The Use and Improvement of Legumes for Ranges

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Despite the interest in range legumes that has persisted in the Western United States since the turn of the century, it is only recently that expanded efforts have been made to use and improve them. Ecological factors governing the success of a range legume include growth factors such as temperature, water, light, nutrients and air. Adaptive environmental factors such as soil texture, soil chemistry, cold and drought tolerance, which are in turn affected by wind, exposure and location on the landscape are also important. Persistence of a range legume is important and is determined by the species reproductive capacity. Management factors such as cattle control, larger acreages, and different weed control practices determine the type of legume that should be used in range. In general, alfalfa remains the species most adapted to northwestern ranges. Expanded interest both in breeding and management of range legumes suggest continued improvement.

The interest in using legumes in ranges began before the turn of the century when early settlers observed native legumes. White and purple prairie clover, American vetch, groundplum milkvetch, American licorice, bread root scurf pea, and lead plant were all grazed at one time or another by the settlers' livestock. Other native legumes such as locoweed and poison vetch were extremely injurious to their stock.

Because of this, and because the desirable native legumes did not perform spectacularly, early interest in range legumes was not stimulated until introductions were made from other countries in the early 1900's. Since then, there has been a continued effort to introduce, evaluate, and recombine the introduced legumes. Alfalfa, Cicer milkvetch, crown vetch, sainfoin, trefoil, and trifoliums have been introduced and improved.

As far as range was concerned, alfalfa was of prime importance, but some of the other legumes found useful niches as hay and cultivated pasture. The early enthusiasm for alfalfa is reflected in the reports of early plant explorers. In 1910, South Dakota's N. E. Hansen said of yellow-flowered alfalfas from the Siberian Steppes, "This plant is a valuable forage in regions where the mercury freezes sometimes without snow; it is green very early in the spring; it endures severe drought; it does well on soils underlain with hardpan; it is considerably resistant to alkali; it flourishes where other common alfalfa from Europe winter-kills."

Meyer, another explorer, commented on "its remarkable resistance to drought, to close grazing" and said, "The roots possess the capacity of producing new plants whenever cut off or when exposed to air on account of soil having been washed away."

Following the drought of the 1930's, there were few attempts to use legumes in range. Two main institutions continued to breed legumes suitable for range use, the South Dakota State University and the Canada Department of Agriculture at Swift Current, Saskatchewan. At the present time, of 160 alfalfa varieties listed in a recent publication, nine could probably be considered primarily range varieties.

However, partially because of the high cost of nitrogen fertilizer, legumes are again being used and improved in range. Researchers are reexamining ecological and management factors affecting successful legume use in range; they are searching for the critical plant characteristics to select legumes to establish, survive, produce and be generally suitable for range use.

Range Legumes and Their Ecology

What do we mean when we speak of ecological factors affecting legume performance in range? The study of an organism's relationship to the environment in which it grows has been termed "ecology." Many factors make up the environment. They include growth factors such as temperature, water, light, nutrients, and air, all of which ultimately affect the legume's physiological processes. Different legume species and varieties have different growth requirements, require different ecological factors and thrive in different environments. Legumes best adapted for a specific set of environmental conditions compete best in natural systems and become dominant when placed in that environment. In managed systems, it is beneficial to select and use legume species best adapted to a specific set of environmental conditions.

Because of the renewed interest in range legumes to increase range production and replace nitrogen used by grasses, the ecology of legumes is very important. Range legumes may be distributed over a wide range of varying ecological factors. Alfalfa is a legume with a wide natural distribution over areas of contrasting temperatures, elevations, and soil types. Therefore, selection of specific ecotypes has been very successful. To date, selected alfalfa has been used primarily for hay and pasture. If alfalfa is to be used in rangeland, several ecological factors become important.

One very important set of adaptive environmental factors for alfalfa in rangeland is the condition of the rangeland soils. Factors such as soil texture and soil chemical characteristics are examples. A range legume such as alfalfa could benefit many varied rangeland soils. Under intensive agriculture, much has been discovered about the effect of soil factors on alfalfa growth. These findings still must be matched to major rangeland soil characteristics to facilitate selection of adapted alfalfa rangeland ecotype varieties. Where information is lacking or extrapolation from agronomic use to range use are impossible, further research will be needed.

Cold and drought tolerance are also important adaptive requirements. In a range legume, both factors are probably tied to its ability to go dormant when moisture

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is limited and temperatures are severe. Several presently available alfalfa varieties can survive much drought and cold temperatures. These varieties may be suitable for range use or may be a starting point for further selection work. The severity of drought and temperature can be lessened or worsened by other environmental factors such as wind, exposure, and location on the landscape. Each of these factors affects persistence or the ability of legumes to remain in rangeland year after year.

Persistence of a range legume is as important as its yield. Therefore, a range legume should be able to reproduce itself under competition from other plants in the range community. Creeping rooted legumes such as rhizomatous alfalfa should have an advantage in reproduction. Other legumes or varieties of alfalfa that produce sufficient amounts of seed to insure reproduction may also be suitable for a range community, but environmental factors which affect flowering and seed set will determine whether seed will be available for replacement plants.

Persistence of a range legume may also be determined by its ability to withstand pests (insects and diseases), wildfire, and grazing. Vegetative proliferation should be an advantage in reducing effects from root rot diseases; low crown may be an advantageous characteristic in reducing fire and grazing damage.

Range Legumes as Affected by Management

Rangelands are managed considerably less and in a different manner than cultivated pastures; acreages are extremely large, terrain is rough, and output per acre is lower. A range legume must, therefore, persist in spite of limited management and in spite of practices which may be to its detriment but nonetheless essential and peculiar to range management. The following are several of the "built-in" management factors breeders will have to consider and overcome if they are to develop top-line range legumes. (a) Heavy and selective grazing. In well-managed pastures, this is not a problem, but under range conditions (in spite of the best intentions) overgrazing and selective grazing of at least part of the range will occur at most times.

Control of cattle movement is more difficult, fences are fewer, and legumes are usually more palatable and less tolerant of overgrazing than their associated grasses. Legumes with low crowns and creeping or fibrous root systems, and growth rhythms that coincide with associated grasses are less likely to be selectively grazed and may recover from overgrazing.

(b) In pasture, legumes frequently thrive because of special management programs: rotations, programmed grazing intensities, and heavy fertilization. These are costly and often unpractical on a range scale. In range, one must be satisfied with a lower yield than in pasture and persistence and extension of the grazing season become equally important as total yield.

(c) Legumes must be noninjurious to livestock. Huge acreages preclude hourly or even daily observation; therefore, injurious factors such as the tendency to cause bloat become more important. Among the institutions investigating bloat-causing factors are Canada Agriculture, Saskatoon, Saskatchewan, and Utah State University. The yellow-flowered alfalfa, *Medicago falcata*, has been said to have less of the foaming characteristic associated with bloat than the purple-flowered *M. sativa*.

(d) Legumes must withstand chemicals and fire used for weed control in range. Because cultural weed control is usually impossible on range, chemicals and fire must be used to control undesirable species. Legumes with low crowns are less susceptible to injury by fire. There are instances in which tolerance to 2,4-D has been bred into legumes. Certain legumes possess some tolerance to EPTC. In all probability, improvement can be made in tolerance to certain herbicides.

Species in Range

There are few complete investigations of the relative importance of various species in range. In general, native legumes have not been too promising because of difficulties of poor establishment and poor seed set. In a recent study of 14 legume species, both native and introduced, evaluated for adaptability to dryland conditions in Colorado, alfalfa was the most promising, followed by Cicer milkvetch, Falcatus milkvetch, and sainfoin. In a second study, alfalfa was the only legume capable of competing in a mixture with crested wheatgrass and the only one surviving extremely arid conditions after five years.

During an extremely cold dry winter and very dry summer (1976-77) at Mandan, the following survival ratings for 13 legumes species were obtained on counted plants. Ninety-six per cent of the yellow-flowered alfalfa survived the winter, higher than all others. Of the surviving yellow-flowered plants, 85 per cent survived severe drought the following summer — Ladak alfalfa and birdsfoot trefoil followed yellow-flowered alfalfas, the species most persistent through the summer. Of the native legumes, ground plum survived best.

There are now many documented cases of extreme longevity of alfalfa in range. In some instances, this may have been due to its not having been grazed or because it grew in a somewhat sheltered spot; in others, it persisted in spite of all odds. Throughout the years, the Agricultural Research Service and Soil Conservation Service conducted many trials with various legumes. These were eventually abandoned and sometimes returned to range. At Mandan, we have yellow- and purple-flowered alfalfa that has persisted, either through reseeding itself or vegetatively, for 40 to 50 years. In an old nursery abandoned 15 years ago, yellow and variegated alfalfa are now the predominant legumes. There are a few purple-flowered plants, and a few Cicer plants. There are sites in North and South Dakota where "a spoonful" of yellow-flowered alfalfa was put out 60 years ago. It has, despite heavy grazing by sheep and cattle, persisted and, in one instance, spread over a mile.

Legumes other than alfalfa have their place. There are many locations where winter temperatures and drought are not so severe and where management practices can be more easily controlled. Under these conditions, Cicer milkvetch, birdsfoot trefoil or sanfoin may eventually be used. Recent breeding work on Cicer in Colorado has significantly improved the hardiness of that species. Improved resistance to crown rot in sainfoin developed in Montana may make that species more desirable. At Mandan, we are collecting surviving plants of birdsfoot trefoil to improve its hardiness and drought tolerance. Birdsfoot trefoil, Cicer, and sainfoin do not cause bloat. Yellow-flowered alfalfa apparently does not have as great a tendency to cause bloat as do purple varieties.

What then are the possibilities for an improved range legume? They are better than ever before. Breeders are exchanging germplasm and conducting cooperative tests. When we began our program at Mandan, we received breeding material from Colorado that had undergone three cycles of intercrossing. This material consisted of 63 lines of variegated and yellow-flowered alfalfa that various breeders had judged the most suitable for range purposes. We are using this as the basis of some of our breeding work. Colorado, Utah and Mandan are planning a cooperative test of alfalfas containing varying amounts of yellow-flowered germplasm from our old plantings. The new methods and machinery for sod-seeding, such as those being tested at Dickinson, ND, suggest the possibility of improved initial establishment of range legumes.

Because of the high cost of nitrogen fertilizers, scientists at Minnesota and Mandan are looking more closely at the mechanism of nitrification by legumes and are trying to evaluate how much of the fixed nitrogen may be available for use by associated vegetation. Results from this renewed interest in legumes for pasture and rangeland should better document the benefits and type of legumes best suited for this use.

Genetic Improvement of Forage Grasses

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Grass breeding at the Northern Great Plains Research Center is directed toward species useful for range, pasture, hay, and other specialized needs. Our primary objective is development of new grass cultivars with improved capability for stand establishment and sustained production of high quality forage under diverse growing conditions. Expertise of plant physiologists, plant pathologists, animal nutritionists, soil scientists, range and pasture management specialists, and others is needed to make maximum progress in breeding forage grasses.

Forage grass breeding was initiated at the Northern Great Plains Research Center, Mandan, ND, by the USDA in 1936 (5). Grass cultivars that have resulted from this breeding program include "Nordan" crested wheatgrass, "Vinall" Russian wildrye, "Green Stipagrass" and "Lodorm" green needlegrass, "Mandan Wildrye" (Canada wildrye), and "Mandan Ricegrass" (a hybrid between green needlegrass and Indian ricegrass). In addition, the USDA Soil Conservation Service has used several advanced strains of grasses from the Mandan program in range and pasture improvement programs in the northern Great Plains.

Grass improvement efforts are directed toward species useful for range, pasture and hay. Grasses are also being bred for such specialized uses as mined-land reclamation and barriers for improved snow distribution on cultivated lands. Production of high-yielding, high-quality forage for different purposes and under diverse environmental conditions requires the use of both native and naturalized (introduced) species. No single grass species can fulfill all our needs. Breeding is currently under way on crested wheatgrass, western wheatgrass, Russian wildrye, blue grama, intermediate wheatgrass, and orchardgrass.

In addition to the breeding work, many other grass species and interspecific hybrids are being evaluated in field performance tests. Table 1 gives a summary of average annual forage yields at Mandan for several grass species grown under different management systems. The yields presented are means of all cultivars included in performance tests for the given species.

Choice of Species

Productive forage breeding programs are costly and time-consuming, so breeding must be concentrated on species that meet critical needs and have potential for

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