Imazethapyr Systems for Peanut (*Arachis hypogaea* L.)

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ABSTRACT

Field studies conducted in 1992 at Tifton and Midville, GA and in 1993 at Attapulgus, GA evaluated imazethapyr systems for weed control, peanut (*Arachis hypogaea L.*) injury, and yield. The standard of imazethapyr + paraquat early postemergence (EPOST) followed by paraquat + 2,4-DB + bentazon postemergence (POST) controlled at least 87% of bristly starbur, prickly sida, smallflower morningglory, and yellow nutsedge and the peanut crop yielded 3310 kg/ha. This standard controlled Florida beggarweed (46 and 83% control) and sicklepod (74 and 88% control) in 1992 and 1993, respectively. Imazethapyr PPI at 36 and 72 g/ha controlled bristly starbur 78 and 100%, respectively, and controlled prickly sida and smallflower morningglory at least 90%. Imazethapyr PPI at 36 and 72 g/ha controlled yellow nutsedge 83 and 80%, respectively. Imazethapyr did not control sicklepod or Florida beggarweed. Control of these two species and high peanut yields required a POST application of a paraquat mixture.

Key Words: Bristly starbur, *Acanthospermum hispidum*, Florida beggarweed, *Desmodium tortuosum*, prickly sida, *Sida spinosa*, sicklepod, *Senna obtusifolia*, smallflower morningglory, *Jacquemontia tamnifolia*, yellow nutsedge, *Cyperus esculentus*.

Imazethapyr, 2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1*H*-imidazol-2-yl]-5-ethyl-3-pyridinecarboxylic acid, an imidazolinone herbicide, was registered for use in peanut during the spring of 1991. Imazethapyr was the first herbicide in peanut to provide residual control of numerous annual broadleaf weeds and perennial sedges (3, 5, 7, 9, 10, 11). The lack of an effective residual soil-applied, broadleaf-active herbicide in the past has resulted in growers making two or more postemergence (POST) herbicide applications to obtain control (9, 11, 12, 13).

Imazethapyr does not control Florida beggarweed [*Desmodium tortuosum* (SW.) DC.] and sicklepod (9, 10, 11), the two most common and troublesome annual broadleaf weeds in southeastern peanut production (2). Consequently, other herbicides must be used. At the time this research was initiated, other herbicides registered in peanut for early postemergence (EPOST) and POST control of Florida beggarweed and/or sicklepod [*Senna obtusifolia* (L.) Irwin and Barneby] included paraquat (1,1'-dimethyl-4,4'-bipyridinium ion) and 2,4-DB [4-(2,4-dichlorophenoxy)- butanoic acid]. Bentazon [3-(1-methylethyl)-(1*H*)-2,1,3-benzothiadiazin-4(3*H*)-one 2,2-dioxide] also is used in mixture with paraquat and/or 2,4-DB since it controls bristly starbur (*Acanthospermum hispidum* DC.), prickly sida (*Sida spinosa* L.), and smallflower morningglory [*Jacquemontia tamnifolia* (L.) Griseb.] (13).

Purple (*Cyperus rotundus* L.) and yellow (*Cyperus esculentus* L.) nutsedge control with imazethapyr has been variable in field research (1, 3, 4), particularly with POST applications. Later greenhouse research showed that imazethapyr at 71 g ai/ha preplant-incorporated (PPI) or EPOST followed by (fb) irrigation were the most efficacious for purple and yellow nutsedge control (6).

Method of application and application rate of imazethapyr have been shown to influence weed efficacy (5, 11). Previous research reported that imazethapyr controlled prickly sida and spurred anoda [*Anoda cristata* (L.) Schlecht.] better when applied either PPI or preemergence (PRE) than when applied POST (11). Later research showed that a POST application of paraquat +

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imazethapyr at 72 g/ha controlled bristly starbur, coffee senna, common cocklebur (*Xanthium strumarium* L.), *Ipomoea* morninglories, prickly sida, and smallflower morningglory better than a paraquat + bentazon mixture (9). Additionally, sicklepod control was better with a paraquat + imazethapyr mixture at four of five locations and it provided equivalent control of Florida beggarweed.

The maximum registered use rate of imazethapyr (Pursuit herbicide product label, 1994, American Cyanamid Co., Princeton, NJ 08540) in peanut is 72 g/ha in a growing season. It may be applied either PPI, PRE, EPOST, or POST. This 72 g/ha rate may be split between soil any combination of soil and POST application. North Carolina research showed that PPI fb EPOST application of imazethapyr at 36 and 36 g/ha was effective for yellow nutsedge control (16). Prior research has shown that only 36 g/ha is effective for the control of several weed species, and the most effective method of application depends on the weed species (5, 11). This research was conducted in soybean [*Glycine max* (L.) Merr.] in Arkansas and in peanut in North Carolina and Virginia (16). Reduced-rate use of imazethapyr needs to be assessed in southeastern peanut production because lower rates would be more economical and potential for injurious carryover to cotton (*Gossypium hirsutum* L.) would be minimized (14, 15). Cotton is increasingly grown in rotation with peanut in Georgia (15). Therefore, the objectives of this study were to evaluate imazethapyr at two rates applied PPI alone and/or in postemergence systems for weed control, peanut injury, and peanut yield.

Materials and Methods

Experiments were conducted near Tifton, GA in 1992, the Southeast Branch Station near Midville, GA in 1992, and the Attapulgus Research Farm near Attapulgus, GA in 1993. The soil type at all locations was a Dothan loamy sand (fine-loamy, siliceous, thermic Kandiudults) with 0.7 to 1.1% organic matter and soil pH ranging from 5.3 to 5.8. These experimental sites are representative of the major peanut production areas in Georgia.

The experimental areas at Tifton and Attapulgus were infested with Florida beggarweed, sicklepod, and yellow nutsedge. The Tifton location also was infested with smallflower morningglory, the Attapulgus area with bristly starbur, and the Midville location with prickly sida.

Peanut cv. Florunner was planted at Tifton on 5 May 1992 and at Midville on 29 April 1992. The cultivar Southern Runner was planted at Attapulgus on 22 April 1993. Florunner was planted at 112 kg/ha and Southern Runner at 133 kg/ha at a depth of 5 cm in a well-prepared flat seedbed using conventional equipment. Southern Runner was planted at a higher seeding rate due to poor seedling vigor (J. Baldwin, pers. commun., 1992).

All herbicides were applied either PPI, EPOST (within 1 wk of peanut emergence), or POST (3 wk after peanut emergence). Broadleaf weeds at the time of EPOST applications were in the cotyledon to 2-leaf growth stage, with yellow nutsedge 10 to 15 cm tall. At the time of POST applications, broadleaf weeds were at the cotyledon to 7-leaf growth stage, and yellow nutsedge was 15 to 38 cm tall. Weed densities at the time of EPOST and POST applications were 18 to 25 plants per m^2 and 30 to 52 plants per m^2, respectively. All EPOST and POST applications included X-77 [a nonionic surfactant containing a alkylarylpolyoxyethylene glycols, free fatty acids, and isopropanol (Valent USA Corp., P. O. Box 8025, Walnut Creek, CA 94596-8025)] at 0.25% by volume of spray volume.

Sixteen herbicide systems which included PPI, EPOST, and/or POST applications were evaluated. Pendimethalin at 1.12 kg/ha was applied as broadcast PPI treatment over the entire experimental area for annual grass and small-seeded broadleaf weed control (13). System one received only pendimethalin and, since pendimethalin was applied to all plots, it will not be mentioned again. System two was the standard and received imazethapyr at 72 g/ha + paraquat at 140 g ai/ha EPOST fb paraquat + 2,4-DB at 280 g ai/ha + bentazon at 560 g ai/ha POST; system three was paraquat + 2,4-DB POST; system four was paraquat + 2,4-DB + bentazon POST; system five was paraquat + 2,4-DB + imazethapyr at 36 g/ha POST; system six was paraquat + 2,4-DB + bentazon + imazethapyr at 36 g/ha POST; system seven was paraquat + 2,4-DB + imazethapyr at 72 g/ha POST; system eight was paraquat + 2,4-DB + bentazon + imazethapyr at 72 g/ha POST; system nine was imazethapyr at 36 g/ha PPI; system 10 was imazethapyr at 36 g/ha PPI fb paraquat + 2,4-DB POST; system 11 was imazethapyr at 36 g/ha PPI fb paraquat + 2,4-DB + bentazon POST; system 12 was imazethapyr at 36 g/ha PPI fb paraquat + 2,4-DB + imazethapyr at 36 g/ha POST; system 13 was imazethapyr at 36 g/ha PPI fb paraquat + 2,4-DB + bentazon + imazethapyr at 36 g/ha POST; system 14 was imazethapyr at 72 g/ha PPI; system 15 was imazethapyr at 72 g/ha PPI fb paraquat + 2,4-DB POST; and system 16 was imazethapyr at 72 g/ha PPI fb paraquat + 2,4-DB + bentazon POST.

A randomized complete block design with three replications was used. All herbicides were applied with a CO_2 backpack sprayer calibrated to deliver 187 L/ha at 180 kPa. Weed control was visually estimated on a scale of 0% (no control) to 100% (complete control) based on population density and plant vigor. Peanut injury was visually estimated on a scale of 0 (no injury) to 100% (complete death of peanut). Peanuts were harvested using conventional harvesting equipment and yields estimated (17).

Two embedded factorials with several common overlapping treatments were included in the 16 systems. Analysis of variance revealed significant factor interactions in both embedded factorials, consequently the 16 systems were analyzed unstructured. Peanut injury, weed control ratings, and peanut yield were subjected to analysis of variance and means were separated with the appropriate Fisher's Protected Least Significant Difference (LSD) Test at the 5% level of probability. There were significant year by treatment interactions for Florida beggarweed and sicklepod, consequently these data will be presented by year. In addition, significant interactions precluded pooling yield data over all locations and years. However, error variances were homogenous and nonsignificant interactions allowed pooling of visual estimates of yellow nutsedge control and yield data from Attapulgus and Tifton.

Results and Discussion

Weed Control, Annual Grasses. Pendimethalin controlled annual grasses which included Texas panicum (*Panicum texanum* Buckl.) and large crabgrass [*Digitaria*

sanguinalis (L.)] (data not shown). Pendimethalin does not have appreciable activity on the large seeded broadleaf weed species or yellow nutsedge found in these studies, consequently this herbicide will not be discussed further (9, 13).

Bristly Starbur. The standard of imazethapyr + paraquat EPOST fb paraquat + 2,4-DB + bentazon POST controlled bristly starbur 98% (Table 1). Paraquat + 2,4-DB POST controlled bristly starbur 26% and control increased to 62% with the addition of bentazon to this mixture. Bentazon controls bristly starbur, but paraquat does not control this species (13). Paraquat + 2,4-DB + imazethapyr at 36 g/ha POST controlled bristly starbur 53% and control increased to 79% with the addition of bentazon. Paraquat + 2,4-DB + imazethapyr at 72 g/ha POST controlled bristly starbur 89% and the addition of bentazon did not increase control. Imazethapyr applied PPI alone at 36 or 72 g/ha controlled bristly starbur 78 and 100%, respectively. A POST treatment numerically increased control when applied after imazethapyr applied PPI at 36 g/ha, but not at 72 g/ha.

Prickly Sida. The standard controlled prickly sida 100% (Table 1). Paraquat + 2,4-DB POST controlled prickly sida 78% while paraquat + 2,4-DB + bentazon controlled 93%. All other treatments controlled prickly sida at least 90%. Imazethapyr at 36 g/ha PPI controlled prickly sida 90% while the 72 g/ha application controlled 100%. Imazethapyr has excellent activity on prickly sida applied either PPI, PRE, or EPOST (10, 11, 13). Neither paraquat nor 2,4-DB alone or in combination provides adequate prickly sida control (9).

Smallflower Morningglory. The standard controlled smallflower morningglory 100% (Table 1). Paraquat + 2,4-DB POST controlled smallflower morningglory 93%. The activity of this combination is largely attributed to 2,4-DB (13). All other treatments controlled smallflower morningglory at least 97%. The efficacy of imazethapyr towards smallflower morningglory with soil and/or foliar activity has been previously documented (5, 9, 10, 13). This research indicates that the maximum registered use rate (72 g ai/ha) of imazethapyr may be reduced by 50% and still provide effective smallflower morningglory control. Bentazon also is effective, but only as a POST treatment (13).

Yellow Nutsedge. The standard controlled yellow nutsedge 87% (Table 1). Paraquat + 2,4-DB POST controlled yellow nutsedge 65%. Paraquat controls yellow nutsedge only to the extent of postemergence foliar burndown; it provides neither translocation to tubers nor soil activity (J. Wilcut, unpubl. data). The addition of bentazon to paraquat + 2,4-DB POST improved control to 87%. Like paraquat, bentazon controls yellow nutsedge postemergence, but does not have soil residual activity (13). All other POST treatments without imazethapyr applied PPI provided equivalent control ranging from 88 to 94%. Imazethapyr PPI alone at 36 or 72 g/ha controlled yellow nutsedge 83 and 80%, respectively. The addition of a POST treatment did not significantly improve yellow nutsedge control for imazethapyr PPI containing systems.

Imazethapyr applied PPI controls yellow nutsedge, however regrowth frequently occurs (6). Imazethapyr controls yellow nutsedge primarily through root-tuber absorption (6). Consequently, dry conditions after soil and/or foliar application would limit absorption and reduce control (7).

Table 1. Imazethapyr systems for weed control in Georgia peanuts, 1992-1993.

Herbicide(s) application timing[a]			Weed species			
PPI	EPOST	POST	Bristly starbur	Prickly sida	Smallflower morningglory	Yellow nutsedge
			%			
None	None	None	0	0	0	0
None	Imaz.(72) + Para.	Para. + 2,4-DB + Bent.	98	100	100	87
None	None	Para. + 2,4-DB	26	78	93	65
None	None	Para. + 2,4-DB + Bent.	62	93	97	88
None	None	Para. + 2,4-DB +Imaz.(36)	53	93	100	91
None	None	Para. + 2,4-DB + Bent. + Imaz.(36)	79	97	100	94
None	None	Para. + 2,4-DB + Imaz.(72)	89	93	100	94
None	None	Para. + 2,4-DB + Bent. + Imaz.(72)	94	100	100	95
Imaz.(36)	None	None	78	90	100	83
Imaz.(36)	None	Para. + 2,4-DB	85	100	100	88
Imaz.(36)	None	Para. + 2,4-DB + Bent.	82	100	100	92
Imaz.(36)	None	Para. + 2,4-DB + Imaz.(36)	92	100	100	85
Imaz.(36)	None	Para. + 2,4-DB + Bent. + Imaz.(36)	94	100	100	88
Imaz.(72)	None	None	100	100	100	80
Imaz.(72)	None	Para. + 2,4-DB	94	97	100	85
Imaz.(72)	None	Para. + 2,4-DB + Bent.	96	100	100	95
LSD (0.05)			24	13	6	20

[a]Pendimethalin was applied at 1.12 kg ai/ha to entire experiment; Para. = paraquat applied at 140 g ai/ha; 2,4-DB was applied at 280 g ai/ha; Bent. = bentazon applied at 560 g ai/ha; Imaz. = imazethapyr applied at 36 or 72 g ai/ha. PPI = preplant incorporated; EPOST = early-postemergence 1 wk after peanut emergence; POST = postemergence 3 wk after peanut emergence.

Florida Beggarweed. The standard controlled Florida beggarweed 46% at Tifton in 1992 (Table 2). Paraquat POST controls Florida beggarweed (9, 10, 12, 13). All other POST treatments did not exceed 60% control. Imazethapyr PPI was ineffective even at 72 g/ha. These data agree with previous results that imazethapyr does not control Florida beggarweed (9, 10).

The standard controlled Florida beggarweed 83% at Attapulgus in 1993 (Table 2). A number of other systems provided equivalent control. The density of Florida beggarweed at Attapulgus was much lower than that at Tifton (data not shown). Again imazethapyr PPI was ineffective regardless of rate.

Sicklepod. Sicklepod control with the standard was 74% at Tifton in 1992 (Table 2). POST treatments alone controlled sicklepod 63 to 81% with no differences among treatments. Imazethapyr PPI alone at 36 and 72 g/ha controlled sicklepod 58 and 78%, respectively. Imazethapyr generally does not control sicklepod and this apparent control may partially be attributed to lack of Florida beggarweed control. However, control was more consistent when imazethapyr was applied PPI at either rate fb a POST application of a paraquat-containing mixture. Previous research has shown that imazethapyr will improve the performance of paraquat-containing treatments with respect to sicklepod control (9).

Sicklepod control was 88% with the standard at Attapulgus in 1993 (Table 2). Imazethapyr at 36 g/ha + paraquat + 2,4-DB POST and paraquat + 2,4-DB + bentazon + imazethapyr at 72 g/ha POST were the only two POST treatments to control sicklepod equivalent to the standard. Imazethapyr PPI at 36 and 72 g/ha alone controlled sicklepod 18 and 26%, respectively, and control was consistently increased when fb a POST treatment containing paraquat + 2,4-DB.

Peanut Response, Peanut Injury. Peanut injury 3 wk after POST treatments ranged 0 to 13%, but was not apparent by 8 wk after treatment (data not shown). All PPI, EPOST, and POST treatments yielded more than pendimethalin alone at Tifton and Attapulgus (average of both locations) (Table 3). The standard of imazethapyr + paraquat EPOST fb paraquat + 2,4-DB + bentazon POST yielded 3310 kg/ha. Paraquat + 2,4-DB + bentazon + imazethapyr (36 g/ha) POST yielded 2780 kg/ha, and was the only POST treatment without imazethapyr applied PPI to yield equivalent to the standard. Imazethapyr PPI at 36 or 72 g/ha alone yielded 2070 and 2160 kg/ha, respectively, and were not equivalent to the standard. These lower yields reflect the lack of Florida beggarweed and sicklepod control.

Yields from imazethapyr (36 g/ha) PPI fb any POST treatment were equivalent to the standard (2930 to 3300 kg/ha). Imazethapyr PPI at 72 g/ha fb paraquat + 2,4-DB POST did not yield equivalent to the standard and the addition of bentazon to the POST treatment provided the highest numerical yield at 3500 kg/ha.

All treatments yielded higher than when pendimethalin was used alone at Midville in 1992 (Table 3). Yield from the standard was 6070 kg/ha. Paraquat + 2,4-DB POST, paraquat + 2,4-DB + imazethapyr at 36 g/ha POST, and imazethapyr (72 g/ha) PPI fb paraquat + 2,4-DB + bentazon POST yielded less than the standard.

Summary

Table 2. Imazethapyr systems for Florida beggarweed and sicklepod control in Georgia peanuts, 1992-1993.

Herbicide(s) application timing[a]			Florida beggarweed		Sicklepod	
PPI	EPOST	POST	Tifton 1992	Attapulgus 1993	Tifton 1992	Attapulgus 1993
			%			
None	None	None	0	0	0	0
None	Imaz.(72) + Para.	Para. + 2,4-DB + Bent.	46	83	74	88
None	None	Para. + 2,4-DB	38	68	63	67
None	None	Para. + 2,4-DB + Bent.	60	62	81	69
None	None	Para. + 2,4-DB +Imaz. (36)	27	78	75	84
None	None	Para. + 2,4-DB + Bent. + Imaz. (36)	8	75	78	77
None	None	Para. + 2,4-DB + Imaz. (72)	26	82	72	74
None	None	Para. + 2,4-DB + Bent. + Imaz. (72)	28	80	74	85
Imaz.(36)	None	None	0	0	58	18
Imaz.(36)	None	Para. + 2,4-DB	34	68	10	64
Imaz.(36)	None	Para. + 2,4-DB + Bent.	37	72	76	63
Imaz.(36)	None	Para. + 2,4-DB + Imaz. (36)	35	79	83	73
Imaz.(36)	None	Para. + 2,4-DB + Bent. + Imaz. (36)	26	88	87	78
Imaz.(72)	None	None	5	0	78	26
Imaz.(72)	None	Para. + 2,4-DB	41	85	88	71
Imaz.(72)	None	Para. + 2,4-DB + Bent.	31	75	93	78
LSD (0.05)			27	11	19	10

[a]Pendimethalin was applied at 1.12 kg ai/ha to all plots; Para. = paraquat applied at 140 g ai/ha; 2,4-DB was applied at 280 g ai/ha; Bent. = bentazon applied at 560 g ai/ha; Imaz. = imazethapyr applied at 36 or 72 g ai/ha. PPI = preplant incorporated; EPOST = early-postemergence 1 wk after peanut emergence; POST = postemergence 3 wk after peanut emergence.

Table 3. Peanut yield with imazethapyr systems in Georgia peanuts, 1992-1993.

Herbicide(s) application timing[a]			Peanut yield	
PPI	EPOST	POST	Tifton 1992 & Attapulgus 1993 (avg)	Midville 1993
			kg/ha	
None	None	None	1360	3030
None	Imaz.(72) + Para.	Para. + 2,4-DB + Bent.	3310	6070
None	None	Para. + 2,4-DB	2550	4800
None	None	Para. + 2,4-DB + Bent.	2550	6270
None	None	Para. + 2,4-DB + Imaz.(36)	2580	4920
None	None	Para. + 2,4-DB + Bent. + Imaz.(36)	2780	6440
None	None	Para. + 2,4-DB + Imaz.(72)	2680	6100
None	None	Para. + 2,4-DB + Bent. + Imaz.(72)	2700	5610
Imaz.(36)	None	None	2070	5280
Imaz.(36)	None	Para. + 2,4-DB	3260	6220
Imaz.(36)	None	Para. + 2,4-DB + Bent.	3330	5380
Imaz.(36)	None	Para. + 2,4-DB + Imaz.(36)	3100	6000
Imaz.(36)	None	Para. + 2,4-DB + Bent. + Imaz.(36)	2930	5770
Imaz.(72)	None	None	2160	5680
Imaz.(72)	None	Para. + 2,4-DB	2680	5840
Imaz.(72)	None	Para. + 2,4-DB + Bent.	3500	4910
LSD (0.05)			590	780

[a]Pendimethalin was applied at 1.12 kg ai/ha to all plots; Para. = paraquat applied at 140 g ai/ha; 2,4-DB was applied at 280 g ai/ha; Bent. = bentazon applied at 560 g ai/ha; Imaz. = imazethapyr applied at 36 or 72 g ai/ha. PPI = preplant incorporated; EPOST = early-postemergence 1 wk after peanut emergence; POST = postemergence 3 wk after peanut emergence.

The standard controlled bristly starbur, prickly sida, smallflower morningglory, yellow nutsedge, as well as Florida beggarweed and sicklepod at Attapulgus in 1993. These data show that paraquat + 2,4-DB + bentazon POST control prickly sida, smallflower morningglory, and yellow nutsedge. Imazethapyr PPI at 36 g/ha gave excellent season-long residual control of prickly sida and smallflower morningglory. Imazethapyr at 72 g/ha applied PPI or POST was required for season-long residual control of bristly starbur. Imazethapyr PPI controlled yellow nutsedge, but did not control Florida beggarweed or sicklepod. However, either rate of imazethapyr applied PPI fb a POST treatment generally provided equivalent levels of weed control and peanut yield. Additionally, either rate of imazethapyr when applied in tank mixture with either paraquat + 2,4-DB or paraquat + 2,4-DB + bentazon usually provided similar levels of weed control and peanut yield.

Peanut yields equivalent to the standard generally required a POST treatment containing either imazethapyr at 72 g/ha, paraquat + 2,4-DB, bentazon + imazethapyr at 36 g/ha, or imazethapyr PPI at either rate fb a POST treatment.

This research suggests that imazethapyr can be used at a reduced rate applied PPI for prickly sida and smallflower morningglory control; however, a POST application containing paraquat + 2,4-DB was required for Florida beggarweed and sicklepod control. Bristly starbur and yellow nutsedge control required 72 g/ha of imazethapyr applied PPI or POST, or imazethapyr at 36 g/ha + bentazon POST.

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