Seeding Rates, and Plant and Stem Density as Tools to Estimate Forage Yield In Glyphosate-Tolerant Alfalfa.

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Introduction

Most growers use the highest alfalfa seeding rates possible to account for establishment losses due to deficient soil preparation, excess or lack of soil moisture, and other. Recently, a publication in a forage magazine features two growers recommending seeding up to 35 lbs/acre of seed to bump the seeding year forage yield and take advantage of high prices, but as indicated by the farmers in the article, the high seeding rate increase forage yield only if harvest frequency is increased and fertilizer rates (P and K are increased). However, there are not replicated trials that indicate that increasing the seeding rate will increase forage yield and quality. All research published, old and new, agrees on the same.

Hall et al. (2004) determined the effect of seeding rate on glyphosate-tolerant alfalfa stand longevity. Seeding rates from 5 to 24 lbs/acre increased plant density and stand loss was 8 times greater in the highest seeding rate than the low density the first 12 months after planting, thereafter the thinning of stands rate was the same for all seeding rates. Plant density on average declined from 10 to 2.5 plants/ft² in 4 years. Seeding rates below 15 lbs/acre had lower stands after four years. Stem density decreased the first two years but it was stable at 35 stems/ft² thereafter.

A recent study by Hall et al. (2010, 2012) reported that in glyphosate-tolerant alfalfa plant density decreased as the stand aged for all seeding rates. Alfalfa density decreased more rapidly in the 20 lbs/acre seeding rate than the 6 lbs/acre seeding rate. In the last 3 years of the study, plant density decreased by an average of 1 and 0.4 plants/ft² for the 20 and 6 lbs/acre seeding rates, respectively. Dry matter yield on average for the 5 years of the study was lower for the lowest seeding rate of 6 lbs/acre.

Objectives

1) Determine the relationship between plants and stem density, and forage yield in glyphosate-tolerant as alfalfa stands age in North Dakota.

2) Develop an accurate and efficient method to estimate forage yield.

3) Determine the optimal and economical seeding rate to maximize yield in the seeding year.

Materials and Methods

Experiment 1

A replicated experiment was established at three locations Fargo, Prosper, and Carrington in 2013 and at Fargo and Prosper in 2014. The experimental design is a RCBD with six seeding rates (0.9, 4.5, 8.9, 13.4, 17.9, and 22.3 lbs/acre of pure live seed) and 3 replicates. Each plot is 22 ft long and 8 rows spaced 6 inches apart.
Once established the plots, plant density, and stem density was evaluated at the end of the season before the last harvest in 2013 and 2014. Stem and plant counts were conducted in the 6-center rows of the plots in 1 m². Forage yield was evaluated in each harvest in 2013 and 2014. Forage yield was taken from 3.2 x 20 ft wide in each cut both years. Harvest stage was, first cut late bud, second cut 10% bloom, and third and fourth cut at 25% bloom.

The data was analyzed by location, year and cut and then combined using PROC Mixed of SAS. Location was a random effect and year, cut, and seeding rate a fixed effects. The three locations from 2013 and the two locations from 2014 were combined for the statistical analysis. Locations and year combinations were analyzed as environments.

**Experiment 2**

A replicated experiment was established in an existing alfalfa stand in April 2013. The field is located in Fargo, ND, and the cultivar used was DKA34-17RR. Seed was broadcasted at 17 lbs/acre in 2007. In this field, 20 plots of 4x 25 ft long will be flagged. Five treatments with 4 reps were established. The experimental units were selected according to the existing plant stand. Since the alfalfa was already established the plots were selected according the current plant and stem density. T1 < 3 plants/ft², T2 3-4 plants/ft², T3 4-5 plants/ft², T4 5-6 plants /ft², and T5 >6 plants/ft². This experiment will result in information about the relationship between plants and stem density and forage yield in an 8 year-old alfalfa stand.

**Experiment 3**

A replicated experiment was established in an existing 2 year-old alfalfa stand in April 2013 at Prosper, ND. The experiment has three glyphosate-tolerant alfalfa cultivars (MaxiPro 3.10 RR, Consistency 4.10 RR, and Graze-N-Hay 3.10 RR) and three replicates. Four plant densities in each variety were established: T1, < 1 plants/ft², T2, 1-2 plants/ft², T3, 3-5 plants/ft², and T4, > 5 plants/ft². Forage yield, and plant and stem density were collected using the same methodology in Exp. 1.

A regression analysis between yield and plant and stem density was conducted to determine the best prediction model for forage yield in Experiment 2 and 3.

**Results**

**Experiment 1**

**Seeding year**

The combined analysis of variance for the five environments (Fargo, Prosper, and Carrington in 2013, and Fargo and Prosper in 2014) detected significant differences among treatments for all parameters evaluated (Table 1).

The seasonal forage yield and the yield in both cuts was significantly lower with the lowest seeding rate. As seeding rate increased, total forage yield increased, but yield for the three highest seeding rates 13.4, 17.9, and 22.3 lbs/acre was not significantly different among rates.

Density fluctuated between 1.0 and 8.6 plants/ft² and 14.4 and 46.2 stems /ft². As for forage yield, lower seeding rates resulted in lower number of plants and stems. The number of stems per plant fluctuated between 6.0 and 17.3 stems/plant. As expected, as seeding rate increased, plant density increased and number of stems per plant decreased. Plants in lower density have more space to develop, so they have more stems to compensate for lost plants in the stand (Fig. 1).
The regression models for forage yield were very similar for number of plants, stems, or seeding rate (Fig. 1a, 1b, and 1c). Maximum forage yield estimated by the regression models was obtained with 8.5 plants/ft$^2$, 53 stems/ft$^2$, or 19 lbs/acre. Estimated forage yield by the model was 2.9 tons/acre for all three models indicating that in the seeding year, the forage yield can be estimated with either, no. plants/ft$^2$ or stems/ft$^2$.

Table 1. Forage yield, plant and stem density and stems per plant in the seeding year of alfalfa all environments combined.

<table>
<thead>
<tr>
<th>Seeding rate (lbs/acre)</th>
<th>Cut 1 Forage yield (tons/acre)</th>
<th>Cut 2 Forage yield (tons/acre)</th>
<th>Total Forage yield (tons/acre)</th>
<th>Plant density (no./ft$^2$)</th>
<th>Stem density (no./ft$^2$)</th>
<th>Stems/plant</th>
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</table>

Figure 1. Seasonal forage yield of alfalfa in the seeding year vs. a) Number of plants, b) Number of stems, and c) Seeding rate. Number of stems per plant in the seeding year versus seeding rate (d).
First Year of Production

The first production year of alfalfa established in 2013 was evaluated in 2014. Results were different in each location, thus results are presented separated by each location (Fig. 2 a, b, c, and d).

Forage yield increased as number of plants and stems/ft\(^2\) increased only in Carrington and Fargo. No significant forage yield increase was detected in Prosper. The maximum forage yield was obtained with 7 to 8 plants/ft\(^2\) or 40 to 50 stems/ft\(^2\) in Fargo and Prosper. In Carrington, maximum forage yield was obtained with 4 plants/ft\(^2\) and 70 stems/ft\(^2\). In Carrington, plant density was much lower than at the other two locations resulting in much greater no. stems /ft\(^2\) and no. stems/plant.

Regression models estimation for forage yield was very similar for both, plants/ft\(^2\) or stems/ft\(^2\). Similarly to the seeding year both methods to estimate forage yield, plants/ft\(^2\) or stems/ft\(^2\), were very similar.

Stand survivability was evaluated by comparing plant and stems count in the fall in 2013 with those of fall of 2014 (Fig. 2c and 2d). In Prosper, stem reduction increased as seeding rate increased, indicating self-thinning. At higher densities interplant competition is stronger, so plants going into the winter weakened by competition most likely will be winter-killed. In Fargo, stem reduction was erratic not showing any clear trends (Fig. 2c).

Surprisingly, in Carrington instead of the expected stand reduction during the winter, actually number of plants and stems increased in comparison with 2013 (Fig. 2d). There is a logical explanation for this. In 2013, the month of August and September were very dry, thus alfalfa did not grow after the second harvest at the end of July. We counted plants and stems in the fall, but plants had not produce new shoots, what explains the lower numbers of stems. Drought-stressed plants likely moved down all reserves to the root because of water stress and reserve them to survive the winter. In 2014, we had normal to above normal rainfall, so plants used their reserves and produced greater number of stems, hence the increase.
Experiment 2 and 3

Maximum forage yield was obtained with 3.75 and 3.15 plants/ft$^2$ in the 5- and 8-year old alfalfa, respectively. The number of stems for maximum yield was 32 and 25 stems/ft$^2$ for the 5- and 8-year old alfalfa, respectively (Fig. 3a and 3b). In 2013, both experiments had maximum forage yield with 55 and 60 stems/ft$^2$ for the 5- and 8-year-old alfalfa, respectively, indicating that a high percentage of plants were lost due to winter kill.
Figure 3. Forage yield and stand reduction of a 5- and 8-yr old alfalfa stands; a) plant density, b) stem density, c) stand reduction in a 5-yr-old alfalfa, and d) stand reduction in an 8-yr-old alfalfa.
Regression model estimations of forage yield in 5- or 8-year old stands were very different for number of plants or number of stems. Estimated forage yield was 4.2 and 6.6 tons/acre for the 5- and 8-year old alfalfa, when counting plants and 5.4 and 6.5 tons/acre for the 5- and 8-year old alfalfa, when counting stems (Fig. 3a and 3b). This indicates that in older stands, 5- year old or older, the number of stems estimates forage yield better than the number of plants.

As plants get older, part of the crown might be dead or injured having less number of stems than a healthy plant with an uninjured crown (Fig. 4), thus counting stems will result in a more accurate forage yield estimation.

Both the number of plants and number of stems decreased in both the 5- and 8-yr-old stand. Plant loss was up 47% of the stand in the fall of 2013 (Fig. 3c). Lower plant losses were observed in the 8-yr-old alfalfa, and that is probably because the 2014 season started with less plants.

The reduction of number of stems was also up to about 47% of the 2013 stems count in both the 5- and 8-yr-old alfalfa. In general, the stem losses were greater than the plant losses. Winter injury to the crown could have damage part of the crown resulting in less number of stems per plant. Stems per plant fluctuated between 7 and 25 in the 5-year-old alfalfa, and 7 to 10 in the 8 year-old alfalfa.

Older alfalfa crowns are not as efficient as younger crowns to compensate the loss of a neighboring alfalfa plant. In the seeding or first year of production, crowns will produce more stems if a neighboring plants is absent.

Fig. 4. Both 8-year-old alfalfa plants. The plant in the left is healthy without winter injury and many stems/plant. The plant in the right has been injured and it has few stems/plant.

Conclusions
Increasing seeding rate above 13 lbs/acre does not increase the forage yield in the seeding year. Plant and stem density generally decreases as plants get older.

In the seeding year and first production year, plant and stem density both predicted forage yield similarly. Thus, both number of plants and stems can be used to estimate forage yield potential in new stands.

In older stands, stem density is a better predictor of potential forage yield than plant density. As stands get older plant and stem density decreases and the ability of the plant crown to produce new shoots to compensate for the loss of a neighboring plants is much decreased.

References

