (Comis, 2002; Weber *et al.*, 2005). Two herbicidal formulations[2] one containing clove oil[3] and the other containing citric and acetic acids[4], have been approved by OMRI for use in organic crop production. Both herbicides are considered to be nonselective postemergence herbicides (Anonymous 2007a, 2007b; Boyd and Brennan, 2006; Chase *et al.*, 2004), but no research has been published regarding their efficacy or injury to peanut. Therefore, field trials were initiated in 2004 to evaluate the tolerance of peanut to direct applications of these herbicides.

Materials And Methods

Field trials were conducted at the Coastal Plain Experiment Station Ponder Farm, near Tifton, GA in 2004 and 2005. The soil was a Tifton loamy sand (fine-loamy, Kaolinitic, thermic Plinthic Kandiudults); 88% sand, 6% silt, 6% clay, with 0.2% organic matter. The experimental design was a factorial arrangement of treatments in a split-plot with four replications. Main plots were two OMRI-approved herbicides; clove oil (70 l/ha;) and a mixture of acetic and citric acid (65 l/ha).

Sub-plots were herbicides applied at vegetative emergence of peanut (VE), two weeks after VE

[1]First and second authors: Res. Agron. , USDA-ARS and Agric. Res. Statistician; Coastal Plain Exp. Sta., Tifton, GA 31793-0748. Third author: President and CEO, Hebert Green AgroEcology; Asheville, NC 28801.

Corresponding author (e-mail: Carroll.Johnson@ars.usda.gov)

[2]Mention of trade names or commercial products is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture, nor implies approval of a product to the exclusion of others that may be suitable.

[3]Matran 2®; 50% clove oil, 50% wintergreen oil, butyl lactate, and lecithin; EcoSMART Technologies, Inc.; 318 Seaboard Lane; Franklin, TN 37067

[4]Ground Force®; acetic acid, citric acid; Abby Science, 15840 Central Avenue NE, Ham Lake, MN 55304.

Table 1. Injury and yield response for weed free DP-1 peanut to naturally derived herbicides in Tifton, GA; 2004 to 2005.

Naturally derived herbicide	Time of application[1]	Visual injury at mid-season 2004	Visual injury at mid-season 2005	Peanut yield 2004	Peanut yield 2005
		(%)		(kg/ha)	
Clove oil					
	VE	0	0	3620	3440
	2-wk	9	0	2920	3100
	4-wk	8	23	3260	3360
	VE/2-wk	7	12	2740	2840
	VE/4-wk	3	6	3010	3130
	VE/2-wk/4-wk	28	19	2190	3230
	Nontreated	0	0	3400	3180
Citric plus acetic acid					
	VE	0	0	3890	3520
	2-wk	0	0	3480	3350
	4-wk	0	0	3350	3200
	VE/2-wk	0	1	3310	3200
	VE/4-wk	4	0	3600	3290
	VE/2-wk/4-wk	0	0	3410	3170
	Nontreated	0	0	3120	3360
LSD (0.05)		8	10	710	410

[1]Abbreviations: VE, vegetative emergence of peanut; 2-wk, two weeks after emergence, 4-wk, four weeks after emergence.

(2 wk), four weeks after VE (4 wk), sequentially VE/2 wk, sequentially VE/4 wk, sequentially VE/2 wk/4 wk, and a nontreated control. All treatments were applied with a tractor mounted CO_2 pressurized plot sprayer calibrated to deliver 234 l/ha using low-drift spray tips (Turbo TeeJet® 11003; Spraying Systems CO.; P. O. Box 7900; Wheaton, IL) treating a swath 1.8 m wide. No adjuvants were added to the herbicide treatments.

DP-1 peanut were planted 18 May 2004 and 23 May 2005. DP-1 was chosen for use in these trials since it has excellent host plant resistance to early leafspot [*Cercospora arachidicola* S. Hori], late leafspot [*Cercosporidium personatum* (Berk. & M. A. Curtis) Deighton], stem rot (*Sclerotium rolfsii* Sacc.), and spotted wilt (tomato spotted wilt tospovirus), which makes the cultivar an excellent choice for reduced input peanut production (Cantonwine *et al*., 2006). Plots were 1.8 m wide and 6.1 m in length. Peanut were seeded in rows 91 cm apart at 112 kg/ha, which produced a final stand of 20 plants/m row. All plots were irrigated sufficiently to prevent drought stress.

All plots were maintained weed-free by using biweekly sweep cultivation for six weeks and weekly hand-weeding. Throughout the duration of the season, neither insecticides nor fungicides were applied to the plots. However, these plots were not able to be certified organic because the peanut seed were treated with non-approved protectants and suitable isolation from adjacent areas routinely treated with pesticides was not maintained.

Observations were made within 12 h of treatment application to note the nature of any immediate and noticeable injury to the peanut. Visual estimations of crop injury were taken mid-season to assess the extent of permanent or prolonged injury to the plant compared with the nontreated control. Ratings were recorded on a scale of 0 to 100, where, 0 = no crop injury and 100 = complete crop injury. Peanut yields were measured by digging, inverting, air-curing, and combining peanut from the entire plot using commercial two-row equipment. Yield samples were mechanically cleaned to remove foreign material. Yields are reported as cleaned farmer stock peanut. All data were analyzed using analysis of variance. Means were separated using Fisher's LSD ($P \leq 0.05$).

Results And Discussion

Data were analyzed separately by year due to differences in meteorological conditions between years. Weather conditions were generally more humid in 2004 compared to 2005, which affected peanut response and recovery from herbicide phytotoxicity.

Visual injury.

Injury symptoms from clove oil appeared less than 12 hours after treatment and were characterized by necrotic peanut tissue (data not shown). New peanut growth did not have foliar necrosis.

Peanut treated with citric plus acetic acid had minimal (≤4%) foliar necrosis.

In general, clove oil was more injurious than citric plus acetic acid when rated mid-season (Table 1). Clove oil applied at VE stage of peanut growth did not injure peanut. Clove oil applied later than VE tended to stunt peanut, with applications at 4 wk being the most injurious time of application. Sequential applications were as injurious as the later applications alone. Clove oil applied three times was the most injurious (19 to 28% visual injury) treatment when rated mid-season. The maximum phytotoxicity from citric plus acetic acid averaged 4% (Table 1), which was nonsignificant. Citric plus acetic acid applied from VE to 4 wk after emergence, alone or sequentially, did not injure peanut.

Peanut yield response.

In 2004, clove oil applied sequentially three times reduced peanut yield by 36% compared to the nontreated control (Table 1). Peanut treated with clove oil in 2004 singly or twice sequentially at any time of application did not reduce peanut yield compared to the nontreated control. Peanut yields in 2005 were not reduced by clove oil at any frequency or time of application.

Citric plus acetic acid applied singly, twice sequentially, or three times sequentially did not reduce peanut yield in 2004 and 2005 (Table 1). This is consistent with the lack of mid-season visual injury.

Previous research showed that clove oil was more efficacious on dicot weeds than citric plus acetic acid (Johnson and Mullinix, 2007). The aforementioned weed control efficacy data and the phytotoxicity data from this research suggest that clove oil is a potential component of an integrated weed management in organic peanut when applied early season. Of the treatments evaluated, a single early-season application of clove oil provides the best combination of dicot weed control and minimal phytotoxicity. Peanut tolerates two sequential applications of clove oil, but the $1112/ha cost per application of clove oil makes this prohibitive. Despite excellent peanut tolerance, citric plus acetic acid does not have potential for use in organic peanut due to poor weed control efficacy (Johnson and Mullinix 2007).

Acknowledgments

The technical efforts of Daniel R. Evarts and Andy M. Hornbuckle are recognized as a significant contribution to the success of this research project. This research was partially supported by a grant from the Southern Regional Sustainable Agricultural Research and Education Program, through Hebert Green Agroecology, Inc.

Literature Cited

Anonymous. 2007a. Ground Force Herbicide Product Label. Abby Science, 15840 Central Avenue NE, Ham Lake, MN 55304. http://www.abbysciencelabs.com/ground_force_organic_herbicide.htm. (Last accessed 2 August 2007).

Anonymous. 2007b. Matran EC Herbicide Product Label. EcoSMART Technologies, Inc. 318 Seaboard Lane, Franklin, TN 37067. http://www.ecosmart.com/UploadedFiles/LabelPDF/radF77B412200513143929.pdf. (Last accessed 2 August 2007).

Boyd, N.S. and E.B. Brennan. 2006. Burning nettle, common purslane, and rye response to a clove oil herbicide. Weed Technol. 20:646-650.

Cantonwine, E.G., A.K. Culbreath, K.L. Stevenson, R.C. Kemerait, Jr., T.B. Brenneman, N.B. Smith, and B.G. Mullinix, Jr. 2006. Integrated disease management of leaf spot and spotted wilt of peanut. Plant Dis. 90:493-500.

Chase, C.A., J.M. Scholberg, and G.E. MacDonald. 2004. Preliminary evaluation of nonsynthetic herbicides for weed management in organic orange production. Proc. Fla. State Hort. Soc. 117:135-138.

Comis, D. 2002. Spray weeds with vinegar? USDA Agricultural Research Service. http://www.ars.usda.gov/is/pr/2002/020515.htm. (last accessed 7 August 2007).

Culbreath, L. 2005. Are they nuts? Southern researchers and farmers tackle organic peanuts. The New Farm on line at: www.newfarm.org/features/2005/1105/peanuts/culbreath.shtml. (last accessed 11 December 2006).

Johnson, W.C. III. and B.G. Mullinix, Jr. 2007. Potential weed management systems for organic peanut production. Peanut Sci. (in press).

Organic Farming Research Foundation. 2001. Final results of the third biennial national organic farmers survey. 18 August 2001. http://ofrf.org/publications/pubs/3rdsurvey_results.pdf. (last accessed 11 December 2006).

Tworkoski, T. 2002. Herbicide effects of essential oils. Weed Sci. 50:425-431.

Weber, C.L., III, M.A. Harris, J.W. Shrefler, M. Durnova, and C.A. Christopher. 2005. Organic weed control with vinegar. pp. 34-36. *In.* 2004 Vegetable Trial Report. Oklahoma State Univ., Division of Agric. Sci. and Natural Res., Dept. of Hort. and Landscape Architecture; Stillwater, OK. MP-162.