Peanut Control in Rotational Crops

Alan C. York*, David L. Jordan, and John W. Wilcut[1]

ABSTRACT

Volunteer peanut (*Arachis hypogaea* L.) can reduce the effectiveness of crop rotation as a component in a peanut disease management program. Experiments were conducted in three states to evaluate peanut control with glyphosate [*N*-(phosphonomethyl)glycine] or with herbicides commonly applied postemergence for broadleaf weed control in corn (*Zea mays* L.) and cotton (*Gossypium hirsutum* L.). Two sequential applications were needed for acceptable control with corn and cotton herbicides. Greater than 80% control of peanut was achieved with dicamba (3,6-dichloro-2-methoxybenzoic acid) applied early postemergence (EPOST) followed by dicamba or ametryn [*N*-ethyl-*N*'-(1-methylethyl)-6-(methylthio)-1,3,5-triazine-2,4-diamine] applied late postemergence (LPOST). MSMA (monosodium salt of methylarsonic acid) applied EPOST followed by oxyfluorfen [2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl)benzene] + MSMA LPOST and fluometuron [*N,N*-dimethyl-*N*'-[3-trifluoromethyl) phenyl]urea] + MSMA applied EPOST followed by prometryn [*N,N*'-bis(1-methylethyl)-6-(methylthio)-1,3,5-triazine-2,4-diamine] + MSMA, cyanazine [2-[[4-chloro-6-(ethylamino)-1,3,5-triazin-2-yl]amino]-2-methylpropanenitrile] + MSMA, lactofen {(±)-2-ethoxy-1-methyl-2-oxoethyl 5-[2-chloro-4-(trifluoromethyl)phenoxy]- 2-nitrobenzoate} + MSMA, or oxyfluorfen + MSMA LPOST controlled peanut at least 80%. Single applications of glyphosate at 0.84 to 1.12 kg ae/ha controlled peanut at least 80% and were at least as efficacious as the same total rate of glyphosate applied sequentially.

Key Words: *Arachis hypogaea* L., disease management, ametryn, cyanazine, dicamba, fluometuron, glyphosate, lactofen, linuron, MSMA, oxyfluorfen, prometryn, 2,4-D.

Biotic diseases cause an estimated 22% loss in yield of peanut in the United States (12). Early and late leafspot, caused by *Cercospora arachidicola* Hori and *Cercosporidium personatum* (Berk. & Curt.) Deighton, respectively, are responsible for the greatest losses. Other major diseases impacting upon yields include southern blight (*Sclerotium rolfsii* Sacc.), nematodes, and various pod and root rots. Sclerotinia blight (*Sclerotinia minor* Jagger) and cylindrocladium black rot [*Cylindrocladium crotalariae* (Loos) Bell & Sobers] are significant problems in North Carolina and Virginia (12). Sclerotinia blight also is a problem in Oklahoma, and cylindrocladium black rot is becoming more prevalent in Georgia.

The extensive yield losses occur even though growers rely heavily upon pesticides and various cultural practices to manage diseases. In North Carolina, for example, 100% of the crop is treated with multiple applications of fungicides for early and late leafspot at a cost of $104/ha (15). Additionally, 34% of the crop is treated with nematacides at a cost of $59/ha, 16% is treated for southern blight, sclerotinia blight, and rhizoctonia limb rot (*Rhizoctonia solani* Kuhn.) at a cost ranging from $54 to $124/ha, and 8% is treated with metham-sodium (sodium methyldithiocarbamate) for control of cylindrocladium black rot at a cost of $126/ha.

[1]Prof., Dep. Crop Science, Box 7620, N. C. State Univ., Raleigh, NC 27695-7620; Asst. Prof., Dep. Agron., Northeast Res. Stn., Louisiana State Univ., P. O. Box 438, St. Joseph, LA 71366; and Assoc. Prof., Dep. Agron., Coastal Plain Exp. Stn., Univ. Georgia, Box 748, Tifton, GA 31793-0748.

*Corresponding author.

Rotating peanut with non-host crops such as corn and cotton is a key component of a management system for nematodes and soil-borne and foliar diseases of peanut (2, 8). In addition to agronomic and weed management benefits (13, 18), crop rotation assists in disease management by reducing the initial inoculum (2, 8, 10, 11). Long rotations are more effective than short rotations (2, 3, 13).

Volunteer peanut can emerge in crops planted the year following a peanut crop. The severity of the infestation depends upon peanut harvesting losses, fall or winter tillage programs, consumption by birds and other wildlife, and time of seedbed preparation for the rotational crop. A spring tillage operation after most of the peanut has emerged and prior to planting the rotational crop is an effective control practice in conventional-tillage systems but delays planting of the rotational crop (A. C. York, unpublished data).

Preemergence herbicides such as atrazine [6-chloro-*N*-ethyl-*N*'-(1-methylethyl)-1,3,5-triazine-2,4-diamine] applied to corn and fluometuron applied to cotton are only partially effective on volunteer peanut (A. C. York and J. W. Wilcut, unpublished data). The mediocre control with these root-absorbed herbicides likely is due to many volunteer peanut emerging from below the herbicide-treated zone. Studies to determine the competitive effects of volunteer peanut on rotational crops have not been conducted. Volunteer peanut is seldom present at populations sufficient to suspect an impact on yield of cultivated rotational crops. However, volunteer peanut populations of two or more plants/m^2 have been observed in no-till cotton (A. C. York, unpublished data).

Uncontrolled volunteer peanut can produce disease inoculum that likely reduces the effectiveness of crop rotation for disease management. The objective of this study was to evaluate peanut control with various postemergence (POST) herbicides that could be applied to corn or cotton grown in rotation with peanut.

Materials and Methods

General information. Separate experiments evaluating corn herbicides, cotton herbicides, and glyphosate were conducted on the Upper Coastal Plain Research Station at Rocky Mount, NC, in 1992; the Peanut Belt Research Station at Lewiston, NC, in 1993; the Attapulgus Research Farm at Attapulgus, GA, in 1993; and the Northeast Research Station at St. Joseph, LA, in 1993. Soil types included Marlboro sandy loam (clayey, kaolinitic, thermic Typic Paleudults) with 1.2% organic matter and pH 5.8 at Rocky Mount, Rains fine sandy loam (fine-loamy, siliceous, thermic Typic Ochraquults) with 2.3% organic matter and pH 5.8 at Lewiston, Dothan sandy loam (fine-loamy, siliceous, thermic, Plinthic Kandiudults) with 0.7% organic matter and pH 5.7 at Attapulgus, and Commerce silt loam (fine-silty, mixed, nonacid, thermic, Aeric Fluvaquents) with 0.6% organic matter and pH 5.3 at St. Joseph.

The experiments were conducted in conventionally planted peanut fields. It was assumed that the response of planted peanut to POST herbicides would be similar to the response of volunteer peanut. Peanut was planted in 97-cm rows with conventional planting equipment in late April or early May in North Carolina and Georgia and early July in Louisiana. Aldicarb [2-methyl-2-(methylthio)propionaldehyde *O*-(methylcarbamoyl)oxime] at 0.8 kg ai/ha was applied in-furrow during planting at the North Carolina and Georgia locations. Cultivars were 'NC 9' and 'NC 7' in North Carolina in 1992 and 1993, respectively, and 'Florunner' in Georgia and Louisiana. Metolachlor [2-chloro-*N*-(2-

ethyl-6-methylphenyl)-*N*-(2-methoxy-1-methylethyl)acetamide] at 2.24 kg ai/ha was applied preemergence to control annual grasses at the North Carolina locations. Sethoxydim {2-[1-(ethoxyimino)butyl]-5-[2-(ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one} at 0.28 kg ai/ha was applied POST to control annual grasses in Louisiana.

Treatments in each experiment included various herbicides or herbicide combinations applied EPOST, LPOST, or EPOST followed by LPOST. Herbicides were applied in a volume of 187 L/ha at 275 kPa. A nonionic surfactant[2] at 0.25% (v/v) was included with all applications. Appropriate non-treated checks were included. Plot size was two rows by 4 m with an untreated row between each plot. The experimental design was a randomized complete block with three replications in Georgia and Louisiana and four replications in North Carolina.

EPOST treatments were applied when peanut was 5 to 8 cm (diam.) in North Carolina and 10 to 12 cm in Georgia and Louisiana. LPOST treatments were applied when peanut was 10 to 20 cm (diam.) in North Carolina and 20 to 30 cm in Georgia and Louisiana. The early and late applications in North Carolina were made when cotton in adjacent fields planted approximately the same time as peanut in the experiments was 8 to 10 cm tall and 20 to 30 cm tall, respectively. These growth stages of cotton correspond to the typical time of early and late postemergence-directed (POST-DIR) herbicide applications (17).

Corn herbicides. The experiment focused on POST herbicides commonly used on corn for broadleaf weed control in the major peanut-producing regions. Bromoxynil(3,5-dibromo-4-hydroxybenzonitrile) was not evaluated because previous research has shown peanut tolerance of bromoxynil (A. C. York, unpublished data). Nicosulfuron {2-[[[[(4,6-dimethoxy-2-pyrimidinyl)amino]carbonyl]amino]sulfonyl]-*N*,*N*-dimethyl-3-pyridinecarboxamide} and primisulfuron {2-[[[[[4,6-bis(difluoromethoxy)-2-pyrimidinyl]amino]carbonyl]-amino]sulfonyl]benzoic acid}, which are used primarily for annual and perennial grass control, also were not evaluated. Previous research (7, 9, 14) has shown that peanut is tolerant of nicosulfuron but relatively sensitive to primisulfuron.

The experiment with corn herbicides was conducted in North Carolina in 1992 and 1993 and in Louisiana in 1993. Treatments included a factorial arrangement of the dimethylamine salts of 2,4-D [(2,4-dichlorophenoxy)acetic acid] and dicamba applied EPOST and ametryn, linuron [*N'*-(3,4-dichlorophenyl)-*N*-methoxy-*N*-methylurea], and the dimethylamine salts of 2,4-D and dicamba applied LPOST. Application rates of 2,4-D, dicamba, ametryn, and linuron were 0.56 kg ae/ha, 0.28 kg ae/ha, 1.12 kg ai/ha, and 1.12 kg ai/ha, respectively.

Cotton herbicides. The experiment with cotton herbicides was conducted in North Carolina in 1992 and 1993 and in Georgia and Louisiana in 1993. The experiment was designed to evaluate single and sequential applications of herbicides currently registered for POST-DIR application to cotton. Treatments consisted of a factorial arrangement of MSMA and fluometuron + MSMA applied EPOST and MSMA, fluometuron + MSMA, prometryn + MSMA, cyanazine + MSMA, lactofen + MSMA, and oxyfluorfen + MSMA applied LPOST. Fluometuron, prometyrn, cyanazine, lactofen, and oxyfluorfen were applied at 1.68, 0.73, 1.12, 0.22 and 0.56 kg ai/ha, respectively; MSMA was applied at 2.24 kg ae/ha.

DSMA (disodium salt of methylarsonic acid) was not included in this experiment because results would be expected to be similar to those with MSMA. Although methazole [2-(3,4-dichlorophenyl)-4-methyl-1,2,4-oxadiazolidine-3,5-dione] applied POST-DIR effectively controls many broadleaf weeds in cotton (6, 19), it was not included because all registrations for methazole were scheduled for cancellation in December, 1993 (1). DPX-PE350 [2-chloro-6-(4,5-dimethoxypyrimidin-2-ylthio)benzoate], an experimental herbicide being developed for cotton that effectively controls a number of problem broadleaf weeds when applied POST (4), was not included because previous research has shown peanut tolerance of this herbicide (5).

Glyphosate. Glyphosate currently can be applied to the row middles of cotton using shielded spray equipment.[3] Transgenic cotton resistant to glyphosate applied POST is expected to be commercially available within a few years (16).

The experiment was conducted in North Carolina, Georgia, and Louisiana in 1993. Treatments included the isopropylamine salt of glyphosate at 0.42, 0.56, 0.84, and 1.12 kg/ha applied EPOST, LPOST, or EPOST followed by LPOST. The experiment also was conducted in North Carolina in 1992, but glyphosate was applied only at 1.12 kg/ha.

Statistical analysis. Peanut control was estimated visually 18 to 26 days after the LPOST applications using a scale of 0 (no control) to 100 (complete control). Data were subjected to analysis of variance with basic partitioning appropriate for the factorial treatment arrangements. Data were transformed to the arcsine square root prior to analysis. A treatment by location interaction precluded pooling data over locations. Significant EPOST by LPOST interactions were observed in all experiments. Means were separated by Fisher's protected LSD at $P \leq 0.05$. Non-transformed means are presented with statistical interpretation based upon transformed data.

Results and Discussion

Corn herbicides. Peanut control by all herbicides except 2,4-D applied EPOST in North Carolina in 1992 was greater than with no treatment (Table 1). Applied EPOST, dicamba was more effective than 2,4-D at all locations.

Peanut control was similar with dicamba, 2,4-D, ametryn, and linuron applied LPOST in Louisiana (Table 1). Control by these four herbicides applied LPOST was similar to that with dicamba applied EPOST and greater than that with 2,4-D EPOST. Control by dicamba, ametryn, and linuron applied LPOST was similar at both locations in North Carolina except that linuron was more effective than ametryn in 1993. Control by dicamba, ametryn, and linuron applied LPOST exceeded control by 2,4-D applied either EPOST or LPOST but was similar to that with dicamba EPOST.

No herbicide treatment completely controlled peanut. However, greater control generally was noted with sequential herbicide applications. Dicamba applied EPOST followed by either dicamba, ametryn, or linuron LPOST, and 2,4-D applied EPOST followed by linuron LPOST were more effective than any single herbicide application at all locations (Table 1). At two of the three locations, 2,4-D applied EPOST followed by ametryn LPOST was more effective than any single application. Dicamba applied

Table 1. Peanut control with single and sequential applications of herbicides normally applied postemergence to corn.[a]

Herbicides[b]		North Carolina		Louisiana
EPOST	LPOST	1992	1993	1993
			%	
None	None	0 i	0 h	0 h
None	2,4-D	13 h	36 g	40 f
None	Dicamba	46 fg	55 ef	43 f
None	Ametryn	44 g	49 f	53 ef
None	Linuron	54 efg	65 cde	45 f
2,4-D	None	0 i	33 g	27 g
2,4-D	2,4-D	16 h	49 fg	55 def
2,4-D	Dicamba	65 cde	69 cd	80 ab
2,4-D	Ametryn	74 abc	74 bc	82 ab
2,4-D	Linuron	71 bcd	80 ab	70 bcd
Dicamba	None	58 ef	58 ef	45 f
Dicamba	2,4-D	59 de	60 de	63 cde
Dicamba	Dicamba	80 ab	87 a	87 a
Dicamba	Ametryn	81 ab	85 ab	87 a
Dicamba	Linuron	86 a	86 ab	75 abc

[a]Means within a column followed by the same letter are not different according to Fisher's protected LSD test at $P \leq 0.05$.
[b]Ametryn, dicamba, linuron, and 2,4-D were applied at 1.12, 0.28, 1.12, and 0.56 kg/ha, respectively.

[2]Valent X-77 Spreader, containing alkylarylpolyoxyethylene glycols, free fatty acids, and isopropanol. Valent U.S.A. Corp., 1333 N. California Blvd., Walnut Creek, CA 94596-8025.

[3]Roundup herbicide label. Monsanto Agric. Co., 800 N. Lindbergh Blvd., St. Louis, MO 63167.

EPOST followed by either dicamba or ametryn LPOST controlled peanut at least 80% at all locations. Greater than 80% control also was noted with dicamba applied EPOST followed by linuron LPOST at two of the three locations.

Cotton herbicides. Applied EPOST, fluometuron + MSMA controlled peanut better than MSMA alone in North Carolina and Georgia (Table 2). Similar control was noted with MSMA and fluometuron + MSMA applied early POST in Louisiana. Both MSMA and fluometuron + MSMA were more effective applied EPOST compared with LPOST in Georgia and Louisiana (Table 2). In North Carolina, MSMA was more effective applied LPOST while similar control was noted with EPOST and LPOST applications of fluometuron + MSMA.

Varying results were noted with the LPOST treatments. All herbicides applied LPOST were similarly effective in Louisiana, with control ranging from 55 to 65% (Table 2). In North Carolina in 1992, similar results were observed with MSMA and lactofen + MSMA while fluometuron + MSMA, prometryn + MSMA, cyanazine + MSMA, and oxyfluorfen + MSMA were more effective than MSMA alone. In North Carolina in 1993, similar results were noted with MSMA, fluometuron + MSMA, and cyanazine + MSMA. However, prometryn + MSMA, lactofen + MSMA, and oxyfluorfen + MSMA were more effective than MSMA alone. In Georgia, all combinations except prometryn + MSMA controlled peanut better than MSMA applied alone.

Similar to results with the corn herbicides, sequential applications of the cotton herbicides generally were more effective than single applications (Table 2). Regardless of herbicides used, peanut was controlled at least 95% with sequential applications in Louisiana and in North Carolina in 1993. Although control generally was less in Georgia and in North Carolina in 1992, several sequential treatments controlled peanut at least 80%. MSMA followed by oxyfluorfen + MSMA and fluometuron + MSMA followed by prometryn + MSMA, cyanazine + MSMA, lactofen + MSMA, and oxyfluorfen + MSMA controlled peanut at least 80% at both locations. In North Carolina in 1992, MSMA followed by lactofen + MSMA, fluometuron + MSMA followed by MSMA, and fluometuron + MSMA followed by fluometuron + MSMA also controlled peanut at least 80%.

Glyphosate. With single applications of glyphosate, peanut control generally increased as the glyphosate rate increased (Table 3). The exception to this trend was the LPOST applications at Georgia where approximately 40% control was noted with all rates. The poor control with LPOST applications at this location may have been due to extreme moisture stress at the time of application. Control with the EPOST applications in Georgia was similar to that in North Carolina.

Regardless of the rate, glyphosate was more effective when applied LPOST in North Carolina in 1993 (Table 3). Similar results were noted with 1.12 kg/ha in 1992. In contrast, early application was more effective in Louisiana. The reason for these contrasting results is unclear. However, it may be related to size of peanut when treated. Peanut at time of EPOST application in Louisiana was similar in size to peanut at the LPOST application in North Carolina.

In contrast to results with corn and cotton herbicides, there appeared to be no advantage of sequential applications of glyphosate compared with single applications. In North Carolina in 1993, no sequential application was more effective than glyphosate at 0.84 kg/ha applied LPOST (Table 3).

Table 2. Peanut control with single and sequential applications of herbicides normally applied postemergence-directed to cotton.[a]

Herbicides[b]		North Carolina		Georgia	Louisiana
EPOST	LPOST	1992	1993	1993	1993
		%			
None	None	0 j	0 f	0 k	0 d
None	MSMA	31 h	70 d	22 j	63 c
None	Fluo + MSMA	49 ef	72 cd	31 i	62 c
None	Prom + MSMA	39 fg	76 bc	27 ij	58 c
None	Cyan + MSMA	52 e	68 d	32 i	55 c
None	Lact + MSMA	22 hi	77 b	39 gh	60 c
None	Oxyf + MSMA	72 cd	78 b	51 f	65 c
MSMA	None	19 i	58 e	33 hi	85 b
MSMA	MSMA	59 e	99 a	56 ef	100 a
MSMA	Fluo + MSMA	70 d	96 a	75 cd	100 a
MSMA	Prom + MSMA	72 cd	95 a	71 d	100 a
MSMA	Cyan + MSMA	70 d	96 a	59 e	99 a
MSMA	Lact + MSMA	80 bcd	95 a	75 cd	100 a
MSMA	Oxyf + MSMA	86 ab	99 a	83 ab	100 a
Fluo + MSMA	None	57 e	70 d	43 g	88 b
Fluo + MSMA	MSMA	84 ab	99 a	73 d	100 a
Fluo + MSMA	Fluo + MSMA	87 ab	96 a	74 cd	100 a
Fluo + MSMA	Prom + MSMA	85 ab	95 a	80 bc	100 a
Fluo + MSMA	Cyan + MSMA	85 ab	98 a	80 bc	100 a
Fluo + MSMA	Lact + MSMA	82 abc	96 a	85 ab	100 a
Fluo + MSMA	Oxyf + MSMA	91 a	97 a	88 a	100 a

[a]Means within a column followed by the same letter are not different according to Fisher's protected LSD test at $P \leq 0.05$.
[b]Cyan = cyanazine, fluo = fluometuron, lact = lactofen, oxyf = oxyfluorfen, and prom = prometryn. MSMA, cyanazine + MSMA, fluometuron + MSMA, lactofen + MSMA, oxyfluorfen + MSMA, and prometryn + MSMA were applied at 2.24, 1.12 + 2.24, 1.68 + 2.24, 0.22 + 2.24, 0.56 + 2.24, and 0.73 + 2.24 kg/ha, respectively.

Table 3. Peanut control with single and sequential applications of glyphosate.[a]

Glyphosate rate	Application time	North Carolina 1992	North Carolina 1993	Georgia 1993	Louisiana 1993
kg/ha		%			
0.42	EPOST		35 h	31 e	83 cde
0.56	EPOST		46 gh	42 d	88 cde
0.84	EPOST		74 de	68 c	98 ab
1.12	EPOST	81 b	81 cd	81 ab	100 a
0.42	LPOST		53 fg	40 de	47 f
0.56	LPOST		64 ef	39 de	62 f
0.84	LPOST		96 ab	41 d	80 e
1.12	LPOST	96 a	98 a	43 d	94 bcd
0.42	EPOST + LPOST		77 d	72 bc	87 de
0.56	EPOST + LPOST		90 bc	71 c	97 abc
0.84	EPOST + LPOST		99 a	82 a	100 a
1.12	EPOST + LPOST	92 a	100 a	83 a	100 a

[a]Means within a column followed by the same letter are not different according to Fisher's protected LSD test at $P \leq 0.05$. All treatments significantly greater than non-treated check.

Control by glyphosate at 0.84 kg/ha applied LPOST was greater than control by glyphosate applied sequentially at 0.42 kg/ha and similar to control with glyphosate applied sequentially at 0.56, 0.84, or 1.12 kg/ha. Similarly, control by glyphosate applied LPOST at 1.12 kg/ha was greater than control with glyphosate applied sequentially at 0.56 kg/ha and similar to control with glyphosate applied sequentially at 0.84 or 1.12 kg/ha.

No sequential application was more effective than glyphosate at 1.12 kg/ha applied EPOST in Georgia (Table 3). Control by glyphosate applied EPOST at 0.84 kg/ha was similar to control by glyphosate applied sequentially at 0.42 or 0.56 kg/ha. Control by glyphosate applied EPOST at 1.12 kg/ha was greater than control by glyphosate applied sequentially at 0.56 kg/ha and similar to the control with glyphosate applied sequentially at 0.84 or 1.12 kg/ha.

In Louisiana, control by glyphosate at any rate applied EPOST was similar to the control with that rate applied sequentially (Table 3). Control by glyphosate applied sequentially at 0.42 kg/ha was less than control by glyphosate at 0.84 kg/ha applied EPOST while control by glyphosate at 0.56 kg/ha applied sequentially was similar to control with glyphosate at 1.12 kg/ha applied EPOST.

Conclusions

Although substantiative research has not been conducted, one would expect controlling volunteer peanut in rotational crops would reduce disease pressure in subsequent peanut crops. Results of our experiments demonstrate that planted peanut can be controlled with herbicides commonly applied POST in corn or cotton. Because there is no reason to expect volunteer and planted peanut to respond differently to these POST herbicides, it is reasonable to assume these herbicides would control volunteer peanut in corn or cotton. Research is needed to verify or refute this assumption.

Considering average prices[4] for dicamba ($38/kg), ametryn ($12/kg), and linuron ($39/kg), the most efficacious and cost effective herbicide program for peanut control in corn would be two sequential applications of dicamba. Although somewhat less effective than two applications of dicamba, an early application of an amine formulation of 2,4-D followed by a late POST-DIR application of ametryn would be a reasonably effective and cost efficient alternative where proximity to sensitive crops precludes the use of dicamba.

Several options are available to control volunteer peanut in cotton. Although fluometuron + MSMA applied EPOST followed by oxyfluorfen + MSMA LPOST tended to be the best treatment across locations, five sequential treatments controlled peanut at least 80% at all locations (Table 2).

Based upon banded applications covering one-third of the planted area and average prices[4] of $6.40, $12, $18, $119, $96, and $16.25/kg for MSMA, cyanazine, fluometuron, lactofen, oxyfluorfen, and prometryn, respectively, costs of the five sequential treatments range from $24 to $38/ha. Fluometuron + MSMA followed by either cyanazine + MSMA or prometryn + MSMA would be the most economical treatment. However, with several effective treatments to choose from, the best treatment would be one that also effectively controls other weeds present.

In no-till cotton, a program consisting of one of the five sequential treatments mentioned above POST-DIR in a band under the cotton plus glyphosate applied once to the row middles with shielded spray equipment should effectively control volunteer peanut and would be more economical than two broadcast applications of the typical POST-DIR herbicides. When glyphosate-tolerant cotton becomes commercially available, glyphosate applied POST overtop of cotton would be an alternative to currently available herbicides that must be directed to cotton.

[4]Average of prices quoted by two major pesticide distributors in North Carolina in the fall of 1993.

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