Weed Technology 2013 27:401–404

Notes

Tolerance of Hooker's Evening Primrose (*Oenothera elata*) Transplants to Postemergence Herbicides

Amber N. Bates, Gerald M. Henry, and Cynthia B. McKenney*

Greenhouse trials were conducted to determine Hooker's evening primrose transplant tolerance to POST-applied herbicides. Herbicide treatments consisted of glyphosate at 1.68 kg ae ha^{-1}, glufosinate at 0.84 kg ai ha^{-1}, fenoxaprop at 0.10 kg ai ha^{-1}, fluazifop at 0.45 kg ai ha^{-1} + a nonionic surfactant (NIS) at 0.25% v/v, sulfosulfuron at 0.06 kg ai ha^{-1} + NIS at 0.25% v/v, quinclorac at 0.42 kg ae ha^{-1} + methylated seed oil (MSO) at 0.5% v/v, mesotrione at 0.21 kg ai ha^{-1}, and the combination of quinclorac + mecoprop + dicamba at 0.42 + 0.21 + 0.06 kg ae ha^{-1} + MSO at 0.5% v/v. Fluazifop (14%) and fenoxaprop (19%) treatments did not result in any significant phytotoxicity 7 d after treatment (DAT) compared with the nontreated check. Hooker's evening primrose exhibited 26 to 37% phytotoxicity in response to quinclorac, glyphosate, or sulfosulfuron 7 DAT. Phytotoxicity $\geq$ 50% was observed for mesotrione, glufosinate, and the combination of quinclorac + mecoprop + dicamba 7 DAT. Phytotoxicity increased for all treatments 28 DAT. Fluazifop (21%) was the only treatment that did not exhibit phytotoxicity symptoms different from the nontreated check 28 DAT. Hooker's evening primrose exhibited 31 to 40% phytotoxicity with applications of fenoxaprop, glyphosate, or glufosinate 28 DAT. Phytotoxicity was $\geq$ 58% with all other treatments 28 DAT. Fluazifop exhibited similar above-ground (12.4 g) and below-ground (16.4 g) biomass as the nontreated check (10.8 and 14.7 g, respectively) 28 DAT. All other treatments resulted in 1.6 to 5 g of above-ground biomass and 0.8 to 4.3 g of below-ground biomass 28 DAT. Fluazifop (24.3) and fenoxaprop (18.8) applications resulted in a plant growth index (PGI) that was not significantly different from the nontreated check (24.7) 28 DAT. A PGI $\leq$ 16.2 was observed for all other treatments 28 DAT.
Nomenclature: Dicamba; fenoxaprop; fluazifop; glufosinate; glyphosate; mecoprop; mesotrione; quinclorac; sulfosulfuron; Hooker's evening primrose, *Oenothera elata* Kunth OEEL
Key words: Biomass, oilseed crops, entals, phytotoxicity, plant growth index.

Experimentos de invernadero fueron realizados para determinar la tolerancia de trasplantes de Oenothera elata a herbicidas aplicados POST. Los tratamientos de herbicidas fueron glyphosate a 1.68 kg ae ha^{-1}, glufosinate a 0.84 kg ai ha^{-1}, fenoxaprop a 0.10 kg ai ha^{-1}, fluazifop a 0.45 kg ai ha^{-1} + surfactante no-iónico (NIS) a 0.25% v/v, sulfosulfuron a 0.06 kg ai ha^{-1} + NIS a 0.25% v/v, quinclorac a 0.42 kg ae ha^{-1} + aceite de semilla metilado (MSO) a 0.5% v/v, mesotrione a 0.21 kg ai ha^{-1}, y la combinación de quinclorac + mecoprop + dicamba a 0.42 + 0.21 + 0.06 kg ae ha^{-1} + MSO a 0.5% v/v. Los tratamientos de fluazifop (14%) y fenoxaprop (19%) no resultaron en fitotoxicidad significativa 7 d después del tratamiento (DAT) en comparación con los testigos no tratados. O. elata mostró 26 a 37% de fitotoxicidad en respuesta a quinclorac, glyphosate, o sulfosulfuron 7 DAT. Fitotoxicidad $\geq$50% se observó con mesotrione, glufosinate, y la combinación de quinclorac + mecoprop + dicamba 7 DAT. La fitotoxicidad incrementó para todos los tratamientos 28 DAT. Fluazifop (21%) fue el único tratamiento que no mostró síntomas de fitotoxicidad diferentes al testigo no tratado 28 DAT. O. elata mostró 31 a 40% de fitotoxicidad con aplicaciones de fenoxaprop, glyphosate, o glufosinate 28 DAT. La fitotoxicidad fue $\geq$58% con todos los demás tratamientos 28 DAT. Fluazifop mostró biomasa aérea (12.4 g) y subterránea (16.4 g) similares al testigo no tratado (10.8 y 14.6 g, respectivamente) 28 DAT. Todos los demás tratamientos resultaron en 1.6 a 5 g de biomasa aérea y 0.8 a 4.3 g de biomasa subterránea 28 DAT. Las aplicaciones de fluazifop (24.3) y fenoxaprop (18.8) resultaron en un índice de crecimiento vegetal (PGI) que no fue significativamente diferente al testigo no tratado (24.7) 28 DAT. Un PGI $\leq$16.2 se observó en todos los demás tratamientos 28 DAT.

Hooker's evening primrose is a biennial to short-lived perennial herb that grows 0.4 to 2.5 m tall (Dietrich et al. 1997). Hooker's evening primrose is native to North America, ranging from Oregon and California, east to Colorado and Texas, and south to Mexico (Arnold 2008, Dietrich et al. 1997). Leaves are dull green to gray-green in color with bluntly dentate or subentire margins (Dietrich et al. 1997). Yellow-colored flowers (3 to 3.5 cm wide) occur from June through September and give rise to gray-green seed capsules (2 to 6.5 cm long) (Correll and Johnston 1970, Dietrich et al. 1997). Capsules dehisce into four sections and may contain as many as 500 seeds (Harte 1994).

Tolerance to a variety of habitats ranging from xeric to aquatic along with the production of showy flowers have led to the utilization of Hooker's evening primrose in landscapes throughout USDA hardiness zones 6 to 11 (Arnold 2008). A similar species, Common evening primrose (*Oenothera biennis* L.), has been commercially grown for seed production in over 15 different countries (Carter 1988). Common evening primrose seed oil contains γ-linolenic acid (GLA), which

DOI: 10.1614/WT-D-12-00090.1
* First and third authors: Graduate Research Assistant and Professor, respectively, Dept. of Plant and Soil Science, Texas Tech University, Lubbock, TX 79409; second author: Associate Professor, Dept. of Crop and Soil Sciences, University of Georgia, Athens, GA 30602. Corresponding author's E-mail: gmhenry@uga.edu

has been used to treat ailments including dermatitis, rheumatoid arthritis, high blood pressure, immune diseases, diabetes, respiratory infections, and cancer (Barre 2001; Deng et al. 2001). In recent years, common evening primrose cakes created from cold pressing practices for oil have been heavily sought after for their use as radical scavengers in dietary supplements, anti-aging compounds in cosmetics, and natural preservatives in "health" products (Peschel et al. 2007). Oil production throughout the world reached 3,000 to 5,000 tons annually in the later part of the 20th century (Simpson and Fieldsend 1993). During this same time frame, demand for *Oenothera* spp. seed multiplied 10- to 15-fold over a period of 15 yr (Simpson and Fieldsend 1993). Similar seed production and oil content has been documented in Hooker's evening primrose; however, cultivation of this species for oil production has been limited (Balch et al. 2003).

Several *Oenothera* spp. have been identified as difficult to control weeds in agronomic environments. Common evening primrose is a problem in glyphosate-resistant crops grown primarily in Iowa (Owen 2008) and along roadsides and waste areas in Canada (Hall et al. 1988). Cutleaf evening primrose (*Oenothera laciniata* Hill) has become an increasing problem in cotton production in the southern United States following the rapid adoption of conservation tillage (Culpepper et al. 2005). Tolerance to several POST herbicides has also led to an increase in cutleaf evening primrose in horticultural crops, such as pecans and strawberries (Gilreath and Santos 2005, Smith et al. 2001).

Previous research has focused on the efficacy of herbicides for the control of *Oenothera* spp. rather than their tolerance when grown as an oilseed crop (Armel et al. 2003, Culpepper et al. 2005, Reynolds et al. 2000, Stringer et al. 1985). Glyphosate (0.84 kg ae ha^{-1}) or paraquat (0.7 kg ai ha^{-1}) applied alone exhibited 60 and 56% control of cutleaf evening primrose, respectively, 28 d after treatment (DAT) (Culpepper et al. 2005). Tank-mixing glyphosate (0.84 kg ha^{-1}) with 2,4-D (0.56 kg ae ha^{-1}) increased cutleaf evening primrose control to 97% 28 DAT. Reynolds et al. (2000) observed similar control (80 to 100%) 28 DAT when tank-mixing glyphosate (0.56 kg ha^{-1}) or paraquat (0.53 kg ha^{-1}) with 2,4-D (0.75 kg ae ha^{-1}). Combinations of glyphosate (0.84 kg ha^{-1}) plus flumioxazin (0.036 kg ai ha^{-1}) or paraquat (0.7 kg ha^{-1}) plus dicamba (0.28 kg ae ha^{-1}) provided 83% control of cutleaf evening primrose 28 DAT (Culpepper et al. 2005). However, Stringer et al. (1985) only observed 9 to 12% control and a 23 to 41% reduction in shoot weight of common evening primrose 4 wk after treatment (WAT) in response to ethofumesate at 0.4 or 1.6 kg ai ha^{-1}. Mesotrione at a rate of 0.035 to 0.14 kg ha^{-1} only provided 35 to 50% control of cutleaf evening primrose 4 WAT in corn (Armel et al. 2003).

Differential responses of *Oenothera* spp. to POST-applied herbicides suggest that options may exist for the control of weeds present within Hooker's evening primrose when grown as an oilseed crop. No research has examined the tolerance of Hooker's evening primrose to POST herbicides. Enhanced weed control during early establishment may reduce competition for water and nutrients as well as increase seed yield. Therefore, the objective of this research was to determine the tolerance of Hooker's evening primrose to various POST-applied herbicides in order to identify potential herbicide programs for its production in the field as an oilseed crop.

Table 1. POST herbicide treatments applied in the greenhouse in Lubbock, TX[a].

Treatment	Rate
non-treated check	—
glyphosate	1.68 kg ae ha^{-1}
quinclorac + mcpp + dicamba[b]	0.42 + 0.21 + 0.06 kg ae ha^{-1}
glufosinate	0.84 kg ai ha^{-1}
fenoxaprop	0.10 kg ai ha^{-1}
fluazifop	0.45 kg ai ha^{-1}
mesotrione	0.21 kg ai ha^{-1}
sulfosulfuron	0.06 kg ai ha^{-1}
quinclorac	0.42 kg ae ha^{-1}

[a] POST herbicides were applied on July 13, 2010 or May 5, 2011.

[b] Quinclorac + mcpp + dicamba and quinclorac alone were applied with a methylated seed oil at 0.5% v/v. Sulfosulfuron and fluazifop were applied with a nonionic surfactant at 0.5% v/v.

Materials and Methods

Experiments were conducted in 2010 and 2011 at the Texas Tech University Plant and Soil Science Greenhouse in Lubbock, TX. One 4-mo-old Hooker's evening primrose seedling (approximately 7 cm wide) was transplanted into each 11.3-L pot containing a Brownfield sandy clay loam (Loamy, mixed, superactive, thermic Arenic Aridic Paleustalfs) with a pH of 8.1 and organic matter content of 1.4%. Slow release fertilizer (14-14-14) (Osmocote, The Scotts Company LLC, Scottslawn Rd., Marysville, OH 43041) was applied at the time of transplant at a rate of 97 kg ha^{-1} N. Greenhouse temperatures were maintained at 34/26 C (day/night) with average midday (1200 and 1300 hr) solar radiation ranging from 636 to 754 μmol m^{-2} s^{-1}. Irrigation was supplied through an overhead irrigation system calibrated to deliver approximately 3.8 cm of water wk^{-1}. Transplants were allowed to acclimate for 28 d before the application of herbicide treatments. Pots were arranged in a randomized complete block design with five replications. Herbicide treatments (Table 1) were applied July 13, 2010 and May 5, 2011, and consisted of glyphosate (Roundup ProMax®, Monsanto Co., 700 Chesterfield Parkway North, St. Louis, MO 63167) at 1.68 kg ae ha^{-1}, glufosinate (Finale®, Bayer Environmental Science, 2 T.W. Alexander Dr., Research Triangle Park, NC 27709) at 0.84 kg ai ha^{-1}, fenoxaprop (Acclaim Extra®, Bayer Environmental Science, 2 T.W. Alexander Dr., Research Triangle Park, NC 27709) at 0.10 kg ai ha^{-1}, fluazifop (Fusilade II®, Syngenta Professional Products, P.O. Box 18300, Greensboro, NC 27419) at 0.45 kg ai ha^{-1} + a nonionic surfactant (NIS) (X-77® nonionic surfactant, Loveland Industries Inc., Greeley, CO 80632) at 0.25% v/v, sulfosulfuron (Certainty®, Monsanto Co., 700 Chesterfield Parkway North, St. Louis, MO 63167) at 0.06 kg ai ha^{-1} + a NIS at 0.25% v/v, quinclorac (Drive XLR8®, BASF Specialty Products, 26 Davis Dr., Research Triangle Park, NC 27709) at 0.42 kg ae ha^{-1} + methylated seed oil (MSO) (Dyne-Amic®, Helena Chemical Company, 225 Schilling Blvd., Suite 300, Collierville, TN 38017) at 0.5% v/v, mesotrione (Tenacity®, Syngenta Professional Products, P.O. Box 18300, Greensboro, NC 27419) at 0.21

https://doi.org/10.1614/WT-D-12-00090.1 Published online by Cambridge University Press

Table 2. Response of *Oenothera elata* Kunth transplants to POST herbicides in the greenhouse in Lubbock, TX.[a]

Treatment	Rate	7 DAT[b]	28 DAT	Above-ground	Below-ground	PGI
		% phytotoxicity		biomass (g)		
non-treated check	—	0	0	10.8	14.7	24.7
glyphosate	1.68 kg ae ha^{-1}	34	35	2.4	1.5	14.6
quinclorac + mcpp + dicamba[c]	0.42 + 0.21 + 0.06 kg ae ha^{-1}	56	90	1.7	0.8	8.6
glufosinate	0.84 kg ai ha^{-1}	59	40	2.4	1.1	15.5
fenoxaprop	0.1 kg ai ha^{-1}	19	31	5	4.3	18.8
fluazifop	0.45 kg ai ha^{-1}	14	21	12.4	16.4	24.3
mesotrione	0.21 kg ai ha^{-1}	50	63	3.6	1.4	12.3
sulfosulfuron	0.06 kg ai ha^{-1}	37	69	2	1.1	16.2
quinclorac	0.42 kg ae ha^{-1}	26	58	1.6	0.8	14.3
LSD	—	19	28	5.6	9.9	8.1

[a] Data were pooled across experiments.

[b] Abbreviations: DAT, days after treatment; PGI, plant growth index; LSD, least significant difference.

[c] Quinclorac + mcpp + dicamba and quinclorac alone were applied with a methylated seed oil at 0.5% v/v. Sulfosulfuron and fluazifop were applied with a nonionic surfactant at 0.5% v/v.

kg ai ha^{-1}, and quinclorac + mecoprop + dicamba (Onetime®, BASF Specialty Products, 26 Davis Dr., Research Triangle Park, NC 27709) at 0.42 + 0.21 + 0.06 kg ae ha^{-1} + MSO at 0.5% v/v. A nontreated check was included for comparison. Treatments were applied using a CO_2 pressurized backpack sprayer equipped with XR8004VS nozzle tips (Teejet, flat-fan extended range spray tips. Spraying Systems Co., North Ave. and Schmale Rd., Wheaton, IL 60129) calibrated to deliver 375 L ha^{-1} at 221 kPa.

Data collected included Hooker's evening primrose phytotoxicity, biomass measurements, and plant growth index (PGI). Phytotoxicity was evaluated 7 and 28 DAT on a scale of 0 (no Hooker's evening primrose phytotoxicity) to 100% (complete plant death). Plants exhibiting 25% phytotoxicity were slightly stunted and had minor leaf tip burn and leaf chlorosis; while plants exhibiting 50% phytotoxicity were stunted, chlorotic, slightly necrotic, and exhibited epinasty/stem collapse. Plants were destructively harvested 28 DAT in both experiments. Plants were divided into shoots and roots, dried, and weighed to determine above-ground and below-ground biomass (g). Plant height and two plant widths (perpendicular to each other) were recorded 28 DAT. Plant growth index was calculated by averaging the plant height and two plant widths according to Behandary et al. (1997). Percent Hooker's evening primrose phytotoxicity, biomass measurements, and PGI were arcsine square root transformed prior to analysis. Transformation did not improve variance homogeneity; therefore, nontransformed data were used in analysis and presentation. There were no significant experiment-by-treatment interactions, so data were combined and subjected to analysis of variance, using error partitioning appropriate to a randomized complete block design analysis in the general linear models procedure provided by SAS (SAS, Statistical Analysis Systems, 2002–2008, Release 9.2, Statistical Analysis Systems Institute, Cary, NC 27513). Means were separated using Fisher's protected LSD at the 0.05 significance level.

Results and Discussion

Phytotoxicity. Fluazifop (14%) and fenoxaprop (19%) treatments did not result in any significant phytotoxicity 7 DAT compared with the nontreated check (Table 2) Hooker's evening primrose exhibited 26 to 37% phytotoxicity in response to quinclorac, glyphosate, or sulfosulfuron 7 DAT. Phytotoxicity $\geq$ 50% was also observed for mesotrione, glufosinate, and the combination of quinclorac + mecoprop + dicamba 7 DAT.

Hooker's evening primrose phytotoxicity increased for all treatments by 28 DAT (Table 2). Fluazifop (21%) was the only treatment that did not exhibit phytotoxicity symptoms different from the nontreated check 28 DAT. Hooker's evening primrose exhibited phytotoxicity of 31 to 40% with applications of fenoxaprop, glyphosate, or glufosinate 28 DAT. Culpepper et al. (2005) observed slightly greater injury (60%) of cutleaf evening primrose with applications of glyphosate at (0.84 kg ha^{-1}) 28 DAT, while Shankle et al. (2001) observed 91% control 3 WAT with glyphosate at 1.1 kg ha^{-1}. Phytotoxicity was $\geq$ 58% with applications of quinclorac, mesotrione, sulfosulfuron, and the combination of quinclorac + mecoprop + dicamba 28 DAT, with the highest level of phytotoxicity (90%) resulting from the combination of quinclorac + mecoprop + dicamba. Armel et al. (2003) observed 35 to 50% control of cutleaf evening primrose 4 WAT in response to mesotrione at 0.035 to 0.14 kg ai ha^{-1}. Mesotrione at 0.21 kg ai ha^{-1} resulted in 63% Hooker's evening primrose phytotoxicity 28 DAT in our research.

Biomass (g). Hooker's evening primrose treated with fluazifop exhibited similar above-ground biomass (124 g) and below-ground biomass (16.4 g) as compared to the nontreated check (10.8 and 14.7 g, respectively) 28 DAT (Table 2). All other treatments resulted in significant reductions in above-ground biomass and below-ground biomass 28 DAT. Stringer et al. (1985) observed only 9 to 12% injury of cutleaf evening primrose with 23 to 41% reduction in shoot fresh weight 4 WAT in response to ethofumesate applied at 0.4 to 1.6 kg ai ha^{-1}.

Plant Growth Index. Fluazifop (243) and fenoxaprop (18.8) applications resulted in a plant growth index (PGI) that was not significantly different from the nontreated check (24.7) 28 DAT (Table 2). A PGI $\leq$ 16.2 was observed for all other treatments 28 DAT, with the lowest PGI (8.6) resulting from the combination treatment of quinclorac + mecoprop + dicamba.

Methods employed for the growth of Hooker's evening primrose in this study may have contributed to greater

https://doi.org/10.1614/WT-D-12-00090.1 Published online by Cambridge University Press

phytotoxicity. Plants grown under greenhouse conditions are often more susceptible to herbicides, and therefore exhibit higher levels of phytotoxicity. Lingenfelter and Curran (2007) observed 98% control of wirestem muhly [*Muhlenbergia frondosa* (Poir.) Fern.] in the greenhouse in response to glyphosate (0.42 and 0.84 kg ha^{-1}) 4 WAT. The same applications made in the field only resulted in 60 to 87% control 4 WAT depending on year and location. Conversely, Coffman and Gentner (1980) reported 68 and 30% Italian ryegrass [*Lolium perenne* L. spp. *multiflorum* (Lam.) Husnot] phytotoxicity 1 WAT in response to trifluralin at 1.1 kg ai ha^{-1} when applied in the field and greenhouse, respectively. Transplant size may also have an effect on herbicide phytotoxicity. Hooker's evening primrose transplants utilized in our research were 7 cm wide and allowed to acclimate for 28 d in the greenhouse before herbicide application. Larger transplants or a longer acclimation period may have reduced herbicide phytotoxicity. Miller et al. (2003) observed greater yields (34 kg ha^{-1} x 1000^{-1}) of large transplant (5 to 6 true leaf) cabbage (*Brassica oleracea* L.) compared to small transplants (4 to 5 true leaf) (5 kg ha^{-1} x 1000^{-1}) in response to PRE applications of pendimethalin at 1.7 kg ai ha^{-1}.

No data with respect to floral induction or seed yield were recorded in response to herbicide treatments. Early assessments of plant phytotoxicity (28 DAT) in response to herbicide applications may not accurately describe long-term effects on plant growth and reproduction. For example, protoporphyrinogen oxidase (PPO) inhibitors may initially cause high levels of foliar damage, but have negligible impact on long-term yield. Taylor-Lovell et al. (2001) reported that sulfentrazone and flumioxazin applications resulted in greater soybean [*Glycine max* (L.) Merr.] injury and stand count reductions than yield reductions. They attributed this to the ability of soybean plants to grow aggressively in order to compensate for stand thinning (Taylor-Lovell et al. 2001). A 75% stand count reduction in the cultivar 'P9305' only resulted in a 15 to 20% yield loss (Taylor-Lovell et al. 2001). Contrarily, synthetic auxin herbicides may cause low levels of observable injury initially, but lead to flower abortion and large reductions in long-term yield. Robinson and Johnson (2012) observed a 10% reduction in soybean yield resulting from 19 and 15% soybean injury when plants at the fifth trifoliate and full flowering stage, respectively, were exposed to 2,4-D. However, synthetic auxin herbicides investigated in our research (quinclorac + mecoprop + dicamba or quinclorac) resulted in high levels of initial Hooker's evening primrose phytotoxicity (26 to 56% 7 DAT and 58 to 90% 28 DAT).

Based upon the results of this trial, fenoxaprop and fluazifop may be used for POST weed control in Hooker's evening primrose without causing excessive phytotoxicity and growth reduction when it is grown as an oilseed crop. Although nonselective herbicides, glyphosate and glufosinate, resulted in $\leq$ 40% Hooker's evening primrose phytotoxicity 28 DAT, large reductions in biomass and PGI may result in too high of a yield loss to warrant use in a production system for Hooker's evening primrose.

Acknowledgements

The authors acknowledge the cooperation of Tyler Cooper, Leslie Beck, A.J. Hephner, Vikram Baliga, Kaylee Decker, and Daniel Cunningham for their excellent technical assistance in this project.

Literature Cited

Armel, G. R., H. P. Wilson, R. J. Richardson, and T. E. Hines. 2003. Mesotrione combinations in no-till corn (*Zea mays*). Weed Technol. 17:111–116.

Arnold, M. 2008. Landscape Plants for Texas and Environs. 3rd ed. Stipes Publishing. 92p.

Balch, S. A., C. B. McKenney, and D. L. Auld. 2003. Evaluation of gamma-linolenic acid composition of evening primrose (*Oenothera*) species native to Texas. HortScience 38:595–598.

Barre, D. E. 2001. Potential of evening primrose, borage, black currant, and fungal oils in human health. Ann. Nutr. Metab. 45:47–57.

Behandary, R. M., T. Whitwell, and J. Briggs. 1997. Growth of containerized landscape plants is influenced by herbicide residues in irrigation water. Weed Technol. 11:793–797.

Carter, J. P. 1988. Gamma-linolenic acid as a nutrient. Food Technol. 42:72–82.

Coffman, C. B. and W. A. Gentner. 1980. Persistence of several controlled release formulations of trifluralin in greenhouse and field. Weed Sci. 28:21–23.

Correll, D. S. and M. C. Johnston. 1970. Manual of the vascular plants of Texas. Renner, TX: Texas Res. Foundation. 1131p.

Culpepper, A. S., D. S. Carlson, and A. C. York. 2005. Weed science: preplant control of cutleaf evening primrose (*Oenothera laciniata* Hill) and wild radish (*Raphanus raphanistrum* L.) in conservation tillage cotton (*Gossypium hirsutum* L.). J. Cotton Sci. 9:223–228.

Deng, Y. C., P. Lapinskas, J. Li, and H. M. Hua. 2001. Studies on the cultivation and uses of evening primrose (*Oenothera spp.*) in China. Econ. Bot. 55:83–92.

Dietrich, W., P. H. Raven, and W. L. Wagner. 1997. Systematics of *Oenothera* section *Oenothera* subsection *Oenothera* (Onagraceae). Systematic Botany Monographs, Vol. 50. 234p.

Gilreath, J. P. and B. Santos. 2005. Weed management with oxyfluoren and napropamide in mulched strawberry. Weed Technol. 19:325–328.

Hall, I. V., E. Sreiner, P. Threadgill, and R. W. Jones. 1988. The biology of Canadian weeds. 84. *Oenothera biennis* L. Can. J. Plant Sci. 68:163–173.

Harte, C. 1994. *Oenothera*: Contributions of a plant to biology. Berlin, Germany: Springer-Verlag. 1–261p.

Lingenfelter, D. D. and W. S. Curran. 2007. Effect of glyphosate and several ACCase- inhibitor herbicides on wirestem muhly (*Muhlenbergia frondosa*) control. Weed Technol. 21:732–738.

Miller, A. J., R. R. Bellinder, B. Xu, B. J. Rauch, M. C. Goffinet, and M.J.C. Welser. 2003. Cabbage (*Brassica oleracea*) response to pendimethalin applied posttransplant. Weed Technol. 17:256–260.

Owen, M. 2008. Review: weed species shifts in glyphosate-resistant crops. Pest Manag. Sci. 64:377–387.

Peschel, W., A. Plescher, M. Sonnenschein, and W. Dieckmann. 2007. High antioxidant potential of pressing residues from evening primrose in comparison to other oilseed cakes and plant antioxidants. Ind. Crops Prod. 25:44–54.

Reynolds, D., S. Crawford, and D. Jordan. 2000. Cutleaf evening primrose control with preplant burndown herbicide combinations in cotton. J. Cotton Sci. 4:124–129.

Robinson, A. and W. G. Johnson. 2012. Response of soybean yield components to 2,4–D. Weed Sci 61: 68–76.

Simpson, M.J.A. and A. F. Fieldsend. 1993. Evening primrose: harvest methods and timing. Acta Hort. 331:121–128.

Shankle, M. W., K. M. Bloodworth, and D. B. Reynolds. 2001. Comparison of new preplant burndown options for cotton production. Proc. South. Weed Sci. Soc. 54:32.

Smith, M. W., M. E. Wolf, B. S. Cheary, and B. L. Carroll. 2001. Allelopathy of bermudagrass, tall fescue, redroot pigweed, and cutleaf evening primrose on pecan. HortScience 36:1047–1048.

Stringer, D., W. G. Richardson, and C. Parker. 1985. Tolerance of *Oenothera biennis* to various herbicide treatments. Tests Agrochemicals Cultivars 6:124–125.

Taylor-Lovell, S., L. M. Wax, and R. Nelson. 2001. Phytotoxic response and yield of soybean (*Glycine max*) varieties treated with sulfentrazone or flumioxazin. Weed Technol. 15:95–102.

Received November 14, 2012, and approved November 16, 2012.