KEY WORDS
seed predation, seed damage, nursery seedlings, oak, *Quercus alba* L.

NOMENCLATURE
USDA NRCS (2004)

ABSTRACT

A combination of cover crops and straw mulch effectively protect fall-sown hardwood seeds from cold temperature damage and predation at our nursery in central Indiana. Before using this treatment, we experienced 30% to 90% crop losses on a regular basis, but now our seedbed densities are consistently at target and the resulting seedlings are larger. Specialized equipment facilitates the task and paid for itself through increased crop revenues in just 1 y.

Figure 1. Supply of large round bales of wheat straw covered with plastic sleeves.
Photos by Jeanie Redicker, Vallonia Nursery

Fall-sown seeds of many tree and shrub species are susceptible to damage from cold temperatures that regularly occur in fall and winter, and to wildlife predation. Before we began using straw as mulch at Vallonia Nursery in Indiana, significant losses of 30% to 90% of the fall-sown white oak (*Quercus alba* L. [Fagaceae]) seeds occurred almost every other year. At Vallonia, we sow about 6.1 to 7.3 ha (15 to 18 ac) per year at an average cost of US$ 1200 to 2400 per ha (US$ 3000 to 6000/ac), so these losses were substantial. Cold temperatures were one reason for seed loss. Cold temperatures would kill a section of the root beginning just below the seed and extending for 2.5 to 5 cm (1 to 2 in). However, the shoot and cotyledons and the lower 10 to 25 cm (4 to 10 in) of root would appear healthy and remain alive. Death of a major part of the root at this stage of growth greatly reduced viability as measured by no emergence of a viable shoot in spring. The damage occurred as early as mid-November during sudden cold fronts when temperatures dropped in association with strong winds. We have observed that a low temperature of –9 °C (16 °F) following a normal, mild fall will damage white oak seeds in unprotected nursery seedbeds, whereas unprotected seeds of other hardwood species can be injured by a winter temperature of –18 °C (0 °F). Species susceptible to cold injury when fall planted at Vallonia Nursery are listed in Table 1.

A second reason for seed loss at Vallonia was predation. Almost all species of *Carya* Nutt. [Juglandaceae], *Corylus* L. [Betulaceae], *Juglans* L. [Juglandaceae], and *Quercus* L. [Fagaceae] are highly desirable as a food source for wildlife, and most of these species are fall-sown at our nursery. Deer typically cause the most damage, but other wildlife species such as blue jays, crows, and squirrels can cause serious damage during a winter when soil is not frozen. Hunting wildlife can help prevent seed predation in some situations, however, regulations, safety, and negative public and employee relations make hunting impractical in tree nurseries in Indiana. Most deer damage occurs at night when

STRAW MULCH PREVENTS LOSS OF FALL-SOWN SEEDS TO COLD TEMPERATURES AND WILDLIFE PREDATION

| Jim Wichman, Robert Hawkins, and Paula M Pijut

hunting is not permitted. Propane cannons and other scare devices can be a deterrent for some species of wildlife, but many species quickly acclimate to these scare tactics, and landowners adjacent to the nursery may object to their use.

Despite establishment of a very dense cover crop of wheat or rye during the fall, we would still lose seed crops once every 3 y. Small herds of deer would locate areas where seeds were unprotected and dig up large areas of seedbeds at night. Predation by deer does not seem to be related to location of the seedbeds and adjacent woods. We thought that straw seemed to be a material that could mimic conditions in the woods where seeds would drop to the ground and then be covered by leaves. In a preliminary study, in which we applied straw over the seedbed by hand, we observed that deer did not dig up the white oak seeds. From then on we began mulching all seeds subject to deer predation even though some species were not damaged by cold winter temperatures.

HOW WE USE MULCH

We evaluated the use of straw mulch to reduce damage to seed from cold temperatures, loss of seed to wildlife predation, and to delay emergence in early spring when frost is likely to occur. Wheat straw (Figure 1) was used because it is readily available in most years and fairly free of weed seed. Wheat crops in Indiana are sprayed with Harmony® herbicide (thifensulfuron) to control wild onion, wild garlic, and broadleaf weeds. Straw from other small grains, such as rye, should also work. We do not recommend hay because it is more likely to carry weed seeds, and we think it may be difficult to remove by burning.

We cover fall-sown tree seeds with 1.3 cm (0.5 in) of soil. Our experience indicates that shallowly sown seeds are less prone to cold injury because they are better acclimated to cold temperatures through exposure, and they will emerge earlier in the spring, producing larger seedlings. More deeply sown seeds are less acclimated to cold and can be damaged by a sudden drop in temperature. We sow a cover crop of rye or wheat seeds along with the tree seeds (Figure 2), or immediately thereafter, at a rate of 126 to 135 kg/ha (112 to 120 lb/ac). These cover crops germinate quickly, provide an anchor to hold straw mulch from being blown away by wind or washed away by rain (Figure 3), and form a dense root mass that deters squirrels and other wildlife from digging up seeds (Hawkins 2004).

We recommend that straw mulch be applied within 2 d after seeding beds so that wildlife does not have a chance to determine where seeds have been sown. Apply 10 to 15 cm (4 to 6 in) of loose straw to beds seeded with species from Groups 1 and 2 (Table 1). Apply 5 to 10 cm (2 to 4 in) of loose straw to beds seeded with species from Group 3 (Table 1). Hand application of straw mulch is labor intensive, requiring approximately 20 h of labor to cover 0.4 ha (1 ac). A bale shredder can reduce the need for hand labor by 80% to 100%. Alternatively, a bale unroller will roll out straw from a round bale, but the thickness of the straw is variable and addi-

Figure 2. Sowing oak acorns from large hopper on the front of the planter and wheat seeds from small hopper on the back. (Planter built by Jack Seifert and crew.)

Figure 3. Appearance of straw mulch beds in early winter.

Figure 4. Removing straw from seedbeds in early spring. Fire quickly removes the straw to allow uniform emergence of seedlings.

TABLE 1

Hardwood seed species susceptible to cold injury when fall planted at Vallonia Nursery [z].

Susceptibility	Species
GROUP 1: VERY SUSCEPTIBLE	
	Eastern chinkapin, *Castanea pumila* (L.) P. Mill. (Fagaceae)
	White oak, *Quercus alba* L. (Fagaceae)
	Swamp chestnut oak, *Q. michauxii* Nutt. (Fagaceae)
	Chinkapin oak, *Q. muehlenbergii* Engelm. (Fagaceae)
GROUP 2: MODERATELY SUSCEPTIBLE	
	Pawpaw, *Asimina triloba* L. Dunal. (Annonaceae)
	Hickory spp., *Carya* Nutt. (Juglandaceae)
	Pecan, *C. illinoinensis* Wangenh. K. Koch (Juglandaceae)
	Hazelnut spp., *Corylus* L. (Betulaceae)
	Black walnut, *Juglans nigra* L. (Juglandaceae)
	Sawtooth oak, *Q. acutissima* Carr. (Fagaceae)
	Swamp white oak, *Q. bicolor* Willd. (Fagaceae)
	Overcup oak, *Q. lyrata* Walt. (Fagaceae)
	Bur oak, *Q. macrocarpa* Michx. (Fagaceae)
GROUP 3: GENERALLY NOT SUSCEPTIBLE	
	Scarlet oak, *Q. coccinea* Muenchh. (Fagaceae)
	Pin oak, *Q. palustris* Muenchh. (Fagaceae)
	Red oak, *Q. rubra* L. (Fagaceae)
	Black oak, *Q. velutina* Lam. (Fagaceae)

[z] Personal observations at Vallonia Nursery

tional hand spreading will be required. Do not shred the straw too finely, as with a drum grinder, as strong winds will blow straw off seedbeds.

We apply herbicide (glyphosate or paraquat) in late winter (February in Indiana) to desiccate the wheat or rye crop. Apply herbicide early as it takes longer for the product to work at winter temperatures. Removal of straw mulch is normally needed to prevent significant delays in seedling emergence. We burn the straw (Figure 4) 1 wk prior to seedling emergence (March to April in Indiana). If the winter has been wet, burning the nursery seedbeds a second time may be required. The first fire removes the dry top layer allowing the lower layers to dry out. If clumps of unburned straw remain, we use a Bush Hog® (http://bushhog.com) to break up the clumps, allowing burning to take place more readily.

Removing straw mulch with fire has several advantages: 1) very little labor is required; 2) it can be accomplished quickly; 3) weeds and weed seeds will be killed; and 4) seeds are not damaged by the heat. Caution, however, should be taken when using fire for straw removal. Avoid days when wind will carry smoke toward highways or occupied buildings, or possibly spread fire to adjacent areas. Having an irrigation system installed in the field is always a good safety precaution. Notify local fire officials so they can respond to neighbors who may report a fire. Other alternative methods of straw mulch removal, such as hand removal or a straw baler, may be available, but these would likely be more labor intensive or could damage seedlings that are ready to emerge.

COSTS AND BENEFITS

The cost of using straw mulch can vary, depending mostly on the application depth. We figure our costs associated with cover crops and straw mulch to be US$ 7270 and for burning to be $350 for a total cost of $7620. Using 1.7 x 1.7 m (5.5 x 5.5 ft) round bales, we need 17.5 bales/ha (7/ac) to cover seedbeds (containing Group 3 seeds: Table 1) to a depth of 5 to 10 cm (2 to 4 in). For Group 1 and 2 seeds (Table 1), we need 37.5 bales/ha (15/ac) to cover seeds with 10 to 15 cm (4 to 6 in) of straw. A round bale is equivalent to about 20 standard bales (51 x 51 x 102 cm [20 x 20 x 40 in]). In Indiana a 5.5 x 5.5 ft bale costs approximately US$ 26. When space is available, we grow wheat as a crop on nursery property. The crop of grain is exchanged with a local farmer for harvesting the grain and baling the straw. This greatly reduces the cost of straw. Therefore, the cost per acre can vary from US$ 0 to $390. The cost of the equipment (Figure 5) that will load, shred, and spread large, round bales of straw is about US$ 9000 (Haybuster®, Duratech Industries, Jamestown, ND, http://www.haybuster.com).

We spend approximately US$ 80,000 to $90,000 on seeds that we use in this system at Vallonia Nursery. The revenue generated from the sale of shippable seedlings more than covers the cost on each individual species that we protect annually. The expense of using straw mulch to reduce cold damage, prevent wildlife predation, and delay spring emergence when frost is likely to occur, quickly pays for itself many times over in a single year (Figure 6). Larger seedlings and higher seedbed densities were also achieved when nursery seedbeds were mulched with straw immediately after seeds were planted in fall. This method works very well for us; it might work well for other tree nurseries, too.

REFERENCES

Hawkins B. 2004. Use of living mulches to protect fall-sown crops. Native Plants Journal 5:171–172.

[USDA NRCS] USDA Natural Resources Conservation Service. 2004. The PLANTS database, version 3.5. URL: http://plants.usda.gov (accessed 06 Jul 2005). Baton Rouge (LA): National Plant Data Center.

AUTHOR INFORMATION

Jim Wichman
Nursery Supervisor
jwichman@dnr.state.in.us

Robert Hawkins
Nurseryman
bhawkins@dnr.state.in.us

Indiana Department of Natural Resources, Division of Forestry
Vallonia Nursery
2782 W Co. Rd.
Vallonia, IN 47281

Paula M Pijut
Research Plant Physiologist
USDA Forest Service, North Central Research Station
Hardwood Tree Improvement and Regeneration Center
Purdue University, Department of Forestry and Natural Resources
715 West State Street
West Lafayette, IN 47907
ppijut@fs.fed.us

Figure 5. The equipment used to load, shred, and spread large, round bales of straw.

Figure 6. Chinkapin oak seedlings in June that were not mulched with straw when the seed was planted the previous fall (top). This seedbed is typical of those we had in 50% of the years before we began using the straw mulch. Compare that to the same seed source planted the same time but mulched (bottom).