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Sunflower Bird Pests

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Introduction

Sunflower (*Helianthus annuus* L.) is annually planted on approximately 26 million hectares in Australia, China, Europe, India, North America, Pakistan, Russia, South America, and Ukraine (National Sunflower Association, 2014). Flocks of granivorous birds, ranging in size from a few to millions, can be found in every sunflower growing region and have been documented to cause serious economic losses (Linz et al., 2011) (Figure 7.1). Avian species that damage sunflower generally belong to the parakeet (Psittacidae), dove (Columbidae), cockatoo (Cacatuidae), sparrow (Passeridae), crow (Corvidae), and blackbird (Icterinae) families (De Grazio, 1989; Linz and Hanzel, 1997; Linz et al., 2011; Rodriquez et al., 1995; van Niekerk, 2009).

Since the 1970s, U.S. scientists have focused on reducing blackbird damage in the Prairie Pothole Region (PPR) of the United States. Population and nesting ecology of blackbirds, the timing and extent of damage, and numerous potential methods of reducing damage were studied (Blackwell et al., 2003; Linz et al., 2011; Peer et al., 2003). Bird damage begins after the ray petals drop from the ripening sunflower heads and achenes begin to develop (Cummings et al., 1989). Sunflower is vulnerable to bird damage until harvest, which can begin 6 weeks or more after plants reaches physiological maturity. Birds seek sunflower because it easy to perch on the heads to quickly access and crack the achenes to obtain the kernel. The high caloric kernel contains proteins and fats needed for breeding season activities, feather replacement, and fat storage prior to migration (Linz et al., 1995). Blackbirds and sparrows prefer oilseed cultivars because they tend to be smaller and have thinner hulls than confectionery varieties (Linz and Hanzel, 1997).

Damage levels vary widely across sunflower growing areas because bird numbers are dependent on landscape features, such as the presence of wetlands and trees that are favored roosting sites and the availability of alternative foods. In the PPR of the United States, which is renowned for wetlands used by migrating birds, many producers have abandoned sunflower and now plant alternative crops that are not subject to serious bird damage and have better options available for managing weeds (Hulke and Kleingartner, 2014; Linz et al., 2011).

Producer complaints from the PPR have motivated scientists to assess bird damage with both models and field surveys. Peer et al. (2003) constructed bioenergetic

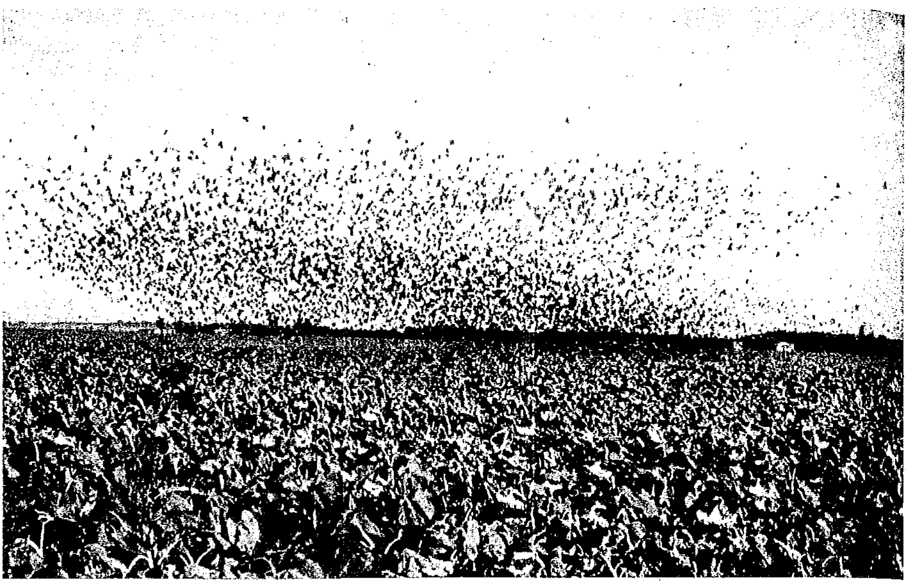

Figure 7.1 Blackbirds in ripening sunflower in North Dakota.
Source: North Dakota State University, Fargo.

and economic models to determine the potential effects blackbirds have on the sunflower crop in the northern Great Plains of North America. They estimated that blackbirds annually damaged \$5.2 million (at \$0.26/kg) of sunflower from 1993 to 1997. During 2009 and 2010, Klosterman et al. (2013) conducted field damage surveys and found that blackbirds damaged about 2.7% of the crop, valued at \$3 million. Damage in 15% of the surveyed fields (n = 27) was over 5.0% and 26% of the fields received greater than 1% damage. Damage above 5% is considered economically important by sunflower growers (Linz and Homan, 2011). Thus, solutions to the blackbird–sunflower problem should be focused on methods that reduce the extreme level of damage suffered by a small proportion of growers.

Outside the United States, recent bird damage data have been reported for South Africa, Argentina, and Iran. In South Africa, van Niekerk (2009) surveyed bird damage and reported that doves damaged 12.7% of the crop, whereas quantitative surveys showed that the damage was 8.4%. In 2007, birds damaged 0.9% of the sunflower crop in Argentina (Linz and Homan, 2011). In Iran, birds are considered important pests of sunflower (Khaleghizadeh and Alizadeh, 2009). In 2003 and 2004, Khaleghizadeh and Alizadeh (2009) surveyed damage in Iran and found that the mean damage rates in Karaj and Khoy regions were 45.3% and 21%, respectively. Older data show that damage can be high (15.0–25.0%) in some localities (Khaleghizadeh, 2011) and low (<3%) in others (Linz and Hanzel, 1997).

Although research continues on this especially difficult problem, some advances have been made to help growers cope with birds. Damage management techniques that are effective, are economically viable, and do not compromise the environment are available. Most of these methods and concepts have been used or can be used in nearly all agricultural ecosystems facing problems with flocking granivorous birds. We will also outline current and planned future research direction by scientists from the U.S. Department of Agriculture, Wildlife Services, National Wildlife Research Center (USDA-WS-NWRC) and their university and private industry collaborators.

Cultural Practices

An obvious bird management strategy is to plant crops (e.g., beans) that are not susceptible to bird damage near traditional roosts (Linz and Hanzel, 1997). Some growers, however, recognize the value of sunflower in their crop rotation and have opted to use time-tested and new cultural practices.

One set of time-tested strategies includes synchronizing planting of sunflower to eliminate availability of early-maturing and late-maturing fields, planting large fields to spread the damage over greater areas, delaying the plowing of harvested grain fields to provide an alternate food source, and controlling weeds and insects that may attract birds to feed in sunflower fields prior to achene development (Linz and Hanzel, 1997; Linz et al., 2011).

A second strategy is to advance the harvest date to avoid late-season bird damage. Sunflower growers can use older products, such as paraquat and sodium chloride, or select newer products, such as glyphosate and saflufenacil, to desiccate the crop after it reaches physiological maturity and advance harvest by 7 to 10 days (Linz et al., 2011). Glyphosate and saflufenacil can be mixed in a spray tank and applied with an airplane or a high-clearance ground sprayer to kill both grasses and desiccate sunflower after the achenes are dried to 30% moisture or less. Desiccation and subsequent early harvest reduces the time for birds to cause additional damage without affecting yield or oil content (Howatt et al., 2008).

A third strategy that is garnering attention from growers is the recent development of short-stature sunflower varieties for short growing seasons in northern sunflower growing areas in North America (Mullally, 2012; Trostle et al., 2013). Specifically, sunflower breeders are developing short-stature varieties that are comparable to standard-height sunflower for such agroeconomic characteristics as days to maturity, yield, oil content, and disease tolerance. Short-stature sunflower provides less cover for birds than standard height hybrids and, although an untested concept, might allow for more effective use of scare devices (e.g., propane cannons, pyrotechnics) because the sound will carry farther. In addition, short-stature sunflowers provide less cover from raptors that forage over sunflower fields, and bird repellents could more easily be applied with a high-clearance ground rig.

Hazing

Sunflower producers sometimes resort to shooting firearms to disperse foraging flocks from sunflower. Although few birds are killed with firearms, shooting seems to help disperse flocks from sunflower and might enhance the effectiveness of other scare devices with a similar sound, such as propane cannons and pyrotechnics (Linz and Homan, 2011). A few growers in the United States hire fixed-wing aircraft and helicopters to chase birds from fields (Linz et al., 2011). Blackbirds appear easier to chase from fields in the PPR after their annual feather replacement is nearly complete in mid-September. Prior to that time, the birds tend to find refuge in dense cattail wetlands and in sunflower and corn fields. The cost of using an aircraft probably outweighs the amount of sunflower seed saved, but a quantitative assessment is not available.

In the United States, propane exploders are the most popular of the mechanical scare devices used by growers and wildlife professionals (Bomford and O'Brien, 1990; Conover, 2002). Cummings et al. (1986) reported that the use of propane cannons can be effective where large numbers of blackbirds are congregated in relatively small areas and the birds have not established feeding sites. We recommend that cannons be fitted with timers and motion sensors and be elevated on metal drums or rotating platforms to enhance the effects of the propane explosion and reduce the rate of habituation. Cannons should be moved as often as practical, but at least weekly. In 2012, U.S. Department of Agriculture (USDA), North Dakota Wildlife Services (WS) field specialists distributed 416 propane cannons and 26,700 rounds of pyrotechnics to 135 sunflower growers that were reporting blackbird damage (Phil Mastrangelo, personal communication, January 14, 2013). Field specialists reinforced the effectiveness of these devices with the use of shotguns. Although experimental efficacy data are not available, sunflower producers have responded favorably to this program since it was instituted in 2007.

Habitat Management

Habitat can be manipulated to increase or decrease the suitability of the landscape for breeding and foraging birds. The USDA's Wildlife Services program has carried out an example of decreasing habitat suitability by conducting a cattail roost management program in North Dakota and South Dakota for 20 years (Linz and Homan, 2011). Wildlife Services used a helicopter to spray an aqueous solution containing 2.2 kg ha^{-1}

of glyphosate to reduce the suitability of dense cattails used for roosting blackbirds (Linz and Homan, 2011). They found that spraying approximately 70% of the cattails in strips dispersed the roosting birds and, furthermore, that the strips remained clear of cattails for at least 4 years (Linz and Homan, 2011). The federal program has ended, but sunflower producers can spray cattails at their own expense. Producers have also burned and cut cattails during late summer and fall, especially during dry years when shallow wetlands can sometimes be accessed with farm equipment.

An example of increasing habitat suitability has been demonstrated twice over the last 30 years when scientists experimented with Wildlife Conservation Sunflower Plots (WCSP) (also known as decoy, lure, and trap crops) in strategic locations to attract blackbirds away from commercial sunflower fields (Cummings et al., 1987; Hagy et al., 2008). An alternative quality food source is critical for enhancing the success of nonlethal blackbird deterrent measures in commercial sunflower (Avery and Cummings, 2003). Ideally, the food source should be available until the commercial fields are harvested. However, a WCSP that is available during early seed development when most bird damage occurs would be valuable. Cummings et al. (1987) suggested that decoy crops would have to be planted on public lands to reduce rent costs. Similarly, Hagy et al. (2008) found that annually planting WCSP on private lands that would need to be taken out of commercial production was not cost effective. A few growers have adapted the basic principle of diverting blackbirds from high-value sunflower to lower-valued crops. For example, growers plant corn, a less valuable crop, near wetlands to buffer their sunflower crop from birds. The birds do eat some corn but the economic loss is tolerable for most growers (Klosterman et al, 2013).

To increase the economic benefits of WCSP, Kantar et al. (2014) are developing a perennial sunflower that could be planted near traditional roost sites to attract blackbirds and other wildlife. In 2013, the first improved perennial sunflower was planted in North Dakota (Figure 7.2). The seed will be increased and will become more generally available over the next few years. State resource agencies have expressed strong interest in planting perennial sunflower to benefit all wildlife. Availability of public lands (e.g., refuges, game management areas, Conservation Reserve Program land) for perennial sunflower plantings will further improve cost benefits for sunflower producers and game managers.

Chemical Repellents

Private and government scientists have aggressively pursued the discovery, development, and registration of an effective, environmentally safe bird repellent (Werner et al., 2010, 2011). Wildlife managers are supportive of these efforts because dispersing birds is a way to reduce the severity of localized damage. Several products featuring methyl anthranilate (MA) as the active ingredient have been registered for use in

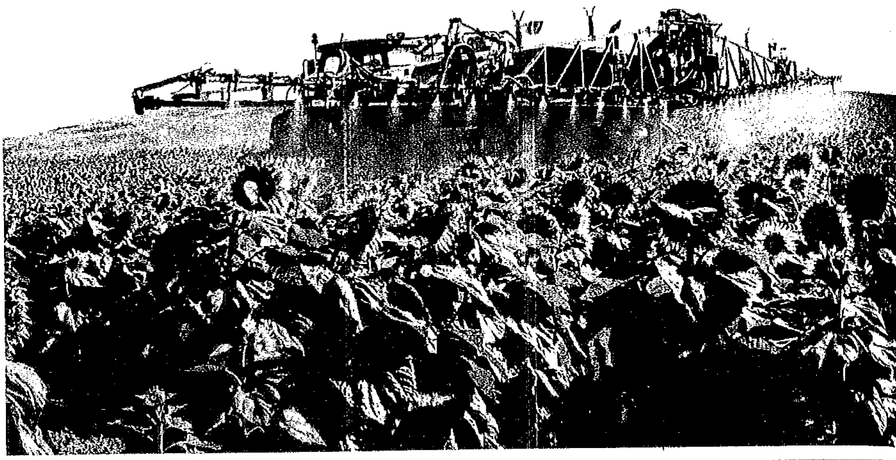

Figure 7.2 High-clearance ground sprayer applying an experimental bird repellent in a ripening sunflower field in North Dakota.
Source: USDA, Wildlife Services.

ripening sunflower. These products are primary repellents and are effective when the peripheral chemical senses (nostrils, eyes, or mouth) are irritated (Clark, 1998). In field studies, however, MA products failed to reduce sunflower damage (Werner et al., 2005). Rates used in these studies may have been insufficient to elicit a negative response from the birds because the threshold level that induces repellency was not reached. Moreover, high variability in damage among fields within treatments and small sample sizes can contribute to lack of enough evidence to find a statistically significant difference between treatments.

Flock Buster® is another primary repellent that is registered in the United States for use on sunflower. The product is unique because it contains a mixture of items, including lemongrass oil, garlic oil, clove oil, peppermint oil, rosemary oil, thyme oil, and white pepper. Werner et al. (2010) found Flock Buster® to be an ineffective bird deterrent under laboratory conditions. Experimental field trials, however, have not been conducted to test its efficacy.

Another group of possibly effective compounds are secondary repellents that effect gastrointestinal illness and cause the birds to learn to associate illness with a particular food that has a certain appearance or taste (Avery and Cummings, 2003). A secondary repellent produces a stronger effect than do primary repellents, but the birds must sample the food, thus causing some damage before becoming ill from ingesting the food. Of these compounds, 9,10-anthraquinone (AQ) appears to be most promising (Linz et al., 2011). Anthraquinone is synthesized for industrial uses such as dyes and papermaking, but also can be found in plants. Cage trials and field trials with the Avipel® formulation have demonstrated that anthraquinone-based repellents can effectively protect seeded corn, sunflower, and rice seed from blackbirds (Werner et al., 2011). Anthraquinone might prove useful for repelling free-ranging birds from ripening crops, but more testing is needed (Avery and Cummings, 2003). For example, Carlson et al. (2013) showed that treating corn husks with AQ is sufficient to induce red-winged blackbirds to feed on untreated corn. There is some evidence that merely spraying the back of the heads of sunflowers (i.e., not the face) is sufficient to deter blackbirds from feeding on the achenes (Werner et al. 2014). In 2013, scientists sprayed AQ on ripening sunflower at an early bloom stage and placed blackbirds in cages to evaluate efficacy (Figure 7.3). Under the conditions of this experiment, the AQ application failed to deter feeding on treated sunflower (Niner et al. 2014).

Figure 7.3 Perennial sunflower plot planted in North Dakota. Perennial sunflower can provide an alternate food source for birds.
Source: USDA, Wildlife Services.

Population Management

Local and regional attempts to reduce blackbird populations associated with sunflower damage have failed. The idea of using decoy traps to capture and euthanize blackbirds was tested because nontarget birds could be released without harm. Cage traps stocked with decoy blackbirds have been used to remove blackbirds in rice-growing areas (Meanley, 1971). Nevertheless, defending large-scale agriculture by trapping has been proven to be ineffective. For example, Weatherhead et al. (1980) concluded that decoy traps removed less than 2% of the trappable number of blackbirds foraging in ripening corn fields. Linz et al. (2010) evaluated two large-sized, mobile decoy traps (11 × 2.5 × 2.5 m) for capturing blackbirds actively feeding on ripening sunflower fields during late summer and early fall. Despite an intensive effort, only 154 blackbirds were captured and most of those birds were captured after the crop had reached physiological maturity and the achenes had become less palatable and the risk for substantial damage had subsided. Linz and colleagues concluded this method to be economically inefficient for protecting sunflower because of lack of efficacy and labor and travel costs associated with maintaining decoy birds.

U.S. Fish and Wildlife Service, Denver Wildlife Research Center (now USDA-WS-NWRC) scientists discovered and developed the compound DRC-1339 (3-chloro-p-toluidine hydrochloride, also 3-chloro-4-methylbenzenamine hydrochloride) as an avicide to kill starlings and blackbirds. In late winter and early spring, the product is used to kill blackbirds that might damage sprouting rice in the southeastern United States (Glahn and Wilson, 1992). The efficacy of reducing migrating blackbird populations to manage crop damage has not been experimentally tested. Blackbirds that reproduce in the PPR disperse throughout the southern United States during winter. Thus, selecting and targeting specific roosts that harbored blackbirds that damaged sunflower in the PPR was not possible. Scientists also evaluated the use of DRC-1339 for killing spring migrating blackbirds in eastern South Dakota and found that costs exceeded the potential benefit of reducing the population (Blackwell et al., 2003; Linz et al., 2003). Finally, DRC-1339 and related compounds were tested for reducing flocks of fall migrating blackbirds feeding on ripening sunflower (Cummings et al., 1990). Linz and Bergman (1996) concluded that the majority of blackbirds preferred to feed on the ripening achenes rather than forage on dry grains placed on the ground. Linz et al. (2012) recognized that ground-based DRC-1339 plots would not work in sunflower, so they tried attracting blackbirds to elevated food trays placed on cages containing live decoy blackbirds. Linz and colleagues hypothesized that the live decoy blackbirds would attract conspecifics to the bait trays, while decreasing risks of nontarget poisonings. Field observations demonstrated that risks to nontarget species were minimal, but the decoy blackbirds failed to attract sufficient numbers of blackbirds to the trays to make this management strategy cost effective

(Linz et al., 2012). We conclude that managing the population of blackbirds with lethal methods is not practical or cost effective.

Conclusion

Since sunflower became an economically viable crop in North America in the 1970s, scientists have concentrated on chemical and physical frightening agents, aversive repellents, bird-resistant sunflower, decoy crops, habitat management, population management, and cultural modifications in an effort to reduce bird damage. Bird damage to agricultural crops is a vexing worldwide problem that is especially difficult for sunflower producers (Linz et al., 2011). We suggest producers and their crop consultants develop a comprehensive bird management plan. This plan might include modifying roost habitat (e.g., pruning trees, thinning dense vegetation in wetlands); using a plant desiccant (e.g., glyphosate, saflufenacil) to accelerate fall harvest; using propane cannons; planting decoy crops in strategic locations; synchronizing planting time of sunflower with neighbors; leaving stubble, especially sunflower, unplowed for as long as possible to provide alternative feeding sites for blackbirds; and planting short-stature sunflower to facilitate bird-hazing strategies.

In the next decade, we are hopeful that an effective bird repellent will be registered for use on ripening sunflower (and other grain crops) and that a perennial sunflower will be available for use as an alternative food source for blackbirds and other birds. Alternative sources of food, possibly in combination with repellents, should help scientists make significant advances in management of blackbird damage in sunflower (Avery, 2002). We caution, however, that there are no perfect solutions to bird damage conflicts.

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References

Avery, M. L. Avian Repellents. In *Encyclopedia of Agrochemicals*; Plimmer, J. R., Ed.; John Wiley & Sons: New York, 2002; Vol. 1, pp 122–128.

Avery, M. L.; Cummings, J. L. Chemical Repellents for Reducing Crop Damage by Blackbirds. In *Management of North American Blackbirds*; Linz, G. M., Ed.; National Wildlife Research Center: Fort Collins, CO, 2003; pp 41–48.

Blackwell, B. F.; Huszar, E.; Linz, G. M.; Dolbeer, R. A. Lethal Control of Red-winged Blackbirds to Manage Damage to Sunflower: An Economic Evaluation. *J. Wildl. Manage.* **2003,** *67,* 818–828.

Bomford, M.; O'Brien, P. H. Sonic Deterrents in Animal Damage Control: A Review of Device Tests and Effectiveness. *Wildl. Soc. Bull.* **1990,** *18,* 411–422.

Carlson, J. C.; Tupper, S. K.; Werner, S. J.; Pettit, S. E.; Santer, M. M.; Linz, G. M. Laboratory Efficacy of an Anthraquinone-based Repellent for Reducing Bird Damage to Ripening Corn. *Applied Animal Behaviour Science* **2013,** *145,* 26– 31.

Clark, L. Review of Bird Repellents. *Proceedings of the Vertebrate Pest Conference* **1998,** *18,* 330–337.

Conover, M. R. *Resolving Human-Wildlife Conflicts: The Science of Wildlife Damage Management*; CRC Press: Boca Raton, FL, 2002.

Cummings, J. L; Knittle, C. E.; Guarino, J. L. Evaluating a Pop-up Scarecrow Coupled with Propane Exploder for Reducing Blackbird Damage to Ripening Sunflower. *Proceedings of the Vertebrate Pest Conference* **1986,** *12,* 286–291.

Cummings, J. L.; Guarino, J. L.; Knittle, C. E.; Royal, W. C., Jr. Decoy Plantings for Reducing Blackbird Damage to Nearby Commercial Sunflower Fields. *Crop Protection* **1987,** *6,* 56–60.

Cummings, J. L.; Guarino, J. L; Knittle C. E. Chronology of Blackbird Damage to Sunflowers. *Wildl. Soc. Bull.* **1989,** *17,* 50–52.

Cummings, J. L.; Schafer, E. W., Jr.; Cunningham, D. J. An Evaluation of DRC-2698 Treated Baits for Reducing Blackbird Populations Associated with Sunflower Damage. *Proceedings of the Fourteenth Vertebrate Pest Conference* **1990,** *14,* 357–360.

DeGrazio, J. W. Pest Birds—An International Perspective. In *Quelea Quelea: Africa's Bird Pest*; Bruggers, R. L., Elliot, C. C. H., Eds.; Oxford University Press: New York; 1989; pp 1–8.

Glahn, J. F.; Wilson, E. A. Effectiveness of DRC-1339 Baiting for Reducing Blackbird Damage to Sprouting Rice. *Proceedings Eastern Wildlife Damage Control Conference* **1992,** *5,* 117–123.

Hagy, H. M.; Linz, G. M.; Bleier, W. J. Optimizing the Use of Decoy Plots for Blackbird Control in Commercial Sunflower. *Crop Protection* **2008,** *27,* 1442–1447.

Howatt, K. A.; Jenks, B. M.; Stahlman, P. W.; Moechnig, M. Potential of Saflufenacil for Preharvest Desiccation of Sunflower. *Proc. North Central Weed Science Soc.* **2008,** *63,* 149.

Hulke, B. S.; Kleingartner, L. W. Sunflower. In *Yield Gains in Major U.S. Field Crops;* Smith, S., Diers, B., Specht, J., Carver, B., Eds.; Soil Science Society of America Spec. Publ. 33. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America: Madison, WI, 2014.

Kantar, M. B.; Betts, K.; Michno, J.-M. S.; Luby, J. J.; Morrell, P. L.; Hulke, B. S.; Stupar, R. M.; Wyse, D. L. Evaluating an Interspecific *Helianthus annuus* × *Helianthus tuberosus* Population for Use in a Perennial Sunflower Breeding Program. *Field Crops Res.* **2014,** *155,* 254–264.

Khaleghizadeh, A. Effect of Morphological Traits of Plant, Head and Seed of Sunflower Hybrids on House Sparrow Damage Rate. *Crop Protection* **2011,** *30,* 360–367.

Khaleghizadeh, A.; Alizadeh, E. Evaluation of Resistance of Sunflower Varieties to Bird Damage. *J. Appl. Entomol. Phytopathology* **2009,** *76,* 115–134 (in Persian with English summary).

Klosterman, M. E.; Linz, G. M.; Slowik, A. A.; Homan, J. J. Comparisons between Blackbird Damage to Corn and Sunflower in North Dakota. *Crop Protection* **2013,** *53,* 1–5.

Linz, G. M.; Bergman, D. L. DRC-1339 Avicide Fails to Protect Ripening Sunflowers. *Crop Protection* **1996,** *15,* 307–310.

Linz, G. M.; Hanzel, J. J. Birds and Sunflower. In *Sunflower Technology and Production*; Schneiter, A. A., Ed.; Agronomy Monograph No. 35; American Society of Agronomy: Madison, WI, 1997; pp 381–394.

Linz, G. M.; Homan, H. J. Current Use of Glyphosate for Managing Invasive Cattail (*Typha* spp.) to Protect Crops Near Blackbird (Icteridae) Roosts. *Crop Protection* **2011,** *30,* 98–104.

Linz, G. M.; Mendoza, L. A.; Bergman, D. L.; Bleier, W. J. Preferences of Three Blackbird Species for Sunflower Meats, Cracked Corn, and Brown Rice. *Crop Protection* **1995,** *5,* 375–378.

Linz, G. M.; Knutsen, G. A.; Homan, H. J.; Bleier, W. J. Baiting Blackbirds (Icteridae) in Stubble Grain Fields during Spring Migration in South Dakota. *Crop Protection* **2003,** *22,* 261–264.

Linz, G. M.; Slowik, A. A.; Homan, H. J.; Byrd, R. Evaluation of Large, Mobile, Decoy Traps for Managing Blackbird Damage to Ripening Sunflower, 2010a. http://www.sunflower nsa.com/research/research-workshop/documents/Linz_DecoyTraps_10.pdf (accessed Feb-ruary 1, 2014).

Linz, G. M.; Homan, H. J.; Werner, S. W.; Hagy, H. M.; Bleier, W. J. Assessment of Bird Management Strategies to Protect Sunflower. *BioScience* **2011,** *61,* 960–970.

Linz, G. M.; Winter, J. B.; Bleier, W. J. Evaluation of Elevated Bait Trays for Attracting Blackbirds (Icteridae) in North Dakota. *Crop Protection* **2012,** *41,* 30–34.

Meanley, B. *Blackbirds and the Southern Rice Crop.* Resource Publication No. 100; U.S. Fish and Wildlife Service, 1971.

Mullally, S. Options Growing with Short-stature Hybrids. *Sunflower Magazine* **2012,** *38,* 22–24.

National Sunflower Association. Sunflower Statistics: World Supply & Disappearance. http://www.sunflowernsa.com/stats/world-supply (accessed February 1, 2014).

Niner, M.; Linz, G., Homan, J.; Clark M. Effectiveness of AV2022 (a.i., 9, 10 Anthraquinone) as an Avian Repellent for Sunflower. In *36th National Sunflower Association Research Forum,* Fargo, ND, 2014.

Peer, B. D.; Homan, H. J.; Linz, G. M.; Bleier, W. J. Impact of Blackbird Damage to Sunflower: Bioenergetic and Economic Models. *Ecological Applications* **2003,** *13,* 248–256.

Rodriguez, E. N.; Bruggers, R. L.; Bullard, R. W.; Cook, R. An Integrated Strategy to Decrease Eared Dove Damage in Sunflower Crops. In *Repellents in Wildlife Management: Proceedings of a Symposium;* Mason, J. R., Ed.; Denver Wildlife Research Center Special Symposium: Denver, CO, 1995; 409–421.

Trostle, C.; Pietsch, D.; Schlegel, A.; Evans, P. Height, Yield, and Oil Content of Short-stature Sunflower (*Helianthus annuus*) vs. Conventional Height Sunflower in the Southern Great High Plains. In 35th National Sunflower Association Research Forum, Fargo, ND, 2013. http://www.sunflowernsa.com/research/research-forum-presentations/2013 (accessed February 1, 2014).

van Niekerk, J. H. Loss of Sunflower Seeds to Columbids in South Africa: Economic Implications and Control Measures. *Ostrich* **2009,** *80,* 47–52.

Weatherhead, P. J.; Greenwood, H.; Tinker, S. H.; Bider, J. R. Decoy Traps and the Control of Blackbird Populations. *Phytoprotection* **1980,** *61,* 65–71.

Werner, S. J.; Homan, H. J.; Avery, M. L.; Linz, G. M.; Tillman, E. A.; Slowik, A. A., Byrd, R. W.; Primus, T. M.; Goodall, M. J. Evaluation of Bird Shield™ as a Blackbird Repellent in Ripening Rice and Sunflower Fields. *Wildl. Soc. Bull.* **2005,** *33,* 251–257.

Werner, S. J.; Linz, G. M.; Tupper, S. K; Carlson, J. C. Laboratory Efficacy of Chemical Repellents for Reducing Blackbird Damage in Rice and Sunflower Crops. *J. Wildl. Manage.* **2010,** *74,* 1400–1404.

Werner, S. J.; Linz, G. M.; Carlson, J. C.; Pettit, S. E.; Tupper, S. K.; Santer, M. M. Anthraquinone-based Bird Repellent for Sunflower Crops. *Appl. Anim. Behav. Sci.* **2011,** *129,* 162–169.

Werner, S. J.; Deliberto, S. K.; Pettit, S. E.; Ellis, J. W.; Carlson, J. C.; Goldade, D. A.; Hofmann, N.M.; Homan, H. J.; Linz, G. M. Experimental Application Strategies for an Avian Repellent on Sunflower Crops. *Crop Protection* **2014,** *59,* 63–70.

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