TITLE: Plant Population and Stem Counts to Predict Yield of Modern Alfalfa Varieties 7.1.20

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Abstract:
Alfalfa forage yield is influenced by both plant density/ ft^2 and stem density/ ft^2. This project's objective was to re-evaluated and update the relationships between plant populations, stem density, and forage yield of modern alfalfa varieties with fall dormancy 4 and 5. Plant populations were established ranging from 6 to 72 plants per ft^2 and yield in the seeding year and the spring of the first production year measured. In the seeding year, there was no consistent association over locations between plant populations with forage yields or stem number with forage yield. While it is was clear that a 6 plants/ft^2 population had the lowest stem numbers and forage yields averaged over locations, differences in stem numbers and yield among the other plant populations were not consistent. Therefore, we could not determine a threshold plant population or stem density that was critical to maximize seeding year yields. Results from a single harvest in the year following seeding contrast with existing recommendation in that we found greatest first harvest yields with stem densities of about 70 stems/ft^2 or greater. This corresponded to plant populations of from 15-30 plants/ft^2.

Introduction: Assessment of stand productivity potential is critical for profitable alfalfa production. Results from this research will allow farmers, crop consultants and crop insurance adjusters to estimate crop yield potential and help determine if an alfalfa stand has been established successfully. This research creates a direct benefit to farmers and the alfalfa industry by fulfilling a need for updated methods that estimate yield in modern alfalfa varieties with fall dormancy rating of 4 and 5.

Traditionally, alfalfa stand productivity was estimated based on plant density per foot square, with plant densities of 3-5 per square foot considered the minimum for productive stands. However, alfalfa has the ability to compensate for stand reductions with increased stems per plant. Therefore, after the seeding year, stem number density is now routinely used to estimate productivity. Alfalfa stem densities above 50 stems per ft^2 have been considered optimum for alfalfa yields with yields declining with decreased stem densities. These recommendations are based on surveys at two Wisconsin locations with 1 to 3 year old hay fields containing a diversity of older varieties described as fall dormant 3 and 4. However, this research did not consider plant and stem counts as predictors of alfalfa yield in the seeding year, when significant yields can be produced and economic returns realized.

METHODOLOGY

Field research was conducted in three diverse environments with different soil types and weather patterns. These include St. Paul, MN on a silt loam soil; Rosemount on a clay loam; and Becker, MN on a sandy loam soil. Treatment effects were measured throughout the establishment year and during the first harvest of the following year.

Experimental design: randomized complete block design with a split plot treatment arrangement with four replicates. Whole plot treatments were 7 plant populations (6, 12, 18, 24, 36, 48, 72 plants per ft^2) while sub-plot treatments were 4 alfalfa varieties (2 varieties at each of 2 fall dormancy levels, fd4 and fd5). (SW5511, SW5509, 5RVR08, and 54VR10).

Methods: Plots (6 ft^2) with a 3 foot surrounding boarder were established in May of 2019 by broadcasting inoculated seed treated with Apron.

Plant populations of 6, 12, 18, 24, 36, 48, 72 plants per ft^2 were established by broadcast seeding at rates of 8, 15, 22, 29, 43, 58, and 84 seeds per ft^2 using a precision planter following by thinning at two weeks after seeding. Weed-free plots were maintained using recommended herbicides. Insects detrimental to alfalfa yield were controlled using appropriate insecticides.

Plant population measurement: Populations and stem numbers were measured 7 weeks following seeding and immediately prior to each harvest in the seeding year and before the first harvest of the following year. Plant populations and stem density were determined by counting alfalfa plants and stems from two random 1 ft^2 areas within each plot.

Yield measurement: Forage yield were measured at 60 days (late bud) following seeding, in August of the seeding year (late bud), and in May of the following year (late bud). Harvested

forage was weighed, and dry matter content determined by drying a subsample and adjusting yield to a dry matter basis.

PROJECT OBJECTIVES AND RESULTS:

OBJECTIVE: determine the relationship of alfalfa plant population density and stem density with forage yield of modern alfalfa varieties.

1. In the seeding year, there was no consistent associations over locations of plant populations with forage yields or stem number with forage yield. While it is was clear that a 6 plants/ft^2 population had the lowest stem numbers and forage yields averaged over locations, differences in stem numbers and yield among the other plant populations were not consistent. Therefore, we could not determine a threshold plant population or stem density that was critical to maximize seeding year yields. Alfalfa varieties had similar response in stem numbers and yield to changes in plant populations.

2. At the first harvest in the spring of the year following seeding, there was a strong association between alfalfa plant populations/ft^2 and alfalfa stems/ft^2. Stem numbers ranges from 50 to 80 /ft^2 while plant populations ranged from 6 to over 30 /ft^2. Alfalfa varieties did not differ in their relationships with plant population densities and stem densities.

3. There was significant overwintering loss in alfalfa plants/ft^2 at the higher seeding rates. While we observed over 60 plants/ft^2 in the fall of the seeding year at all locations, by spring the highest populations were about 30 plants/ft^2.

4. At the first harvest in the spring of the year following seeding, responses of forage yield to plant population/ft^2 and stem densities/ft^2 varied among locations. At St. Paul, there was a curvilinear relationship with plant populations and with stem density with forage yields. Maximum forage yields were obtained at plant population of about 15 plants/ ft^2 and stem counts of about 67 stems/ft^2. At Rosemount and Becker, there was little change in forage yield over the range in plant populations and stem counts, maximum yields were achieved at greater than 30 plant/ ft^2 and stems numbers greater than 70 stems/ft^2.

RESULTS AND DISCUSSION:

Seeding year:

1. We achieved a range of plant densities in the seeding year. Varieties had similar populations per ft^2. Over the season, we were challenged to maintain the highest plant populations due to natural thinning of plants. Figure 1 shows the relationship between target populations or plant density/ft^2 and established populations.

2. There was no consistent association over locations between plant population/ft^2 and forage yields and stem numbers/ft^2 and forage yields (Table 1). While it is was clear that the 6 plants/ft^2

population had the lowest stem numbers and yields over all locations, differences in stem numbers and yield among the other populations were not consistent. Therefore, we could not determine a threshold plant population or stem density that was critical for the seeding year. A factor influencing the yield response may have been the relatively low yields resulting from two harvests the seeding year.

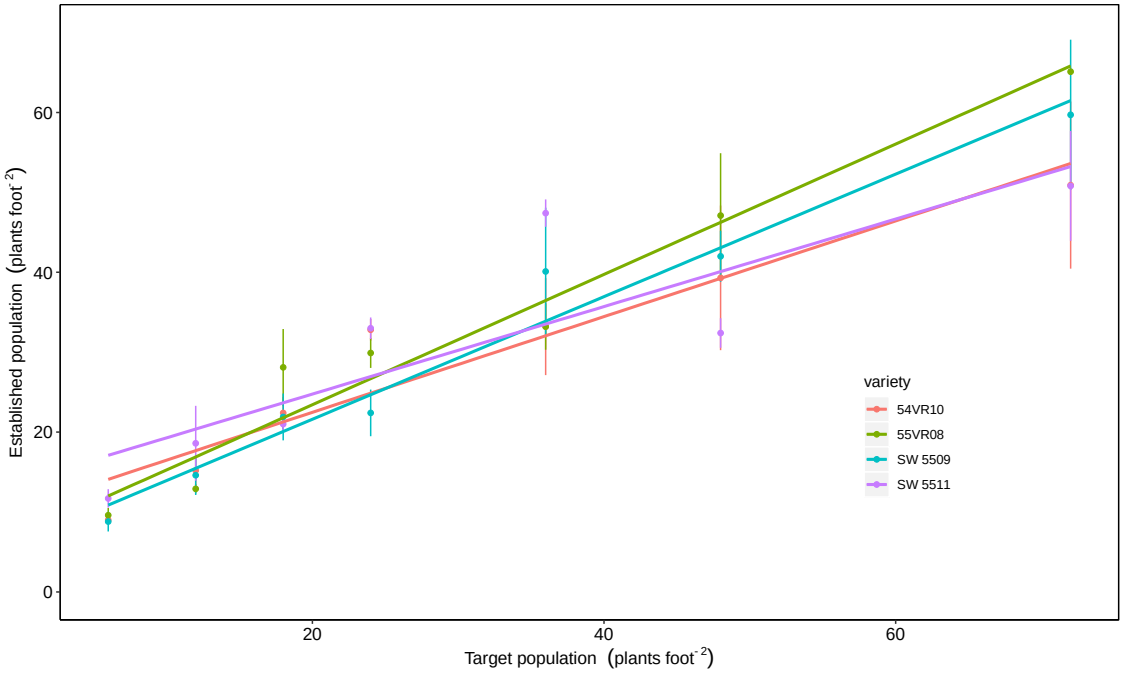


Figure 1. The association of targeted population or stand density with actual established plant population or density.

Table 1. The effect of alfalfa plant populations on stems/ft^2 and forage yield (tons/acre) in the seeding year at St. Paul, Rosemount, and Becker.

Population	Stems/ft^2			Yield (tons/acre)		
Plants/ ft^2	St. Paul	Rosemt	Becker	St. Paul	Rosemt	Becker
6	46	26	30	2.0	1.4	2.0
12	43	28	34	2.2	1.5	2.2
18	43	31	40	2.2	1.7	2.5
24	46	35	40	2.3	1.6	2.5
36	47	42	42	2.4	1.8	2.5
48	47	48	46	2.2	1.8	2.3
72	49	61	50	2.4	2.0	2.6
LSD (0.05)	n.s	21	22	n.s	0.3	n.s

Year after seeding:

At the first harvest in the spring of the year following seeding, there was a strong association between alfalfa plant populations/ft^2 and stems/ft^2. The correlation explained over 90% of the variation in the two variables. Stem numbers ranges from 50 to 80 /ft^2 while plant populations ranged from 6 to over 30 /ft^2 (Figures 2-4). Alfalfa varieties did not differ in their relationship with plant and stems densities. We observed a significant loss in alfalfa plant density at the higher seeding rates during the winter. While we observed over 60 plants/ft^2 in the fall of the seeding year, by spring the highest populations were about 30 plants/ft^2.

Responses of yield to plant population and stem densities varied among locations. At St. Paul, where we observed the widest range of plant populations, there was a curvilinear relationship between plant populations and forage yields and between stem density and forage yields. Plant population of about 15 plants/ ft^2 or above were required for maximum yields while stem counts of about 67 stems/ft^2 or above were required. At Rosemount, where there was little change in yield over the range in plant populations and stem counts, forage yield were greatest at plant densities of 27-30 plants/ ft^2 with stem densities near 71-76 stems/ ft^2. At Becker, the response to increasing seeding rates was linear meaning that maximum yields would be achieved at greater than 30 plants and stems greater than 70 stems/ ft^2.

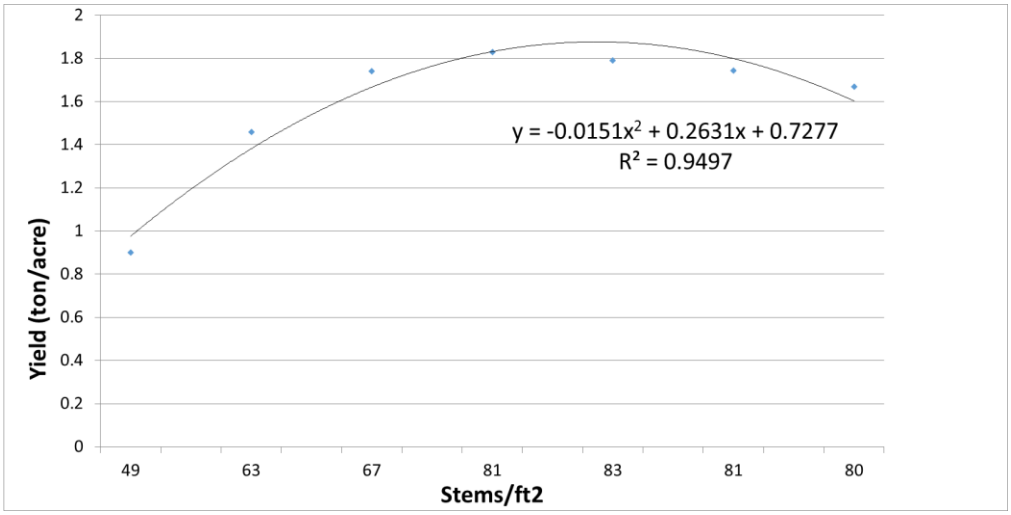
Discussion and Conclusions

Based on results from the seeding year, we concur with Undersander and Cosgrove (2007) who recommended that new seedings should have at least 25 to 30 plants per ft^2. In our trials, these plant populations provided stem numbers and yields that were not consistently different from those of populations as high as 72 plants ft^2.

As stands age, alfalfa populations above 55 stems per ft^2 have been considered optimum for alfalfa yields with yields declining with decreased stem densities (Undersander and Cosgrove;2007). In research in North Dakota (Berti and Samarappuli, 2018) stem counts required for maximum forage yields for 1 old stands were about 46 stems/ft^2. Our results from a single harvest in the year following seeding contrast with existing recommendation in that we found greatest first harvest yields with stem densities of about 70 stems/ft^2 or greater. This corresponded to plant populations of from 15-30 plants/ft^2.

For the limited time period of this study, alfalfa varieties with fall dormancy 4 and 5 had similar plant population, stem density, and forage yield characteristics. As the study continues, variety differences may emerge.

This work is being continued with additional harvests in 2020 and 2021 with populations and stem counts monitored.



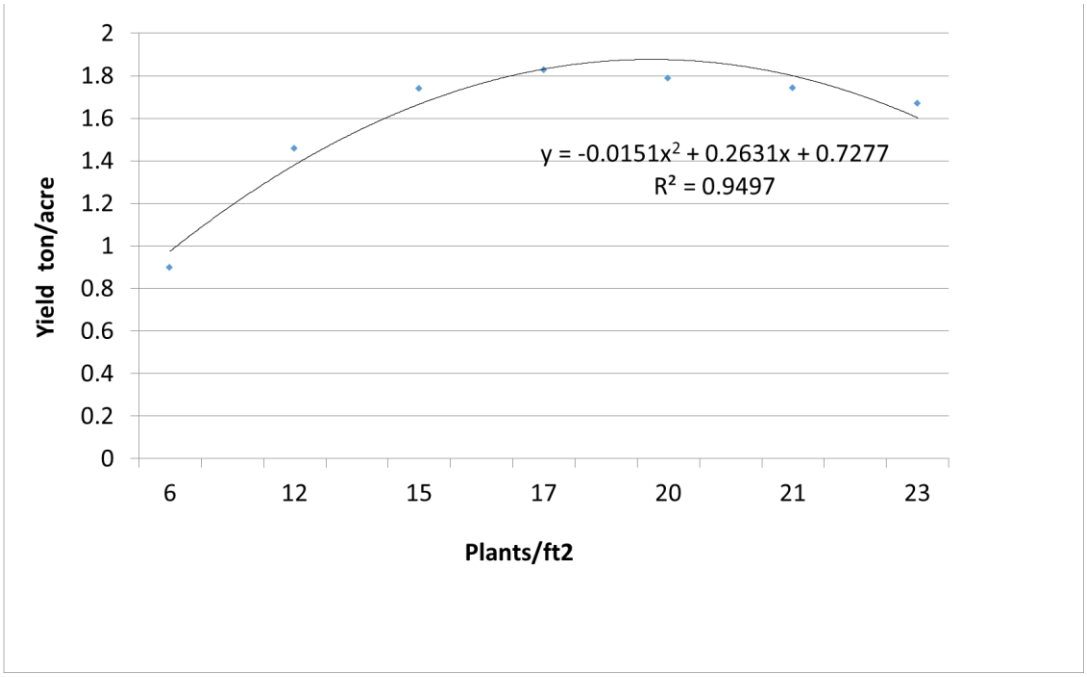
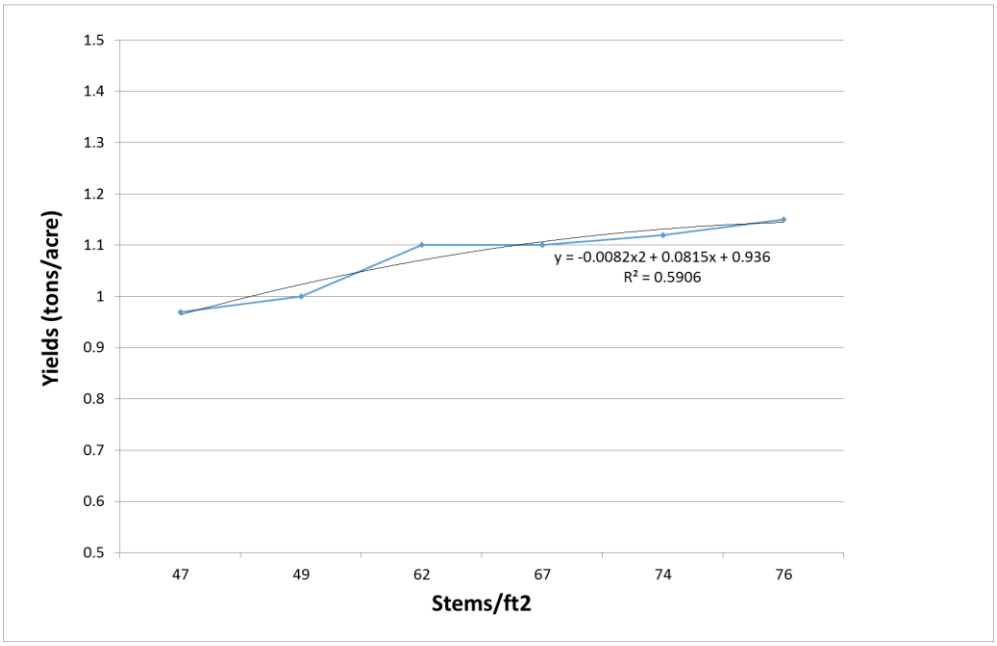


Figure 2. The relationship of stems/ft^2 and plant density/ft^2 with forage yield at the first harvest in 2020 at St. Paul, MN



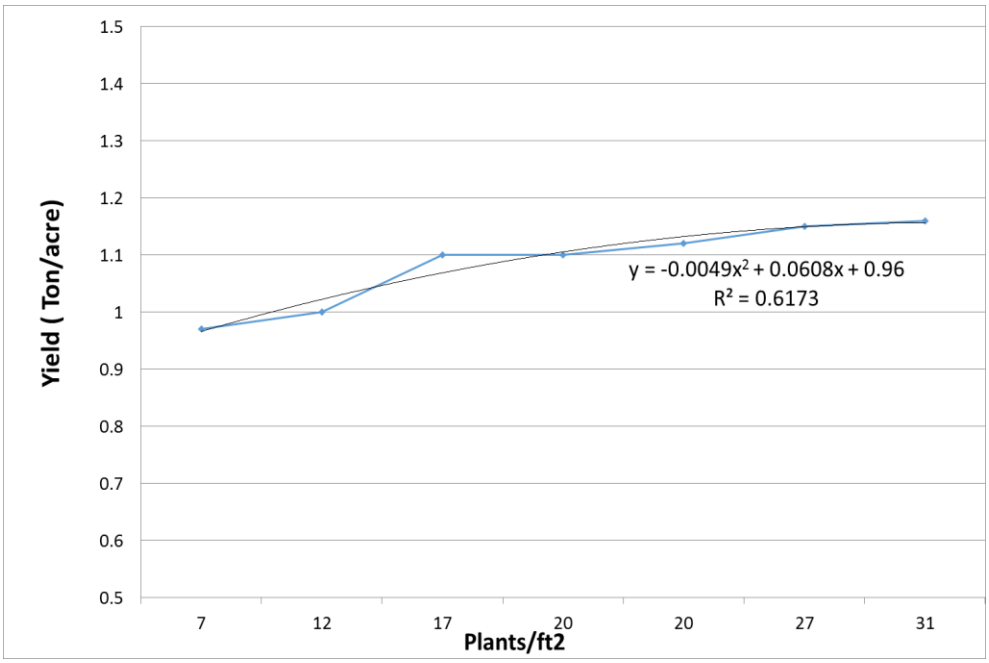
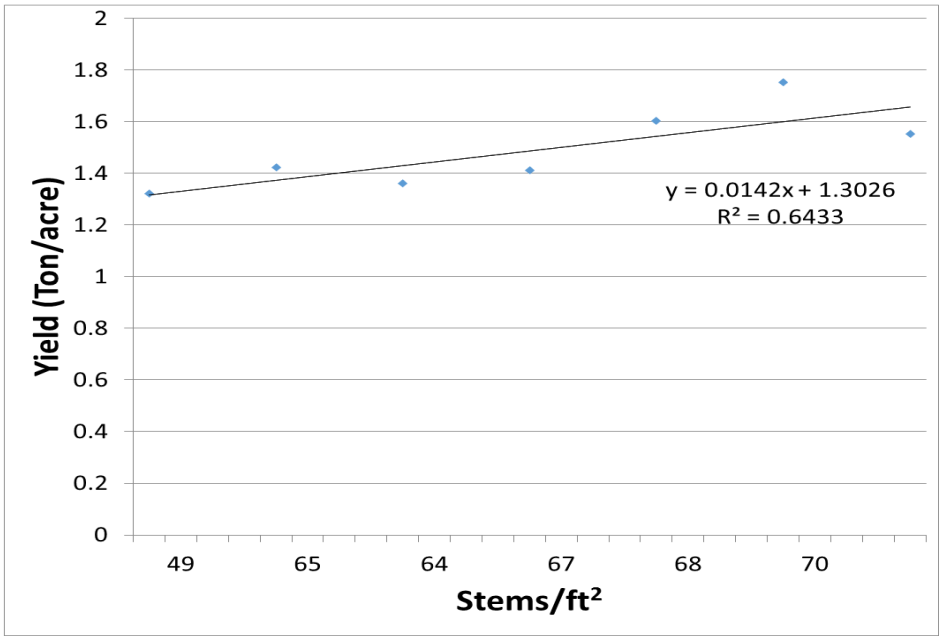


Figure 3. The relationship of stems/ft^2 and plant density/ft^2 with forage yield at the first harvest in 2020 at Rosemount, MN



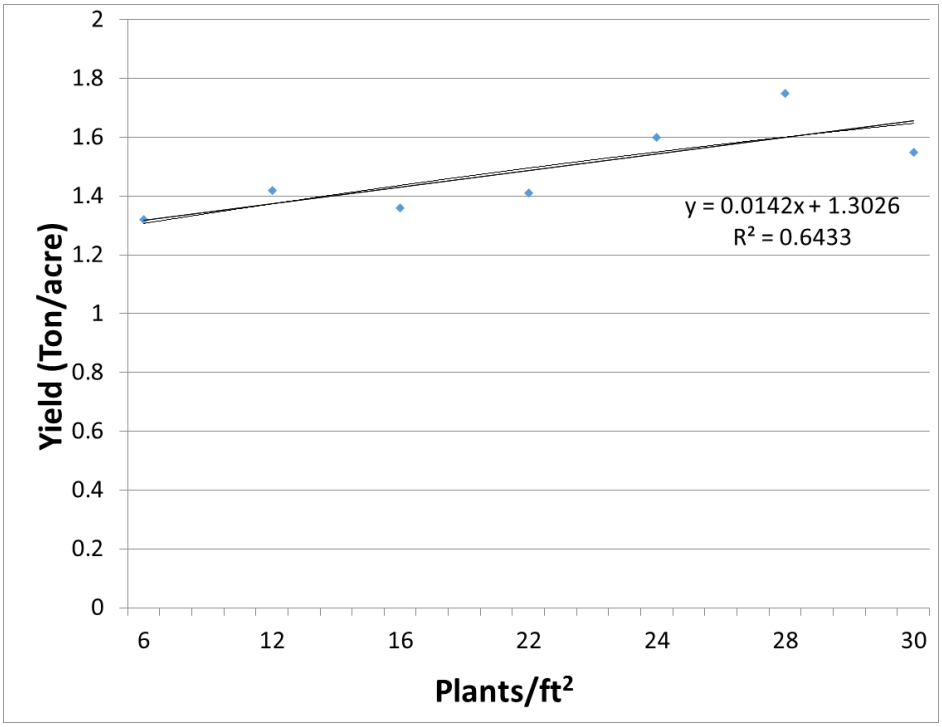


Figure 4. The relationship of stems/ft^2 and plant density/ft^2 with forage yield at the first harvest in 2020 at Becker, MN

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