Range Productivity as Influenced by Biennial Sweetclover in Western South Dakota[1]

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Highlight

Biennial sweetclover was seeded into a Dense Clay Range Site that was severely depleted by drought and overgrazing. Seeded in 1962 without seedbed preparation, sweetclover has reseeded naturally, and remained a compatable associate with the native vegetation during the five-year study. Combined grass and sweetclover production averaged 1804 lb/acre annually compared to 750 for the control. The grass component was increased by an average of 373 lb/acre as a result of legume supplied nitrogen. Western wheatgrass vigor and forage protein were also improved. Native perennial grasses were not reduced in abundance by sweetclover competition. Sweetclover appears well adapted as a legume for rangelands with heavy clay soils in western South Dakota.

Legumes can provide an important source of nitrogen for associated grasses, enabling a mixed stand of legumes and grass to be much more productive than grass growing alone. In the Northern Great Plains, grass-legume combinations have been used almost exclusively for hay, irrigated pastures, and introduced early spring pastures. With few exceptions, this practice has not been exploited extensively for increasing the productivity of native ranges. Application of this principle appears to have great potential if suitable legumes are available for rangeland seeding.

It is generally agreed that native legumes were once a more important component of grasslands, but that intensive grazing by domestic livestock has reduced their abundance. Difficulty of establishment plus limited seed sources have restricted efforts to reestablish native legumes. Presently, the introduction of cultivated legumes into native rangelands may offer the more promising approach to increasing forage production by legume association.

Biennial sweetclover (*Melilotus officinalis*) is an introduced legume naturalized on many ranges in western South Dakota. It is very abundant on certain ranges in so called "clover years" when conditions are favorable for germination and growth. Recognition of the value of sweetclover as a rangeland legume could lead to management conducive to its propagation and greater application of this practice.

Seeding sweetclover into native range was one of eight treatments applied in the spring of 1962 to find means of increasing production and accelerating the recovery of range depleted by drought and overgrazing. Results of this study (Nichols, 1969) indicated that seeding sweetclover into western wheatgrass (*Agropyron smithii*) range was the most effective treatment attempted for increasing productivity of a Dense Clay Range Site. The sweetclover portion of that study was continued and expanded to more fully evaluate its value as a legume for range seeding and is reported in this paper.

Review of Literature

Studies from several geographic locations have shown the value of legumes. Williams et al. (1956) stated that seeding legumes, phosphorus fertilization, and grazing management increased grazing capacity threefold in the annual grasslands of California. Jones and Winans (1967) also working in California reported that seeding subterranean clover (*Trifolium subterraneum*) produced forage that was as high in protein during the winter period as where 80 lb N/acre had been applied. In Oregon, Bedell (1968) stated that the most important forage species for dryland pasture improvement was subterranean clover due to its high yield, rapid growth, superior nutritive value, and ability to grow well with perennial grasses.

Sweetclover, seeded with crested wheatgrass (*Agropyron desertorum*) in Montana, produced more forage than either the grass or legume seeded alone (Gomm, 1964). Lorenz and Rogler (1962) reported that sweetclover added to an old stand of crested wheatgrass in North Dakota showed no advantage in production due to stand loss, but that the addition of alfalfa increased yields comparable to crested wheatgrass fertilized with 30 lb N/acre.

In South Dakota a synthetic variety of alfalfa (*Medicago* spp. var. Travois), which has root proliferating characteristics, has been developed for potential use in pasture and range seeding (Rumbaugh et al., 1965). Stand evaluation of grazing type alfalfas interseeded into dryland pastures and ranges in 16 locations in South Dakota were reported by Rumbaugh and Thorn (1965). Initial stands were considered successful at 7 locations, failures at 7, and partially successful at 2 others. The persistence and influence of alfalfa on range productivity has not been reported for these locations.

A management program involving sweetclover and alfalfa has been successfully applied by a Montana rancher to increase production on rangeland (Miles, 1967a, 1967b, and 1967c).

Study Area and Procedures

The study area was in the Northern Great Plains approximately 12 miles northeast of Newell, South Dakota, on rangeland classified as a Dense Clay Range Site. Soils of this range site are moderately deep, high in clay content (60–65%), and slowly permeable. Soluble salts and pH are not considered adverse to plant growth. The natural vegetation consists predominantly of cool-season species. Western

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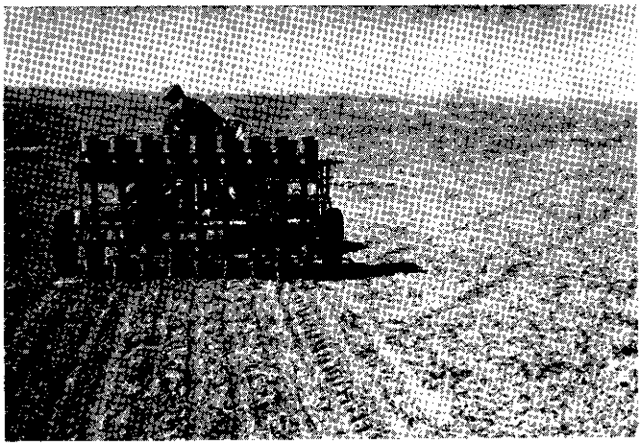

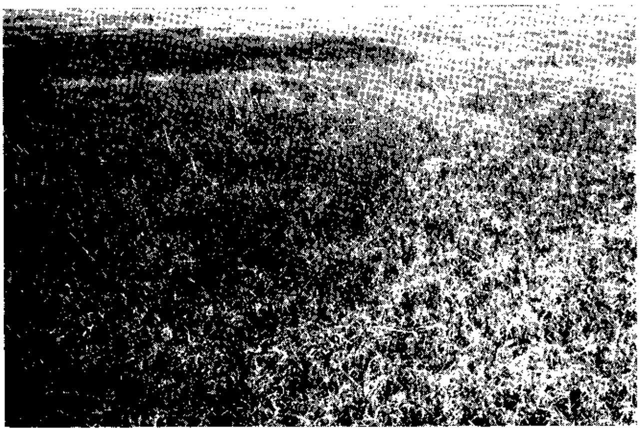

FIG. 1. Upper, drilling sweetclover into a deteriorated Dense Clay Range Site, spring 1962. Range was in extremely poor condition due to drought and overgrazing. Lower, same area with good cover of vegetation, July 1966. Mixed stand of western wheatgrass and second year sweetclover is represented by darker area (left), and, control plot (right).

wheatgrass and green needlegrass (*Stipa viridula*) are the major climax grass dominants, with the latter making up a small percentage of the composition. Perennial forbs are not presently an abundant component of the vegetation. Annual weedy forbs are common on these ranges following depletion by drought and excessive use. Dominance rapidly reverts to climax perennial grasses when grazing pressure is removed and adequate precipitation is received (Nichols, 1969).

Climate is continental. Large temperature variations occur from summer to winter and occasionally from day to day. On the average, temperatures can be expected to exceed 100 F twice a year and drop to lower than 20 F below zero three times a year. The frost-free period averages 131 days from May 16 to September 24. Precipitation has averaged 15.5 inches from 1908–1965, with approximately 78 percent occurring from April through September (Spuhler, et al., 1968).

Sweetclover (var. Madrid) was successfully established by two methods, broadcasting and drilling with a Nisbet grass drill at the rate of 2.5 lb/acre of PLS in the spring of 1962. At that time, the range was severely depleted and nearly devoid of perennial grasses (Fig. 1). Seedbed was not prepared, nor was preparation considered necessary. Methods of seeding were not evaluated separately after 1965 since natural reseeding established similar sweetclover populations. Ten replications in a randomized block design were initially sampled but reduced to sampling of 4 replications in 1966. Data collection commenced in 1963, one year after treatment.

Production estimates were obtained from plots 1 × 20 ft early in the study and modified to 2 × 4.8 ft as the vegetation attained more uniformity. All vegetation within the plots was clipped to near ground level, and reported as oven-dry weight. Sweetclover was separated from the grass for production estimates of each component in all but one year.

The abundance of perennial grass, sweetclover, and other forbs was estimated by placing a ¾ inch loop at one foot intervals along a 100 ft tape in each plot and recording basal presence. Data are presented as percent frequency of occurrence.

For a vigor estimate, extended plant height measurements of at least 10 western wheatgrass plants per plot were obtained during 1966 and 1967 at intervals ranging from weekly, early in the growing seasons, to monthly as plants approach maturity. Height measurements were averaged for each date and plotted to form growth curves. As an estimate of forage quality, clip samples were analyzed for nitrogen (Chapman and Pratt, 1961) and converted to percent crude protein (6.25 × N). The study area was protected from livestock grazing from 1962 to the conclusion of the study.

Results and Discussion

Growing conditions were average or above during the study period. Annual precipitation was 18.5, 14.9, 17.9, 14.4, and 15.8 inches for the years 1963 through 1967, consecutively, compared to the long-term average of 15.5 inches annually. The range which was severely depleted in the spring of 1962 recovered rapidly to a dominance of western wheatgrass (Fig. 1). By the end of the 1964 growing season, range condition was classified as excellent.

Forage production was increased from a 5-year average of 740 pounds per acre for untreated range to 1,804 pounds per acre when seeded to sweetclover (Table 1). Increases ranged from 36 to 493 percent depending on differences in growing conditions and age of sweetclover, seedling year versus second year. Considering the total forage produced over the five years of the study, an additional 5,322 pounds of forage per acre was produced as a result of seeding clover. Since the only direct expense of producing this additional forage was the initial cost of seeding, production increases of this magnitude are considered economically feasible and worthy of attention as a means of increasing range productivity.

Disregarding the portion of the total forage production contributed by the sweetclover, perennial grass production was increased by an average of 374 pounds per acre or 50 percent during the 4 years when separations were made. After 1963, grass production alone, when grown with sweet-

Table 1. Forage production (lb/acre oven-dry) from seeding biennial sweetclover into deteriorated Dense Clay Range Site in 1962 compared to untreated range, 1963–1967.

	Untreated range	Seeded range	Increase lb/acre	Increase percent
Total forage				
1963 (2)[1]	511	3032**[2]	2521	493
1964 (1)	698	949**	251	36
1965 (1)	1063	1833**	770	72
1966 (2)	444	950**	506	114
1967 (1)	983	2257**	1274	130
Average	740	1804	1064	144
Perennial grass portion[3]				
1963	511	358ns	− 153	− 30
1964	—	Not separated	—	—
1965	1063	1424**	361	34
1966	444	625*	181	41
1967	983	2085**	1105	112
Average	750	1123	374	50

[1] Denotes year of biennial sweetclover plant development: (1) = seedling year; (2) = second year.
[2] ** = significantly different ($P < 0.01$); * = significantly different ($P < 0.05$); ns = non-significant ($P > 0.05$).
[3] Primarily western wheatgrass with a small amount of green needlegrass.

clover, was consistently greater than grass production from the control. In 1963, sweetclover production was very high and may have offered sufficient competition to lower grass production, especially since the perennial grasses were recovering from a depleted condition. Even though grass production was lower in 1963, percent frequency data (Table 2) does not indicate that the abundance of perennial grass was adversely affected by sweetclover competition.

Vigor of western wheatgrass, as indicated by periodic seasonal height measurements, was increased by sweetclover association both in 1966 and 1967

Table 2. Frequency (percent) of occurrence of vegetation on range seeded to sweetclover in 1962 compared to untreated range, 1963–1967.

	Perennial grass[1]		Sweetclover		Other forbs	
	Control	Treated	Control	Treated	Control	Treated
1963 (2)[2]	7.6	9.2ns[3]	—	2.0	35.6	33.1
1964 (1)	36.0	29.6ns	—	33.9	9.9	6.4
1965 (1)	35.0	34.4ns	—	17.3	4.4	2.1
1966 (2)	28.0	35.8**	0.5	19.8	4.0	1.0
1967 (1)	15.8	23.0**	—	12.2	2.8	1.0

[1] Primarily western wheatgrass with small amounts of green needlegrass.
[2] Denotes year of sweetclover plant development: (1) = seedling year; (2) = second year of biennial growth habit.
[3] ns = non-significant ($P > 0.05$), ** = significantly different ($P < 0.01$).

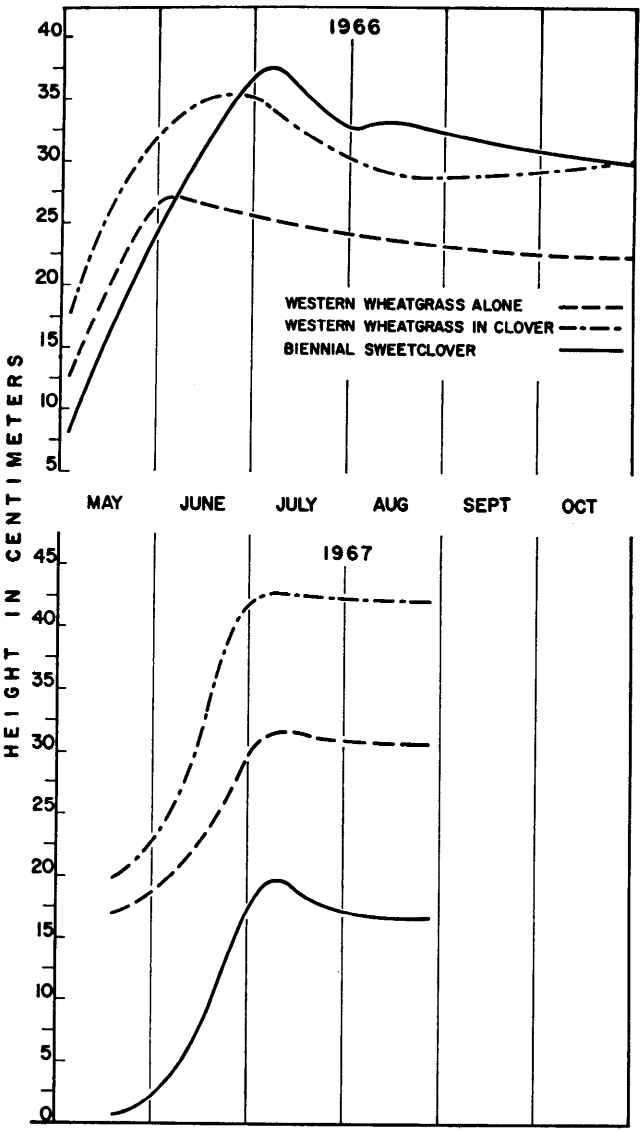

FIG. 2. Growth curves for western wheatgrass on control plots compared with western wheatgrass and biennial sweetclover growing in association, 1966 and 1967. In 1966, sweetclover was in its second year of growth and in 1967 it was in the seedling stage. Time of flowering and seedset are similar for sweetclover and western wheatgrass (approx. June 10–July 10, 1966).

(Fig. 2). Western wheatgrass plants were more vigorous in the spring and maintained a faster rate of growth, making the date of grazing readiness somewhat earlier. For example, in 1966, the height of western wheatgrass growing with clover was 22.4 cm (8.8 inches) on May 12 compared to 16.4 cm (6.5 inches) where sweetclover was not present. By the latter part of August, after which very little additional growth occurred, western wheatgrass with sweetclover was 6 cm (2.4 inches) and 11 cm (4.3 inches) taller than the control in 1966 and 1967, respectively. Color of western wheatgrass grown with sweetclover was noticeably darker green, also indicating an increase in plant vigor.

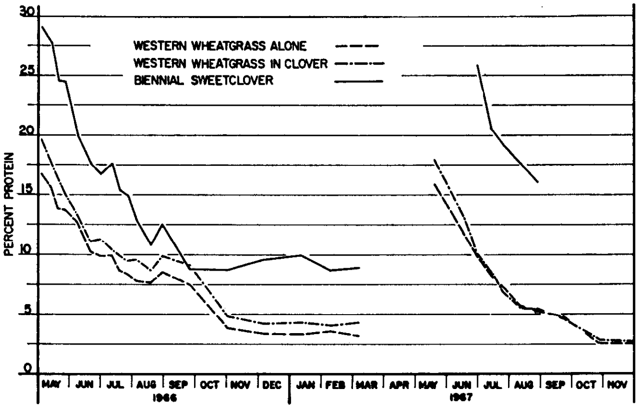

FIG. 3. Percentage crude protein of western wheatgrass on control plots compared to western wheatgrass and biennial sweetclover growing in association, 1966 and 1967.

With the exception of later growth initiation in the spring, seasonal growth, time of flowering, and seedset of sweetclover correspond closely to western wheatgrass. These similarities in phenology are conducive to seasonal grazing management beneficial to both components. For example, early growing season deferment would benefit the cool-season perennial grass, as well as permit sweetclover seedset, which is necessary for stand maintenance.

Plant protein.—In 1966, percent crude protein of western wheatgrass was increased by growing in association with sweetclover (Fig. 3). These differences were evident throughout the growing season and carried into the winter months during plant dormancy. In 1967 the differences in protein percent were evident early in the growing season but disappeared after June. Two diverse growing seasons may have influenced these differences. Favorable growing conditions in the spring of 1967 resulting in taller growth form (Fig. 2) and higher grass production (Table 1) may have decreased differences in grass protein percentages between treatments. Increasing soil nitrogen on nitrogen deficient soils whether from commercial sources (Cosper and Thomas, 1961; Burzlaff et al., 1968) or from legumes (Wagner, 1954) has been shown to increase plant protein percentage, but may be influenced by seasonal growing conditions (Johnson and Nichols, 1969).

From the standpoint of the grazing animal, protein content of western wheatgrass during the early part of the growing season would be adequate regardless of treatment. The principal advantage of higher grass protein when growing in association with sweetclover was the increased length of time that protein was at an adequate level as the growing season progressed and protein content declined. Of more importance, was the much higher protein percentage of the sweetclover forage throughout most of 1966 and 1967. Percent crude protein of the sweetclover was higher than western wheatgrass protein for both years, even into the winter months when essentially all leaf material had fallen from the sweetclover. Animals that graze a mixture of sweetclover and grass would be able to maintain a diet more nearly adequate in protein and possibly other nutrients much longer than where the selection is limited to nearly pure stands of western wheatgrass. A diversified plant cover of different classes of vegetation has been shown to be more desirable from the standpoint of the grazing animals diet than a single forage class (Cook and Harris, 1968). Weaver and Albertson (1956) stated several reasons why a variety of grasses and other plants in the Great Plains were desirable, including greater yield, longer green feed period, higher nutrient value, and effects of insect damage may be lessened.

Soil nitrogen as determined by the Kjeldahl method (Chapman and Pratt, 1961) was significantly higher ($P < 0.01$) from plots where sweetclover was grown. Samples (composite of 20 locations within each of four replications) taken from the 0–4 inch depth at the end of the 1967 growing season contained 1.11 percent nitrogen where sweetclover was growing, compared to 0.95 percent for the control. Although both values are low, soil nitrogen was consistently higher in all replications and averaged 17 percent more in plots growing sweetclover.

Sweetclover has been used extensively and is well recognized as a "soil builder" for cropland. It also appears to have value on rangeland as a source of nitrogen for associated grasses, especially in areas where commercial fertilization may not be economically feasible. Legumes have the advantage of being able to supply nitrogen on a self sustaining basis as long as stands are maintained.

Competition.—Adding an additional component of vegetation such as sweetclover to the existing stands of perennial grass could be expected to offer competition. However, forage production with the exception of 1963 (Table 1), percent frequency (Table 2), and plant vigor (Fig. 2) of western wheatgrass were all enhanced by the addition of sweetclover. This essentially indicates that low soil nitrogen limits potential grass performance on this site, and that sweetclover competition was not sufficient to suppress the response from legume-supplied nitrogen. The addition of sweetclover to the existing vegetation did not replace the perennial grasses or reduce their abundance. On the contrary, by 1966 and 1967 significant increases ($P < 0.01$) in percentage frequency of perennial grass were noted for plots where sweetclover was grown in association with grass. There is also some indication that other forbs (primarily weedy invaders) were less abundant where sweetclover was growing, suggesting that the sweetclover occupied the niche of annual forbs.

Early in the study when the perennial grasses were sparse and recovering from a depleted condition, sweetclover was robust, but as the perennial grasses recovered and became more competitive, sweetclover was reduced in stature and assumed a role more commensurate with the associated grass. The height of sweetclover did not exceed that of the associated grass in 1967 (seedling year sweetclover) and only slightly in 1966 which was second-year sweetclover (Figures 1 & 2). Sweetclover and western wheatgrass are considered compatible associates capable of coexisting in a manner advantageous to the associated grass on the Dense Clay Range Site.

Adaptability of the Dense Clay Range Site to Growing Sweetclover.—The soil and vegetation type of the study area are well adapted to natural reproduction of sweetclover. Frost action forms a surface mantle of loose, friable, soil which apparently aids in covering seed and provides a suitable environment for seedling development. Also, ground cover on this type of range, dominated primarily by western wheatgrass, is sufficiently open for sweetclover seedlings to establish. From 1962 when sweetclover was seeded, adequate stands have been present each year (Table 2). Natural reseeding has been successful every 2 years. In 1964 when seedlings died during the latter part of the growing season due to insufficient moisture, hard seed established new stands in the spring of 1965.

Although not occurring during the study, several unfavorable years may limit sweetclover establishment and growth. Biennial growth habit which necessitates seedling establishment every two years, and difficulty of seedling establishment were listed by Gomm (1964), as two common limitations for sweetclover when used as a dryland legume. These factors have not been a problem in this study. Ability to circumvent adverse environmental conditions by means of seed dormancy could be considered a beneficial adaptation. If seedset occurs periodically, stands of sweetclover are potentially available whenever growing conditions permit. By contrast, perennial legumes which must withstand environmental stress as a living plant may be more easily eliminated from a stand unless readily reestablished by natural seeding.

Substantial acreages of rangeland in western South Dakota are well adapted to growing sweetclover. Soils of approximately ½ million acres are typical of the study location with similar areas in southeastern Montana and northeastern Wyoming. Since its introduction into the western portion of the State, and subsequent escape from cultivated fields and roadside seedings, it has spread over large areas by natural means, primarily on rangelands which have heavy clay soils that are commonly termed "gumbo." Regionally some ranchers have seeded sweetclover on native ranges by airplane. It appears that extensive areas could be benefited by artificial seeding and management designed to increase and maintain sweetclover abundance. Although management suggestions to maintain stands of sweetclover were not a part of this study, numerous contrasting examples of differences in abundance can be readily observed. Sweetclover is most consistently present on winter use ranges or on areas that are not heavily grazed during the early spring growing season. This suggests that deferment during these periods can be helpful in maintaining sweetclover as a component of the vegetation.

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