JUNCUS DIRECT SEEDING METHOD EVALUATION, 2006-2008
STUDY NUMBER: IDPMC-T-0604-WE
2007 PROGRESS REPORT
Derek J. Tilley, Range Conservationist (Plants)
December 19, 2007

Introduction

Direct seeding of wetland species for wetland creation and restoration has certain inherent difficulties. Traditional broadcasting and drill seeding attempts are mostly unsuccessful. Small scale direct seeding experiments evaluating other techniques have indicated however, that there may be methods available that could produce much better establishment of wetland species.

Because seed from many wetland species are buoyant and also require light for germination, broadcast seeding has provided poor results because seed tends to wash away from the seeded area after flooding. Test results have shown that following a broadcast seeding with a packer or imprinter can improve the number of seeds held in place and allow for better onsite germination. However, it can be problematic trying to use small seeded species in conventional seeding equipment. Although seed from some wetland species are extremely small, over 90 million seeds/pound in the case of Baltic rush, inert carriers such as rice hulls can be used to increase the volume of seeded material and facilitate uniform distribution of seed from a drill or broadcast spreader (St. John and others 2005).

Hydroseed mulches can similarly act as an inert carrier in liquid form, much like rice hulls used for dryland plantings. The mulch keeps seed in suspension for more uniform dispersal and also provides structure allowing seed and tackifier to more readily attach to the soil surface. Greenhouse test results have shown that the tackifier used in hydroseeding can effectively glue the seed to the soil surface and prevents seed from washing off site (Tilley and Hoag 2006).

Another relatively new option for seeding wetlands is Submerseed™ from Aquablok Industries (Toledo, Ohio). This technology involves binding seeds with clay or clay-sized material and organic polymers to a dense aggregate core. These aggregates sink, preventing seed from floating to the surface and the clay absorbs water providing a suitable germination medium for the seed (Aquablok 2007).

Trade names are used solely to provide information. Mention of a trade name does not constitute a guarantee of the product by the U.S. Department of Agriculture nor does it imply endorsement by the Department or the Natural Resources Conservation Service over comparable products that are not named.

This project was designed in incremental steps for ease of evaluation and development of seeding rates. The first experiment (trial 1) was conducted in the Aberdeen PMC greenhouse during the summer of 2006. Trial 1 compared seedling establishment from four hydroseed mulches and four dry, inert carriers. The second trial took place in 2007 with the most promising performers from trial 1 and compared each against Submerseed pellets in a controlled outdoor seeding in 4’ X 8’ tanks. Each of these studies is a precursor to field testing the best methods of direct seeding into the PMC wetland ponds. Due to volunteer wetland seed contamination, the ponds were chemically treated in 2006 and in 2007 to ensure a clean, weed-free seed bed for use in seeding evaluations that will take place in 2008.

The goal of this project is to find the techniques that are most efficient, cost effective and successful for seeding common wetland species. Baltic rush (*Juncus balticus*) was chosen for this study because the seed exemplifies the problems faced in direct seeding wetlands, i.e. very small seed that float and seed that requires surface planting to allow adequate light for seed germination. The results obtained from theses studies will be used to develop seeding rates for use with those methods that will provide adequate establishment for wetland revegetation.

Trial 1: GH evaluation of hydroseed mulches and inert broadcast carriers

Materials and Methods

Because tackifier is designed to be used to hold grass, forb and shrub seed to dry soils and critical slopes it was unknown if the glues could withstand sustained flooding and if so, at what rate tackifier should be applied for use in wetland seedings. “Turbo Tack” tackifier from Turbo Technologies Inc. was tested at 1x, 5x and 10x the recommended rate of tackifier with 100 seeds on Petri dish blotters by mixing seeds and tackifier in water and pouring it out onto saturated blotters. Each treatment contained six replications. The blotters and tackifier were allowed to dry overnight, and the blotters were then put under slowly running water from a faucet to wash away any loose seed. Essentially no seed washout was observed, and no significant differences of seed washout were detected between treatments (data not shown). Because a larger amount of tackifier was easier to work with, a 5x rate of tackifier was used for trial 1.

Trial 1 was initiated on April 17, 2006 and was concluded on May 8, 2006. Eight seeding techniques were evaluated; four dry methods including no carrier, rice hulls, shop dry and sand, and four wet or hydroseeding methods including tackifier (tackifier alone with seed and water), Fertil Fibers™ Nutrimulch, straw mulch and wood mulch. Fertil Fibers is a seedmeal-based, protein-rich organic fiber nutrient source designed to deliver a long-term biological release of 6-4-1 N-P-K.

Three replications of each treatment were seeded in 12” X 18” (1.5 ft^2) greenhouse trays filled with a 1:1:1 mixture of peat, sand and perlite. Trays were placed randomly in a 4’ X 8’ X 1’ artificial wetland tank in the PMC greenhouse (figure 1). Mulch was applied at the recommended rate of 2000 lb/ac or 31.5g/tray (McClure, 2006). Tackifier was applied in all wet treatments at 5X the recommended rate (0.25g/tray) which equates to 16.25 lb/ac. The seed used for this trial was Sterling Selection of Baltic rush with a PLS of 89.1%. To more easily handle the very small amount of seed necessary, it was decided to use a very high seeding rate of 500 PLS/ft^2 (0.055g/tray). Hydroseeding applications were simulated by mixing seed, water, mulch and tackifier into a 2 liter kitchen measuring pitcher. The slurry was mixed and agitated for several minutes allowing tackifier crystals to dissolve and a uniform suspension to be made. The hydroseed slurry was then poured over the soil as evenly as possible. Any large clumps of mulch were smoothed out

Figure 1. Treatments in greenhouse trays prior to flooding.

with a spoon. Hydroseed treatments were applied on April 17 and allowed to dry overnight to allow the tackifier to set.

The dry treatments were initiated on April 18, so that all treatments could be flooded at the same time. Seed rates for the dry treatments were the same as those for the hydroseed treatments. Seed was mixed with approximately 1 tablespoon of inert carrier (2.0 g rice hulls, 10 g shop dry and 22 g sand). Inert carriers and seed were mixed in a small tray and spread as evenly as possible by hand over the soil. The no-carrier treatment was sprinkled by hand. Following broadcasting, the dry treatments were pressed into the soil with an imprinting jig designed to simulate a packer wheel.

The wetland tank was flooded on April 18 to a depth of approximately 2 inches above the top of the soil and water was allowed to spill over the edge of the wetland tank. The overflowing water caused any floating seed, mulch or inert material to be swept over the edge of the tank. This insured that no seed was spread to any other tray in the trial. All treatments were totally submerged for 15 minutes. After the first flooding, the water levels were dropped below the bottoms of the trays so the soil could dry slowly and optimum germination conditions could be met. Seventeen days after planting, on May 4, after the plants had a chance to establish and the soil was beginning to dry, the tanks were flooded again, this time for 24 hours, to test if established plants would wash out. Greenhouse temperatures ranged from 75 to 100º F for the length of the trial.

Seedling emergence was evaluated on May 1 (14 days after planting), and again on May 8 (21 days after planting) following the second flooding (figure 2). Four 2” X 12” strips running the 12” length of each tray were evaluated for seedling emergence. Germinants in each strip were totaled and added together to avoid pseudo replication. This total was then divided by 750 expected germinants based on 500 PLS/ft² or 750 PLS/tray.

Results

There were significant differences in establishment between treatments (table 1) There appeared to be a lot of seed washing out from the dry broadcast treatments, significantly more than from Fertil Fibers and tackifier treatments. Straw and wood mulch appear to be too thick and may be covering *Juncus* seeds and prohibiting germination. A lighter mixture of straw or wood may be as effective as Fertil Fibers or tackifier. It would be inaccurate to assume at this point that straw and wood mulches don’t work, only that they don’t work at the tested rates. Fertil Fibers appear to be a thin enough slurry to not cover seeds, and it also works as an effective inert carrier to disperse seed and hold it to the soil. Results from Fertile Fibers and tackifier alone seem promising enough to try these methods in the outdoor trial with a lower seeding rate as opposed to 500 PLS/ft. This would more closely be comparable seeding rate to be used with Submerseed pellets and is a more realistic rate for field applications.

Figure 2. Seedling emergence at time of evaluation.

Table 1. Seedling Germination

Treatment	5/1 (after 1 flood) Plants/ft²	5/8 (after 2 floods) Plants/ft²
No carrier	44 c	50 b
Rice hulls	67 c	71 b
Shop dry	52 c	55 b
Sand	45 c	48 b
Fertil Fibers	311 a	300 a
Straw	74 c	100 b
Wood	31 c	42 b
Tackifier	211 b	206 a

Results were similar after the second flood treatment except seedling emergence in the Fertil Fibers treatment was not significantly different from the tackifier treatment. No significant gains or losses in number of seedlings were detected between the first and second flooding treatments (data not shown). This indicates that once plants are up and have initiated some root growth into the soil they are very unlikely to be washed out by low energy flooding.

Trial 2- Outdoor trial of best performers (2007)

Trial 2 was designed to be a bridging step between greenhouse scale trials and large scale field experiments. The experimental design incorporates a high degree of water control and eliminates the concern of volunteer wetland plant germination. Conducting this trial outdoors also allowed natural drying and temperature conditions to occur, which may influence germination and survival. This experiment compares establishment abilities of the best hydroseed cariers (Fertil Fibers™ nutrimulch+ tackifier and Tackifier alone) and broadcast carriers (rice hulls) from trial 1 and Submerseed™ technology, which was evaluated in earlier trials at the PMC (Tilley and Hoag 2006).

Materials and Methods

Four treatments were planted in five 4’ X 8’ wetland tanks placed outside at the PMC farm. Each tank was divided into four 2’ X 4’ plots, one plot per treatment (figure 3). Each tank thus represented one of five blocks or replications. Because the plot size is small, seeding with a broadcaster or hydroseeder was unfeasible; therefore seeding was completed by hand in a manner similar to that described for trial 1. However, seeding rates were adjusted to rates much closer to those recommended for large area plantings, in this case 350 PLS/ft². Germination rates should, therefore, more accurately reflect those that might be observed in field plantings (table 2). Hydroseed mulch (Fertil Fibers) was applied at 2,000 lb/ac, with 600 gallons of water/60 lb mulch. Tackifier was applied at 5x the recommended rate (recommended=3lb/ac). An 8 ft soaker hose was placed on the long edge of each tank for irrigation. The wetland tanks were oriented to have a slight downward slope opposite the soaker hose to allow directional

Figure 3. Wetland tank divided into 2X4’ plots for treatments.

water flow. All plots were planted on July 9, 2007. After planting, plots were allowed to dry for 2 hours for tackifier glues to set before flooding. Tanks were then flooded and allowed to spill over the shallow side for 15 minutes letting loose seed, rice hulls and other debris to wash over the edge and out of the tank. Excess water was then siphoned off to drop water levels to just cover the seed and soil. The tanks were irrigated regularly (approximately once per week) to maintain moist soil conditions for germination and establishment.

Table 2. Rates

	Rate/ft	Rate/ac
Submerseed	20 pellets (100-200 PLS)	2,000 lb
Fertil Fibers Mulch	20.8 g	2,000 lb
Tackifier	1.25 g	15 lb
Seed	350 PLS (0.0075g)	15,246,000 PLS (0.72lb)
Water (hydroseeding)	2.3 L	3,3000 gal
Rice hulls	1.35 g	130 lb

Plots were evaluated on Aug 20 (42 days after planting). Plant counts were made using a 100 cm X 25 cm" wire grid which was divided into five 25 cm X 20 cm cells. Plants were counted in the first, third and fifth cells and added together for a total number of plants per 1500 cm² and then converted to plants per ft². Because the broadcast and hydroseed treatments were seeded at a higher rate than Submerseed (350 PLS/ft versus 100 to 200 PLS/ft) data were also transformed to compare establishment based on a standard seeding rate (100 PLS/ft). Results were also compared to those data obtained from the 2006 greenhouse seeding study as well as the Submerseed establishment data from Tilley and Hoag (2006). Data were analyzed using Statistix 8 Analytical software and subjected to an analysis of variance with a significance level of $p<0.05$. Means were separated using a Tukey HSD all pairwise comparison.

Results

At planting, globs of tackifier were visible in the tackifier alone and Fertil Fibers plots, presumably due to inadequate mixing prior to planting. When the plots were flooded, rice hulls, Fertil Fiber mulch and some seed were observed washing off of the plots and out of the tank (figure 4).

Figure 4. Loose Fertil Fibers (l) and rice hulls (r) washing off of the plots.

Table 3. Establishment in 2007 outdoor trial.

	Plants/ft² @ seeded rate	Plants/ft² adjusted for 100 PLS/ft²	2006 GH means adjusted for 100 PLS/ft²
Fertil Fibers	42 a	18 a	60
Broadcast (rice hulls)	25 ab	10 ab	14
Tackifier alone	21 bc	9 ab	41
Submerseed	6 c	6 b	66 (Tilley & Hoag 2006)
Critical value (0.05)	18	10	na


Figure 5. Establishment in 2007 outdoor trial.

Fertil Fibers had significantly better emergence than tackifier alone and Submerseed at the seeded rate (p=0.001). At the adjusted seeding rate of 100 PLS/ft, Fertil Fibers had significantly better establishment than the Submerseed treatment (p=0.027).

Much lower emergence was achieved in outdoor conditions versus the greenhouse trial when compared at 100 PLS/ft² (table 3). Submerseed had 10 times better germination under greenhouse conditions than outdoors. Submerseed pellets appear to perform better in high moisture environments and may be better suited for use in broadcasting into shallow water instead of submitting it to numerous wet-dry cycles.

Discussion

Using data from these trials and industry costs, a price breakdown was created comparing five available methods of wetland planting: broadcast seeding with rice hulls as an inert dry carrier, hydroseeding with Fertil Fibers, hydroseeding using only tackifier, Submerseed pellets, and using greenhouse grown plugs (table 4). All costs are based on seeding 100 PLS/ft² (0.2 lb PLS/ac) or planting plugs at 18" spacing. A seeding rate of 0.2 to 1.0 lb PLS/ac would provide 100 to 430 PLS/ft². For broadcasting with rice hulls as an inert carrier, 9 lbs rice hulls per acre should be used with the drill or broadcaster set to 1 bushel of barley. Estimated seed costs ($150/lb) are an average price obtained from three regional seed suppliers: Ernst Conservation Seed, Pawnee Buttes Seed, and Western Native Seed (all 2006); man-hour costs for collecting seed from a local source could increase costs significantly. Tackifier costs are based on the manufacturer's recommended rate (3lb/ac). Hydroseeding equipment cost is based on a one day hydroseeder rental rate.

Broadcasting seed followed by an imprinter is by far the cheapest method and perhaps the least reliable. However, the trials discussed here show that some seed will stay in place if it is pressed firmly into the soil, but not covered. Broadcasting could be a low-cost option, however risky. Poor establishment of desired species could result in increased weeds or erosion.

Hydroseeding appears to be a viable option for a relatively small cost if the proper hydroseeding equipment is available. Hiring a contractor to perform the hydroseed application could dramatically increase costs. Hydroseeding using only tackifier provided fair establishment, but using mulch with nutrient amendments like Fertil Fibers nearly doubled establishment rates in our tests.

Submerseed pellets worked very well in greenhouse tests, but did not perform well in this outdoor trial. Better results may be obtained under wetter conditions such as broadcasting into standing shallow water. This factor may, ultimately, be extremely beneficial in situations where the hydrology of the wetland cannot be controlled, or where wetlands can not be sufficiently drained for large equipment use. Cost for Submerseed, however, is much higher than broadcasting or hydroseeding which may limit its use in more controlled environments.

Greenhouse grown plugs should be planted at 18” spacing or every 2.25 ft^2 using approximately 25 PLS per conetainer (Hoag 1995). For one acre that amounts to a minimum of 19,360 plants total from approximately 500,000 seeds. Estimated cost for greenhouse plug production including delivery and installation is $2.00 per plant or $38,720/ac (Hoag 2007). Using greenhouse grown plugs has several advantages over direct seeding methods; however contracting a greenhouse to produce plugs may be cost prohibitive. Nearly any species can be grown, including species where seeds require pre-stratification and expected establishment is much greater.

Table 4. Cost/ac @ 0.2lb/ac (100PLS/ft)

COST	Broadcast	Hydroseed (FF)	Hydroseed (tack alone)	SS	GH plugs (18” spacing)
Seed ($150/lb)	$30	$30	$30	$30	$10
shipping	na	$440	na	included	included
Carrier	Rice hulls $ negligible	Fertil fibers $670	na	SS	na
Tackifier	na	$60	$60	na	na
Equipment needed	Spreader Imprinter	Hydroseeder $200	Hydroseeder $200	Spreader, ATV	na
Man-hours@$20/hr	8=$160	8=$160	8=$160	8=$160	included
Total	**$200**	**$1,560**	**$520**	**$1,000-8,000**[a]	**$40,000** (includes installation)[b]

[a] Info from Aquablok 2007.
[b] Estimated cost from private companies.

REFERENCES

Aquablok. 2007. Submerseed Composite Seeding Technology. URL: http://www.aquablokinfo.com/ (accessed 20 Nov, 2007).

Ernst Conservation Seed. 2006. http://www.ernstseed.com/ accessed 11 Apr, 2006).

Hoag JC. 2000. Use of greenhouse propagated wetland plants versus live transplants to vegetate constructed or created wetlands. Aberdeen (ID): USDA Natural Resources Conservation Service Plant Materials Center. Riparian/Wetland Project Information Series 7. 7 p.

Hoag JC. 2007. Personal communication. Aberdeen (ID): USDA-NRCS.

Hull, J. 2007. Personal communication. Toledo (OH):Aqualblok Ltd.

Kiwipower. 2007. http://www.kiwipower.com/QEI_Fertil_Fibers.html. (accessed 21 Nov, 2007).

McClure F. 2006. Personal Communication. Swan Valley (ID): Mountain West Hydroseeding. Owner/operator.

Pawnee Buttes Seed. 2006. http://www.pawneebuttesseed.com/seedlist_wetlands.htm

St. John L., Ogle DG, Tilley DJ, Majerus M, Holzworth L. 2005. Mixing seed with rice hulls. USDA-NRCS, Boise, ID. ID-TN 7. 15p.

Tilley DJ, Hoag JC. 2006. Comparison of methods for seeding Nebraska sedge (*Carex nebrascensis*) and Baltic rush (*Juncus balticus*). Native Plants Journal 7: 95-99.

Western Native Seed. 2006. http://www.westernnativeseed.com/wetland.html