Improving Forage-Legume Stand Establishment With New Seeding Methods

Patrick M. Carr, Glenn B. Martin, Burt A. Melchior

North Dakota State University
Dickinson Research Extension Center

Summary

Alfalfa is the most widely grown forage legume in southwestern North Dakota. Poor stand establishment is a major obstacle to successful production of alfalfa and other forage legumes. The objective of this project was to develop early seeding and tillage reduction strategies that enhance forage legume establishment. Alfalfa, black medic, and yellow-flowered sweetclover were dormant seeded and spring seeded in conventional-tillage (CT), reduced-tillage (RT), and no-tillage (NT) seedbeds in all possible combinations during the 2001-2002 growing season. Most legume seedlings were killed following emergence as a result of a wind storm in late April, and < 2 plants/ft^2 remained for most treatments. The field experiment was abandoned after herbicide applications failed to control weed infestations that developed. A second field experiment was conducted during the 2002-2003 growing season. More than 10 plants/ft^2 resulted from some treatments. Weed infestations developed in black medic and sweetclover plots that could not controlled with herbicide applications without damaging legume plants, and some plants were killed when herbicides were applied. Forage yield was determined for alfalfa but averaged only 0.2 tons/acre because of hot and dry conditions that developed in July. Results of this project failed to demonstrate a consistent advantage for dormant seeding or tillage reduction to improve legume forage establishment compared with conventional methods. A multi-year and multi-location study probably is needed to determine the potential that seeding and tillage strategies have for enhancing forage legume establishment in southwestern North Dakota.

Introduction

The North Dakota Agricultural Statistics Service reported that alfalfa was harvested on 1.45 million acres in 1999, ranking alfalfa as the third most widely grown crop in the state. Only spring wheat (8.7 million acres) and sunflower(1.6 million acres) were harvested from more acres. Total production of hay crops (alfalfa plus other unspecified forages) occurred on almost 3 million acres in 1999.

The value of alfalfa as a cash crop in North Dakota cannot be overstated. Alfalfa generated average net returns of \$42/acre in 1999 on cash-rented land, as reported in the ND Farm and Ranch Business Management (NDFRBM) Annual Report for Region 4 (western ND). By comparison, hard red spring wheat generated average net returns of -\$15/acre, durum spring wheat generated -\$5/acre, and sunflower generated -\$24/acre. Net returns generated by other grain- and seed crops included -\$8/acre for barley and -\$6/acre for canola.

Alfalfa and other forage legumes offer many benefits if incorporated into rotations with wheat and other grain- or seed-crops, but there has been a reluctance to incorporate forage legumes into livestock and crop production systems. The small seed size of most forage legumes necessitates seeding at shallow depths, where the seed is vulnerable to soil water deficits resulting from evaporation (Sheaffer, 1989). Dehydration causes death once seeds germinate and radicle emergence occurs.

Adequate soil water and firm soil are prerequisites for successful germination of seed. Emergence of alfalfa seedlings improved as planting depth and soil compaction increased from 0 to 1 inch because soil water and seed-soil contact increased progressively at greater depths (Triplett and Tesar, 1960). These data suggest that no-tillage (NT) systems may offer advantages compared with conventional till-plant (CT) systems, since soil water is conserved and soil compaction increases when tillage is decreased (Gauer et al., 1982).

Superior establishment of alfalfa occurred in NT compared with CT seedbeds in dry conditions (Allen and Entz, 1994). Yield was unaffected by tillage system, presumably because of compensatory growth by alfalfa plants in the CT treatments. Forage yield was reduced when alfalfa was seeded into heavy wheat residue in NT seedbeds under favorable moisture conditions, possibly because emerged seedlings were shaded by wheat residue. Legumes are less tolerant of shading than grass crops (Kendall and Stringer, 1985), and species must be identified that tolerate shading in heavy residue, NT environments.

Recommended planting dates for forage legumes vary by location but coincide with periods of favorable precipitation and temperature (Van Keuren and Hoveland, 1985). Early spring (mid-to late-April) generally is considered the optimal period for forage legume establishment in North Dakota. However, some legume species may be planted as late as early August in some years, provided that soil water conditions favor rapid germination (Meyer, 1999).

Frost- or dormant-seeding may be an alternative to early spring seeding in North Dakota. This practice (seeding before the soil freezes but late enough so that seed does not germinate) can be advantageous when precipitation prevents timely seeding in early spring. Preliminary data from a 6-yr study suggest that dormant seeding is a risky practice with forage legumes in eastern North Dakota (D. W. Meyer, personal communication, 1999). Alfalfa seeded in early November produced successful stands in only two of six years. Seed germinated in the fall and never emerged in two years, while seed germinated in the spring in two years but was later killed by low temperatures.

The development of polymer seed-coatings which delay the imbibition of water by seed until targeted environmental conditions develop suggests that forage legumes can be dormant-seeded successfully, particularly in no-till environments where surface soil temperature is relatively stable from late-fall through early-spring. Dormant-seeding polymer-coated canola and wheat seed is being studied in North Dakota, but similar research with forage-legume species is not being done. Work is needed to determine if polymer seed coatings improve the ability to dormant-seed forage legumes successfully, particularly when coupled with low-disturbance NT drills.

The objectives of this project were to demonstrate that establishing forage legumes successfully is improved as tillage is reduced, to demonstrate that a polymer seed-coating improves dormant-seeding success of forage legumes, and to determine which of several competing methods produced the greatest establishment success among representatives of annual, biennial, and perennial forage-legume species.

Materials and Methods

The project was funded for the 2000-2001 growing season. However, freezing temperatures and snow occurred earlier than expected so the project was begun in 2001.

Alfalfa (cv. Ladak), black medic (cv. George), and yellow-flowered sweetclover (common seed) were dormant seeded using polymer coated seed on 16 November and on 29 November using bare seed in 2001 into both NT and CT seed beds. These same legumes also were seeded on 12 April and 22 May in 2002. Seeding rates were 73 pure live seed (PLS)/ft^2 for alfalfa, 43 PLS/ft^2 for black medic, and 25 PLS/ft^2 for yellow-flowered sweetclover.

Plots were arranged in a randomized complete block with tillage, seeding date, and legume species in a split split-plot arrangement. Tillage treatments comprised whole plots, seeding dates comprised subplots, and legume species comprised sub-subplots. Tillage whole plots dimensions were 40 × 120 ft. Conventional-tillage treatments were established by discing and leveling plots that were seeded to oats in 2000 and then chem-fallowed in 2001 prior to establishing tillage treatments. Less than 30% residue cover remained in CT plots prior to dormant-seeding. No tillage occurred prior to sowing in NT plots. A JD-750 low-disturbance planter with a grass-seed box was used to seed the legume species both CT and NT plots.

Soil temperature at a 1-in depth was recorded at 6-h intervals from the date of dormant seeding until 30 d after the late-spring seeding date from dormant-seeded polymer-coated treatments in both NT and CT plots in two blocks (Hobo® H8 Pro Series, Onset Computer Corp., Bourne, MA). Legume plant stand was determined by counting emerged legume plants in a 5.4-ft^2 (0.5-m^2) area within each sub-subplot (12 5.4-ft^2 areas within each whole plot) on selected dates after spring warmup. Plant development stage was determined for 10 plants randomly selected at these same times.

A severe weed infestation developed after spring seeded legume treatments were established. A decision was made to terminate the study since the weeds could not be controlled by herbicides without damaging forage legume treatments. A second field study was conducted during the 2002-2003 growing season. Polymer coated seed was dormant seeded on 22 November and bare seed on 2 December in 2002. Legume species also were seeded on 10 April and 14 May in 2003.

An application of Raptor at 5 oz/acre along with Poast at 2 pt/acre on 20 May provided good control of wild oats and some annual broadleaf weeds that had begun to infest legume plots, but poor control of wild buckwheat. After consultation with weed scientists, Buctril was applied at 1.4 pt/acre on 16 June. The Buctril application provided good control of wild buckwheat but damaged black medic and sweetclover plants. A second application of Poast occurred on 2 June to control late emerging grass weeds.

Above-ground dry matter production was determined by harvesting forage in a 80-ft^2 area within each alfalfa sub-subplot with a small-plot forage harvester. A 400-g subsample was dried at 122^{o}F (50^{o}C) until a constant weight and recorded. Forage from black medic and sweetclover sub-subplots was not harvested because of damage to plants from the Buctril herbicide treatment.

Data were analyzed using the GLM procedure from SAS (SAS Institute, 2001). Tillage, establishment methods, and legume cultivars were considered fixed effects, while blocks were considered random. Where *F* tests indicated significant differences between whole plots, subplots, and sub-subplots, means were separated using Fischer's protected LSD at $P < .05$.

Results

Legume seedlings did emerge in 2002 from dormant seeding in 2001. Legume plant numbers appeared greater in early April in NT than CT plots, possibly because the crop residue that remained on the surface buffered soil temperatures compared with soil temperatures in CT plots from late Fall through early Spring (Fig. 1 and 2). However, high winds during 23 and 24 April damaged legume seedlings in many plots by and blasting and also by removing and depositing unattached oat residue from NT plots onto CT plots. Some of the residue that was deposited onto CT plots was several inches thick. Moreover, deposition of the residue was uneven. An attempt to return the crop residue that had been moved by wind from NT to CT plots was only partially successful.

Fewer than 2 plants/ft^2 remained in dormant seeded plots as a result of the wind storm in late April (Table 1). Grass and broadleaf weeds became established in plots partially because of the lack of competition due to low legume plant numbers. The 2001-2002 field experiment was terminated because the low plant numbers and weed infestation indicated that additional data would be too damaged to generate useful information.

Alfalfa plant numbers ranged from around 2 to almost 11 plants/ft^2 in plots of the 2002-2003 field experiment, depending on the treatment (Table 2). Black medic numbers ranged from around 1 to over 3 plants/ft^2 and yellow-flowered sweetclover from around 2 to over 6 plants/ft^2, depending on the combination of tillage and seeding method treatments that were considered.

More legume plants occurred when seeding was delayed until the spring compared with dormant seeding (Table 3). No advantage was detected in plant numbers when polymer coated seed was dormant seeded compared with bare seed. Similarly, differences in plant numbers were not detected whether seeding in early or late spring.

Greater plant numbers occurred for alfalfa than either black medic or yellow-flowered sweetclover (Table 3), which probably reflects the heavier seeding rate that was used for alfalfa compared with the other legume species. However, the seeding rates that were used reflect common practice when seeding legume forage species in southwestern North Dakota and eastern Monana. Differences in plant numbers were not detected between tillage treatments in this field experiment, although there was a trend ($P = 0.06$) for plant numbers to be elevated in no-tillage plots.

Fewer legume plants were established in this field experiment than in similar experiments at the Dickinson Research Extension Center were similar seeding strategies were used, for reasons that are unclear. The relatively low plant counts offered limited competition to grass and broadleaf weeds that invaded many plots, including wild buckwheat. An application of Buctril to control wild buckwheat damaged black medic and yellow-flowered sweetclover plants but prevented infestations from developing in alfalfa plots. Forage was not harvested from black medic and yellow-flowered sweetclover plots and only averaged 0.2 tons dry matter/acre across tillage and seeding method treatments for alfalfa plots (Table 4). The low DM yields produced by alfalfa were consistent with forage yields produced in other studies during 2003 and reflected the hot and dry conditions that developed in July and persisted through August.

Discussion

Results of this project failed to support the hypothesis that dormant seeding may enhance legume establishment in southwestern North Dakota. Less than 4 plants/ft^2 resulted from dormant seeding across tillage and legume species treatments. The few plants that resulted from dormant seeding generally were less competitive with weeds for growth resources than the more numerous plants that were established in the Spring. Moreover, there was no advantage to dormant seeding polymer coated seed compared with bare seed. Dormant seeding seems to be a risky practice for establishing forage legume stands in southwestern North Dakota under conditions similar to those encountered during this study.

Differences in legume plant numbers in CT and NT seedbeds were not detected in this project, although there was a trend for numbers to be elevated in NT seedbeds in one of two years. More plants appeared in NT than CT seedbeds in the other year, but many legume plants were killed from sand blasting and being covered with crop residue because of high winds that occurred in late April. A multi-year and multi-location study may be needed to demonstrate the benefits of reducing tillage on legume stand establishment, since data collected from a short-term study at a single location may be more susceptible damage by unforeseen environmental factors.

Acknowledgments

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Table 1. Means and standard deviations for stand counts on three dates for alfalfa, black medic, and yellow-flowered sweetclover (Sweetclover) using different seeding methods in conventional-tillage and no-tillage seedbeds after oats in 2002.

			03 May		03 June		14 June	
Tillage treatment	Seeding method	Crop	F	SD	F	SD	F	SD
			no./ft^2					
Conventional-tillage	Coated & fall seeded	Alfalfa	1.6	1.5	1.3	0.6	1.0	0.6
Conventional-tillage	Coated & fall seeded	Black medic	0.3	0.3	0.6	0.3	0.5	0.1
Conventional-tillage	Coated & fall seeded	Sweetclover	0.9	0.5	1.4	0.8	2.1	0.9
		F	0.9		1.1		1.2	
Conventional-tillage	Non-coated & fall seeded	Alfalfa	0.6	0.4	0.8	0.3	1.2	0.5
Conventional-tillage	Non-coated & fall seeded	Black medic	0.3	0.2	0.1	0.1	0.6	0.2
Conventional-tillage	Non-coated & fall seeded	Sweetclover	0.5	0.3	0.9	0.3	0.7	0.4
		F	0.5		0.6		0.8	
Conventional-tillage	Early spring seeded	Alfalfa	1.6	1.0	2.6	0.5	1.8	0.4
Conventional-tillage	Early spring seeded	Black medic	2.1	1.0	2.5	0.5	3.9	2.4
Conventional-tillage	Early spring seeded	Sweetclover	3.4	1.9	3.6	0.8	3.5	0.8
		F	2.4		2.9		3.1	
Conventional-tillage	Late spring seeded	Alfalfa	--	--	5.5	2.1	4.9	0.9
Conventional-tillage	Late spring seeded	Black medic	--	--	2.3	0.8	1.1	0.6
Conventional-tillage	Late spring seeded	Sweetclover	--	--	2.0	0.7	2.0	1.0
		F	--		3.3		2.7	
No-tillage	Coated & fall seeded	Alfalfa	0.4	0.2	0.4	0.5	0.4	0.3
No-tillage	Coated & fall seeded	Black medic	0.3	0.2	0.3	0.2	0.1	0.1
No-tillage	Coated & fall seeded	Sweetclover	0.2	0.1	0.1	0.1	0.1	0.1
		F	0.3		0.3		0.2	
No-tillage	Non-coated & fall seeded	Alfalfa	0.6	0.3	0.1	0.1	0.2	0.2
No-tillage	Non-coated & fall seeded	Black medic	0.2	0.2	0.1	0.1	0.1	0.2
No-tillage	Non-coated & fall seeded	Sweetclover	0.2	0.1	0.2	0.2	0.4	0.4
		F	0.3		0.1		0.2	
No-tillage	Early spring seeded	Alfalfa	3.5	1.9	1.5	0.9	0.9	0.4
No-tillage	Early spring seeded	Black medic	1.4	0.4	1.1	0.4	1.1	0.2
No-tillage	Early spring seeded	Sweetclover	0.7	0.2	1.1	1.0	0.7	0.6
		F	1.9		1.2		0.9	
No-tillage	Late spring seeded	Alfalfa	--	--	6.5	2.7	4.3	2.3
No-tillage	Late spring seeded	Black medic	--	--	4.5	2.0	2.5	0.6
No-tillage	Late spring seeded	Sweetclover	--	--	3.1	0.8	1.1	0.7
			--		4.7		2.6	

Table 2. Means (F) and standard deviations (SD) for stand counts for alfalfa, black medic, and yellow-flowered sweetclover (Sweetclover) using different seeding methods in conventional seedbeds and no-tillage seedbeds after oats during 2003.

			30 May	
Tillage treatment	Seeding method	Crop	F	SD
			------- no./ft^2 -------	
Conventional-tillage	Coated & fall seeded	Alfalfa	3.2	2.0
Conventional-tillage	Coated & fall seeded	Black medic	1.5	0.6
Conventional-tillage	Coated & fall seeded	Sweetclover	3.0	0.9
		F	2.6	
Conventional-tillage	Non-coated & fall seeded	Alfalfa	1.8	1.1
Conventional-tillage	Non-coated & fall seeded	Black medic	1.3	0.5
Conventional-tillage	Non-coated & fall seeded	Sweetclover	2.3	0.7
		F	1.8	
Conventional-tillage	Early spring seeded	Alfalfa	7.7	2.3
Conventional-tillage	Early spring seeded	Black medic	2.7	0.8
Conventional-tillage	Early spring seeded	Sweetclover	6.4	1.7
		F	5.6	
Conventional-tillage	Late spring seeded	Alfalfa	5.0	1.9
Conventional-tillage	Late spring seeded	Black medic	2.9	2.2
Conventional-tillage	Late spring seeded	Sweetclover	3.2	1.7
		F	3.7	
No-tillage	Coated & fall seeded	Alfalfa	5.7	2.7
No-tillage	Coated & fall seeded	Black medic	1.5	0.3
No-tillage	Coated & fall seeded	Sweetclover	3.3	1.7
		F	6.5	
No-tillage	Non-coated & fall seeded	Alfalfa	3.5	2.3
No-tillage	Non-coated & fall seeded	Black medic	1.2	0.2
No-tillage	Non-coated & fall seeded	Sweetclover	3.9	1.5
		F	2.9	
No-tillage	Early spring seeded	Alfalfa	10.5	2.1
No-tillage	Early spring seeded	Black medic	2.6	0.8
No-tillage	Early spring seeded	Sweetclover	6.4	3.3
		F	6.5	
No-tillage	Late spring seeded	Alfalfa	10.5	5.8
No-tillage	Late spring seeded	Black medic	3.4	1.1
No-tillage	Late spring seeded	Sweetclover	4.6	1.3
		F	6.2	

Table 3. Impact of tillage, seeding method, and legume species on plant counts during 2003 at Dickinson, ND.

Treatment	Established seedlings
	--no./ft^2 --
<u>Tillage</u>	
Conventional-tillage	3.4
No-tillage	4.8
$LSD_{0.05}$	NS
<u>Seeding method</u>	
Dormant-seeding polymer-coated seed	3.1
Dormant-seeding bare seed	2.3
Early spring seeding bare seed†	6.0
Late spring seeding bare seed†	5.0
$LSD_{0.05}$	1.1
<u>Legume species</u>	
Alfalfa	6.0
Black medic	2.1
Yellow-flowered sweetclover	4.1
$LSD_{0.05}$	1.1

†Early spring seeding occurred on 10 April and late spring seeding on 12 May.

Table 4. Means (F) and standard deviations (SD) for plant height and forage yield of alfalfa using different seeding methods in conventional-tillage (Conventional) and no-tillage (None) seedbeds following wheat at Dickinson during 2003.

		Plant height		Forage yield	
Tillage treatment	Seeding method	F	SD	F	SD
		- inches -		- tons/acre -	
Conventional	Coated & fall seeded	13	1.1	0.2	0.1
	Non-coated and fall seeded	13	3.1	0.1	0.1
	Early spring seeded	15	3.0	0.4	0.2
	Late spring seeded	11	0.9	0	0.1
	F	13		0.2	
None	Coated & fall seeded	13	2.0	0.2	0.1
	Non-coated and fall seeded	14	1.7	0.1	0.1
	Early spring seeded	13	3.0	0.3	0.2
	Late spring seeded	10	1.6	0	0.1
	F	13		0.2	

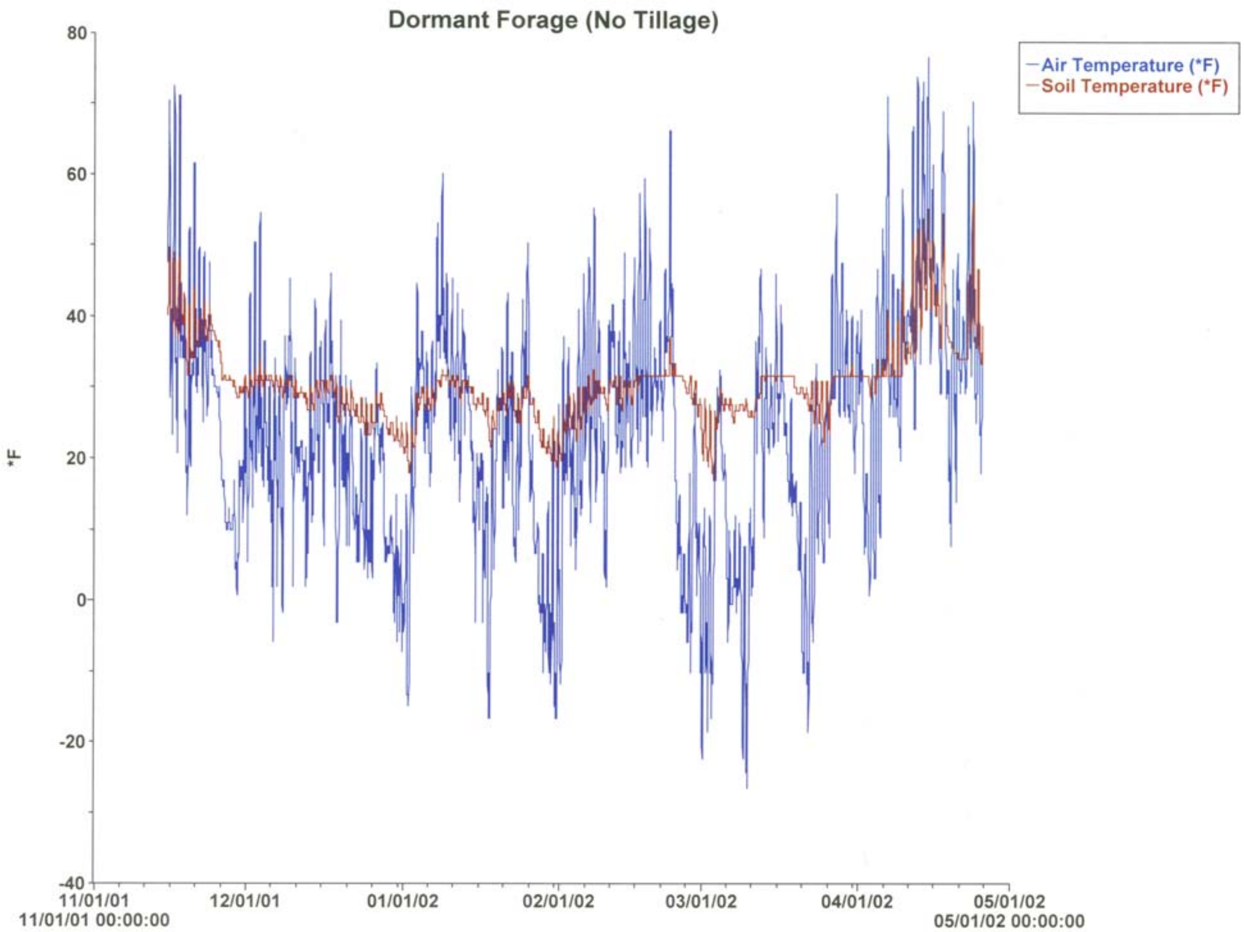

Figure 1. Soil and air temperatures in no-till plots from late Fall through early Spring during 2001 and 2002.

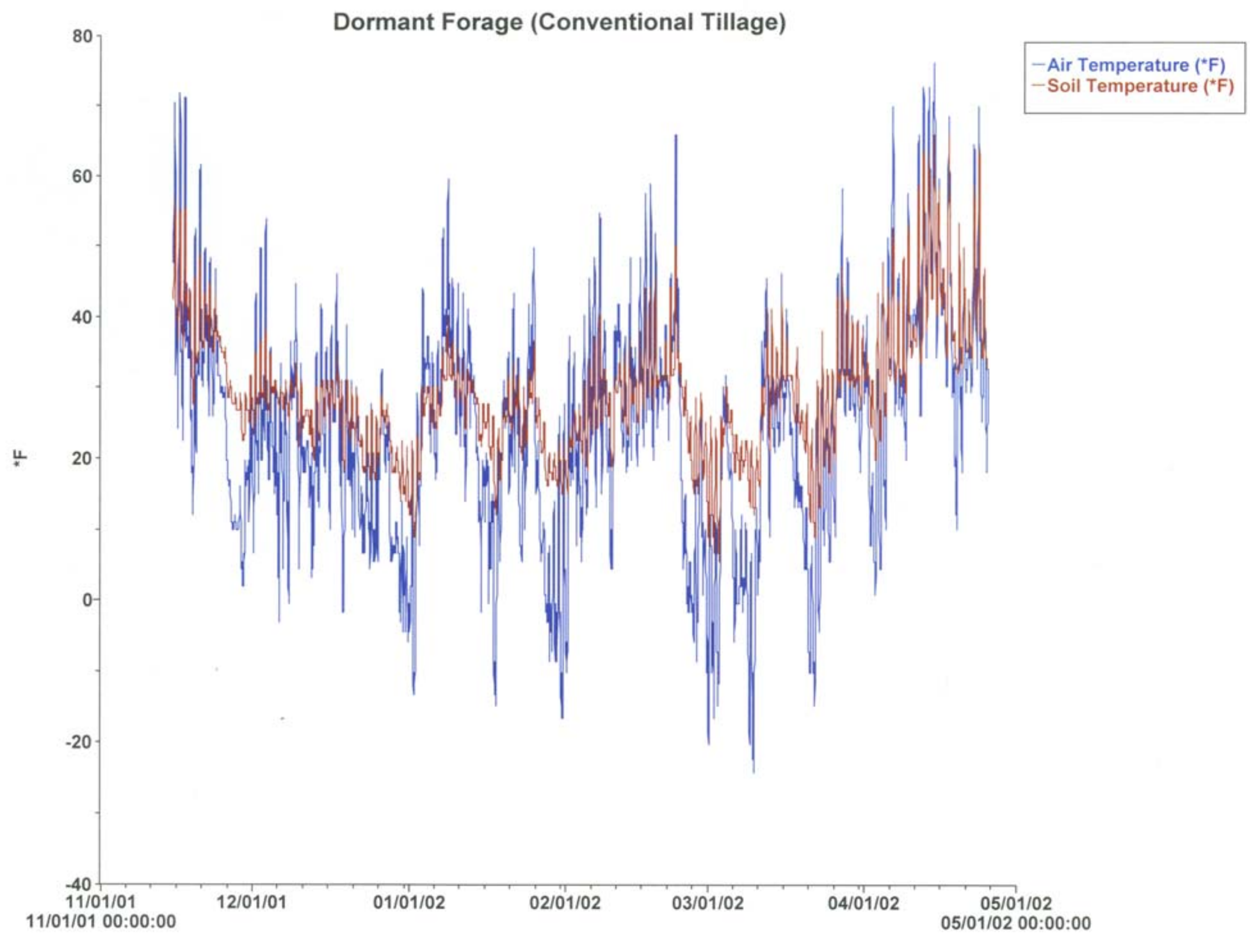

Figure 2. Soil and air temperatures in conventional-till plots from late Fall through early Spring during 2001 and 2002.