EARLY GRASS SEEDLING GROWTH STAGE IMPROVES EXPLANATION OF FUTURE STAND SUCCESS [1]

by

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Abstract. Predicting future grass stand success shortly after seeding improves our understanding of the mechanism of seeding success and makes possible timely decisions on the potential productivity of new grass stands. A 3-year field study with 5 species and 11 seeding dates per year was conducted to evaluate grass development and success when grass was direct seeded into wheat stubble with a double disk cone seeder with depth bands and packer wheels. The number of grass seedlings m^{-2}, the number of adventitious roots, Haun stage, leaf length, leaf area, and number of tillers were measured 45 days after emergence. Earlier results showed that grass stand success can be reasonably predicted from the relationship of seedlings m^{-2} at 45 days after emergence with grass stems or plants m^{-2} 2 years after seeding. However, the simple coefficient of determination (r^2) for these relationships was quite low. Further multiple regression analysis has shown that the R^2 values can be significantly improved by adding the appropriate seedling growth stage to the number of seedlings m^{-2} at 45 days. For smooth bromegrass, the R^2 was improved to 0.75 with the addition of adventitious roots, leaf area, and leaf length. The R^2 was increased to 0.58 for crested wheatgrass and improved to 0.38 for western wheatgrass with the addition of number of adventitious roots. The R^2 for blue grama was increased to 0.65 with the addition of number of adventitious roots. These data show that the explanation of the number of stems or plants m^{-2} estimated 2 years into the future is improved by knowing something about the developmental stage of the seedlings m^{-2} at 45 days after emergence.

Additional Key Words: seedlings m^{-2}, adventitious roots, Haun stage, leaf length, leaf area, multiple regression equation, smooth bromegrass, western wheatgrass, blue grama, crested wheatgrass

Introduction

New grass stands are often needed to replace vegetation after drastic disturbances or as a part of range or pasture land improvement. Reseeding is subject to environmental conditions (Ries and Svejcar 1991 and Ries and Hofmann 1996). It is beneficial to evaluate the success of the seeded grass stands as soon as possible so

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that prompt reseeding or cultural improvement techniques can be applied. Prompt stand success is important for fast economic returns and for lessening excessive soil loss by accelerated erosion. Ries (1996) reported good estimates of grass stand success 2 years after seeding from a measurement of seedlings m^{-2} 45 days after emergence. The purpose of this paper is to report how inclusion of 45 day old secondary stand parameters with seedlings m^{-2} 45 days after emergence improved the explanation of stand success 2 years into the future.

Study Area and Methods

This study was conducted at the Northern Great Plains Research Laboratory, Mandan, North Dakota, to evaluate 11 seeding dates per year over a three year period. The study was conducted on a Parshall fine sandy loam soil (coarse-loamy, mixed *Pachic Haploborolls*) on nearly level terrain. Grass seedings were made directly into spring wheat stubble on August 15, September 4 and 24, October 9, November 1 and April 1 and 21, May 9 and 26, June 10, and July 1 during the seeding years of 1987 (1986-87), 1988 (1987-88), and 1989 (1988-89). All species were seeded in monocultures at 9 kg ha^{-1} pure live seeds at a depth of about 13 mm. Species studied included 3 cool-season grasses, smooth bromegrass (*Bromus inermis* Leyss., 'Lincoln'), western wheatgrass [*Agropyron smithii* Rydb., 'Rodan'; syn. = *Pascopyron smithii* (Rydb.)Love], and crested wheatgrass [*Agropyron desertorum* (Fisch. ex Link) Schult., 'Nordan']. Two warm-season grasses, sideoats grama [*Bouteloua curtipendula* (Michx.) Torr., 'Pierre'] and blue grama [*Bouteloua gracilis* (H.B.K. lag. ex Steud., 'native collection'] were also studied. Environmental conditions during the study were monitored by a weather station located on the study area following National Weather Bureau standards (Ries 1996).

Grass stands were sampled for seedling density (plants m^{-2}) by counting the seedlings present on 5 randomly located 30.5 by 30.5 cm plots at 45 days after emergence. At the same time, the number of adventitious roots, Haun stage (Haun 1973), leaf length, leaf area, and number of tillers on excavated seedlings were counted. The stands were sampled again during the growing season 2 years after the seeding year at near peak biomass accumulation for grass stem density (stems m^{-2} for smooth bromegrass, western wheatgrass, crested wheatgrass and sideoats grama) and grass plant density (plants m^{-2} for blue grama) by counting the number of grass stems or plants from 5 randomly located 30.5 by 30.5 cm plots for each species and seeding date.

Reasonable predictions of grass stand success 2 years after seeding were achieved using the relationship of seedlings present at 45 days after emergence with the grass stems or plants present 2 years after seeding for each species (Ries 1996). Due to a poor relationship across years, sideoats grama was not included in these analyses. These simple regression equations were used to predict the expected number of stems m^{-2} or plants m^{-2} (blue grama) 2 years after seeding. The r^2 for these predictions ranged from 0.35 to 0.50 for smooth bromegrass, western wheatgrass, crested wheatgrass, and blue grama (Table 1).

Multiple stepwise regression was used to evaluate the explanation of stems or plants in stands 2 years after seeding by incorporation of secondary stand parameters of number of adventitious roots, Haun stage, leaf length, leaf area, and number of tillers with seedlings m^{-2} measured at 45 days after seedling emergence.

Results and Discussion

The number of smooth bromegrass stems present in new stands 2 years after seeding was best explained by the number of seedlings, average adventitious roots per seedling, average leaf area per seedling, and average leaf length of the seedlings 45 days after emergence $R^2 = 0.75$; $P>F = 0.0001$ (Table 2). All 45 day parameters were positively related with the number of stems 2 years into the future except for average leaf area which was negatively related. This is biologically explainable because as seedling leaf area increased on individuals at 45 days after emergence, fewer stems were observed in 2 years. This may reflect the beneficial characteristics of limited early leaf area which can protect the seedling from excess water loss and desiccation. More stems of smooth bromegrass were observed in 2 years as the number of seedlings, number of adventitious roots, and leaf length of the seedlings at 45 days increased. These factors indicate that seedling stage along with seedlings m^{-2} 45 days after emergence better explain the stems present 2 years into the future.

The explanation of stems of crested wheatgrass 2 years in the future was higher when the average number of adventitious roots present was added to the number of crested wheatgrass seedlings present 45 days after emergence ($R^2 = 0.58$; $P>F = 0.0001$, Table 3). Both the number of seedlings and number of adventitious roots were positively related to stems m^{-2} in 2 years. This relationship is also biologically explainable because seedlings with more adventitious roots are more developed and predictive of stems in the future because the seedlings are more likely to survive to support the stands 2 years into the future.

The number of western wheatgrass stems 2 years in the future was best explained by both the number of seedlings and the average number of adventitious roots on each at 45 days after emergence ($R^2 = 0.38$; $P>F = 0.0001$, Table 4). The biological reasoning is the same as for crested wheatgrass. Seedlings with more adventitious roots were more likely to survive and add to the stems m^{-2} present in 2 year old western wheatgrass stands. The R^2 of 0.38 is still quite low and it is believed that this reflects the characteristics of western wheatgrass seedlings as a slow establishing species which propagates readily from vegetative rhizomes. Western wheatgrass seedlings can readily take advantage of favorable weather conditions that occur after 45 days of seedling emergence by developing new stems through vegetative reproduction. For this reason, the number of western wheatgrass seedlings 45 days after emergence is not as highly related to the number of stems present in 2 years as for smooth bromegrass and crested wheatgrass.

Blue grama plants present 2 years after seeding were best explained by both the number of blue grama seedlings and the average number of adventitious roots per seedling 45 days after emergence ($R^2 = 0.65$; $P>F = 0.0001$, Table 5). These are similar results to those observed for crested wheatgrass and western wheatgrass. By knowing the number of blue grama seedlings and the average number of adventitious roots per seedling at 45 days after emergence, good estimates of the number of blue grama plants expected in new stands 2 years into the future could be made.

Summary

In all cases, the number of adventitious roots present on seedlings 45 days after emergence better explained the stems or plants m^{-2} 2 years after seeding. These data provide added support to the premise that grass seedlings need to have adventitious roots in order to be considered established (Hyder et al. 1971 and Ries and Svejcar 1991). Smooth bromegrass stems m^{-2} 2 years into the future were more explainable when developmental stage parameters of leaf area and leaf length of the seedlings 45 days after emergence were considered along with number of seedlings and number of adventitious roots per seedling. Smooth bromegrass is a fast establishing perennial grass so the knowledge of leaf length and leaf area at 45 days after emergence further refines our understanding of stems m^{-2} 2 years into the future of smooth bromegrass stands. Western wheatgrass is a slow establishing perennial grass that readily reproduces vegetatively from rhizomes. Therefore, the R^2 for this species was lower than for the other grasses since weather conditions after 45 days of emergence can greatly improve stands of this species 2 years in the future. Using secondary seedling parameters along with seedlings m^{-2} present 45 days after emergence provide more explanation of stems or plants m^{-2} in stands 2 years into the future than using just the number of seedlings present 45 days after emergence.

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Table 1. Simple regression equations quantifying the relationship of stems m^{-2} or plants m^{-2} at 2 years after seeding with seedlings m^{-2} present at 45 days after emergence (n=99) [1,2,3,4].

smooth bromegrass	
stems m^{-2} @ 2 yrs. = 270.43 + 4.11 (seedlings m^{-2} @ 45 days)	$r^2 = 0.48$**
western wheatgrass	
stems m^{-2} @ 2 yrs. = 374.49 + 7.27 (seedlings m^{-2} @ 45 days)	$r^2 = 0.35$**
crested wheatgrass	
stems m^{-2} @ 2 yrs. = 544.53 + 6.80 (seedlings m^{-2} @ 45 days)	$r^2 = 0.50$**
blue grama	
plants m^{-2} @ 2 yrs. = 5.10 + 0.18 (seedlings m^{-2} @ 45 days)	$r^2 = 0.50$**

[1] n = 99; 11 seeding dates x 3 years x 3 replications.
[2] P>T = 0.0001 for intercept.
[3] P>T = 0.0001 for regression coefficient.
[4] P>F = 0.0001 for overall equation.
** P<0.01

Table 2. Multiple regression equation quantifying the relationship of stems m^{-2} 2 years after seeding with seedlings m^{-2} and significant secondary seedling parameters 45 days after emergence for smooth bromegrass (n=99).

stems m^{-2} @ 2 yrs. = 132.54 + 1.17 (X1) + 61.34 (X2) - 0.52 (X3) + 65.61(X4) $R^2 = 0.75$**

Intercept: P>F = 0.0001.
X1 (seedlings m^{-2} @ 45 days): P>F = 0.0073.
X2 (average number of adventitious roots/seedling @ 45 days): P>F = 0.0011.
X3 (average leaf area/seedling [mm^2] @ 45 days): P>F = 0.0001.
X4 (average leaf length/seedling [cm] @ 45 days): P>F = 0.0001.
** P>F = 0.0001

Table 3. Multiple regression equation quantifying the relationship of stems m^{-2} 2 years after seeding with seedlings m^{-2} and significant secondary seedling parameters 45 days after emergence for crested wheatgrass (n=99).

stems m^{-2} @ 2 yrs. = 333.37 + 5.95 (X1) + 129.66 (X2) $R^2 = 0.58^{**}$

Intercept: P>F = 0.0003.
X1 (seedlings m^{-2} @ 45 days): P>F = 0.0001.
X2 (average number of adventitious roots/seedling @ 45 days): P>F = 0.0001.
** P>F = 0.0001

Table 4. Multiple regression equation quantifying the relationship of stems m^{-2} 2 years after seeding with seedlings m^{-2} and significant secondary seedling parameters 45 days after emergence for western wheatgrass (n=95).[1]

stems m^{-2} @ 2 yrs. = 323.69 + 5.34 (X1) + 93.78 (X2) $R^2 = 0.38^{**}$

Intercept: P>F = 0.0001.
X1 (seedlings m^{-2} @ 45 days): P>F = 0.0001.
X2 (average number of adventitious roots/seedling @ 45 days): P>F = 0.0062.
** P>F = 0.0001

[1]Four western wheatgrass plots flooded – no data – 1988.

Table 5. Multiple regression equation quantifying the relationship of plants m^{-2} 2 years after seeding with seedlings m^{-2} and significant secondary seedling parameters 45 days after emergence for blue grama (n=99).

plants m^{-2} @ 2 yrs. = 2.26 + 0.12 (X1) + 3.73 (X2) $R^2 = 0.65^{**}$

Intercept: P>F = 0.0493.
X1 (seedlings m^{-2} @ 45 days): P>F = 0.0001.
X2 (average number of adventitious roots/seedling @ 45 days): P>F = 0.0001.
** P>F = 0.0001