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Effects of Seeding Date on Warm-Season Grass Establishment

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ABSTRACT

Establishment of perennial warm-season native grasses is often difficult in the Northern Great Plains. Many parameters, including seeding date, affect establishment. In North Dakota, the Natural Resources Conservation Service (NRCS) recommends seeding warm-season grasses in the spring. Finding additional seeding date options that produce successful stands could be beneficial for some planting situations. A four-year study was conducted at the USDA Natural Resources Conservation Service Plant Materials Center, Bismarck, ND (PMC) to evaluate establishment of warm-season grasses seeded in the spring, late summer, and dormant seasons. Big bluestem (*Andropogon gerardii* Vitman), Indiangrass [*Sorghastrum nutans* (L.) Nash], switchgrass (*Panicum virgatum* L.) sideoats grama [*Bouteloua curtipendula* (Michx.) Torr.], and blue grama [*Bouteloua gracilis* (Willd. ex Kunth) Lag. ex Griffiths] monocultures were seeded annually within each of the three seeding windows into small grain stubble and black-tilled (devoid of vegetation and stubble) seedbeds. Plants/ft^2 ranged from 2.4 to 2.8 in the spring planting, 1.4 to 1.8 in the dormant planting, and 0.8 to 1.6 in the summer planting. Spring seedings gave the most consistent and greatest establishment density regardless of seedbed. This study supports NRCS Technical Guide rcommendations for spring planting of warm-season grasses for resource conservation programs in North Dakota.

INTRODUCTION

Perennial warm-season grasses in the Northern Great Plains can actively grow in the hot summer months when cool-season grasses have become dormant and less productive. They offer wildlife habitat, erosion control, and quality forage for livestock and wildlife during a time when cool-season grasses have become dormant (Sedivec et. al 2009). Perennial warm-season grasses can be difficult to establish in the Northern Great Plains. Poor seedbed preparation, low seed quality, lack of proper planting equipment, planting depth and weed competition are factors that lead to poor establishment of these grasses (Moser and Vogel 1995) Seeding date is another critical factor for establishment of warm-season grasses in the Northern Great Plains (Meyer and Gaynor 2002, Ries and Hofmann 1996, Hsu and Nelson 1986). The North Dakota NRCS (USDA NRCS 2021) recommends spring seeding (May-June) warm-season grasses for conservation programs. Extending the planting window of warm-season grasses into early summer or during the dormant season, may be desirable to land managers, especially if conditions are favorable for establishment of acceptable stands of warm-season grasses prior to the onset of winter or the following spring.

Research in Minnesota found dormant seedings of little bluestem [*Schizachyrium scoparium* Michx. Nash] and sideoats grama did not establish well compared to spring seedings (Meyer and Gaynor

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2002). Ries and Hofmann (1996) reported sideoats grama consistently established into wheat (*Triticum aestivum* L.) stubble in Mandan, ND when planted 1 April and 9 May and blue grama most consistently established when seeded 1 November, 21 April, and 9 May. According to O'Brien et al (2008), dormant seeding of big bluestem and switchgrass produced acceptable stands following a December dormant seeding in Nebraska.

Temperature and moisture affect germination and morphological development of plants. Hot and dry conditions at the soil surface are detrimental to germination and emergence. Frasier et al. (1987) found different cycles of wet and dry periods affected seedling establishment of various grasses, including sideoats grama. Jordan and Haferkamp (1989) stated germination, a critical stage in establishment of seedlings on semiarid rangelands, is often limited by temperature even when moisture conditions are favorable. Understanding morphological development during germination and seedling development is essential to select appropriate seeding and seeding management practices (Moser 2000). According to Moser and Vogel (1995), warm-season grasses should not be planted in late summer in the northern Great Plains because they do not have time to develop sufficiently before winter, which make them susceptible to winter kill. There are differences among species in germination and morphological development, which relates to moisture and temperature. A study by Hsu and Nelson (1986) found Indiangrass had a lower base temperature for germination and emergence than switchgrass. Smart and Moser (1997) suggest switchgrass be planted in early spring rather than late April and May in Nebraska when the risk of unfavorable moisture conditions is reduced during the period of adventitious root development which is necessary for successful establishment. Wilson and Briske (1979) found the soil surface had to remain moist for 2-4 days for blue grama seeds to germinate and initiate growth of seminal roots with additional moisture required 2-8 weeks later for adventitious root development.

Climatic conditions can be difficult to predict. However, spring conditions in North Dakota, on average, offer more moisture and less hot, dry conditions than the summer. Dormant seedings can offer temperature and moisture conditions that can break down any seed dormancy and thus start germination early in the spring when conditions are favorable. However, if seeds germinate too early in the spring, seedlings may be killed by late frosts. As the grasses are seeded shallow, dormant seedings can lend themselves to seed disturbance by wind if there is no snow cover. Rodent predation is also a concern.

There is limited information on perennial warm-season grass establishment beyond the spring seeding date in the Northern Great Plains. Objective of this study is to evaluate establishment of warm-season perennial grasses seeded in the spring, summer, and late fall (dormant) into small grain stubble and tilled soil (black) seedbeds in North Dakota.

MATERIALS AND METHODS

Study was located at the USDA-NRCS Bismarck PMC, Bismarck, North Dakota in 2014-2017, Major Land Resource Area (MLRA) of this site is 53B; central dark brown glaciated plains. Study was planted on four different field sites on a Mandan silt loam, which is assigned to the Loamy ecological site and the Loam forage suitability group. Five warm-season species were seeded annually in the spring, summer and late fall (dormant). Dormant seedings were made of big bluestem, Indiangrass, switchgrass, sideoats grama and blue grama when the soil temperature was 40^0 F or below. Seedings were made into two seedbeds; tilled (black and devoid of vegetation and

residue) and a standing stubble of barley (*Hordeum vulgare* L.) in years 2014-2016 and oats (Avena sativa L.) in 2017 summer seeding. Plots were seeded using a no-till, single cone plot drill that seeded 9 rows with 7.5-inch row spacings. Seeds were planted approximately ¼ to ½ inch deep. Each plot size was 5.6 ft X 25 ft. Different warm-season cultivars were sometimes planted in different years to prevent cross pollination with the same species in nearby foundation seed production fields (Table 1).

Seeding rates were 1.5 times the recommended rate for warm-season grass seedings in the North Dakota field office technical guide. (USDA-NRCS 2021; Table 1). Seeding rates were increased to accommodate the small number of seed planted in the experimental plots and the likelihood of some seed adhering to the inside of the drill tubes. Plots were arranged in a randomized complete block with three replications. Spring seedings were in mid to late May; summer seedings were in mid to late August, and dormant seedings were in early to mid-November when soil temperature was below 40^0 F (Table 2).

Plant density was measured using a frequency grid method (Vogel and Masers 2001). In this method, the frequency of 1 or more plants within a defined grid were counted rather than the number of individual plants. Stands were considered successful if plant densities were 1.8 plants/ft^2 or greater. Stands were not evaluated the year of seeding, but were evaluated after 2-3 years of growth because some seed may be dormant or have weak seedlings and counts made before plants were well established may not be an accurate indication of final stand. Only counts of established plants were reported (Table 2).

Glyphosate was applied at the standard recommended labeled rate of 0.75 ae/acre to control actively growing weeds prior to seeding. The stubble crops, barley and oats, were seeded at approximately 80 lb/acre the year prior to planting the warm-season grasses. Residue was clipped and removed from the field leaving a stubble height of approximately 8-10 inches. Weeds were clipped with a rotary mower and residue removed from established grass plots to control weeds or whenever weed pressure became severe.

Annual temperature and rainfall were obtained from an official weather station at the Bismarck airport, which is adjacent to the Bismarck PMC (Table 3).

Plant density was analyzed separately for each warm-season grass by seedbed and year using the analysis of variance procedure in Statistix 10 for a randomized complete block design (Analytical Software, Tallahassee, FL). Mean separation was performed using Tukey's HSD at $P<0.05$.

RESULTS AND DISCUSSION

Successful stands of grass established at least one of the four years for all seeding windows. Warm-season grass establishment was most consistently achieved by seeding in the spring. Grass establishment was similar in black-tilled and stubble seedbeds, with a few exceptions. In 2015 seedings, stands were acceptable for all seeding windows in black-tilled plots but not stubble plots. Less residue in the stubble seedbed at the time of seeding may have resulted in better warm-season grass establishment. Of all species, establishment was poorest for blue grama seeded into stubble. Although mulch can be beneficial in blue grama establishment, too much mulch can be detrimental to establishment of this small seeded grass. It can result in poor seed-to-soil contact and/or can cause

adventitious roots to be elevated above the soil surface where conditions are not favorable for survival (Hyder et al. 1971). Daily precipitation data, which was not recorded in this study would better explain moisture cycle effects on establishment of each species. Temperature and weed pressure are other parameters that affect germination and stand establishment of grasses. No weed competition ratings were recorded in this study, so the hypothesis that weed pressure was greater in wetter years and resulted in poorer stands for some species could not be confirmed or refuted.

Spring Seeding: Rainfall and temperatures were near normal during April-June 2014-2017 (Table 3) and provided favorable conditions for seed germination and subsequent seedling establishment (Jordan and Haferkamp 1989). Precipitation was greater than 2 inches above the average in May and June 2015 (Table 3). This may partially explain why stand densities were superior in spring planted, tilled seedbeds in 2015 (Table 4). Plants/ft^2 varied among year, species and seedbeds (Table 4). When averaged over years, spring seeding frequently produced a significantly greater number of plants/ft^2 than summer or dormant seedings (Table 4). Average plant density ranged from 2.4 plants/ft^2 for big bluestem, blue grama and Indiangrass to 2.7 plants/ft^2 for switchgrass seeded into stubble and from 2.4 to 2.8 plants/ft^2 for Indiangrass and switchgrass, respectively when seeded into a tilled seedbed. According to Vogel and Master (2001) plant density greater than 1.8 plants/ft^2 is considered a successful stand. Adequate stands were most consistently achieved when grasses were seeded in the spring (Table 4).

Summer Seeding: Overall, summer seedings resulted in poor or inadequate stand densities. Hot, dry conditions likely contributed to establishment failure. The highest average temperatures at Bismarck are in July and August (Table 3). Temperatures were near normal from July-August 2013-2017 and slightly above normal in September for those years. In June, July and August 2013, temperatures were near average and precipitation was below normal. Lack of soil moisture at planting in 2013 may have impacted germination resulting in the poorest stand densities (Table 4). Precipitation greater than 2 inches above the normal in August 2014 likely contributed to successful stands of sideoats grama and Indiangrass in stubble and all species in tilled seedbeds (Table 4). Comparing all species seeded in the summer, blue grama establishment was the poorest. Summer seedings in stubble were successful in 2016 for big bluestem, sideoats grama and switchgrass.

Dormant Seedings: Dormant seedings generally had better establishment than summer seedings, but poorer than spring seedings (Table 4). This is in agreement with findings of Meyer and Gaynor (2002) who found spring seedings of sideoats gama and little bluestem were more successful than dormant seedings. Establishment in dormant seedings was sometimes comparable to the spring seedings, but not consistently. Possible causes for establishment failure in dormant seedings could include rodent predation, movement of seed by wind in winter with no snow cover, or germination in early spring followed by a killing frost. Dormant plantings generally failed two of the four years in both stubble and black-tilled plots. Sideoats grama and switchgrass failed only once throughout the study; in dormant seeded, black -tilled plots.

CONCLUSION

Warm-season grass establishment can vary from year to year. Our study agrees with findings of Ries and Hofmann (1996) that the most successful seeding dates can be identified, but failure can occur in any year because of unfavorable environmental conditions. Spring seeding of big bluestem, switchgrass, blue grama, sideoats grama and Indiangrass most consistently produced successful

grass stands. Although there was some success with dormant seeding, results were not consistent. Additional research is needed before recommending dormant seeding. Summer seeding overall, was not successful, likely due to hot and dry conditions. Planting into stubble did not improve establishment of the grasses in this study. Outcome may have varied with different amounts of residue. Additional warm-season grass seeding date studies in a variety of soils and climatic conditions in North Dakota and other States would provide additional insight into warm-season grass establishment.

Results of this study support NRCS technical guide recommendations for seeding warm-season grasses in the spring in North Dakota for resource conservation programs.

Table 1. Warm season grass species, planting year of each cultivar/source and seeding rate in 2014-2017 NRCS, Bismarck, ND.

Cultivar/source	2014	2015	2016	2017	Seeding rate (PLS lb/acre)[1/]
Big bluestem					
Bison			X		9.0
Bonilla	X[2/]	X			9.0
Bounty				X	9.0
Blue grama					
Bad River Ecotype	X	X	X		3.0
ND origin				X	3.0
Sideoats grama					
Pierre	X	X	X		9.0
ND origin				X	9.0
Indiangrass					
Tomahawk	X	X	X	X	8.25
Switchgrass					
Forestburg	X	X	X	X	5.25

[1/] Pure Live Seed (PLS) lb/acre; the listed number is 1.5 times the recommended ND NRCS rate. [2/]X - indicate planting year of cultivar/source years without "X" indicate cultivar/source not planted.

Table 2. Seeding and data collection dates for spring, summer and dormant warm-season grass planting, NRCS, Bismarck, ND

PMC Field	Spring Seeding	Summer Seeding	Dormant Seeding	Data Collection
	----------date----------			
1 (2014)	27 May 2014	20 Aug. 2013	5 Nov. 2013	6 July 2017
2 (2015)	27 May 2015	13 Aug. 2014	20 Nov. 2014	30 June 2017
3 (2016)	6 May 2016	8 Aug. 2016	15 Nov. 2016	20 June 2018
4 (2017)	18 May 2017	24 Aug. 2017	1 Nov. 2017	4 Sept. 2019

Table 3. Monthly average temperature and total monthly precipitation recorded from 2013-2019 at the Bismarck, North Dakota airport (NOAA Weather Data), NRCS Bismarck, ND.

	2013	2014	2015	2016	2017	2018	2019	50 yr ave 1968-2019
	----------mean avg. temp. (F°)----------							
January	13.9	13.8	19.1	17.1	11.1	13.0	13.0	11.2
February	21.9	9.6	12.0	32.5	22.6	8.6	-0.4	16.8
March	22.7	27.2	36.1	39.0	31.0	26.5	22.7	29.2
April	34.5	41.1	45.4	45.0	45.3	36.2	44.2	43.3
May	54.7	55.8	53.9	57.2	56.9	61.4	52.2	55.4
June	64.7	63.4	66.4	68.0	67.9	70.0	67.2	64.8
July	70.0	68.5	71.8	71.8	75.9	71.6	72.6	71.0
August	71.0	68.7	70.2	68.9	67.1	70.7	67.5	69.1
September	63.8	60.2	64.4	60.0	60.4	57.9	60.4	58.6
October	42.0	47.8	48.9	48.1	46.8	42.2	39.2	44.8
November	27.6	21.5	33.3	39.6	31.7	25.5	29.1	29.1
December	7.4	19.8	22.1	10.5	19.6	23.6	17.5	15.9
	----------total precip.(in.)----------							
January	0.25	0.38	0.75	0.21	0.64	0.42	0.81	0.47
February	0.34	0.19	0.39	0.43	0.76	0.33	0.99	0.49
March	0.83	0.82	0.45	0.43	0.52	1.57	0.99	0.85
April	1.81	1.95	0.37	4.15	0.96	0.62	1.14	1.47
May	7.37	0.85	5.31	1.96	0.25	1.60	3.25	2.36
June	2.71	3.02	4.98	4.38	1.74	3.45	2.82	3.02
July	1.63	0.73	1.51	5.10	1.68	3.89	3.52	2.65
August	1.37	4.75	1.41	1.88	5.09	1.04	5.32	2.22
September	4.36	0.37	0.37	1.22	1.39	2.28	5.74	1.63
October	4.73	0.15	1.07	0.24	0.18	1.50	3.36	1.24
November	0.09	0.60	0.21	1.42	0.16	1.11	1.03	0.64
December	1.26	0.11	0.91	2.05	0.42	0.67	0.61	0.55
TOTAL	26.75	13.92	17.73	23.47	13.79	18.48	29.58	17.60

Table 4. Plant density of warm season grasses planted into stubble and black seedbeds in the spring, summer and dormant planting season in 2014-2017 and 4-year average, NRCS, Bismarck, ND

Warm Season Grass	Stubble					Black				
	2014	2015	2016	2017	Avg	2014	2015	2016	2107	Avg
Big bluestem	----------plants/ft^2 **----------									
Spring	3.3a	2.8a	1.7a	1.9a	2.4a	2.5a	3.2a	2.1a	2.1a	2.5a
Summer	0.8b	1.5b	2.0a	0.8b	1.3b	0.3b	2.9a	1.5a	1.3a	1.5b
Dormant	2.4a	2.4ab	1.0a	0.5b	1.6b	2.7a	2.0b	0.7b	1.5a	1.7b
Blue grama										
Spring	3.2a	2.7a	1.0a	2.7a	2.4a	2.7a	3.6a	1.8a	2.2a	2.5a
Summer	0.1c	1.7a	1.1a	0.1c	0.8b	0.5b	2.6b	1.6a	0.9a	1.4b
Dormant	2.3b	1.9a	0.6a	1.1b	1.5b	2.0a	2.1b	0.7a	1.2a	1.5b
Indiangrass										
Spring	3.4a	2.8a	1.4a	1.9a	2.4a	2.4ab	3.4a	2.0a	1.9a	2.4a
Summer	2.1b	2.2a	0.7ab	0.1b	1.3b	1.9b	2.5a	1.4b	0.4b	1.6a
Dormant	2.5b	2.6a	0.3b	0.4b	1.4ab	2.7a	2.5a	0.3c	0.6b	1.5a
Sideoats grama										
Spring	3.3a	2.9a	1.7ab	2.4a	2.6a	2.5a	3.3a	2.6a	2.1a	2.7a
Summer	1.6b	1.8a	1.9a	0.2b	1.4b	0.3b	2.7ab	2.0b	0.7b	1.4b
Dormant	2.0b	2.0a	1.0b	1.0b	1.5b	2.3a	2.4b	0.9c	1.9a	1.9ab
Switchgrass										
Spring	3.3a	3.1a	2.1a	2.4a	2.7a	2.4a	3.5a	2.5a	2.6a	2.8a
Summer	0.8b	0.6b	2.5a	0.0c	1.0b	0.3b	2.3b	2.4a	0.1b	1.3b
Dormant	2.5a	2.6a	0.7b	1.0b	1.7b	2.4a	2.0b	0.8b	1.8a	1.8b

* Means in columns, within a year and 4-year average for a warm season grass, followed by the same letters are not significantly different $P<0.05$ according to Tukey's HSD.

**Plants/ft^2 are based on frequency grid method (Vogel and Masters 2001). Stands are considered adequate with plant densities of 1.8 plants/ft^2 or greater.

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