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Alfalfa Culture

Brief Notes on Crop Theory and Management

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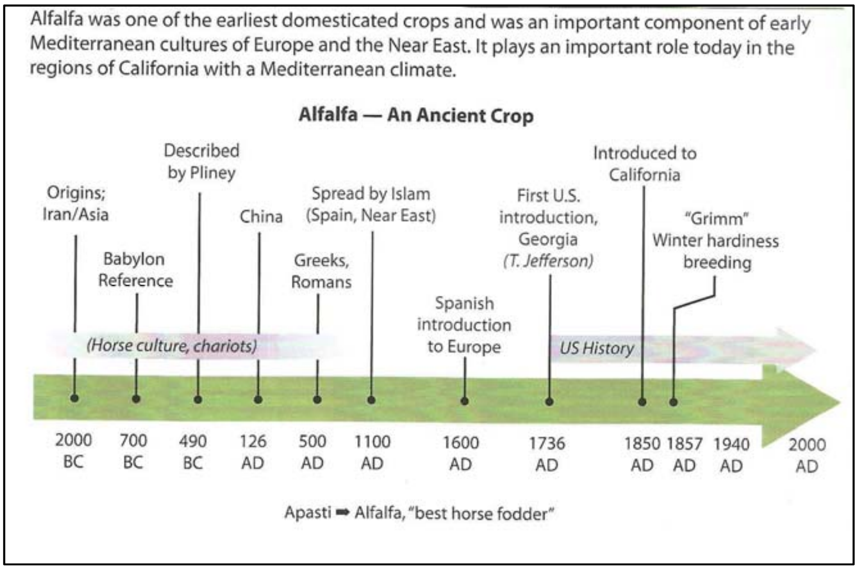
Brief Notes on Crop Theory and Management

David Kopec, Guest Lecture: – University of Arizona.

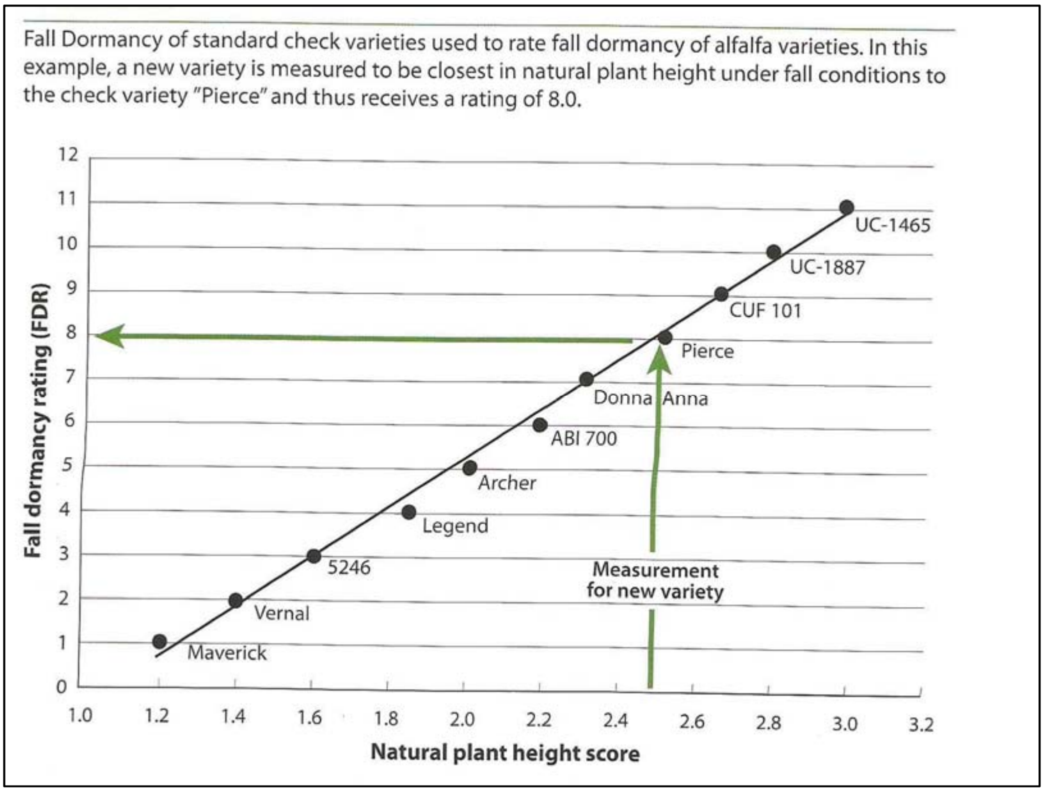
Alfalfa is a domesticated crop which has at least a 4,000 year history. It is believed to have originated from present day Turkmenistan, Iran, Turkey, and the Caucasus. Alfalfa has been written about as early as 1300 B.C. in Turkey. The forage culture of alfalfa was used by the Roman Empire, which enabled the army to better feed its military horses, and increase milk and meat production for it soldiers **(See Fig 1 below).** Today, alfalfa is grown worldwide on 37 million hectares, with 70% of production coming from the U.S., Russia, and Argentina.

Figure 1: Domestication of alfalfa



The first question regarding selection of an alfalfa type is to know its dormancy. Dormancy is defined as the degree of growth (plant height) during the fall season. Fall dormancy (FD) is controlled genetically and is the plant's response to cool temperatures and length of day (hours of daylight).

Figure 2: Varietal differences of alfalfa fall dormancy



An example of varietal FD is provided above in **Figure 2.** Plants are scored on a height basis in the fall which determines the fall dormancy rating itself (FDR). Shorter plants are more dormant, while taller plants are non-dormant. The non-dormant types thus have greater growth in the fall and early winter. Fall dormant varieties are in FDR class 1-4, semi-dormant varieties are in class 5-7, and 8-11 are non-dormant. In this classification system, cultivar classes are based on fall season plant height. The longer and colder the winter season is, the greater the need there is for using a dormant variety.

After initial planting, it is important for the farmer to pay attention to development of the base of the plant, called the crown. The crown needs to go through the initial phase of what is called "contractile growth". This is explained as follows: As the primary and secondary roots grow, the portions of the stem underneath the cotyledon node shortens and thickens. This is a result of cells in the hypocotyl expand laterally and become shorter, lengthwise. The visible result is a rough appearance of crown, roots and stems, which will elongate afterwards in the life span of the plant. As result of this growth, the unifoliate leaf may be pulled underneath the soil, which then forms the "crown". **(see sidebar Fig. 3)**

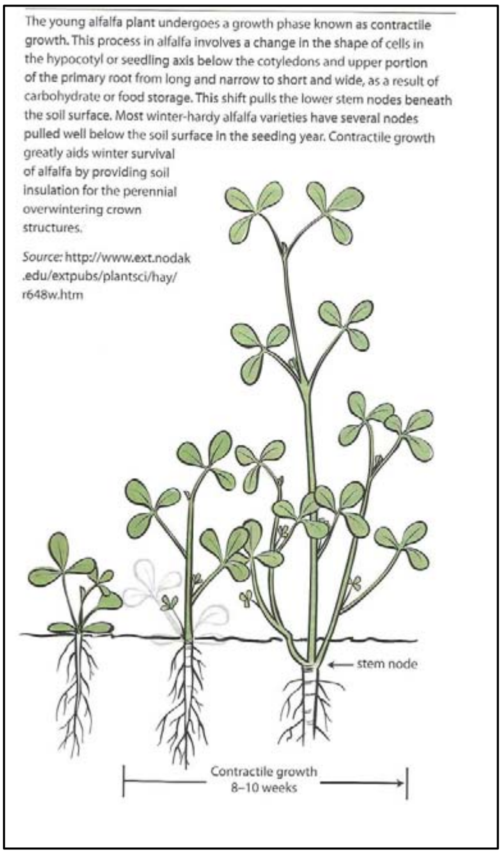


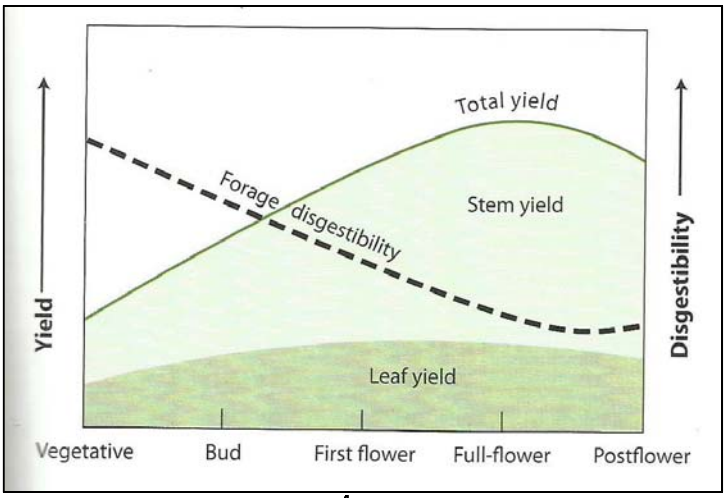
Fig. 3: Initial development of alfalfa plant

The crown will thus contain growing cells for new leaves, stems, and roots. Varieties which have greater Fall dormancy have more pronounced contractile growth, so the nodes remain deeper underground, a benefit for winter survival. It is important to have this "contractile growth" to occur, before the first cutting harvest occurs. Plants should be allowed to reach 20 to 30 cm to promote food storage in roots and crowns, before the first (and following) cutting.

Plant Age and Quality:

As alfalfa grows and matures, nutritional quality decreases. In young plants (pre-bud) forage quality is high due to a favorable leaf to stem ratio. As the plant matures, the proportion of leaves to stems decreases, since older plants are more stemmy. Stems become more fibrous with age, and as a result, overall feed quality decreases, with age (**Figure 4).**

Figure 4: Forage yield relative to quality (forage digestibility) at different alfalfa stages



The yield of high quality alfalfa is enhanced by not harvesting until flower buds can be seen at stem tips. During strict vegetative growth (before flower buds appear) yield increases faster than quality decreases. During flowering, reduction in quality becomes rapid, since fast increases in fiber concentration (cellulose and lignin) occurs in the stems.

This is why cutting time and frequency (based on plant maturity) has the greatest impact on forage quality. Cutting based on plant stage of development uses the alfalfa plant itself as a “harvest indicator”. This usually produces more consistent yield/quality combinations than the single effects of cultivars, production years and grower locations. So yield and quality are essentially a trade-off in alfalfa.

Quality is expressed as the proportion of fiber versus crude protein. Low amounts of acid detergent fiber (ADF) and neutral detergent fiber (NDF), result in high total digestible nutrients (TDN) and favorable feed value (high crude protein and NEL).

Once again, “early or frequent cuttings” performed to enhance quality should not be so close together, since food for root reserves will not be sufficient for top re-growth for the next cutting. Also, harvesting “immature” alfalfa in the cool Spring can result in inadequate fiber for ruminants. This can be critical for animals used for reproduction and lactation. In this case, another feed supplement is necessary.

Seedling Establishment:

Adapted cultures (in Europe mostly dormant types) are seeded in the spring. Fall or late Summer terms are also possible but risky, as the successful stand establishment depends on soil moisture and course of weather before beginning of Winter season. On prepared bare ground, alfalfa seed should be sown at 20 kg/ha. Seed can be sown by either using a drill seeder, a slit –type seeder, or less favorably, by the broadcast method. The seed bed is usually rototilled, leveled, and dragged flat before overseeding. Following seeding, a surface culti-packer or ring-roller is often used to make seed/soil contact.

Emergence is highly dependent on soil moisture. In Central Europe, spring is normally the accepted period for obtaining soil moisture. Fertility of the soil can also be an important part of alfalfa production and quality. The soil nutrients most commonly in short supply for alfalfa are phosphorous, followed by potassium, sulfur, and the trace elements of molybdenum and boron.

Amounts of plant available nutrients are often soil/climate dependent. Soil testing is essential for confirming a suspected nutrient limitation. Plant tissue testing is also important to confirm a suspected nutrient deficiency, especially for sulfur and boron. **(See tables 1 and 2).** Tables 1 and 2 provide guidelines for visual plant nutrient deficiencies and selection method for testing (soil or tissue testing).

The best time to sample plant tissue is when alfalfa is in the one-tenth (1/10) bloom stage. Since alfalfa is often cut before this stage (cut at the bud stage for quality purposes), leaf phosphorous concentration should be at least 1200 ppm PO_4 –P, at mid bud stage, and higher (1600 ppm) at early bud stage. For sulfur, testing should be done at first cutting, because this is the best time to detect a deficiency for sulfur.

Different plant parts are analyzed for different nutrients. Table 1 provides a collection procedure for nutrients deficiency symptoms.

Table 1: Nutrient deficiency symptoms observed in alfalfa

Deficiency	Symptoms
Nitrogen	Generally yellow, stunted plants
Phosphorus	Stunted plants with small leaves; sometimes leaves are dark blue-green
Potassium	Pinhead-size yellow or white spots on margins of upper leaves; on more mature leaves, yellow turning to brown leaf tips and edges
Sulfur	Generally yellow, stunted plants
Boron	Leaves on the upper part of plant are yellow on top and reddish purple on the underside; internodes are short
Molybdenum	Generally yellow, stunted plants

Table 2: Interpretation of test results for alfalfa plant tissue samples taken at one-tenth bloom

Nutrient	Plant Part	Unit	Plant Tissue Value[a]			
			Deficient[b]	Marginal	Adequate	High
Phosphorus (PO_4–P)	Middle third, stems	ppm	300–500	500–800	800–1,500	Over 1,500
Potassium	Middle third, stems	%	0.40–0.65	0.65–0.80	0.80–1.5	Over 1.5[c]
Sulfur (SO_4–S)	Middle third, leaves	ppm	0–400	400–800	800–1,000	Over 1,000[d]
Boron	Top third	ppm	Under 15	15–20	20–40	Over 200[e]
Molybdenum	Top third	ppm	Under 0.3	0.3–1.0	1–5	5–10[f]

a. Phosphorus concentration should be higher if alfalfa is cut at bud stage, 1,200 ppm at mid-bud, and even higher, 1,600 ppm, if cut at very early bud stage. Other nutrient concentrations should be approximately 10% higher than when sampled at the one-tenth bloom growth stage (multiply tabular values by 1.10), (ppm = mg/kg).

b. An economic yield response to fertilizer applications is very likely for values below the deficient level, somewhat likely for values in the marginal level, and unlikely for values over the adequate level.

c. Alfalfa having greater than 3% potassium may cause animal health problems, particularly if the magnesium concentration is not greater than 0.25%.

d. Alfalfa having greater than 3,000 ppm SO_4–S may intensify molybdenosis in ruminants.

e. A concentration over 200 may cause reduced growth and vigor.

f. A concentration over 10 may cause molybdenosis in ruminants. Copper concentrations should be twice as high as molybdenum concentrations.

Tables 3 and 4 provide below suggested soil and plant tissue tests for alfalfa, as well as the soil interpretation for phosphorous, potassium, and boron. Application of nitrogen is seldom beneficial since alfalfa is a nitrogen fixing legume.

Table 4 (on right): Suggested tests for a complete examination of soil and alfalfa tissue

Table 3: Relative reliability of soil and plant tissue testing for nutrient deficiency

Nutrient	Soil Testing	Tissue Testing
Phosphorus	Good	Excellent
Potassium	Good	Excellent
Sulfur	Very poor	Excellent
Boron	Poor	Excellent
Molybdenum	Not recommended	Excellent

Soil	Plant Tissue
pH[a]	Phosphorus (PO_4–P)
Phosphorus	Potassium
Potassium	Sulfur (SO_4–S)
EC_e[a]	Boron
Calcium, Magnesium, Sodium[a]	Molybdenum
SAR[a]	Copper

a. These tests evaluate factors that affect the availability of nutrients and the presence of undesirable salt levels. EC_e = electrical conductivity of saturated paste extract (dS/m or mmho/cm); SAR = sodium adsorption ratio.

Table 5: Interpretation of soil test results for alfalfa production

Nutrient	Extract[b]	Soil Value (ppm)[a] Deficient	Marginal	Adequate	High
Phosphorus	Bicarbonate	<5	5–10	10–20	>20
Potassium	Ammonium acetate	<40	40–80	80–125	>125
Boron	Saturated paste	0.1[c]	0.1–0.2	0.2–0.4	>0.4[d]

a. An economic yield response to fertilizer application is very likely for values below the deficient level, somewhat likely for values in the marginal range, and unlikely for values over the adequate level.

b. Soil test values are based on use of the cited extract; values for other extracts are different.

c. Soil testing is not a suitable method to diagnose a deficiency. Use a plant tissue test.

d. Possible toxicity to sensitive crops, such as cereals.

In rare cases where nitrogen would provide a beneficial response, it is most likely due to failure of the nitrogen fixing rhizobium bacteria to become established with the alfalfa roots. This is caused by low soil pH, cold soil, compacted soil, waterlogged soil, or a shallow or layered root zone. The most common cause of nitrogen deficiency is poor seed inoculum resulting in poor root nodule formation. Most seed in the USA can be purchased with inoculum coatings, if not, inoculum can be applied to the stand after emergence. Seed inoculation is the normal and more beneficial practice.

A mixture of stunted/light green/yellow plants mixed among normally taller/green plants is an indication of poor root nodule formation. A visual inspection of the roots in both areas of the field should show less nodules in the areas where alfalfa is growing poorly.

Alfalfa for grazing or hay:

Alfalfa can be fed directly to pigs and horses which have a single or "true" stomach. Alfalfa is also fed to dairy and beef cattle, sheep, and goats all which have a four compartment stomach where rumen is the largest. For cattle, alfalfa can be provided through direct grazing or in a more controlled fashion as in a hay or silage mixture. A summary of alfalfa quality standards for various classes of dairy cows is provided in table **6 below**.

Table 6: Minimum quality of alfalfa required for various classes of cattle

	Nutrient Parameter (DM basis)		
Class of dairy animal	TDN	NDF %	CP
Calf	59.0[1]	42.0	20.0
Heifer	59.0	42.0	20.0
Bull	55.0	50.0	17.0
Dry Cow	55.0	50.0	17.0
Milking Cow			
Transition: 0–21 days in milk	62.0	36.0	23.0
90 lb (41 kg) milk/day	62.0	36.0	23.0
75 lb (34 kg) milk/day	59.0	42.0	20.0
50 lb (23 kg) milk/day	59.0	42.0	20.0

Source: National Research Council. Nutrient Requirements of Dairy Cattle, 7th rev. ed. 2001. National Academy Press, Washington, DC.

[1]TDN as expressed on a 100% DM basis, calculated from ADF or NDF. TDN is often expressed on a 90% DM basis by multiplying this number by 0.9.

Abbreviations: ADF = acid detergent fiber

CP = crude protein

DM = dry matter

NDF = neutral detergent fiber

TDN = total digestible nutrients

Almost 95% of alfalfa in the U.S. is used for hay and not for direct grazing. In the CZ Republic, 90% of alfalfa is used for silage from wilted forage, which has typical dry matter content of approximately 40%. In Australia, New Zealand and Argentina, grazing of alfalfa is more common. The *"advantages and disadvantages"* of grazing compared to feedlot forage systems are provided in the table below.

Advantages and Disadvantages of Grazing vs. Feedlot Forage Systems

Advantages

- Low cost
- Low fossil fuel requirement
- Animal health
- Animal welfare
- Reduced waste issues—dispersed nutrient cycling
- Consumer preference in some markets
- Sustainability of agricultural systems

Disadvantages/Challenges

- Lower per-animal productivity
- Bloat risk
- Variable yield over season
- Lack of control over quality
- Labor requirements
- Compaction of soil, plant damage
- Need for higher level of management
- Weed intrusion
- Difficulty in balancing rations
- Control of manures from pastures

Stand loss and subsequent management:

With time, stand loss decreases from any number of factors (short cutting cycle intervals, soil compaction from equipment, natural drought, etc.). Adequate stand density should have the following plants per square meter.

- End of year 1 = 105-215
- End of year 2 = 95-125
- End of year 3 = 65 – 95

If an alfalfa stand has less than 55 plants per square meter, it is a good candidate for either reseeding with alfalfa or inter-seeding with an annual legume or grass.

The actual number of total plant stems per unit area is also used to judge the status of the alfalfa stand. The number of total stems per square meter evaluation is as follows:

- Seedling stand = 265 or more
- End of year 1 = 160-260
- End of year 2 = 105-160
- End of year 3 = 65-125

When stand loss goes below 85 plants per square meter, weeds usually invade which further decrease the remaining yield and quality together. Therefore, four basic options are available:

- Do nothing / or remove the field
- Overseed with alfalfa
- Interseed with another legume
- Interseed with a grass

Overseeding with alfalfa:

Usually a no-till disc-type grain drill can be used to reseed. A broadcast seeder followed by a ring-roller (culti-packer) can also be used. Much of the broadcast seed may not emerge due to poor soil/contact reasons. "Overseeding rates" for alfalfa into alfalfa range from 10-20 kg/ha. When overseeding, the existing adult plants should be 15 cm tall or less.

When overseeding alfalfa, legumes are usually included for dairy, while grasses are often used for horse/hay, beef cattle, and dry cows. Grasses often include barley, oats, wheat, or triticale for green chop/hay. Annual legumes are higher in crude protein (like alfalfa) and low in fiber content. Clovers can be used, some of which may tolerate wet soil conditions more so than alfalfa.

Annual legumes used in the USA include narrow leaf clover, (*Trifolium angustifolium*) crimson clover, medics, Persian clover, vetch, and berseem clover. Annual legumes used in the CZ Republic include *Medicago lupina, Trifolium alexandrinum, T. resupinatum and T. incarnatum*. Annual clovers suffers from drought conditions, Medicago lupina is a low yield producing forage. Red clover can also be used. Berseem clover is bloat resistant and has good yields generally.

Annual grasses for inter-seeding include annual ryegrass (*Lolium multiflorum var. Westerwoldicum*) of both 2n and 4n types. Barley and wheat are sometimes used as "annuals" as well.

Perennial grasses for inter-seeding alfalfa include bromegrass (*Bromus inermis*) (grazing), orchardgrass (cool climate), forage-type perennial ryegrass, Timothy (cool climate) and in some cases, endophyte free tall fescue. Inter-seeding with a legume or a grass can give a field another one to two years of productive life to a low density alfalfa field.

A normal field may be three to four years old, followed by retirement. When an alfalfa field is retired, it is highly recommended that the alfalfa field be rotated out of alfalfa to a very different crop. Often grasses are chosen because many broadleaf weeds (in the alfalfa field) can be controlled easily with herbicides in a monocot crop (grasses). Likewise, a change to a different crop often leads to quick reductions in specific insect pests and soil nematode reductions.

A stand of Alfalfa can be removed with glyphosate, a non-selective herbicide. The stand must be well watered and be in an active growing state. If it is winter dormant, the herbicide will not work well at all.

Reference Guide and Credit:

Irrigated Alfalfa Management. 2009. Charles G. Summers, Daniel H. Putnam. Eds. University of California Agriculture and Natural Resources. Publication # 3512. (372 pps).

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