USE OF DEER REPELLENTS TO PRESERVE WILDLIFE FOOD PLOTS FOR GAME BIRDS

WENDY M. ARJO, USDA, APHIS, Wildlife Services, National Wildlife Research Center, Olympia, WA, USA
KIMBERLY K. WAGNER, USDA, APHIS, Wildlife Services, Sun Prairie, WI, USA
CHAD D. RICHARDSON, USDA, APHIS, Wildlife Services, Directorate of Environment and Safety, Fort Riley, KS, USA
DALE L. NOLTE, USDA, APHIS, Wildlife Services, National Wildlife Research Center, Fort Collins, CO, USA

Abstract: Food plots are a vital element for the survival of game bird species such as bobwhite quail (*Colinus virginianus*) on Fort Riley Military Installation in Kansas. However, white-tailed deer (*Odocoileus virginianus*) tend to eat the sorghum when it starts to ripen in September and continue feeding on it through November and December, often leaving no food for the quail during the winter. We conducted pen and field trails to determine if repellents were an effective and feasible method to protect grain sorghum food plots from deer damage. Two-choice pen trials with both deer and game bird species were used to determine preference and avoidance of milo treated with Liquid Fence® and Plantskydd™. Individual food plots on Fort Riley were used to test both repellents' effectiveness in protecting a 6-row perimeter around established food plots. When given a choice both bobwhite quails and pheasants avoided Plantskydd ($P < 0.001$). Both repellents were avoided versus the control in the pen trials for white-tailed deer ($P \leq 0.0001$); however, we found no difference in seed head damaged between field control plots and plots treated with Liquid Fence or those with Plantskydd ($F_{7,23} = 0.88$, $P = 0.54$). Although milo treated in the pens deterred white-tailed deer, we feel the use of repellents for treating food plots may be cost prohibitive and less effective than other deterrents such as netting fences.

Key Words: bobwhite quail, *Colinus virginianus*, deer, food plots, milo, *Odocoileus*, repellents

Proceedings of the 11th Wildlife Damage Management Conference. (D.L. Nolte, K.A. Fagerstone, Eds). 2005

INTRODUCTION

Winter and spring are energetically stressful periods for northern bobwhite quail (*Colinus virginianus*) populations and many studies have determined that a late winter food source is often the missing link for game bird survival (Robel 1965, 1969, 1973; Robel et al. 1974, Roseberry and Klimstra 1984). For example, winter mortality rates in bobwhite quail populations on Fort Riley Military Reserve, Kansas were estimated to range from 39 to 85% (Robel and Fretwell 1970). Depending on the time of year, type of food, location, and proximity to other required resources such as cover and water, food plots can provide a valuable source of energy to wildlife such as such as deer (*Odocoileus sp.*), turkey (*Meleagris gallopavo*), bobwhite quail, and pheasants (*Phasianus colchicus*) (Ellis et al. 1969, Robel et al. 1974, Robel and Kemp 1977, Madison and Robel 2001). In 1959, in an effort to reduce winter mortality, food plots were established on Fort Riley as part of a habitat improvement program outlined by Army regulations (Robel et al. 1974).

Grain sorghums such as milo (*Sorghum vulgare*), are valuable food crops that are well utilized by game birds (Robel 1973; USDA 1979). Seed heads of grain sorghum tend to hold together well into the winter and then finally senesce in late winter providing a high energy food source. One drawback to grain sorghum food plots planted for game birds is that other wildlife species, such as white-tailed deer *(O. virginianus)*, raccoons (*Procyon lotor*), and red-winged blackbirds (*Agelaius phoeniceus*) also utilize these food plots. Damage to food plots by these species, especially deer, often leave little or no grain by mid to late-winter when it is essential for game birds. Prior to 1970, white-tailed deer populations in the United States were still relatively low and probably caused little damage to food plots planted for game birds. Rapid population growth in the last 30 years has resulted in dense deer populations, particularly in the Midwest (Gladfelter 1984), which has resulted in severe damage to food plots by deer.

Fort Riley annually plants 191 food plots, approximately 1 ha each in size, the majority of which are in grain sorghum. Food plots are planted primarily to benefit upland game birds, however a few are planted to clover varieties and wheat intended for deer and elk (*Cervus elaphus*). Annual planting costs are approximately $30,000, which includes seed, labor, fertilizer, and herbicide. Obviously, with this kind of investment it is understandable why minimizing deer damage is important and warranted. Recently, a number of new deer repellents have emerged on the market that may show promise in a field environment (Nolte and Wagner 2000). In this study, we attempted to determine if repellents are an effective and feasible method to protect grain sorghum food plots from deer damage. Our specific objectives were to assess whether repellents: 1) deterred deer from foraging on milo in pen trails; 2) impeded bobwhite quail and pheasant foraging; and 3) reduced milo damage by deer in field trails.

METHODS

Recent studies have demonstrated sulfur-based repellents effective in repelling deer (Notle and Wagner 2000). We chose two liquid sulfur repellents, Liquid Fence® (Liquid Fence, Inc., Brodheadsville, PA) and Plantskydd™ (Tree World®, Leekawanna, NY) at pre-packaged concentrations, to use in the pen and field trials. Use of these repellents does not constitute endorsement by the National Wildlife Research Center (NWRC) or Animal and Plant Health Inspection Service (APHIS). All animal care and use for this study was approved by NWRC's Institutional Animal Care and Use Committee, protocol number 895.

Pen Trials for Pheasants and Quail

Pen trials for both the white-tailed deer and the game birds were conducted at the National Wildlife Research Center, Olympia Field Station in Olympia, Washington. Eight adult ring-necked pheasants and 10 Northern bobwhite quail were used in a two-choice pen test to assess the effectiveness of selected repellents. Quail were kept in 61 X 48 X 41 cm stainless steel cages and pheasants in 180 X 76 X 76 cm stainless steel cages. Birds had unlimited access to water. Except during the test periods, birds also had unlimited access to game bird feed. Milo was treated with repellents by placing seeds, one layer thick, on screen racks. Seeds were then sprayed with the repellent and allowed to dry for 24 hours. Control milo was sprayed with water. The two-choice test consisted of a two-day pretreatment period and a four-day treatment period followed by a second two-day pretreatment and four-day treatment period. During the pretreatment periods, birds were given access to control feed starting at 0900 in two food dishes located at opposite front corners of their cage. Pheasants received 100 g milo in each dish and quail received 30 g milo in each dish. The regular bird feed was removed, but birds had unlimited access to water. The test dishes were removed nine hours later and replaced with the standard bird feed. Amount of feed consumed from each dish was recorded.

The treatment periods were conducted on four consecutive days immediately after the pretreatment period. The amount of food in each dish was identical to that given during the pretreatment period, but the food in one dish was treated with repellent and the food in the remaining dish was untreated. In the first treatment period, repellents were randomly assigned so half the pheasants received food treated with Liquid Fence and half the pheasants received food treated with liquid fence. A similar process was used to assign repellent treatments to quail. Repellent assignments were reversed during the second treatment period. Birds received the same repellent all four days of a treatment period. Treatments were randomly assigned to sides of each bird's pen on the first day of the experiment and then alternated on each subsequent day. The procedure for placing food in the pen and measuring the amount of feed consumed was identical to the pretreatment period.

Intake from the two-choice tests were used to calculate preference scores by dividing intake of treated milo by total intake (treatment + control). A preference score of 0.5 indicates indifference; > 0.5 indicates preference for the treatment; < 0.5 indicates preference for the control. For analysis of variance (ANOVA), the test response was created by subtracting the preference score from 0.5. Thus, a test response of 0 similarly corresponds to indifference while also lending itself for simple statistical tests of significance. For each species, a three-way mixed-model ANOVA was conducted with day, period, treatment, and all two- and three-way interactions the fixed effects (proc Mixed, SAS® Version 8.0, SAS institute Inc., Cary, N.C.). The random effects were subject, subject*treatment, subject*period, subject* day, subject*treatment*day, and subject* treatment*period. Residuals from the model resulting from the test response were examined for distribution and constant variance by examining residual plots.

Pen Trials for White-tailed Deer

Ten white-tailed deer were used in a two-choice pen trial. Deer were placed in stalls measuring 2.5 X 5 m prior to the test. A pretreatment period of two weeks was used to acclimate deer to the stalls and to determine if they consumed milo was acceptable. Deer were given free access to water and were released from their test pens everyday after four hours. Deer were also given free access to deer feed when not involved in trials. After the pretreatment period, a four-day two-choice treatment period occurred. Deer were randomly assigned a repellent the first day, and treatments were randomly assigned to one side of the pen on the first day. The treatment dish position was altered on subsequent days. Deer received each milo treatment (150 g) for two consecutive days along with 150 g of control. Milo was treated with repellents in the same manner as described for the bird pen tests. Preference scores were examined as previously described for the quail and pheasant trials.

Field Trials

Field trials were conducted on the 44,500 hectare, Fort Riley Military Installation in flint hills region of northeast Kansas. The native vegetation of the flint hills has remained largely intact and the region is one of the largest tallgrass prairies remaining in the world. The dominant grasses include big bluestem *(Andropogon gerardi),* little bluestem *(Andropogon scoparius),* Indian grass *(Sorghastrum nutans),* and switch grass *(Panicum capillare)*. The drainages in the flint hills support woody vegetation ranging from brushy habitats of buckbrush *(Symphoricarpos orbiculatus),* smooth sumac *(Rhus glabra),* and roughleaf dogwood *(Cornus drummondi*), and other shrubs, to mature woodlands consisting of species such as bur oak *(Quercus macrocarpa),* hackberry *(Carya cordiformis),* black walnut *(Juglans nigra),* green ash *(Fraxinus pennsylvanica),* and American elm *(Ulmus americana)* (Richardson et al. 1995).

Six food plots were chosen to test the effectiveness of the repellents on grain sorghum. Repellent applications (Plantskyd and Liquid fence) were randomly assigned to food plots (three received Plantskydd, three received Liquid fence). The six control plots were located from 20 meters to 1 kilometer from the treatment plots. Control plots were located in the same general habitat type and where deer densities were believed to be similar to areas with their corresponding treatment plots. The cost to treat entire food plots was prohibitive, so the efficacy of treating a six-row perimeter of the treated plots was assessed. Repellent applications began in early September 2001 just prior to the usual start of deer damage. The repellents were applied to the seed heads of plants in the first six rows (rows were spaced 75 cm apart) on the perimeter of each treated field using a 3-gallon backpack sprayer. In accordance to manufacturer's label, Plantskydd was only applied once. Liquid fence was applied at one-month intervals for a total of three applications during the field test.

Crop damage was measured at each plot at the end of the 12-week test period. The six-row treated perimeter was divided into 10 equally spaced segments. Seed heads were evaluated in a 0.5 m x 2 m sample area at the center of each designated segment. The numbers of damaged and undamaged seed heads were recorded for each sample area. Every seed head in each sample area was also collected and weighed. This procedure was repeated to include 10 equally spaced segments at another sample area located 12 m inside the field's perimeter to assess seed head damage on the interior (untreated area) of the plot. Data were normalized using a square root transformation. A two-way ANOVA, with treatment and location as factors, was used to test for difference between the repellents.

RESULTS

Pen Trials for Pheasants and Quail

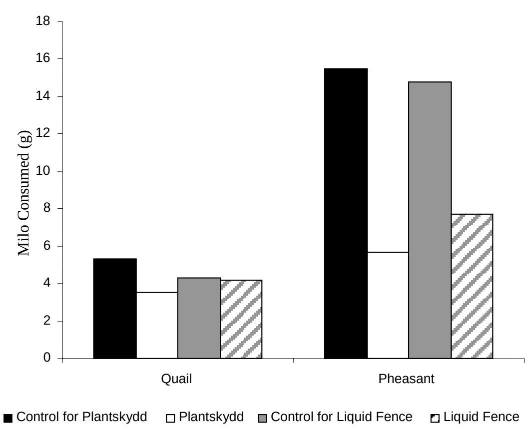

Figure 1. Milo consumed by ring-necked pheasants and bobwhite quail during a two-choice test.

For quail, treatment was the only significant fixed effect (P = 0.0117), indicating that test responses (and therefore preference scores) of the two treatments differed. Tests of the null hypotheses indicated that quail response to the Liquid Fence treatment was indifference (P = 0.9119) while Plantskydd was avoided versus the control (P = 0.0008).

For pheasants, there were no significant fixed effects. This indicates no difference between treatments (P = 0.1843). Further examination of the test responses indicated that both Liquid Fence (P < 0.0001) and Plantskydd (P < 0.0001) were avoided versus the control (Table 1). Inspection of the residuals plots obtained from both models demonstrated that residuals were normally distributed and exhibited constant variance.

Table 1. Preference scores for treated milo from two-choice pen trials for three species.

Preference Scores	Plantskydd	Liquid Fence
Quail	0.3807	0.4967
Pheasant	0.2483	0.3161
Deer	0.0535	0.1758

Pen Trials for White-tailed Deer

During the pretreatment period deer readily ate the red milo. Milo treated with Liquid Fence was consumed on average of 40.4 ± 63.8 *SD* g/animal where as only an average of 15.5 ± 46.0 g/animal of Plantskydd-treated milo were consumed. The average amount consumed for Plantsykdd would be considerably less (0.69 g /animal) if one animal were removed from the analysis. This buck ate all the milo, treated and untreated, each day accounting for the majority of the individual deer variation we observed. Treatment was the only fixed effect slightly significant (P = 0.05) indicating preference scores of the two treatments differed. Examination of the test responses indicated that both Plantskydd (P < 0.0001) and Liquid Fence (P = 0.0001) were avoided versus the control. Residuals were normally distributed and exhibited constant variance.

Field Trials

We found no difference in seed head damaged between control plots and plots treated with Liquid Fence or those with Plantskydd ($F_{7,23}$ = 0.88, P = 0.54; Fig.2). Location of the damage, border versus interior, did not factor into the model (P = 0.20). The average amount of damaged seed heads on the border plots treated with Liquid Fence appears to be less; however, this can be attributed to one individual plot where damage was significantly reduced. Several factors might account for this difference including the availability of herbivores in the area and production of the plot. Compared to the other plots, this plot had a greater amount of available seed heads.

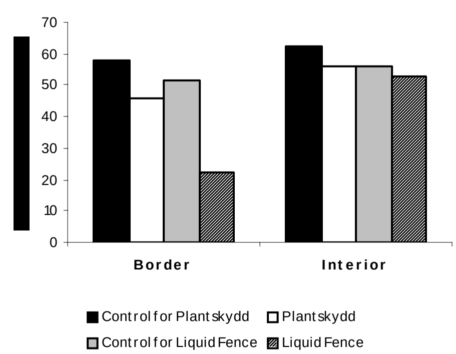

Figure 2. Impact of repellent treatments on deer damage to milo at Fort Riley Military Installation, Kansas.

DISCUSSION

The benefits of food plots on Fort Riley for bobwhite quail have been previously reported (Robel et al. 1974; Robel and Kemp 1977; Madison and Robel 2001). Food plots for pheasants (Ellis et al. 1969; Peoples et al. 1994; Bogenschutz et al. 1995) are also thought to enhance over-winter survival and increase reproductive success (Shuman et al. 1988). Some argue that starvation rarely causes severe winter loss in ring-necked pheasants (Gates and Hale 1974); however, pheasants may benefit from food plots by the herbaceous cover they provide. During the winter, pheasants increase their exposure to predators because they travel greater distances and spend more time foraging (Gatti et al. 1989). Food plots also provide a dependable winter food source for white-tailed deer, and food resources on the small plots planted on Fort Riley may be depleted sooner by the additional foraging pressure. Deer tend to eat the sorghum when it starts to ripen in September and continue feeding on it through November and December. In the presence of a high white-tailed deer population, therefore, the benefits of food plots to game birds may not be available when severe winter weather begins. Protection of these food plots as a source for late winter forage for game birds is important. Several factors affect the success of protecting food plots: 1) density of the animal inflicting the problem; 2) prior experience of animal with the food; 3) mobility of the animal; 4) availability of alternative food; 5) accessibility of alternative sites; 6) weather; 7) palatability of treated food relative to alternative food (Dolbeer et al. 1994; Mason 1997; Nolte 1999; Nolte and Wagner 2000). Deer density on Fort Riley is high and the population mobility and prior experience has shown that food plots are a readily accessible food source in winter. If winters are severe, then alternative food choices may be reduced. To therefore effectively protect food plots, the idea of reducing palatability by treating the food must be exploited.

Chemical repellents are an alternative, non-lethal management tool, which may prevent deer from depleting the food plots, or at least delay foraging until late winter, and may give the game birds time to benefit from the food plot production. Repellents that are applied directly to foods with the aim of reducing consumption are most effective (Mason 1998). Products containing egg or other animal proteins decreased observed seedling damage, with products containing decaying animal proteins showing the greatest efficacy (Lewison et al. 1995; Wagner and Nolte 2001). Plantskydd was found effective at reducing deer damage in western red cedar (*Thuja plicata*) (Bergguist and Orlander 1996; Nolte 1998; Wagner and Nolte 2001).

When given a choice, both bobwhite quails and pheasants avoided Plantskydd, and to a lesser extent, Liquid Fence. Most of the pen-fed white-tailed deer avoided the Plantskydd treated milo in favor of the untreated milo. More Liquid Fence treated-milo was consumed than the Plantskydd, but it was still not preferred over the control milo. Neither product was shown to reduce deer damage in the field. Damage in the interior of the plots was similar to the border which suggests that a six-row perimeter was not a large enough deterrent. Milo treated with both repellents was offered 24 hr after application in the pen trials, which may account for the stronger avoidance response observed. Although we followed the manufacture's recommended treatment, it is likely that sampling three months after application negated any early benefits we might have observed.

Damage to food plots usually occurs from September through December as the milo ripens. Successful protection of the food plots during this narrow window may offer some reprieve to game bids during the latter winter. Although both the pen trials and the field test showed that deer ate treated milo, milo treated more frequently (as in the pen trails) was avoided and untreated milo preferred. In order to obtain this level of repellent concentration, repellents would have to be applied more frequently than recommended, which could be cost prohibitive. Even with heavier application, deer damage may still occur due to individual deer preference, population pressure, and availability of alternative food sources. Alternative methods for protecting food plots, such as netting fence, are likely to be a better and more cost-effective method. In addition, this temporary enclosure does not require as strong or durable of support as needed for conventional fencing (Nolte 1999). Netting, at least 1.4 m high, with spaces of approximately 15 cm, would allow birds to travel unimpeded, but would deter deer movements. To prevent birds from flying into the netting, ribbon can be tied at regular intervals. Small enclosures around several 1 ha plots, would not impede military maneuvers, and would allow for protection of a few food plots for the benefit of upland game birds on Fort Riley.

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