Appendix H

Growing Alfalfa in the Yukon

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Alfalfa (*Medicago sativa*) is a drought tolerant, high protein, high yielding, perennial legume that can be a stand alone forage crop or included in a mixed forage stand. As a legume, alfalfa is capable of providing its own Nitrogen from the air. Nitrogen is the most limiting nutrient to crop growth in almost all Yukon crops; therefore, incorporating this crop into a seed mix or in rotation allows for much needed Nitrogen in the farm soil/crop system. Although alfalfa is a hardy plant, the Yukon's climatic conditions are on the edge of this plant's tolerance. Below are some points to keep in mind if you are thinking of growing and maintaining an alfalfa stand in the Yukon.

Variety Selection

Variety selection is important to gain maximum yields and maintain stand longevity. There are 240 registered alfalfa cultivars through the US National Alfalfa and Forage Alliance (National Alfalfa and Forage Alliance 2007) with a range of characteristics including 11 fall dormancy ratings, 6 winter survival ratings, and 5 disease resistance ratings. The Canadian Food Inspection Agency maintains the registration list for available Canadian cultivars. The CFIA list includes 163 cultivars (Canadian Food Inspection Agency 2007). There are a number of hardy varieties for Yukon conditions, among these are the Peace and Anik varieties. Peace is often still used as the check variety in research trials. As well, Peace has historically produced greater biomass in Yukon when compared to other varieties. There are new cultivars being touted by seed companies as higher producers and with greater winter hardiness that may work in Yukon conditions. Select varieties that have good winterhardiness, high fall dormancy ratings and resistance to diseases - especially root rots and bacterial wilts.

Inoculation

In order for alfalfa to successfully accumulate N from the air, the plants have to form a bond with bacteria known as rhizobia. These bacteria are attached to the seed and after seed germination infect the root of the alfalfa. Inoculant comes as pretreated seed, as a peat based formula or as a granular formula. Pretreated seed is the most

commonly used method of inoculation today. Rice et al. (2001) compared peat-based and preinoculated seed and found that rhizobium numbers are usually greater on freshly inoculated seeds than on pre-inoculated seeds, so it can be extrapolated that onsite seed inoculation provides greater assurance that the roots will achieve adequate nodulation. These are living organisms and it is important that these bacteria be kept in cool, dry, dark conditions prior to seeding. There are a number of different rhizobia that are used to inoculate alfalfa. Most frequently used in Canada is the pre-inoculated seed with Nitragin, Inc cultures. Another good option that has been tested in the Yukon is a peat based inoculum from Philom Bios called TagTeam®.

To see if the alfalfa is in fact accumulating nitrogen, check the root nodules for pink colouring using a fingernail to split the nodule in half. Pink colouring in the nodules indicates the presence of leghemoglobin, which is similar to our blood hemoglobin, which binds to the oxygen in the root nodules to allow for the oxygen sensitive dinitrogenase enzyme to fix atmospheric N (Dakora 2003). This colour shows that the rhizobia and alfalfa are creating plant available N.

Overall, the inoculation and subsequent infection to form nodules is critical. In their absence plant protein content and yield will be low (Rice and Olsen 1992; Sparrow 1988).

Soil Conditions

Proper nutrient levels and ratios are key to successful production and stand longevity. Other soil conditions to consider for field selection include pH, salinity and compaction.

Fertilization is based on the replenishment of nutrients extracted by the crop and takes into consideration the immobilization, leaching, or volatilization of some nutrients that are lost from the soil or otherwise unavailable for plant uptake. The single most important controllable environmental factor affecting N fixation under field conditions is soil N. Adding fertilizer N to legumes decreases the fraction of plant N derived from NF (Vance et al. 1988). Although alfalfa does not need fertilizer N, many other nutrient additions are required in order to maintain balanced soil/plant nutrition. Alfalfa

continuously depletes soil nutrients. An 11 t/ha alfalfa crop removes 69-85 kg/ha of P_2O_5, 300-370 kg/ha K_2O and 30-37 kg/ha S.

Proper fertilization helps in stand establishment, overwintering, persistence, promotion of early growth, increasing yield and quality, and improving disease resistance. Takhini Valley soils are only weakly weathered and therefore contain most required micro nutrients in sufficient quantities, but some key macro nutrients are in low supply. Alfalfa production removes a range of nutrients from the root zone which must be replenished. Nutrient levels are easily monitored with conventional soil tests and amendments can be applied where needed.

As with all other crops, pH affects the growth of alfalfa. Alfalfa flourishes in pH of 6.5-8; in acidic conditions (pH < 6.0) its production is substantially reduced. Slightly alkaline soils are found throughout the south central Yukon, providing ideal pH for alfalfa establishment. A study by Panciera and Sparrow (1995) showed that in acidic soils in the Delta Junction area of Alaska the DM yields were 5 times less on soils with pH of 5.3 compared to 6.5-7. Field trials in Alaska compared alfalfa production in neutral (pH 7.2) and acidic (pH 5.4) soils and found yields reduced by almost 50% in acidic conditions (Sparrow et al. 1993). Rice (1977) studied alfalfa growth in a range of pH at Beaverlodge, Alberta, and found a negative trend in nodulation scores and alfalfa yield as soil pH decreased from 6.0 – 5.0 (Rice et al. 1977).

Saline conditions exist in many places in the Yukon, typically in depressional sites adjacent to slopes, where the accumulation of salts occurs near the surface from the evaporation of water. Yield losses can be expected if saturated electrical conductivity levels are above 2 dS/m in the upper soil profile.

Alfalfa is most productive in deep, uncompacted, well-drained soils, which allow for deep root development. Under severe compaction alfalfa will have trouble becoming established.

It is important to soil test before planting in order to determine which nutrients are needed and to check the pH and salinity level of the soil.

Seeding

Alfalfa is a small seeded crop with a variable seeding depth dependent on the soil texture. Heavy soils should be seeded 0.6-1.25 cm; in light soils, seed can be placed 1.25-3.8 cm into the soil. Seed should be placed near the maximum depth to access greater soil moisture, yet placing the seed deeper risks that the hypocotyl will not reach the soil surface. Seeding rates should be around 10 kg/ha. The small initial size of the alfalfa seedling reduces its competitive ability (Fick et al. 1988), so earlier seeding and germination is best. In dryland conditions spring rainfall distribution for germination and cold soils at planting can present problems for establishment, this has been shown in Alaska (Panciera and Sparrow 1995).

Irrigation

Although alfalfa is drought tolerant, the Yukon's semi-arid status results in precipitation levels that are below the minimum crop water demand for a good yielding crop. Irrigation will provide higher yields in this environment. In addition, a lack of precipitation at seeding can result in poor stand establishment.

Alfalfa requires replenishment of the evapotranspiration (ET). Factors that affect ET include solar radiation, temperature, wind speed, humidity and also stage of plant growth. ET in the south central Yukon ranged from 344 - 405 mm in 2005 and 2006 with precipitation providing 40% of the required water. The remaining gap between ET and precipitation is closed through irrigation. Non-irrigated crops need to be planted as early as possible in the spring to take advantage of existing soil moisture (Panciera and Sparrow 1995). For non-irrigated crops, seed should be planted as early as possible in the spring to take advantage of existing soil moisture.

It is important to maintain moisture levels to minimize plant stress, which ultimately affects DM yield and long term stand survival. On the other hand, excess soil water is also a concern as it decreases the growth of seedlings and promotes the development of fungal diseases.

Winter Survival

Winterkill is the term used to describe the failure of an overwintering crop to survive low temperatures and concomitant cold injury (Leep et al. 2001). A plant's

capability to overwinter is based on the ability to go dormant, and to survive stresses through the winter including frost, frost heave, ice formation, low temperatures, and fungal and bacterial infection (Bertrand and Castonguay 2003). Snow depth is critical for insulating alfalfa crowns and preventing winterkill. Where possible, put up wind breaks perpendicular to the dominant winter wind direction to capture snow in field.

Alfalfa requires time in the fall to build up the root energy reserves to survive the long, cold winters in the Yukon. For best results, harvest should occur in mid summer, and wait to graze the regrowth after freeze up, around early November.

Diseases also cause winter death of plants. Yukon's cold soils promote the growth of fungal diseases. Three diseases to watch for in field are verticillium wilt (*Verticillium albo-atrum*), Brown Root Rot (*Phoma sclerotioides*), and winter molds (*Sclerotinia spp*).

Symptoms of Verticillium Wilt – leaves become yellow, often in a v-shaped or one-sided pattern. Plants wilt and xylem tissue of taproot becomes brown. Stem remains green for awhile after all the leaves on a shoot are killed. Verticillium wilt is primarily found on irrigated fields (Stuteville and Erwin 1990).

Symptoms of Brown Root Rot – the taproot is destroyed around the plow pan level. Infected plants appear weak and are easily pulled up by hand. Symptoms include dark, necrotic lesions of the lateral and taproots, which are brown with a blackish border (McKenzie and Davidson 1975). Young lesions are generally brown and circular with dark perimeters. Maturing lesions generally expand asymmetrically and eventually girdle the root. Rhizobium nodules can also be infected and rotted. The fungus grows at subzero temperatures in the range of -7^{o}C to 27^{o}C (Stuteville and Erwin 1990).

Symptoms of Winter Molds (also known as snow molds) – these are most damaging to seedling stands, which are seeded in the late summer, a practice not recommended in the Yukon. Produces a cotton weblike growth on the stems and crowns of infected plants (Stuteville and Erwin 1990). Individual stems in patchy areas wilt.

The alfalfa stand will quite often rebound from the disease of concern when conditions improve but reduced yields are likely. These diseases can be somewhat managed by control plowing, spring planting, disinfecting equipment, maintaining proper soil fertility, and using alfalfa cultivars that have resistance to the disease. A considerable amount of time has been used in the breeding programs for disease resistance. Check the disease ratings for each variety and use disease resistant cultivars if available and check to see if that cultivar is suitable for this northern climate.

Weed Control

Weed control can become a concern in a poorly established stand, so the first defence against weeds is to maintain a healthy, vigorous monoculture or mixed stand. In circumstances with high populations of broad leaf weeds, there are a few options for weed management including chemical applications and mechanical weeding.

Synthetic auxins are used for a range of broad leaf weed species. 2,4-DB (or Embutox 625), is specific for application on alfalfa crops. 2,4-DB affects protein synthesis and normal cell division, disrupting plant cell growth in newly forming stems and leaves leading to malformed growth and tumors (Alberta Agriculture 2007). The product should be used early in the year between the first trifoliate and the fourth trifoliate. Read the product label for specific instructions and mixing instructions.

Other options to minimize competition from weeds include mechanical removal of weeds by handpicking, tilling, cutting or flaming. Many broad leaf weeds are annual or biennial, therefore requiring seed production for propagation. If no seeds are set, the weed population will slowly diminish in the stand over time.

Planting into Mixed Stands

Be wary of mixing brome and alfalfa in the same stand if you are planning on adding N fertilizer (>25 kg/ha), or allowing free range grazing. There is little point in including the alfalfa in the mix as it will be outcompeted for resources very quickly and will be reduced in the stand over a couple of years.

Crop Rotation

There are a number of options for cropping alfalfa including seeding into an existing grass stand, seeding as part of a forage mix, seeding with a companion crop or seeding as a stand-alone crop. When seeding as a stand-alone crop, alfalfa is a suitable crop to use in rotation with other field crops to increase soil available N for the subsequent crops. It is important to select crops that are not susceptible to the same diseases. Oilseeds, cereals, and some vegetable crops are good options.

Harvesting and Grazing Management

Harvesting and grazing management is one of the keys to successful alfalfa stand establishment in the North. In order to grow alfalfa in the Yukon, farmers will need to harvest early, by mid July at the latest, and must wait until after freeze up, around early November to graze the regrowth. Late fall grazing or cutting prior to freeze up, cuts the leaves that should be synthesizing substances that are translocated to the crowns and roots (McKenzie et al. 1988). Cutting during this period interferes with the accumulation of food reserves because new growth is produced at the expense of winter reserves.

Cracking alfalfa stems at harvest is good practice to reduce the drying time in the field. The faster the hay dries and the more uniformly it dries, the better the hay quality and less leaf loss. Reconditioner units with rollers crack alfalfa stems, drying them more quickly. In years where excessive moisture is a problem at harvest large round bales can be produced and wrapped in plastic for either haylage or silage.

Rotational grazing is a good option for alfalfa in a pasture, as opposed to straight grazing, which allows the preferential grazing of the alfalfa from the stand ahead of the grass. Straight grazing pressure will result in reduced alfalfa plants in the stand over time (Papadopoulos et al. 2005). Animals in a rotational grazing are removed after they have grazed the area thoroughly, allowing the pasture to regrow, in contrast to straight grazing where the animals have free access to all the plants and can preferentially graze legumes. Harvesting has a rapid negative effect on NF with declines of 5 - 30% reported (Vance et al. 1988). It is important to note that frequent cutting can increase protein content, but is also associated with slow regrowth, plant death, weed invasion and drastic yield reductions (Vance et al. 1988).

Feeding

Alfalfa is a high protein, high calcium, high energy forage that can be used as feed for horses, dairy goats, dairy cattle, beef cattle, and game farm animals, and is also sold through pet stores for rabbits and guinea pigs. A high protein source, with upward of 20% protein levels, feeding alfalfa can result in overheating and colic in inactive horses. Care must be taken in feeding this ration to sedentary animals. Often veterinarians will recommend that only a small percentage of the hay feed mix be alfalfa (Ewing 1997). As when changing any feed ration, farmers must be watchful for changes in the animal's behavior and, if there are any concerns, consult a veterinarian.

If you have any questions about alfalfa production in the Yukon please consult the Yukon Agriculture Branch at 867-667-5838.