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Final Study Report
A multi-location study including Jimmy Carter Plant Materials Center (Americus, GA), East Texas Plant Materials Center (Nacogdoches, TX); and Tucson Plant Materials Center (Tucson, AZ)

Cover Crop Growth Characteristics of 'SoilSaver' Black Oats and 'Cosaque' Black Seeded Oats for Use in Conservation Planning Tools

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ABSTRACT

Plant growth characteristics of living and residue cover are important inputs for wind and water erosion prediction models. There is limited information on specific plant growth parameters of 'SoilSaver' black oats (*Avena strigosa* Schreb.) and 'Cosaque' black seeded oats (*Avena sativa* L.) for conservation planning tools. The objective of this study was to characterize the growth characteristics of 'Cosaque' and 'SoilSaver' in different geographical locations in the southeastern and southwestern U.S. Plots of each oat species were established in Americus, GA, Nacogdoches, TX and Tucson, AZ. Plant height and precent canopy cover were taken monthly, and at cover crop termination. Biomass was also collected at critical times during and after termination. Plant height, canopy cover and biomass varied across locations and oat species. SoilSaver was damage by cold temperatures in Americus and Nacogdoches and to a lesser extent Cosaque. Both oat species were heavily damaged in Nacogdoches that led to a decrease in plant growth and productivity. In contrast, both oat species grew well in Americus and provided good to excellent canopy cover and biomass by termination. In Tucson, both oat species provided respectable canopy cover and biomass, especially Cosaque, despite low moisture of the semi-desert environment in southern AZ. Plant growth measurements provided key vegetative inputs for Natural Resources Conservation Service's (NRCS) wind and water erosion prediction models for conservation planning and for cover crop guidance documents.

INTRODUCTION

Natural Resources Conservation Service's conservation planners rely on different conservation planning tools (e.g., Wind Erosion Prediction System (WEPS) and Revised Universal Soil Loss Equation (RUSLE2) to assess soil erosion from agricultural fields by wind and water, then determine the most effective conservation practice(s) to address the resource concern. Erosion prediction models use a variety of inputs. A key input is plant growth parameterization. Both living vegetative cover, and subsequent residue cover, significantly impact predicted wind and water erosion. Detailed information on growth and productivity of single species cover crops are often lacking in the scientific literature that can be easily extracted and inserted into databases that drive these conservation planning tools.

Plant growth characteristics of Cosaque black seeded oats and SoilSaver black oats are needed for erosion prediction models when planted and managed as a cover crop. SoilSaver is recommended for the lower Coastal Plain, including USDA Plant Hardiness Zones (PHZ) 8b-10a (USDA-ARS, 2016; https://planthardiness. ars.usda.gov/). It has performed well as a fall planted cover crop in Zone 8b but has winterkilled in this zone. Brakie and Shadow (2020) suggested a later planting date may reduce winterkill of

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black oats in Zone 8b. Plantings made in the northern zones are not recommended due to insufficient cold hardiness and risk of winterkill (USDA-ARS, 2016). Cosaque exhibited good winterhardiness in PHZ 7b in North Mississippi. It is recognized as a potential overwintering cover crop in the upper Mid-South while SoilSaver may be a better choice for the lower Mid-South because of mild winters (Richard and Allison, 2020).

The NRCS Plant Materials Program, which is a network of 25 plant materials centers (PMCs) strategically located in different regions of the U.S., has extensive knowledge and experience with data collection procedures that can be customized to meet the type of data requirements for erosion prediction models. The objective of this study was to characterize the growth characteristics of Cosaque black seeded oats and SoilSaver black oats for NRCS conservation planning tools at PMCs in the southeastern and southwestern U.S.

MATERIALS AND METHODS

The study was conducted at the Jimmy Carter PMC, Americus, GA; East Texas PMC, Nacogdoches, TX and the Tucson PMC, Tucson, AZ (Table 1). A 0.1 acre of each oat variety (~ 100-ft long by 44- ft wide) was planted in mid to late October in 2021 and 2022 in Americus, and 2022 in Nacogdoches and Tucson. Oats were drilled at 60 pure live seed/acre. No irrigation was used in Americus and Nacogdoches; however, plots were flood irrigated one time in Tucson after planting. Plots were fertilized with 30 lb N/acre after planting. Phosphorus and potash were at a medium soil test level and soil pH between 6.0-6.5. Monthly rainfall and minimum and maximum temperature for October-April/May 2021-2023 were obtained from PRISM (https://prism.oregonstate.edu/) (Appendix A).

Plant photos were taken monthly after planting and termination with a Samsung Galaxy® tablet equipped with a digital camera. Canopeo/Foliage Application (https://canopeoapp.com/#/login) was used to estimate percent canopy cover when applicable. Visual estimate of canopy cover was also used in the later months and at termination when shadows from leaves and stems, and dead or decaying residue interfered with Canopeo's ability to estimate vegetative cover.

Height was determined monthly by measuring from the soil surface to the absolute plant height from multiple locations within each oat plot. Four random samples were clipped for biomass determination at 60 days after planting, at cover crop termination, and 1 month after cover crop termination. Growth stage of the oat species was reported at termination.

Plant parameters were analyzed separately for each oat species and location using the descriptive statistics option in Statistix 10 (Analytical Software, Tallahassee, FL) for mean and standard deviation.

Table 1. Plant Materials Center, soil type, study years, month and year of planting and termination.

Plant Materials Center	Latitude, Longitude	Soil type	# of Years Study was Conducted	Planted	Terminated
Americus, GA	32° 6' 1.8756" N 84° 15' 34.9632" W	Orangeburg loam sand	2	10/20/2021 10/27/2022	5/5/2022 4/19/2023
Nacogdoches, TX	31°30'07.6" N 94°45'49.1" W	Woden fine sandy loam	1	10/17/2022	4/18/2023
Tucson, AZ	32° 15' 12.4560" N 110° 54' 42.4404" W	Comoro sandy loam and Vinton loamy sand	1	10/20/2022	4/21/2023

RESULTS AND DISCUSSION

Monthly Plant Height

Plant height increased monthly after planting and varied across locations and years prior to termination (Table 2). In Americus, Cosaque reached a height of 118 cm (~4-ft) in 2023, 5 months after planting while SoilSaver reached a height of 61 cm (2-ft)., 4 months after planting in 2022. The sudden decline in plant height in month 3 in Nacogdoches can be attributed to cold weather in East Texas in December 2022, including 9° F in late December that caused severe plant damage and partial stand loss. Although SoilSaver is recommended as a winter cover crop in the lower Coastal Plain (Plant Hardiness Zone, including zones 8b-10a) it has shown to be susceptible to cold damage and winterkill in some years (USDA ARS, 2016). SoilSaver had 80% leaf tip damage, and to a lesser degree, Cosaque (20%) from cold weather in late December in 2022 and early January in 2023, in Americus but they recovered and continued to provide adequate plant height and soil coverage. Cosaque has exhibited better cold tolerance than SoilSaver in the southeastern U.S. where it has been recognized as having value as an overwintering cover crop (USDA, NRCS, 2020). The shorter growth of Cosaque (45 cm; ~ 1.5-ft) and SoilSaver (34 cm; 1.1-ft) in Tucson is likely due to inadequate soil moisture during the growing (6.5 inches vs. +30 inches at the other locations) that prevented the plants from reaching taller heights.

Table 2. Plant height in cm of 'Cosaque' black seeded oats and 'SoilSaver' black oats by month after planting, USDA-NRCS Plant Materials Centers in Americus, GA, Nacogdoches, TX and Tucson, AZ.

Month after planting	1		2		3		4		5	
Cultivar	CO[1/]	SS[2/]	CO	SS	CO	SS	CO	SS	CO	SS
Americus, GA										
2021-2022	10.5	15	11	16	27	32	33	61	51	N/A[3/]
SD[4/]	±0.4	±1.8	±2.3	±2.4	±5.3	±6.5	±3.7	±5.6	±3.2	
2022-2023	-----	16	24	24	39	39	42	42	118	N/A
SD		±0.8	±2.4	±3.3	±6.5	±3.8	±5.6	±4.1	±5.7	
Nacogdoches, TX	13	16	23	36	15	14	17	11	N/A	N/A
SD	±8.5	±14.1	±18.2	±6.4	±6.8	±9.6	±3.9	±2.1		
Tucson, AZ	9	7	15	11	34	20	37	23	45	34
SD	±.08	±0.5	±1.2	±1.4	±4.1	±2.1	±4.2	±2.1	±5.7	±4.2

[1/]Cosaque; [2/]SoilSaver; [3/]not applicable; [4/]standard deviation.

Monthly Percent Canopy Cover

Percent canopy cover of both oat species generally increased monthly after planting across locations (Table 3). Both oats established and grew quickly in Nacogdoches as indicated by the positive canopy cover 1 month after planting. However, canopy cover was markedly reduced 2 months after planting because of the cold weather in December that severely damaged the plants or caused stand loss. Cosaque recovered and provided greater than 50% canopy cover in the later months while SoilSaver failed to provide adequate canopy cover for soil protection. Both oat species also recovered from cold in late December and early January in Americus, resulting in good to excellent canopy cover prior to termination. Both varieties provided satisfactory canopy cover in Tucson prior to termination despite the low moisture associated with the semi-desert environment of Tucson, AZ.

Plant Height, Growth Stage and Canopy Cover at Termination

Plant height, canopy cover and growth stage of Cosaque and SoilSaver varied across locations at cover crop termination (Table 4). SoilSaver ranged in height of 169 cm (5.5-ft) in Americus in 2023 to 32-34 cm (~1-ft) in Nacogdoches and Tucson while Cosaque ranged in height of 99 cm (3-ft) in Americus to 34 and 54 cm (1-ft and 1.7-ft) in Tucson and Nacogdoches, respectively. Plant height at these locations was affected by cold damage in Nacogdoches and limited moisture in Tucson. Physiological growth stage of both oat species was similar at termination and ranged from seed ripening (soft dough) in Americus in 2023 to flowering in Nacogdoches and Tucson. Both oat species provided good to excellent canopy cover in Americus. The low canopy cover in Nacogdoches was related to cold damage that reduced stand of both oat species, especially SoilSaver. Previous evaluation of Cosaque and Soil Saver in Nacogdoches found both oat species provided excellent fall cover with Cosaque exhibiting had better winter survival than SoilSaver but was more susceptible to foliar diseases (USDA-NRCS, 2020).

Table 3. Percent canopy cover of 'Cosaque' black seeded oats and 'SoilSaver' black oats by month after planting and termination, USDA-NRCS Plant Materials Centers in Americus, GA, Nacogdoches, TX and Tucson, AZ.

Month after planting	1		2		3		4		5	
Cultivar	CO[1/]	SS[2/]	CO	SS	CO	SS	CO	SS	CO	SS
Americus, GA 2021-2022	13	29	42	75	83	84	85	80	80	70
SD[3/]	±2.4	±5	±4.5	±4.8	±4.6	±4.4	±6.5			
2022-2023	15	16	36	6	51	55	68	92	90	
SD	±4.3	±3	±15.4	±3.6	±5.8	±8.1	±13.6	±7.3		
Nacogdoches, TX	56	76	36	11	50	29	53[5/]	27[5/]	N/A[4/]	N/A[4/]
SD	±7.7	±9.9	±7.7	±4.9	±11	±9.5	±7.8	±9.8		
Tucson, AZ	6	4	22	17	68	34	76	58	76[5/]	71[5/]
SD	±2.6	±0.9	±6.7	±3.4	±15.6	±11	±16.5	±14.9	±7.4	±8.6

[1/]Cosaque; [2/]SoilSaver; [3/]standard deviation; [4/]not applicable; [5/]Canopy cover is a visual estimate.

Biomass 60 days after planting, Termination and 1 Month after Termination

Biomass production 60 days after planting, at termination and 1 month after termination are presented in Table 5. Biomass varied by oats species and harvest time. Cosaque generally produced more biomass than SoilSaver at each biomass harvest time. In Americus, Cosaque produced over 9000 lb/acre at termination in 2022 and over 7000 lb/acre in 2021. Conversely, SoilSaver produced similar biomass (>7000 lb/acre) at termination both years. In Nacogdoches, Cosaque produced over 3000 lb/acre at termination which was over 1400 lb/acre more biomass than SoilSaver. Despite limited moisture in Tucson, Cosaque produced over 6000 lb/acre at termination which was about twice the amount of biomass as SoilSaver. Biomass reported for Soil Saver in this study agrees with other biomass estimates of black oats (USDA-ARS, 2016).

As expected, there was a loss in biomass 1 month after termination as residue began to decay after termination and differed among locations and oat varieties. Loss in biomass ranged from 801 lb/acre in Soil Saver in Americus to over 2800 lb/acre for Cosaque in Tucson.

Table 4. Plant height, canopy cover, and growth stage of 'Cosaque' black seeded oats and 'SoilSaver' black oats at termination, USDA-NRCS Plant Materials Centers in Americus, GA, Nacogdoches, TX and Tucson, AZ.

Plant Parameters	Height		Canopy Cover		Growth Stage	
Cultivar	CO[1/]	SS[2/]	CO	SS	CO	SS
Americus, GA 2022	No data	No data	90[4/]	90[4/]	Seed ripening (dough)	Seed ripening (dough)
2023	99	169	85[4/]	90[4/]	Seed ripening (dough)	Seed ripening (dough)
SD	±4.6	±8.4	------	------		
Nacogdoches, TX	32	32	53[4/]	27[4/]	Flowering	Seed head emergence
SD	±2.7	±3.9	±7.8	±9.8		
Tucson, AZ	54	34	76[4/]	71[4/]	Flowering	Flowering
SD	±9.6	±4.3	±7.6	±8.6		

[1/]Cosaque; [2/]SoilSaver; [3/]standard deviation; [4/]visual estimate of canopy cover.

Table 5. Biomass (lb/acre) 60 DAP (days after planting), at termination, and 1 MAT (month after termination) of 'Cosaque' black seeded oats and 'SoilSaver' black oats, USDA-NRCS Plant Materials Centers in Americus, GA, Nacogdoches, TX and Tucson, AZ.

	Biomass 60 DAP		Biomass at Termination		Biomass 1 MAT	
Cultivar	CO[1/]	SS[2/]	CO	SS	CO	SS
Americus, GA 2021-2022	No data	2436	9776	7426	8333	5703
SD[3/]		±615	±1862	±1121	±1324	±1524
2022-2023	----	-----	7188	7620	5280	6819
SD			±990	±727	±943	±1884
Nacogdoches, TX	962	421	3342	1910	No data	No data
SD	±363	±113	±883	±975		
Tucson, AZ	481	332	6042	3115	3161	1616
SD	±109	±101	±1064	±538	±576	±498

[1/]Cosaque;[2/]SoilSaver; [3/]standard deviation.

CONCLUSION

A key input in conservation planning tools is plant growth of living vegetative cover, and subsequent residue cover that influence wind and water erosion prediction models. Monthly plant height and percent canopy cover measurements after planting, and at termination, and biomass at critical times during and after termination, provided crucial plant growth measurements of Soil Saver black oats and Cosaque black seeded oats for inclusion into databases that drive NRCS conservation planning tools. Furthermore, the information is useful in other cover crop guidance documents on the growth and productivity of Soil Saver black oats and Cosaque black seeded oats.

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Appendix A. Monthly total rainfall and minimum and maximum temperature at each PMC location in 2021-2023.