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Bushkiller (*Cayratia japonica*) Response to Selected Herbicides

Amanda M. West, Robert J. Richardson, Andrew P. Gardner, and Steve T. Hoyle*

Bushkiller, an aggressive perennial vine native to Southeast Asia, has invaded several sites in Alabama, North Carolina, Texas, Louisiana, and Mississippi. Bushkiller has only recently been discovered in North Carolina. The potential economic and environmental consequences associated with established exotic invasive perennial vines and the lack of published control measures for bushkiller prompted research to be conducted at North Carolina State University that may be used in an early-detection rapid-response program. Field and greenhouse studies were conducted to determine bushkiller response to selected foliar-applied herbicides. Field study 1 evaluated efficacy of glyphosate, triclopyr, triclopyr plus 2,4-D, triclopyr plus aminopyralid, and triclopyr plus glyphosate applied postemergence to bushkiller. No control was evident from any treatment at 10 mo after application. In a separate experiment, aminocyclopyrachlor, imazapyr, metsulfuron, sulfometuron, and sulfometuron plus metsulfuron were applied postemergence to bushkiller. Control with aminocyclopyrachlor, imazapyr, sulfometuron, and sulfometuron plus metsulfuron was 88 to 99% at 10 mo after application. Each treatment was also applied to bushkiller in a greenhouse trial. Aminocyclopyrachlor and triclopyr-containing treatments generally resulted in the greatest control, lowest dry weights, and shortest vine lengths among the treatments. These results indicate that several herbicides may be employed initially in an early-detection, rapid-response program for bushkiller. Additional research is needed to determine how effective these herbicides would be in multiple-season treatments that may be required at well established bushkiller infestation sites.

Nomenclature: 2,4-D; aminocyclopyrachlor, 6-amino-5-chloro-2-cyclopropyl-4-pyrimidinecarboxylic acid; aminopyralid; glyphosate; imazapyr; metsulfuron; sulfometuron; triclopyr; bushkiller, *Cayratia japonica* (Thunb.) Gagnep.
Key words: Herbicide; perennial vines.

Bushkiller [*Cayratia japonica* (Thunb.) Gagnep.] is a perennial, herbaceous vine in the Vitaceae family with an aggressive, twining growth habit that overtops surrounding vegetation. Bushkiller may be distinguished by pedate quinquefoliate leaves with the terminal leaflet longer than the four lateral leaflets (Krings and Richardson 2006). It has discontinuous tendril formation and axillary, corymbose, or umbellate inflorescences with flowers that are red, yellow, and white (Hsu and Kuoh 1999; Krings and Richardson 2006; Ohwi et al. 1984). Creeping roots of bushkiller develop much-elongated rhizomes over time as the vine becomes established.

Bushkiller is native to temperate, subtropical, and tropical forests in Australia, India, Japan, Malaysia, Southeast Asia, and Taiwan (Hsu and Kuoh 1999). It was first reported in Texas in 1964 (Brown 1992) and has since been documented in Alabama, Louisiana, Mississippi, and North Carolina (Hansen and Goertzen 2006; Krings and Richardson 2006; Shinners 1964; USDA-NRCS 2006). The growth habit of bushkiller resembles that of kudzu [*Pueraria montana* (Lour.) Merr. var. *lobata* (Willd.) Maesen & S. Almeida], which is estimated to cost $100 to 500 million per year in forest productivity losses (Forseth and Innis 2004). Bushkiller has been observed to overtop trees and grow as a monoculture in North Carolina (West 2008).

Exotic perennial vines such as bushkiller may become invasive in annual and perennial cropping systems, tree plantations, agro-forestry, forest restoration/regeneration, parks, and natural areas. Suckering from adventitious buds, roots, and rhizomes is typical of perennial vines, making manual control methods such as mowing or hand removal impractical (Averill et al. 2008; Berisford et al. 2006; Chachalis et al. 2001; Harrington et al. 2003; Lawlor and Raynal 2002; Main et al. 2006; Mueller et al. 2003). For example, perennial invasive vines such as kudzu, trumpet

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Interpretive summary

Bushkiller is an exotic invasive perennial vine in the Vitaceae family that has been documented in Texas, Louisiana, Mississippi, Alabama, and North Carolina. In North Carolina, bushkiller has recently been listed as a Class B Noxious Weed by the North Carolina Department of Agriculture. Bushkiller aggressively overtops neighboring vegetation, making it problematic ecologically and economically. An extensive literature review provided no guidelines for control of bushkiller. Therefore, selected herbicides were evaluated to initiate development of bushkiller control guidelines. Further studies are needed to document the effects of multiple-season applications of these herbicides. Our results from one season of treatments indicated that multiple-season applications of a selected herbicide will be necessary for eradication of existing bushkiller infestations.

creeper [*Campsis radicans* (L.) Seem. ex Bureau], Virginia creeper [*Parthenocissus quinquefolia* (L.) Planch.], Chinese yam (*Dioscorea oppositifolia* L.), and European swallowwort [*Cynanchum rossicum* (Kleopow) Borhidi] typically require multiple-season treatments with systemic herbicides because a single treatment does not provide eradication (Averill et al. 2008; Berisford et al. 2006; Bradley et al. 2003; Chachalis et al. 2001; Harrington et al. 2003; Lawlor and Raynal 2002; Main et al. 2006; Mueller et al. 2003; Richardson et al. 2009). Due to the development of much-elongated rhizomes over time, an early-detection, rapid-response plan must be crafted to eradicate bushkiller as soon as a new infestation is discovered.

An extensive literature review indicated that control recommendations for bushkiller and other *Cayratia* were not available. Bushkiller was being added to the North Carolina state noxious weed list (NCAC 2009), therefore immediate assessment of herbicide efficacy was needed. The objective of this research was to evaluate selected foliar-applied herbicides in field and greenhouse settings for bushkiller control. Short-term data were collected to rapidly screen for the most effective early-detection, rapid-response treatment of bushkiller.

Materials and Methods

Field studies were conducted in Lexington and Charlotte, NC, on established bushkiller stands. The Lexington site was located in a buffer area on a small farm (35°49′08.37″N, 80°17′17.06″W) and the Charlotte site was in a riparian utility easement along Douglas Branch (35°12′34.2″N, 80°47′1.60″W). Plots were 90 m^2 (969 ft^2) (9.5 × 9.5 m) (31.2 × 31.2 ft) and contained 100% coverage of bushkiller, with shoot lengths ranging from 5 to 15 m. Plots were selected to exclude trees and bushkiller height did not exceed 1 m. Both sites had sandy loam soils and were surrounded by oak–hickory forest species, and at the Charlotte site the bushkiller vines were climbing toward the canopy of nearby hardwoods (West, personal observation). At the Charlotte and Lexington sites, average high temperatures were near average for the 7 d prior to application until the seventh day after, at 29.5 and 28.0 C, respectively. Over the 3 d prior to herbicide application, precipitation was approximately 20 cm (7.9 in) at Charlotte and 10 cm at Lexington.

A representative selection of herbicides registered or in development for noncropland control of perennial weed species was included in this research as significant spatial and temporal restrictions were in place. 2,4-D, glyphosate, and triclopyr have been frequently used for perennial vine control (Averill et al. 2008; Berisford et al. 2006; Bradley et al. 2003; Chachalis et al. 2001; Harrington et al. 2003; Lawlor and Raynal 2002; Main et al. 2006; Mueller et al. 2003; Richardson et al. 2009). Aminopyralid, imazapyr, metsulfuron, and sulfometuron were also selected due to registrations for perennial weed control on sites similar to those where bushkiller has become established in North Carolina (Anonymous 2006a, 2006b, 2007, 2008). Finally, aminocyclopyrachlor was included because it is a new active ingredient herbicide from E. I. Du Pont de Nemours under development for perennial weed control (Claus et al. 2008). Herbicide applications at both sites were made August 8, 2007. Space was significantly limited, so desired treatments were split into two trials by site. Treatments in field study 1 (Lexington) included glyphosate[1] at 1.12 kg ae ha^{-1} (1 lb ae A^{-1}), triclopyr[2] at 1.12 kg ae ha^{-1}, and triclopyr at 1.12 kg ae ha^{-1} applied in mixture with 2,4-D[3] (1.12 kg ae ha^{-1}), aminopyralid[4] (0.12 kg ae ha^{-1}), or glyphosate (1.12 kg ae ha^{-1}). Treatments in field study 2 (Charlotte) included aminocyclopyrachlor[5] at 0.35 kg ae ha^{-1}, imazapyr[6] at 1.12 kg ae ha^{-1}, metsulfuron[7] at 0.057 kg ae ha^{-1}, sulfometuron[8] at 0.17 kg ae ha^{-1}, and sulfometuron (0.17 kg ae ha^{-1}) plus metsulfuron (0.057 kg ae ha^{-1}). Treatments in both field studies were applied with a CO_2-pressurized backpack sprayer equipped with a handgun[9] at the rate of 280 L ha^{-1} (30 gal A^{-1}). Herbicide solutions were mixed immediately prior to application. Each treatment included a methylated seed oil[10] at 1% (v/v), as well as a marker dye[11] at 0.1% (v/v) to ensure adequate coverage.

Visual estimates of aboveground weed control were determined at 1 and 10 mo after treatment (MAT) in comparison to a nontreated control. Weed control was rated on a 0 to 100% scale where 0% equals no plant response and 100% equals plant death. Phytotoxicity symptoms (chlorosis and necrosis) were assessed for each treatment in comparison to the nontreated control for weed control ratings. For example, a rating of 40 would indicate 40% of the plant exhibited phytotoxicity symptoms. The field herbicide trials were conducted with spatial and temporal restraints. In cooperation with the land managers, these trials were conducted once with three treatment replications and control ratings were based on a 10-mo time limitation prior to initiation of eradication efforts and site spraying. Therefore, in lieu of repeating, a greenhouse trial was conducted to collect additional data on each treatment.

In the greenhouse trial, bushkiller was propagated from root stock collected in Winston-Salem, NC. Root fragments 4 cm in length were planted in 9-cm^2 pots containing a commercial potting mix.[12] Plants were allowed to grow and were then treated when approximately 30 cm tall. Pots were watered daily and fertilized weekly with 36–6–6 water-soluble fertilizer.[13] Treatments were equivalent to those applied in the field, but were combined into a single trial. Herbicides were applied using an air-pressurized indoor spray chamber equipped with a single flat fan nozzle[14] utilizing 280 L ha^{-1} spray volume. After spraying, plants were returned immediately to the greenhouse. A nontreated control and a pretreatment reference were included. The pretreatment reference was harvested at the time of herbicide application to provide an initial value for dry weights and vine length. Each treatment was replicated four times with each replication comprising one pot with one bushkiller plant. Treatments were arranged in a completely randomized design and the trial was repeated in time. Visual estimates of weed control were determined at 5 wk after treatment (WAT) in comparison to a nontreated control. At 5 WAT, maximum living vine length was measured and plants were harvested and divided into roots and shoots. Plant materials were then oven dried at 50 C to a constant moisture content for dry weight determination.

All data were subjected to analysis of variance and means were separated using Fisher's Protected LSD ($P \leq 0.05$) in SAS version 9.1.[15] Percentage data were arcsine square root transformed prior to analysis, but nontransformed means are presented for clarity. Controls were not included in statistical analysis of visual ratings, but were included for comparisons of shoot dry weights, root dry weights, and vine length at the termination of the study.

Results and Discussion

In the Lexington trial, glyphosate, triclopyr, and triclopyr mixtures controlled bushkiller 80 to 93% at 1 MAT (Table 1). However, at 10 MAT following spring regrowth there was no visible difference between these treatments and the nontreated control. West (2008) observed similar results at a bushkiller infestation site in a residential area of Winston-Salem, NC. Control with triclopyr applied as cut-stem (100%) or foliar (5% v/v) treatments was limited at the end of one growing season (West 2008). At this residential site, 3 yr of triclopyr applications with two treatments per season were required to decrease bushkiller aboveground cover approximately 80%. Similar results were also observed by Suzuki (1988), who found triclopyr more efficient at controlling bushkiller than glyphosate.

Table 1. Bushkiller control with selected postemergence herbicides in Lexington, NC.[a,b]

Herbicide[c]	Rate	1 MAT [d]	10 MAT
	kg ae ha^{-1}	%	
Glyphosate	1.12	93 a	0 a
Triclopyr	1.12	88 ab	0 a
Triclopyr + 2,4-D	1.12 + 1.12	90 ab	0 a
Triclopyr + aminopyralid	1.12 + 0.12	90 ab	0 a
Triclopyr + glyphosate	1.12 + 1.12	80 b	0 a
Nontreated control	—	0	0

[a] Weed control rated on 0 to 100% scale; 0% equals no plant response and 100% equals plant death.

[b] Abbreviation: MAT, months after treatment.

[c] Methylated seed oil at 1% v/v included with each treatment.

[d] Means within a column followed by the same letter are not significantly different according to Fisher's Protected LSD test at $P \leq 0.05$. Nontreated control not included in statistical analysis of visual ratings.

Greater control was observed in the Charlotte trial. At 1 MAT, aminocyclopyrachlor controlled bushkiller 97%, whereas control with other treatments did not exceed 33% (Table 2). At 10 MAT, bushkiller control was 88 to 99% with aminocyclopyrachlor, imazapyr, sulfometuron, and sulfometuron plus metsulfuron. No control was observed at 10 MAT from metsulfuron alone.

In the greenhouse trial, complete control was observed with aminocyclopyrachlor and triclopyr-containing treatments (Table 3). Imazapyr, metsulfuron, and sulfometuron plus metsulfuron controlled bushkiller 78 to 92%. The pretreatment reference shoot dry weight was 1.76 g (0.06 oz). Plants treated with imazapyr, metsulfuron, or sulfometuron did not differ from the pretreatment reference, whereas treatments containing aminocyclopyrachlor or triclopyr lost biomass during the course of the trial. This likely reflects a more rapid death from the aminocyclopyrachlor and triclopyr treatments and some decomposition of the shoot material in the warm, moist greenhouse environment. Because phototoxicity is slower to develop with imazapyr, metsulfuron, and sulfometuron, it is not surprising that shoot biomass was unchanged over the 5-wk period. In contrast to the other treatments, bushkiller treated with glyphosate accumulated biomass (63% increase) during the course of the trial and had a shoot dry weight of 2.86 g, which was similar to the nontreated control at 3.42 g. Root biomass response was somewhat different than the shoot. Glyphosate-treated bushkiller still accumulated biomass as compared to the

Table 2. Bushkiller control with selected postemergence herbicides in Charlotte, NC.[a,b]

Herbicide [c]	Rate	1 MAT [d]	10 MAT
	kg ae ha^{-1}	—— % ——	
Aminocyclopyrachlor	0.35	97 a	99 a
Imazapyr	1.12	33 b	93 a
Metsulfuron	0.057	28 b	0 c
Sulfometuron	0.017	10 c	88 b
Sulfometuron + metsulfuron	2.24 + 1.12	28 b	91 ab
Nontreated control	—	0	0

[a] Weed control rated on 0 to 100% scale; 0% equals no plant response and 100% equals plant death.

[b] Abbreviation: MAT, months after treatment.

[c] Methylated seed oil at 1% v/v included with each treatment.

[d] Means within a column followed by the same letter are not significantly different according to Fisher's Protected LSD test at $P \leq 0.05$. Nontreated control not included in statistical analysis of visual ratings.

pretreatment reference (45% increase), but root biomass was lower with all other treatments. Similarly, living vine length of bushkiller treated with glyphosate was 58% greater than the pretreatment reference, whereas all other treatments reduced vine length. Root dry weight and vine length of the nontreated control was greater than with glyphosate-treated plants indicating that glyphosate did reduce bushkiller growth rate. However, the tolerance of these relatively small plants in the greenhouse to glyphosate is surprising.

These results indicate that triclopyr and triclopyr mixtures effectively controlled small plants in the greenhouse, but were less effective in the field. In comparison, glyphosate was ineffective in both situations and aminocyclopyrachlor was effective in both. Extremely fast foliar toxicity that prohibits herbicide translocation is one possible reason to explain the differential bushkiller response to triclopyr under the different situations. However, bushkiller exhibited a similar rapid response to aminocyclopyrachlor, and field control at 10 MAT was far greater with aminocyclopyrachlor. In Canada thistle [*Cirsium arvense* (L.) Scop.], aminocyclopyrachlor foliar absorption occurred within 24 h of treatment and translocation peaked by 96 h after treatment (Bekun et al. 2010). Bekun et al. (2010) reported 8.6% aminocyclopyrachlor accumulating in roots, whereas Tworkoski and Sterrett (1984) reported less than 2% translocation of triclopyr to Canada thistle roots. Greater and more rapid translocation of aminocyclopyrachlor than triclopyr to bushkiller roots would explain the noted difference in field control at 10 MAT.

Distribution of bushkiller is limited thus far, so control efforts must focus on eradication to ensure the plant does not spread, causing further damage economically or ecologically. Our results provide an initial step toward the development of effective eradication programs; however, further research is needed to evaluate multiple-season applications of these herbicides.

Table 3. Bushkiller response to selected postemergence herbicides in the greenhouse at 5 wk after treatment.[a,b]

Herbicide[c]	Rate	Control	Shoot dry wt.	Root dry wt.	Vine length
	kg ae ha^{-1}	%	—— g ——		cm
Aminocyclopyrachlor	0.35	100 a	0.43 def	0.0 d	0 e
Glyphosate	1.12	10 e	2.86 a	3.20 b	49 b
Imazapyr	1.12	78 c	1.14 bc	0.39 d	20 de
Metsulfuron	0.057	81 bc	1.04 cde	0.17 d	21 de
Sulfometuron	0.17	59 d	1.84 b	0.47 d	32 cd
Sulfometuron + metsulfuron	0.17 + 0.057	92 ab	1.17 bcd	0.34 d	12 ef
Triclopyr	1.12 + 1.12	100 a	0.43 def	0.03 d	0 e
Triclopyr + 2,4-D	1.12 + 1.12	100 a	0.37 ef	0.03 d	1 e
Triclopyr + aminopyralid	1.12 + 0.12	100 a	0.50 deg	0.04 d	0 e
Triclopyr + glyphosate	1.12 + 1.12	100 a	0.26 f	0.01 d	0 e
Nontreated control	—	—	3.42 a	5.07 a	74 a
Pretreatment reference[d]	—	—	1.76 bc	2.21 c	31 cd

[a] Weed control rated on 0 to 100% scale; 0% equals no plant response and 100% equals plant death.

[b] Means within a column followed by the same letter are not significantly different according to Fisher's Protected LSD ($P \leq 0.05$). Nontreated control not included in statistical analysis of visual ratings.

[c] Methylated seed oil at 1% v/v included with each treatment.

[d] Pretreatment control was harvested on day of herbicide treatment and represents plant size at time of treatment.

Sources of Materials

[1] Touchdown Pro®, Syngenta Crop Protection, Inc., Greensboro, NC.

[2] Garlon® 3A, Dow AgroSciences LLC, Indianapolis, IN.

[3] Weedar® 64, Nufarm Americas Inc., Burr Ridge, IL.

[4] Milestone®, Dow AgroSciences LLC, Indianapolis, IN.

[5] Aminocyclopyrachlor, 80% WG, E. I. du Pont de Nemours and Company, Wilmington, DE.

[6] Arsenal®, BASF, Research Triangle Park, NC.

[7] Escort XP®, E. I. du Pont de Nemours and Company, Wilmington, DE.

[8] Oust® XP, E. I. du Pont de Nemours and Company, Wilmington, DE.

[9] No. 5 nozzle, Spraying Systems, Co., Wheaton, IL.

[10] SunEnergy®, Brewer International Co., Vero Beach, FL.

[11] Hi Light® Spray Indicator. Becker Underwood Inc., Ames, IA.

[12] Metro Mix® 200, Sun Gro Horticulture, Bellevue, WA.

[13] Miracle-Gro® Water Soluble Lawn Food, The Scotts Company, Marysville, OH.

[14] Teejet® XR8003, Spraying Systems Company, Wheaton, IL.

[15] SAS v. 9.1, SAS Institute Inc., Cary, NC.

Literature Cited

Anonymous. 2006a. Arsenal® herbicide label. BASF Corporation. http://www.cdms.net/LDat/ld746002.pdf. Accessed: Novemeber 21, 2008.

Anonymous. 2006b. Oust XP® herbicide label. Dupont Crop Protection. http://www.dupont.com/ag/us/prodinfo/prodsearch/information/H65144.pdf. Accessed: November 21, 2008.

Anonymous. 2007. Escort ® herbicide label. DuPont Crop Protection. http://www.dupont.com/ag/us/prodinfo/prodsearch/information/H65521.pdf. Accessed: Novemeber 21, 2008.

Anonymous. 2008. Milestone® herbicide label. Dow AgroSciences. http://www.cdms.net/ldat/ld77N006.pdf. Accessed: Novemeber 21, 2008.

Averill, K. M., A. DiTommaso, and S. H. Morris. 2008. Response of pale swallow-wort (*Vincetoxicum rossicum*) to triclopyr application and clipping. Invasive Plant Sci. Manag. 1:196–206.

Bekun, B., R. B. Lindenmayer, S. J. Nissen, P. Westram, D. L. Shaner, and G. Brunk. 2010. Absorption and translocation of aminocyclopyrachlor and aminocyclopyrachlor methyl ester in Canada thistle (*Cirsium arvense*). Weed Sci. 58:96–102.

Berisford, Y. C., P. B. Bush, and J. W. Taylor, Jr. 2006. Leaching and persistence of herbicides for kudzu (*Pueraria montana*) control on pine regeneration sites. Weed Sci. 54:391–400.

Bradley, K. W., E. S. Hagood, Jr, and P. H. Davis. 2003. Evaluation of postemergence herbicide combinations for long-term trumpetcreeper (*Campsis radicans*) control in corn (*Zea mays*). Weed Tech. 17: 718–723.

Brown, L. E. 1992. *Cayratia japonica* (Vitaceae) and *Paederia foetida* (Rubiaceae) adventive in Texas. Phytologia 72:45–47.

Chachalis, D., K. N. Reddy, and C. D. Elmore. 2001. Characterization of leaf surface, wax composition, and control of redvine and trumpetcreeper with glyphosate. Weed Sci. 49:156–163.

Claus, J., R. Turner, G. Armel, and M. Holliday. 2008. DuPont aminocyclopyrachlor (proposed common name) (DPX-MAT28/KJM44) herbicide for use in turf, IWC, bare-ground and brush markets. Page 277 *in* Proceedings of the 5th International Weed Science Congress.

Forseth, I. N. and A. F. Innis. 2004. Kudzu (*Pueraria montana*): history, physiology, and ecology combine to make a major ecosystem threat. Crit. Rev, Plant Sci. 23:401–413.

Hansen, C. J. and L. R. Goertzen. 2006. *Cayratia japonica* (Vitaceae) naturalized in Alabama. Castanea 71:248–251.

Harrington, T. B., L. T. Rader-Dixon, and J. W. Taylor. 2003. Kudzu (*Pueraria montana*) community responses to herbicides, burning, and high-density loblolly pine. Weed Sci. 51:965–974.

Hsu, T.-W. and C. Kuoh. 1999. *Cayratia maritima* B.R. Jackes (Vitaceae), a new addition to the flora of Taiwan. Bot. Bull. Acad. Sin. 40:329–332.

Krings, A. and R. J. Richardson. 2006. *Cayratia japonica* (Vitaceae) new to North Carolina and an updated key to the genera of Vitaceae in the Carolinas. SIDA 22:813–815.

Lawlor, F. M. and D. J. Raynal. 2002. Response of swallow-wort to herbicides. Weed Sci. 50:179–185.

Main, C. L., J. E. Beeler, D. K. Robinson, and T. C. Mueller. 2006. Growth, reproduction and management of Chinese yam (*Dioscorea oppositifolia*). Weed Technol. 20:773–777.

Mueller, T. C., D. K. Robinson, J. E. Beeler, C. L. Main, D. Soehn, and K. Johnson. 2003. *Dioscorea oppositifolia* L. phenotypic evaluations and comparison of control strategies. Weed Technol. 17:705–710.

[NCAC] North Carolina Administrative Code. 2009. Noxious weeds. North Carolina Board of Agriculture. 02 NCAC 48A.1702.

Ohwi, J., F. Meyer, and E. Walker. 1984. Flora of Japan. Washington, DC: Smithsonian Institution. Pp. 618–620.

Richardson, R. J., M. Marshall, R. E. Uhlig, and B. H. Zandstra. 2009. Virginia-creeper (*Parthenocissus quinquefolia*) and wild grape (*Vitis* spp.) control in Fraser fir (*Abies fraseri*). Weed Technol. 23: 184–1887.

Shinners, L. H. 1964. *Cayratia japonica* (Vitaceae) in southeastern Louisiana: new to the United States. SIDA 1:384.

Suzuki, K. 1988. Studies on weed control in a citrus orchard III: control of broad leaf perennial weeds. Bull. Fruit Tree Res. Stn. B Okitsu Japan 15:21–34.

Tworkoski, T. J. and J. P. Sterrett. 1984. Translocation of triclopyr and glyphosate in Canada thistle after root treatments of 6-benzyladenine and indole-3-butyric acid. Page 208 *in* Proceedings of the 11th Plant Growth Regulator. Society, Lake Alfred, FL.

[USDA-NRCS] U.S. Department of Agriculture–Natural Resources Conservation Service. 2006. PLANTS Database. http://plants.usda.gov. Accessed: August 30, 2008.

West, A. M. 2008. Biology and management of bushkiller (*Cayratia japonica*). Masters thesis. Raleigh, NC: North Carolina State University. 115 p.

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