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# Shoot Morphology of Eleven Alfalfa Populations

Jessica A. Schmuck

*South Dakota State University*

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Author: Jessica A. Schmuck

Faculty Sponsor: Dr. Lan Xu

Department: Natural Resources Management

# ABSTRACT

Alfalfa (*Medicago sativa* L.) is a major component of feed for dairy and beef cattle and one of the most productive forage species in North America. Alfalfa has been planted on millions of acres. More than 100 varieties have been developed in North America over the past 100 years. However, historically, alfalfa persistence under grazing in semiarid rangeland has generally been poor. Recently, it was discovered that naturally-selected populations of predominantly yellow-flowered alfalfa have been proven to be adapted to rangelands of western South Dakota and adjacent areas. A study was initiated in May 2006 to evaluate persistence and vigor of eleven alfalfa populations (conventional-hay type, pasture type, pure *falcata*, and predominately *falcata*) by transplanting seedlings into native and tame grasslands in South Dakota. The objective of this experiment was to investigate shoot morphology of eleven alfalfa populations in tame grasslands. The experiment was a randomized complete block design with three replications of five plants in 1.2 m long single-row plots. For each population, aboveground biomass of all plants was harvested and ten stems were randomly selected on July 25, 2008. For each stem, the morphological characteristics measured included: a) length & basal diameter, b) number of nodes, branches, pods, c) ratios of leaf to stem, branch to stem, reproductive to vegetative biomass. The results showed that pure *falcata* cultivar Don had the shortest and thinnest stem, the highest proportion of total stem weight in leaves and reproductive to vegetative biomass ratio, but the lowest stem total biomass. Naturally-selected predominately *falcata* population from Wind River Seed Co. had the longest, thickest, heaviest, most branched and pods produced stem compared to the other populations.

**Keywords:** *Medicago sativa, M. falcata*, yellow-flowered alfalfa, legume, shoot morphology, persistence

# INTRODUCTION

Alfalfa (*Medicago sativa* L.) is a major component of feed for dairy and beef cattle and one of the most productive forage species in North America. Alfalfa is native to the Middle East and Central Asia. It was introduced into the US in the early twentieth century. Alfalfa has been planted on millions of acres and more than 100 varieties have been developed in North America over the past 100 years (Rumbaugh, 1982). Historically, alfalfa persistence under grazing in semiarid rangeland has generally been poor. Recently, it was discovered that naturally-selected populations of predominantly yellow-flowered alfalfa have been proven to be adapted to rangelands of western South Dakota and adjacent areas (Xu, 2008a). In 1982, alfalfa was reported to naturally reseed in Utah (Rumbaugh, 1982). In 1997, Norman G. Smith reported alfalfa had naturally reseeded on his ranch in western South Dakota (Smith, 1997). Then, in 2000, it was found that alfalfa naturally reseeded on the Grand River National Grassland near Smith ranch (Xu, 2008b).

Alfalfa, a legume, is an important economical forage crop for livestock because it is highly productive and nutritious. Alfalfa is high in vitamins (e.g., carotene), magnesium, minerals, fiber, and protein (Balliette, 1998). Interseeding alfalfa into the degraded pastures has been shown to be an efficient approach to increasing forage production, forage quality, and animal output in the Northern Great Plains (Smith 1997). Meanwhile, naturally reseeded alfalfa demonstrates value for rehabilitating depleted rangelands, by means such as increasing soil nitrogen, organic carbon, which resulted in improving forage production (Mortenson, 2004).

By evaluating morphological characteristics one can select preferential traits for specific environmental conditions and utilization purposes and provide useful information for breeding programs. For example, forage quality of alfalfa is mainly influenced by leaf to stem ratio, the higher leaf to stem ratio the better quality (Rotili, 2001). Similarly, seed production highly depends on pods production, larger canopy and highly branched shoots, and leaf to branch ratio will potentially increase forage production.

The objective of this study was to investigate shoot morphology of eleven alfalfa populations among different functional types in tame grasslands.

# METHODS & MATERIALS

## Study Materials

In May 2006, seeds of eleven alfalfa populations (Table 1) were germinated in plastic cone-containers in a greenhouse of South Dakota State University. Populations consisted of three conventional-hay type cultivars (5454, 6200HT, Vernal), four predominately *falcata* (Mandan A9191, SD202, SD203, Falcata), two pure *falcata* (Don, SD201), and two pasture type cultivars (Alfagraze, Travois).

## Study Area

Seedlings of these 11 populations were transplanted into a tame grassland field plot at the east of the campus in Brookings, SD. The climate is cold in winter and warm in summer with mean annual precipitation 500 mm and mean annual temperature is 6°C (Figure 1). Soil type is dominated by Brandt silty clay loamy, while the vegetation is mixed-grass prairie (Xu, 2008a). Alfalfa generally grows from April to October, when precipitation and temperature are high (Figure 1).

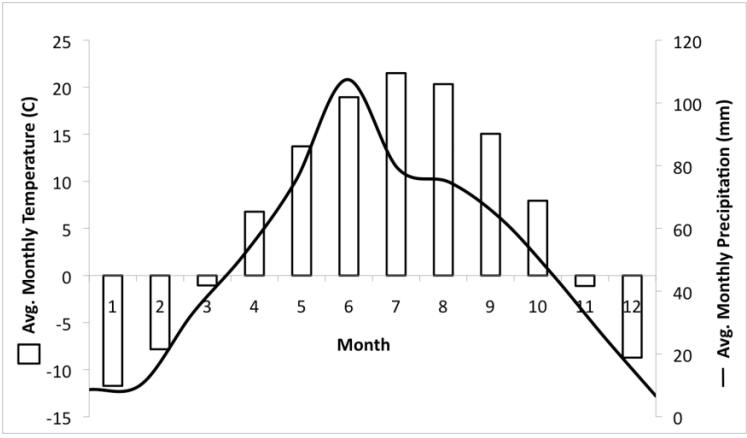


**Figure 1: Average monthly temperature and average monthly precipitation at SDSTATE field plot in Brookings, SD. Data from 1971 to 2000.**

**Table 1: Eleven alfalfa populations evaluated by shoot morphological characteristics**

| Entry | Description | Developer/Marketer/Origin |
|---|---|---|
| 5454 | Cultivar Conventional Hay-Type | Pioneer Hi-Bred Int'I |
| 6200 HT | Cultivar, Conventional Hay-Type | Garst Seed Co. |
| Vernal | Cultivar, Conventional Hay-Type | Univ. of Wisconsin |
| Alfagraze | Cultivar, Pasture-Type | America's Alfalfa |
| Travois | *Cultivar, Pasture-Type* | SDSU |
| Don | Pure falcata, rangelands-Type | USDA-ARS, Logan, UT |
| SD201 | Pure faclata, experimental YFA for forage and wildlife habitat | SDSU |
| Mandan A9191 | Experimental from Mandan, ND | USDA-ARS, Mandan, ND |
| SD202 | PYFA experimental from feral rangeland in NW, SD, coiled-shaped seed pod | SDSU |
| SD203 | PYFA experimental from feral rangeland in NW, SD, sickle-shaped seed pod | SDSU |
| Falcata | PYFA developed by N. Smith, Lodgepole, SD, for interseeding rangelend | Wind River Seed Co. |

## Experimental Design

On May 30 and 31 of 2006, three replications of five plants from each of the populations were planted on 1.2 meter long single-row plots. Plots were in a randomized complete block design. All aboveground plant biomass was harvested on June 25, 2008. From each population, ten stems were randomly selected and bagged together. The bags were labeled by population and placed directly in the freezer. The bags were thawed individually throughout January and February 2010. Each stem was placed in an individual plastic bag and stored in the refrigerator.

## Data Collection

For each shoot, the morphological characteristics measured included: a) length & basal diameter, b) number of nodes, branches, pods, c) ratios of leaf to stem, branch to stem,

reproductive to vegetative biomass. The main stem length was measured in centimeters from base to tip with a meter stick. The basal diameter below the first node was measured with a caliper. The number of nodes on the main stem and the number of primary branches were counted. The node with the first branch was recorded as first node, second node, etc. The flower color and pod shape were noted. The branch leaves were bagged separately from the main stem leaves. The primary branches were removed from the main stem and placed in a paper bag. The paper bags were placed in a VWR Drying Oven set at 60°C for at least 72 hours. The biomass of the branches, leaves, stem, and reproductive structures were then weighed with an Acculab Vicon electronic scale.

## Data Analysis

Ratios were calculated as follows: leaf biomass divided by stem biomass, branch biomass divided by main stem biomass, and reproductive structure biomass divided by vegetative structure biomass. The data was analyzed using the SAS program, PROC ANOVA. If the p-values were less than 0.05, they were considered statistically significant.

# RESULTS

Pure *facata* – rangeland type cultivar Don had the significant smallest and thinnest stem among the 11 populations in terms of stem length and diameter. The rest of 10 populations had similar stem length and diameter (Fig. 1). But Don had the highest leaf proportion in total stem biomass and the highest reproductive biomass to vegetative biomass ratio ($P<0.0001$).

Naturally-selected predominately *falcata* population had the most branched stem ($P<0.0001$) among the 11 populations. It also produced the most pods ($P=0.0191$) and the total stem biomass ($P=0.0307$).

Conventional-hay type 5454 cultivar had significantly less branches and percentage of leaf in the total biomass of stem.

# DISCUSSION

From a forage quality standpoint, pure *falcata* cultivar Don has demonstrated high forage quality than other populations since it had the fine stems and highest proportion of total stem weight in leaves. Generally, stem or branches contain fewer nutrients, such as protein, than leaves (Balliette, 1998). Compared to forage yield, Don had less biomass production than Conventional-Hay-sativa-type 6200 HT and naturally-selected predominately *falcata*. However, the production of the grass-Don mixture (tall fescue-Don and meadow brome -Don) was significantly higher than the production of the grass monocultures (Peel et al 2009), which probably contributed to Don's ability to fix nitrogen through nodules in its root system, enriching the soil for the grasses. In addition, low growth habit makes Don more suitable under grazing condition in rangelands. Predominantly *falcata* was developed in western of South Dakota near Lodgepole for interseeding rangeland under grazing. This naturally-selected predominantly *falcata* population had the largest and more branched stems than the other populations. It also had the highest biomass per stem and seed pod production, which led to high seed production. It is no surprise to observe predominantly *falcata* had the highest seed pod production since it was purposely selected and developed for high seed production in order to interseed degraded rangelands.

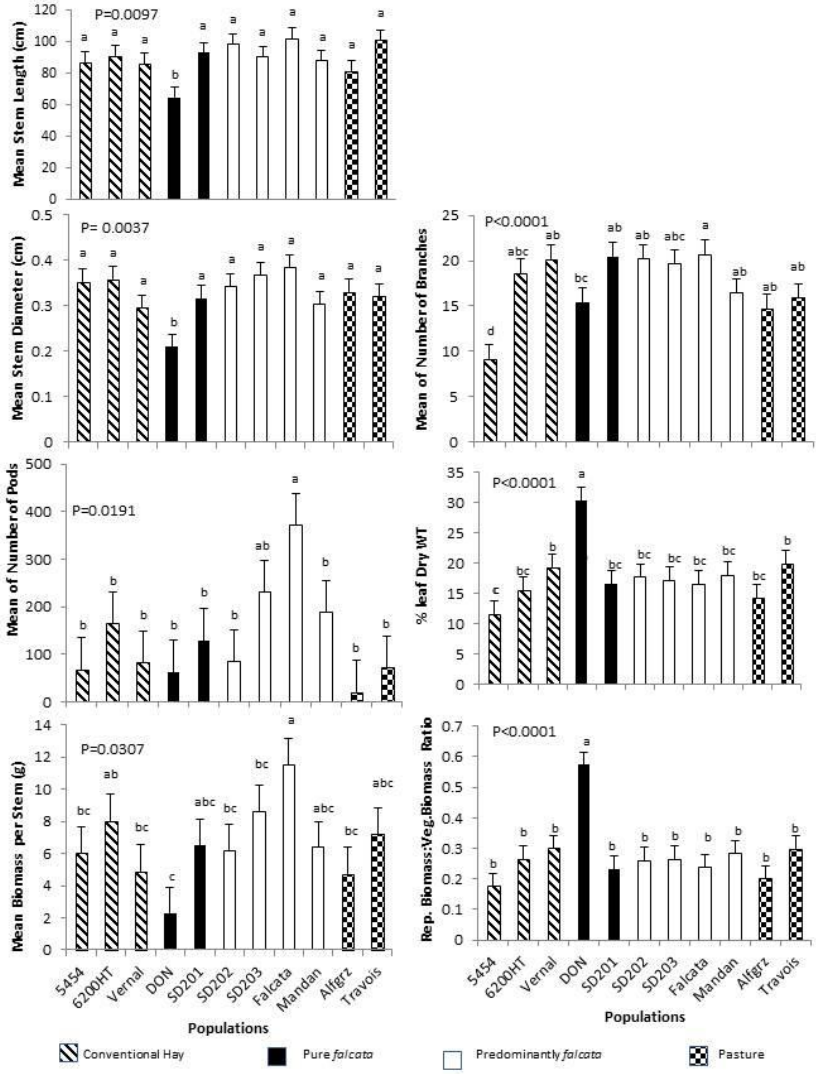


**Figure 2. Shoot morphological characteristics of 11 alfalfa populations. Columns shared the same letter indicated no statistically significantly difference at α=0.05.**

# CONCLUSIONS

Shoot morphology varies among the 11 populations. In general, pure *falcata* cultivar Don

has high forage quality and the capability to improve degraded rangelands and persists under harsh environments. Predominately *falcata* type is most productive through producing large and more branched stems for the forage. Predominately *falcate* also has high seed production, which indicates that the predominately *falcata* has the potential to persists through recruitment from seedlings and maintain itself through seed bank.

# LIMITATIONS

To improve on the process of measurement, a more sensitive analytical scale could be used. It also would have been beneficial to place individual stem in ten separate bags for each population during the harvest. This would have made measurement more accurate. Leaves that fell off the stems while in the bag could have been included in measurements if stems had been separated. It would provide more useful information if the morphology evaluation under grazing treatments and less precipitation conditions.

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