Evaluation of Forage Legumes for Rangelands of the Central Great Plains

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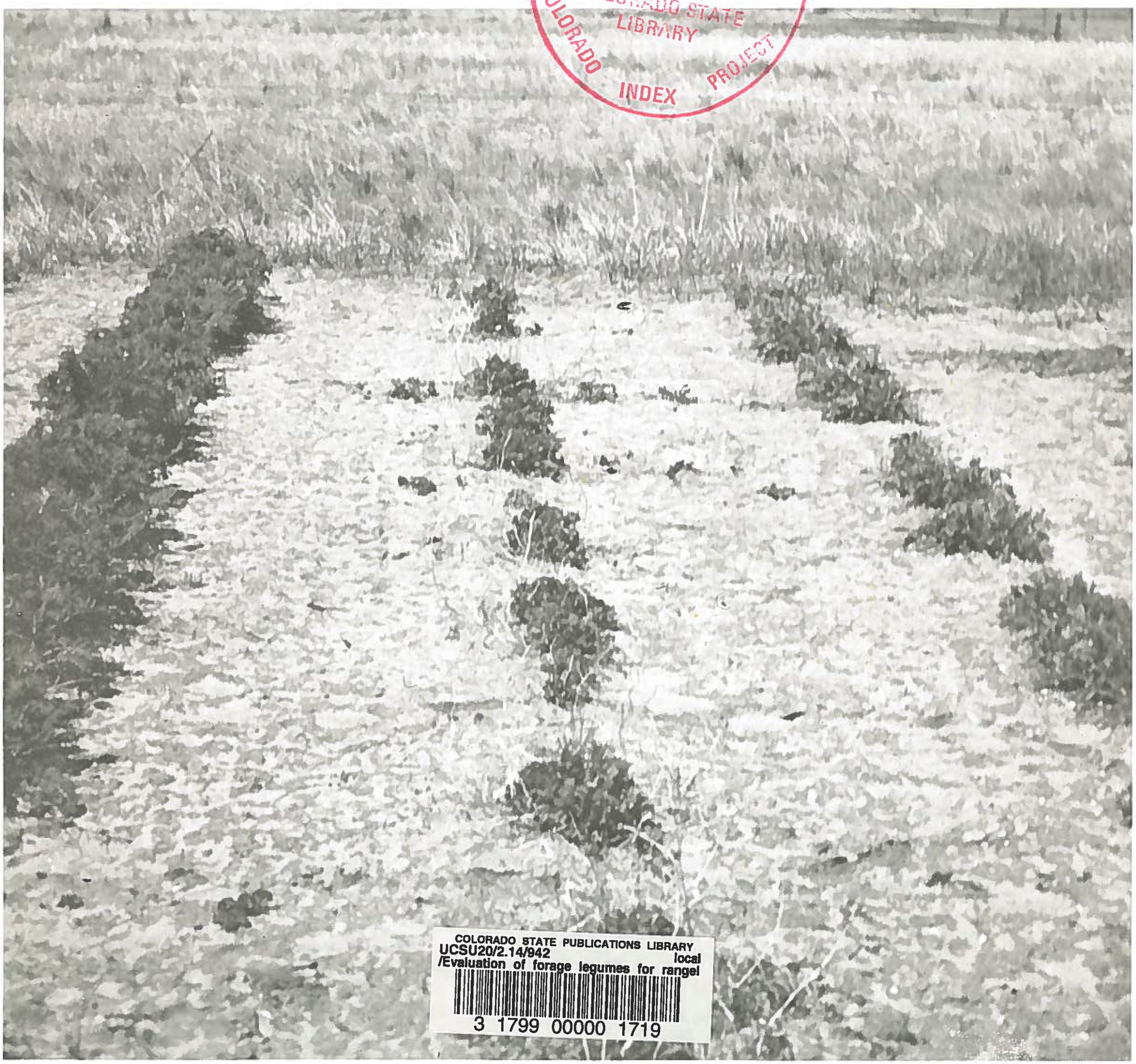

Evaluation of Forage Legumes for Rangelands of the Central Great Plains*

by
C. E. Townsend
G. O. Hinze
W. D. Ackerman
E. E. Remmenga**

*Colorado State University Experiment Station in cooperation with the U.S. Department of Agriculture, Agricultural Research Service.

**Research geneticist, Agricultural Research Service, USDA, and faculty affiliate, Crops Research Laboratory, Colorado State University; associate agronomist, Central Great Plains Field Station (Akron), Colorado State University Experiment Station; agricultural research technician, Agricultural Research Service, USDA; and professor, Department of Statistics, Colorado State University, Fort Collins; respectively.

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INTRODUCTION

A cooperative dryland legume breeding program involving the Agricultural Research Service, U.S. Department of Agriculture, and the Colorado State University Experiment Station was initiated in 1968. The ultimate goal of the program is to develop a forage legume that will increase the quantity and quality of forage produced in the dryland pastures and rangelands of the Central Great Plains. The first step of this cooperative venture was to determine the one or more species that appeared to have the characteristics needed to satisfy the goal of the program. Three of several preliminary studies that were designed to select the most promising one or more species are described in this bulletin. The three studies will be discussed separately.

STUDY I

The productivity of many acres of rangeland and dryland pasture in the Great Plains must be increased if future demands for red meat are to be met. This need includes increased forage production on both native ranges and abandoned cropland. In addition, some acreage still under crop cultivation would be more productive if seeded to forages.

Productivity of depleted rangeland and abandoned cropland can be increased by revegetating with more desirable species. F. B. Gomm[1] showed that legumes have the potential to increase not only the quantity but also the quality of forage when seeded on abandoned cropland. In eastern Colorado, beef production was greater when alfalfa was included in a mixture with intermediate wheatgrass and in mixtures with blue grama, sideoats grama, and sand lovegrass than when alfalfa was excluded from the mixtures.[2] The interseeding of legumes (primarily alfalfa) and certain introduced grasses (primarily crested wheatgrass) into native ranges shows promise of increasing forage productivity.[3,4,5] Nitrogen fertilizer also has been used to increase productivity.[6] The value of legumes as nitrogen fixers under range conditions is not known.

The major emphasis in the improvement of forage species adapted to the Great Plains has been directed towards the grasses,[7] while the use of legumes for improving rangelands has received very little attention. W. R. Kneebone[8] evaluated both native and introduced legume species for their potential use in revegetating the rangelands of western Oklahoma. In general, the native species were not promising because they were difficult to establish and were poor seed producers as well. Several introduced species, i.e., Chinese milkvetch, falcatus milkvetch, cicer milkvetch, sweet clover, sainfoin, and alfalfa appeared to be adapted to the area. Of these species, alfalfa seemed to have the most promise, but its use probably would be restricted to the sandy soils.

In the late 1940's, personnel of the Soil Conservation Service, U.S. Department of Agriculture, made a collection of legumes native to the Great Plains and adjacent prairies. M. D. Atkins[9] reported that seed of more than 60 species was collected and evaluated alone and in mixtures with grasses at Manhattan, Kansas; Waterloo, Nebraska; and Mandan, North Dakota. The native legumes also were compared with introduced species. Alfalfa and cicer milkvetch, both introduced species, performed best with cool-season grasses such as bromegrass and intermediate wheatgrass. Alfalfa and mat milkvetch, another introduced species, performed best with shortgrasses on loamy soils. In general, the native legumes did not perform as well as the best introduced species.

The purpose of the present study was to evaluate several native and introduced legume species for their potential use in dryland pastures and rangelands of the Central Great Plains.

Materials and Methods

Seed for this study was obtained from several sources within the U.S. Department of Agriculture and from one commercial source.[10] Seed of all native and some introduced species was in very short supply, and we increased the seed supply of such species at Fort Collins. However, there were several native species from the Soil Conservation Service collection, as well as from our collection, whose seed production characteristics were such that we were unable to obtain enough seed for evaluation. Percentage of seed germination of all entries was good.[11]

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[1] Gomm, F. B. 1964. A comparison of two sweetclover strains and Ladak alfalfa alone and in mixtures with crested wheatgrass for range and dryland seeding. J. Range Manage. 17:19-22.

[2] Dahl, B. E., A. C. Everson, J. J. Norris, and A. H. Denham. 1967. Grass-alfalfa mixtures for grazing in eastern Colorado. Colo. Agr. Exp. Sta. Bull. 529-S.

[3] Hervey, D. F. 1960. Improving Great Plains rangelands by interseeding. Proc. 8th Int. Grass. Cong., Reading, England. p. 216-220.

[4] Houston, W. R. and R. E. Adams. 1971. Interseeding for range improvement in the Northern Great Plains. J. Range Manage. 24:457-461.

[5] Rumbaugh, M. D. and T. Thorn. 1965. Initial stands of interseeded alfalfa. J Range Manage. 18: 258-261.

[6] Rogler, G. A. and R. J. Lorenz. 1969. Pasture productivity of crested wheatgrass as influenced by nitrogen fertilization and alfalfa. U.S. Dept. of Agric. Tech. Bull. No. 1402. 33 p.

[7] Rogler, G. A. 1973. The wheatgrasses. In M. E. Heath, D. S. Metcalfe, and R. E. Barnes (eds.). Forages, 3rd edition. pp. 221-230. The Iowa State Univ. Press.

[8] Kneebone, W. R. 1959. An evaluation of legumes for western Oklahoma rangelands. Oklahoma State Univ. Bull. B-539. 13 p.

[9] Atkins, M. D. 1953. New legumes for the Northern Plains. Crops and Soils, Vol. 5, pp. 16-18.

[10] M. D. Atkins (retired, formerly regional plant materials specialist, Soil Conservation Service, Lincoln, Nebraska) provided remnant seed of the native collection. P. R. Henson (retired, formerly research agronomist, Agricultural Research Service, Beltsville, Maryland) provided seed of most introduced species. M. W. Peterson (research agronomist, Logan, Utah) furnished seed of A-169 alfalfa. Seed of M-1678 and M-1976 sainfoin was obtained from R. J. Schaeffer (agronomist, Northrup, King and Company, Twin Falls, Idaho).

[11] Townsend, C. E. and W. J. McGinnies. 1972. Temperature requirements for seed germination of several forage legumes. Agron. J. 64:809-812.

Fourteen species of forage legumes, including several varieties within some species (Table 1), were evaluated for their potential as a range or dryland pasture legume at two locations in the Central Great Plains -- The Central Plains Experimental Range (Nunn, Colorado) and the Central Great Plains Field Station (Akron, Colorado). The soil at the Nunn location is a Vona sandy loam; that at the Akron location is a Weld silt loam. Average annual precipitation is 12 inches at Nunn and 16.5 inches at Akron.

Plantings were made on prepared seedbeds with a single-row cone seeder equipped with a disc-furrow opener and a packer wheel. Scarified seed of all species except Illinois bundleflower were inoculated with Rhizobium[12] and planted to a depth of 1/2 inch. Seedings were made on April 16, 1970 at Nunn and on April 24, 1970 at Akron. The experimental design was a randomized complete block with four replications. A plot consisted of a single row 25 feet long. Spacing between plots was 3 feet.

Where possible, we used irrigation to aid plant establishment since the adaptability of a species can not be tested until the species becomes established. Sprinkler irrigation was used at Akron; the last irrigation was in mid June. After seedling emergence was completed at Nunn, two of the four replications were furrow irrigated; the last irrigation was in late July. Weeds were controlled by cultivation and mowing. Blister beetles invaded the Nunn nursery in late May and did considerable damage to all entries except sainfoin.

Because the purpose of the study was to obtain information on the adaptability of the various species, we were concerned primarily with persistence and general growth habit. Consequently, forage yield data were not obtained. The species were scored for stand (1=excellent, 5=nothing), vigor (1=best, 5=poorest), and presence or absence of flowering in the year of establishment. Total plant height was measured in inches. In the seedling year, the notes were taken in September. In subsequent years, the entries were scored for stand in April or May, and vigor and height notes were taken in June. The forage was clipped to a height of about 2 inches and removed in June. Regrowth was negligible.

Although pocket gophers can damage legumes, they were not a problem at the Akron location because the nursery was located in a farming area and the gopher population was evidently low. However, at Nunn the nursery was located in a more typical range site and gophers had to be trapped.

Results and Discussion

Considerable variability existed among the legumes for the various characters measured in 1970, the year of establishment (Table 1). Establishment of most entries was satisfactory at both locations, with the alfalfas having the best stand at both locations. At both locations, stands of *Astragalus* sp. (Progeny 72), *Vicia* sp., and Illinois bundleflower were poor. In establishment studies conducted in 1971 involving nine of the same species used in the present study, C. E. Townsend and W. J. McGinnies[13] obtained results similar to those reported herein.

Although the data are not presented, the 1971 stand of all surviving species was similar to that in 1970. By the spring of 1972, the stand of many entries had declined appreciably. The loss in stand at both locations was probably caused by the limited precipitation received during the summer of 1971 and the winter of 1971-72. The apparent discrepancy between the 1972 and 1973 stand readings at Akron was because the season had been very dry and some species appeared to be dead when the readings were made in April 1972. However, they began to grow after receiving precipitation.

At the end of the study in 1973, the alfalfas had the best stand of all species. *A. galegiformis*, falcatus milkvetch, and two of the cicer milkvetch entries had satisfactory stands at both locations. The excellent stand of prairie milkvetch at Nunn is not surprising because this species is quite common in the native ranges of the immediate area. Eski sainfoin had a satisfactory stand only at Nunn. Where the same species were tested, our results were similar to those reported by Kneebone.[8]

Vigor of the alfalfas, crownvetches, Illinois bundleflower, some cicer milkvetch and sainfoin entries, and falcatus milkvetch was good to excellent at both locations in 1970. *Astragalus* sp. (Progeny 72), *Vicia* sp., and prairie milkvetch were relatively nonvigorous species at both locations. The vigor of most entries in 1971 was similar to or better than in 1970. A few species did not survive the first winter. Illinois bundleflower died at both locations. *Astragalus* sp. (Progeny 72) died at Akron and only a few plants remained at Nunn. The vigor of the alfalfas, crownvetches, sainfoins, falcatus milkvetch and most entries of cicer milkvetch was good to excellent at both locations. By 1972, alfalfa was still the most vigorous species.

All entries had an intermediate to upright habit of growth except mat milkvetch (Progeny 16) and licorice milkvetch which were extremely prostrate. Height for most entries was greater at Nunn in 1970 and was greater in 1971 than in 1970 at both locations. All species except falcatus milkvetch, prairie milkvetch, and *Vicia* sp. flowered at either one or both locations during the year of establishment.

Most legumes, such as alfalfa, not only improve the quality and quantity of forage, but also fix atmospheric nitrogen when grown in symbiotic association with the proper bacteria (*Rhizobium* spp.). The nitrogen fixing ability of sainfoin, however, is questionable because effective strains of rhizobia are not presently available.[14] Little, if any, information is available on the ability of some of the legumes included in this study to fix nitrogen. Therefore, seed of several native and introduced milkvetch species (native -- slender milkvetch, Canada milkvetch, tineleaved milkvetch, and prairie milkvetch; introduced -- cicer milkvetch, falcatus milkvetch, and licorice milkvetch) was sent to Dr. Joe C. Burton (vice-president, the Nitragin Co., Inc., Milwaukee,

[12] All Rhizobium inoculum was provided by the Nitragin Co., Inc., Milwaukee, Wisconsin. Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the U.S. Department of Agriculture and does not imply its approval to the exclusion of other products that may be suitable.

[13] Townsend, C. E. and W. J. McGinnies. 1972. Establishment of nine forage legumes in the Central Great Plains. Agron. J. 64:699-702.

[14] Burton, J. C., and R. L. Curley. 1968. Nodulation and nitrogen fixation in sainfoin (*Onobrychis sativa* Lam.) as influenced by strains of rhizobia. In C. S. Cooper and A. E. Carleton (eds.). Sainfoin Symp. pp. 3-5. Mont. Agr. Exp. Sta. Bull. 627.

Wisconsin) who evaluated them for nodulation after inoculation with *Rhizobium* sp. He found that all legumes became well nodulated with apparently effective nodules, as indicated by the presence of red hemoglobin pigment. Consequently, these species have the potential of fixing nitrogen under favorable conditions.

Summary

Of the 14 species of forage legumes evaluated for adaptability to the dryland conditions of the central Great Plains, alfalfa was the most promising on both the sandy and loamy soils. In addition, falcatus milkvetch, cicer milkvetch, and *A. galegiformis* appeared to be adapted to the region. Of the last three species, cicer milkvetch probably has the most potential and *A. galegiformis* the least. Plants of *A. galegiformis* have very coarse stems and do not appear to be suitable for either hay production or grazing. One native species, prairie milkvetch, appeared to have some potential on sandy soils while some of the sainfoins performed satisfactorily at the site with sandy soils, none showed promise at the site with the loamy soils. Based on the results of this study, alfalfa, cicer milkvetch, falcatus milkvetch, and possibly sainfoin merit additional evaluation for potential use under dryland or range conditions.

STUDY II

Sainfoin has received considerable attention in recent years as a possible forage legume for the dryland regions of the northern Rocky Mountains and adjacent Great Plains.[1,2,3,4] Sainfoin has several desirable characteristics; i.e., it is nonbloating, has large seed, is relatively easy to establish, and produces a nutritious forage. An undesirable characteristic, however, is that effective strains of rhizobia are not presently available for nitrogen fixation.[5] Sainfoin was found to be superior to alfalfa in regions where only one hay harvest was taken.[6,7] However, M. R. Hanna and S. Smoliak[8] reported that the hay yields of the better yielding sainfoins were not likely to be higher than the yield of alfalfa, especially if more than one harvest was taken. A. E. Carleton et al.[9] recommended sainfoin for dryland pasture and hay in areas of Montana which receive 13 inches or more of precipitation annually. D. W. Koch et al.[10] evaluated the effect of cutting systems on the yield, water-use efficiency, and forage quality of Eski sainfoin in eastern Colorado. Cutting treatments did not significantly influence forage yield; however, yields were highest at the late-bloom stage of growth. They concluded that sainfoin had good drought resistance and produced a good quality forage.

Crownvetch is used for seeding roadsides and mine spoil areas in the more humid regions of the United States.[11] The species has not been used as a forage crop to any extent. To our knowledge, it has not been evaluated previously under dryland conditions in Colorado. Alfalfa is the most important and widely grown forage legume in the United States. Also, it is one of the most promising forage legumes for dryland seedings in the Great Plains.

The purpose of this study was to determine the relative forage yielding ability and persistence of sainfoin, crownvetch, and alfalfa when grown alone and in a mixture with crested wheatgrass.

Materials and Methods

A dryland forage legume hay trial was seeded at the Central Great Plains Field Station, Akron, Colorado, May 3, 1968. The varieties of legumes seeded are given in Table 2. The experimental design was a split-plot with four replications. The whole plots were 10 feet wide and 20 feet long. Legumes were seeded in rows 1 foot apart. Half of the plot was overseeded with Nordan crested wheatgrass so that the rows of the grass and legume were separated by a 6-inch spacing. Seeding rate was relatively high for all species and sprinkler irrigation was used for stand establishment. Scarified seed inoculated with the proper *Rhizobium* sp. was planted to a depth of 1/2 inch with a single-row seeder. Plots were hand-weeded. Stands were satisfactory for all species.

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1 Carleton, A. E., C. S. Cooper, R. H. Delaney, A. L. Dubbs, and R. F. Eslick. 1968. Growth and forage quality comparisons of sainfoin (*Onobrychis viciaefolia* Scop.) and alfalfa (*Medicago sativa* L.). Agron. J. 60:630-632.

2 Cooper, C. S. and C. W. Roath. 1965. Sainfoin for hay in Montana? Mont. Agr. Expt. Sta. Quart. "Now" 1(3):3-5.

3 Murray, G. A. and A. E. Slinkard. 1968. Forage and seed production potential of sainfoin in northern Idaho. In C. S. Cooper and A. E. Carleton (eds.). Sainfoin Symp. 74-76. Mont. Agr. Exp. Sta. Bull. 627.

4 Roath, C. W. Sainfoin for dryland hay in western Montana. In C. S. Cooper and A. E. Carleton (eds.). Sainfoin Symp. pp. 26-28. Mont. Agr. Exp. Sta. Bull. 627.

5 Burton, J. C. and R. L. Curley. 1968. Nodulation and nitrogen fixation in sainfoin (*Onobrychis sativa* Lam.) as influenced by strains of rhizobia. In C. S. Cooper and A. E. Carleton (eds.). Sainfoin Symp. pp. 3-5. Mont. Agr. Exp. Sta. Bull. 627.

6 Cooper, C. S. and C. W. Roath, 3-5.

7 Murray, G. A. and A. E. Slinkard.

8 Hanna, M. R. and S. Smoliak. 1968. Sainfoin yield evaluations in Canada. In C. S. Cooper and A. E. Carleton (eds.). Sainfoin Symp. pp. 38-43. Mont. Agr. Exp. Sta. Bull. 627.

9 Carleton, A. E., C. S. Cooper, R. H. Delaney, A. L. Dubbs, and R. F. Eslick, 630-632.

10 Koch, D. W., A. D. Dotzenko, and G. O. Hinze. 1972. Influence of three cutting systems on the yield, water use efficiency, and forage quality of sainfoin. Agron. J. 64:463-467.

11 Leffel, R. C. 1973. Other legumes. In M. E. Heath, D. S. Metcalfe, and R. E. Barnes (eds.). Forages, 3rd edition. pp. 208-220. The Iowa State Univ. Press.

Forage was harvested from a 3- by 15-foot strip in each plot to a stubble height of 2 inches. A forage sample was taken from each plot and oven dried. Only one harvest was taken each year on June 25, 1969, June 23, 1970, and June 16, 1971.

Results and Discussion

There were significant differences among legumes for forage yield in each of the 3 years (Table 2). Ladak alfalfa was the highest yielding legume both in pure stand and in the mixture with crested wheatgrass in all years except 1970 when several crownvetch varieties yielded exceptionally well. Alfalfa initiated growth early enough in the spring to compete satisfactorily with crested wheatgrass, and it was the only legume that consistently yielded more in a pure stand than in the grass mixture.

In general, the forage yielding ability of the sainfoins was disappointing. Also, they developed a yellow color that indicated nitrogen deficiency. Sainfoin does not have the ability to fix nitrogen when inoculated with the presently available rhizobia strains. Eski was consistently the best producing variety, and M-1678 was the poorest. With the exception of Eski, yields were generally higher with the sainfoins in the grass mixture than in pure stands. Under dryland conditions in central Montana, A. L. Dubbs[12] reported that the hay yield of Eski in pure stands was equal to that of an Eski-crested wheatgrass mixture.

The data reported by D. W. Koch et al.[13] were obtained on a nursery site adjacent to ours in the same years. Our yield of Eski sainfoin in the first harvest year was substantially lower than theirs. However, the yields of Eski in the second harvest year were very similar for the two studies. The reason for the difference in the yield of Eski in the two studies for the first harvest year is not known, but it may have been related to available soil moisture. We seeded our nursery in the spring of 1968 on an area that had been cropped the previous year. Although we used sprinkler irrigation for establishment, we stopped irrigating in early summer. Their nursery was seeded on fallow soil in the late summer of 1968. Consequently, their seeding may not have had the opportunity to extract as much moisture from the soil profile as our seeding.

Since there was considerable variability among the crownvetch varieties for forage yield, trends could not be established. During the first harvest year, the yields of the crownvetches in pure stand were equal to or higher than yields in the mixture. Yields of most crownvetch varieties in both pure stand and mixture were similar to or higher than yields of Eski sainfoin through the second harvest year. However, Eski sainfoin produced more in pure stand than did the crownvetches in the third harvest year. Under the limited moisture conditions of this study, the crownvetches did not spread by rhizomes.

There was a substantial loss in stand of all crownvetch and sainfoin varieties by the third harvest year (1971). However, the loss in stand of Eski was less than that of the other sainfoin varieties. The loss in stand of the legumes resulted in higher yields for the mixture because there was a satisfactory stand of crested wheatgrass. By the fourth harvest year, there was such a poor stand of the crownvetches and sainfoins that they were not harvested. However, there was still a good stand of Ladak alfalfa in both the pure stand and grass mixture.

Summary

Ladak alfalfa, five varieties of crownvetch, and four varieties of sainfoin were seeded in a pure stand and in a mixture with Nordan crested wheatgrass at the Central Great Plains Field Station, Akron, Colorado. Sprinkler irrigation was used for stand establishment. Thereafter, the study was conducted under dryland conditions. Only one harvest was made each year because there was not sufficient moisture to produce regrowth.

Forage yields were taken for 3 harvest years, and yields of Ladak alfalfa were the highest or nearly the highest in pure stand each year and the highest in the mixture in 2 of 3 years. Alfalfa was the only legume capable of competing in a mixture with crested wheatgrass. By the third harvest year, there was a considerable reduction in stand of all legumes except alfalfa. By the fourth harvest year, the stands of the crownvetch and sainfoin varieties had deteriorated to such an extent that yields were not taken. There were good stands of alfalfa and crested wheatgrass.

STUDY III

Cicer milkvetch, a rhizomatous species, has the potential of becoming an important legume for pasture and conservation[1,2,3] but relatively little effort has been devoted to improving the species through systematic breeding. Two varieties, Oxley and Lutana, have been released,[4,5] and phenotypic variability within the species for agronomic characters appeared sufficient to permit improvement.[6] Our observations indicate that cicer milkvetch merits attention as a dryland legume. However, information is not available

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[12]Dubbs, A. L. 1968. The performance of sainfoin and sainfoin-grass mixtures on dryland in central Montana. In C. S. Cooper and A. E. Carleton (eds.). Sainfoin Symp. pp. 22-25. Mont. Agr. Exp. Sta. Bull. 627.

[13]Koch, D. W., A. D. Dotzenko, and G. O. Hinze. 1972. Influence of three cutting systems on the yield, water use efficiency, and forage quality of sainfoin. Agron. J. 64:463-467.

[1]Hafenrichter, A. L., J. L. Schwendiman, H. L. Harris, R. S. MacLauchlan, and H. W. Miller. 1968. Grasses and legumes for soil conservation in the Pacific Northwest and Great Basin States. U.S. Dept. Agr. Handbook 339. 69 p.

[2]Seamands, W. J. 1966 Irrigated pasture study. Agr. Ext. Ser. Bull. 437. Univ. of Wyoming. 14 p.

[3]Stroh, J. R., A. E. Carleton, and W. J. Seamands. 1972. Management of Lutana cicer milkvetch for hay, pasture, seed, and conservation uses. Montana Agr. Expt. Sta. Bull. 666. 17 p.

[4]Johnston, A., S. Smoliak, R. Hironaka, and M. R. Hanna. 1971. Oxley cicer milkvetch. Canad. J. Plant Sci. 51:428-429.

[5]Stroh, J. R., A. E. Carleton, and A. A. Thronburg. 1971. Registration of Lutana cicer milkvetch. Crop Sci. 11:133.

[6]Townsend, C. E. 1970. Phenotypic diversity for agronomic characters in *Astralagus cicer* L. Crop Sci. 10:691-692.

on the adaptability of the species to rather diverse environments. Therefore, the purpose of this study was to evaluate selected plants for forage yield, height, rate of spread, and persistence when grown under irrigation and on dryland.

Materials and Methods

Twenty-five plants that spread well under irrigation at Fort Collins were selected. Propagules from these plants were rooted in the greenhouse and transplanted to the field in May 1970. The four field locations and associated soil types were: Agronomy Research Center, Fort Collins, Nunn clay loam; Central Plains Experimental Range, Nunn, Vona sandy loam; Central Great Plains Field Station, Akron, Weld silt loam; and Eastern Colorado Range Station, Akron, Devone sandy loam. The annual precipitation is about 16.5 inches at the two Akron locations, 12 inches at Nunn, and 15 inches at Fort Collins. The nursery at Fort Collins was irrigated as needed throughout the study. At the other locations, the plants were irrigated by hand through early August 1970 to aid establishment and, thereafter, received only natural precipitation.

The experimental design was a randomized complete block with six replications. A plot consisted of a single propagule of each parental plant spaced on 4-foot centers at Fort Collins and on 3-foot centers at the other locations. Weeds were removed by hand within the nursery through 1972. Plant height and green weight were taken during the third week of June and the second week of September. Plants were harvested to a stubble height of 1½ inches. Spread, an average of the north-south and east-west measurements, was taken in September of each year.

The study was terminated at Fort Collins after the 1972 growing season because the plants of some progenies were growing together. The study was continued through the 1974 growing season at the other three locations, but detailed data are not presented for 1973 and 1974.

Results and Discussion

Differences among locations were large for forage yield and related characters (Table 3). The yields were highest at Fort Collins under irrigation. The Nunn site was the most arid and had the lowest forage production. The two Akron locations differed in forage yields. For both harvests in 1971 and for the second harvest in 1972, the highest yields were on the loamy soil at the field station, but in 1972 the first harvest yields were highest on the sandy soil of the range station. Although the 1973 data are not presented, reasonably good yields were obtained from the second harvest at the range station, but there was not enough growth to permit a second harvest at the field station. In 1974 there was excellent plant growth at both locations at the first harvest, but substantial regrowth occurred only at the range station. Few progenies performed well over all sites, but two ranked high or relatively high for forage yield at all locations. Under dryland conditions cicer milkvetch performs better on sandy rather than loamy soils.

Forage yields were higher at the first harvest in 1971 than in 1972 at the dryland sites because of retained moisture from irrigation used for establishment the previous year. Compared to the first harvests, second harvests at the dryland locations were low because of limited soil moisture. The lower forage yields for the second harvests corresponded to shorter plant height. At Fort Collins in 1971, the first harvest yielded less than the second harvest because a hail storm completely defoliated the plants in late May.

Considerable variability existed among locations and progenies for spread (Table 3). The best spread was under irrigation at Fort Collins where, by the end of the third growing season in September 1972, plants of several progenies had grown together. Maximum spread was reached by 1972 at the two Akron locations and soil type did not influence rate of spread. Dryness prevented spreading after 1971 at the Nunn site. Rate of spread in cicer milkvetch appears to be greater than with creeping-rooted alfalfa. D. H. Heinrichs[7] reported that 2 years were required for evidence of spread for most creeping-rooted alfalfa plants. In this study, all cicer milkvetch plants evidenced spread within one year. However, observations suggest that seeded progenies of cicer milkvetch spread very little under dryland with relatively narrow row spacing.

Persistence was excellent at the two Akron locations because all plants were alive at the end of the 1974 growing season. However, persistence was relatively poor at Nunn because some plants of several progenies died during the 1973 season; by the end of the 1974 season, only six progenies had satisfactory persistence. Plants grown from seed, however, may have better persistence than asexually propagated plants because of the well-developed tap root. Pocket gophers were not a problem in these nurseries or in seeded cicer milkvetch plots in adjacent nurseries, but gophers did considerable damage to adjacent alfalfa plots at the Eastern Colorado Range Station. Both annual and perennial weedy species were invading the nursery at Nunn. In comparison, only a relatively few plants of several annual species were invading the nurseries at the two Akron sites.

Summary

Twenty-five cicer milkvetch plants, differing in vigor and growth habit, were vegetatively propagated and grown under irrigation at Fort Collins and on dryland at the Central Plains Experimental Range, Nunn; Eastern Colorado Range Station, Akron; and Central Great Plains Field Station, Akron. They were evaluated for rate of spread, forage yield, height, and persistence. The study was terminated at Fort Collins after the third growing season because some plants were growing together. On dryland, maximum spread was reached by the end of the second growing season at Nunn and by the end of the third growing season at the Akron locations. Rate of spread was similar at the Akron sites. Forage yields were greatest under irrigation at Fort Collins. Yields were not consistent at the two Akron locations, but it appeared that cicer milkvetch is better adapted to the sandy soil at the range station than to the loamy soil at the field station. Yields were lowest at Nunn. Persistence through the fifth growing season was excellent at the Akron locations, but poor at Nunn.

Cicer milkvetch appears to be adapted to dryland areas of the central Great Plains that receive 16 or more inches of precipitation annually.

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[7] Heinrichs, D. H. 1971. Spreading rate of creeping-rooted alfalfa. Canad. J. Plant Sci. 51: 367-370.

Table 1. Means for the various measurements[1] taken on 14 legume species seeded in 1970 in adaptability nurseries located near Akron and Nunn, Colorado.

Species and Variety	Stand-1970		Stand-1972		Stand-1973		Vigor-1970		Vigor-1971		Vigor-1972	Height-1970		Height-1971		Flowering-1970	
	Akron	Nunn	Akron	Nunn	Akron	Nunn	Akron	Nunn	Akron	Nunn	Nunn	Akron	Nunn	Akron	Nunn	Akron	Nunn
Crownvetch																	
Chemung	2.6	2.4	5.0	3.6	4.8	5.0	1.9	1.8	1.1	1.5	3.0	17.0	20.0	27.0	28.0	Yes	Yes
Emerald	2.3	2.0	4.8	3.3	4.3	4.5	1.8	1.3	1.4	1.4	2.3	15.0	20.0	27.0	25.0	Yes	Yes
Penngift	2.1	2.0	4.8	3.1	4.1	4.6	2.0	2.0	1.5	2.3	3.3	15.0	18.0	22.0	25.0	Yes	Yes
Beltsville comp.	2.9	1.9	4.9	3.5	4.5	4.5	2.0	1.5	1.1	1.3	2.5	14.0	17.0	26.0	24.0	Yes	No
Virginia comp.	2.9	2.1	4.4	2.9	4.0	4.5	2.1	2.1	1.9	2.0	3.0	17.0	18.0	27.0	24.0	Yes	Yes
Sainfoin																	
Eski	2.6	1.1	4.3	1.4	4.1	2.4	2.3	1.3	1.0	1.1	1.1	18.0	22.0	33.0	35.0	Yes	Yes
Onar	3.4	1.4	3.4	3.3	4.3	3.4	2.3	1.4	1.1	1.3	1.9	17.0	25.0	36.0	31.0	Yes	Yes
M-1678	4.1	2.6	4.8	4.0	4.3	4.0	3.4	2.8	1.5	1.3	3.1	8.0	20.0	31.0	29.0	Yes	Yes
Milkvetch																	
cicer	1.4	2.6	3.4	1.9	2.1	2.8	1.3	2.0	1.3	1.3	1.4	14.0	18.0	23.0	29.0	Yes	Yes
"	1.3	3.0	4.5	3.0	2.3	2.8	1.8	3.4	2.1	2.6	2.4	12.0	13.0	22.0	20.0	Yes	Yes
"	2.5	not seeded	4.0	--	3.5	-	1.8	-	1.9	-	-	14.0	-	23.0	-	Yes	-
"	1.6	2.9	5.0	3.6	2.5	3.5	1.5	3.3	1.4	2.6	2.9	12.0	12.0	25.0	23.0	Yes	Yes
falcatus	1.1	1.6	4.3	1.3	1.0	2.5	2.1	2.1	1.0	2.0	2.3	15.0	17.0	28.0	26.0	No	No
canada	3.0	3.4	5.0	4.5	5.0	5.0	3.1	2.6	3.0	2.1	3.9	13.0	17.0	22.0	24.0	Yes	Yes
prairie	4.1	2.3	4.0	1.0	4.9	1.6	4.3	3.4	4.5	2.5	2.4	5.0	9.0	14.0	15.0	No	No
mat	2.3	3.5	4.8	3.4	4.6	3.0	2.5	2.9	4.0	4.9	3.6	26.0	34.0	10.0	14.0	Yes	Yes
licorice	3.0	3.6	5.0	4.0	4.8	4.5	2.9	3.0	3.3	3.3	3.3	9.0	12.0	22.0	24.0	Yes	Yes
A. globiceps	3.5	3.6	2.1	3.4	4.0	4.0	2.4	2.5	1.1	1.5	3.3	19.0	28.0	35.0	29.0	Yes	Yes
A. galegiformis	2.4	3.6	1.5	2.8	1.0	2.5	2.8	2.9	1.0	1.3	1.6	14.0	17.0	43.0	44.0	Yes	Yes
Progeny 72	3.9	4.0	-	4.4	-	4.8	4.1	4.0	Died	5.0	4.9	8.0	13.0	-	18.0	Yes	Yes
Alfalfa																	
Ladak	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	22.0	26.0	27.0	27.0	Yes	Yes
A-169 (Colo. Increase)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	19.0	24.0	23.0	26.0	Yes	Yes
A-169	1.3	1.0	1.0	1.0	1.0	1.0	1.1	1.0	1.0	1.0	1.0	17.0	28.0	25.0	26.0	Yes	Yes
Vetch																	
bramble vetch	2.0	1.9	5.0	4.9	5.0	4.5	2.4	2.1	3.4	2.6	4.6	17.0	21.0	19.0	21.0	Yes	No
Vicia sp.	3.5	4.1	4.8	4.3	3.8	3.9	3.9	3.8	2.6	3.3	3.3	6.0	11.0	25.0	21.0	No	No
Illinois bundleflower	3.9	3.6	-	-	-	-	1.0	1.9	Died	Died	-	27.0	29.0	-	-	Yes	Yes

1 Stand and vigor: 1=best and 5=poorest; height: inches.

Table 2. Hay yields in tons per acre in each of three years for Ladak alfalfa, five varieties of crownvetch, and four varieties of sainfoin seeded alone and in a mixture with Nordan crested wheatgrass.[1]

Species and variety	1969	Avg.	1970	Avg.	1971	Avg.
Alfalfa						
Ladak	1.70		1.25		1.65	
Mixture	1.47	1.59	1.00	1.13	1.28	1.46
Crownvetch						
Penngift	1.58		1.18		0.13	
Mixture	0.37	0.97	1.04	1.11	0.87	0.50
Emerald	1.31		1.29		0.64	
Mixture	1.02	1.16	1.54	1.42	0.96	0.80
Maryland Hay Type	1.55		1.02		0.39	
Mixture	0.93	1.24	1.45	1.24	1.01	0.70
Maryland Pasture Type	0.90		1.27		0.57	
Mixture	0.86	0.88	1.24	1.26	0.92	0.74
Chemung	0.63		0.94		0.53	
Mixture	0.63	0.63	1.00	0.97	0.80	0.67
Sainfoin						
Eski	0.93		1.11		0.73	
Mixture	0.72	0.82	0.77	0.94	0.73	0.73
M-1678-N.K.	0.26		0.16		0.06	
Mixture	0.33	0.29	0.73	0.45	0.68	0.37
M-1976-N.K.	0.70		0.75		0.51	
Mixture	0.56	0.63	0.80	0.78	0.70	0.60
Onar	0.40		0.30		0.28	
Mixture	0.35	0.37	0.61	0.46	0.53	0.40
$LSD_{.05}$		0.35		0.32		0.18

[1]Central Great Plains Field Station, Akron, Colorado.

Table 4. A list of botanical and common names of plants mentioned in this publication.

Botanical Name	Common Name
Agropyron desertorum	Crested wheatgrass
" intermedium	Intermediate wheatgrass
Astragalus canadensis	Canada milkvetch
" chinensis	Chinese milkvetch
" cicer	Cicer milkvetch
" drummondii	Drummond milkvetch
" falcatus	Falcatus milkvetch
" galegiformis	
" globiceps	
" glycyphyllos	Licorice milkvetch
" gracilis	Slender milkvetch
" pectinatus	Tineleaved milkvetch
" striatus	Prairie milkvetch
" sp. (unknown)	Mat milkvetch
" sp. (unknown)	"Progeny 72"
Bouteloua curtipendula	Sideoats gramma
" gracilis	Blue gramma
Bromus inermis	Smooth bromegrass
Coronilla varia	Crownvetch
Desmanthus illinoensis	Illinois bundleflower
Eragrostis trichodes	Sand lovegrass
Medicago sativa	Alfalfa
Melilotus spp.	Sweetclover
Onobrychis viciifolia	Sainfoin
Vicia tenuifolia	Bramble vetch

Table 3. The mean and range for green weight, height, and spread of individual cicer milkvetch plants for two years, four locations, and two harvests per year.

Character		1971		1972		1971		1972	
		1st harvest	2nd harvest	1st harvest	2nd harvest	1st harvest	2nd harvest	1st harvest	2nd harvest
		Agronomy Research Center, Fort Collins				Central Plains Experimental Range, Nunn			
Green wt. (lbs.)	Range	.86-3.70	2.07-6.26	5.02-10.99	3.35-9.30	.77-3.11	.26-.73	.48-1.56	.24-.95
	Mean	2.45	4.85	9.10	6.72	1.85	.46	.95	.53
	L.S.D. .05	.79	1.28	2.60	1.54	1.08	ns	.70	.42
Height (inches)	Range	16-23	21-29	31-41	26-41	17-31	9-14	13-23	5-12
	Mean	20	25	36	32	24	11	17	7
	L.S.D. .05	3	3	4	5	6	ns	5	3
Spread (inches)	Range		12-35		24-48		11-24		11-23
	Mean		27		39		17		17
	L.S.D. .05		6		7		7		7
		Central Great Plains Field Station, Akron				Eastern Colorado Range Station, Akron			
Green wt. (lbs.)	Range	1.52-3.24	.33-1.28	.59-1.59	.35-1.43	.99-2.95	.11-.88	.46-2.38	.11-1.30
	Mean	2.44	.66	1.10	.84	2.03	.46	1.26	.62
	L.S.D. .05	ns	.51	.53	.59	.77	.26	.55	.57
Height (inches)	Range	27-40	7-16	13-21	7-12	19-31	8-17	12-20	5-11
	Mean	33	11	18	9	24	13	16	7
	L.S.D. .05	4	3	4	4	5	4		4
Spread (inches)	Range		12-26		20-33		11-27		13-37
	Mean		18		26		20		25
	L.S.D. .05		6		5		6		6

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