Sweetclover: An Alternative to Fallow for Set-Aside Acreage in Eastern North Dakota

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North Dakota had an estimated 6.6 million acres in fallow during 1986, which represents a 27 percent increase since 1981 (5). East central (187 percent), Southeast (109 percent), Northeast (49 percent), and Central (40 percent) reporting districts had the largest percentage increases, presumably due to set-aside provisions of the federal farm program.

During the typical 20-month fallow period some moisture is stored, weeds are suppressed with four to eight cultivations, and nitrate-nitrogen is accumulated from organic matter decomposition. However, the fallow practice is wasteful and typically stores only 20 to 30 percent of available precipitation. Accumulated nitrate-nitrogen may be leached below the rooting depth when precipitation is abundant, contaminating ground water supplies. Wind and water erosion are major problems with fallow since excessive tillage for weed control leaves little crop residue on the soil surface. Soil losses from 10 to 50 tons per acre annually are not uncommon, especially on marginal cropland.

Use of a legume, like sweetclover, on set-aside acreage may be a viable alternative to fallow. Legume usage in cropping systems is certainly not a new idea. Sweetclover was used extensively in the northern Great Plains in the 1940s prior to the availability of a cheap inorganic nitrogen fertilizer source (4). Norum et al. (10) reported that generally it was not profitable to plow under sweetclover, peas, or winter rye for green manure and then fallow the rest of the season in the spring wheat subregion because gains achieved in favorable moisture years were lost in dry years. Haas and Boatwright (6) at Mandan found wheat grain yields after wheat, corn, and green-manure fallow were similar when 80 pounds of nitrogen and 40 pounds of phosphate were applied per acre. They concluded fertilizers were more effective in increasing wheat yields than the use of legumes and grasses.

Miller and Dexter (9) at Fargo, however, reported that fertilized wheat grain yields were about 11 to 14 percent higher when produced on land previously cropped to soybean (an annual legume) than following corn, sugarbeet, and sunflower and 40 percent higher than wheat following wheat. Likewise, Stoa and Zubriski (12) reported fertilized wheat grain yields were 11 to 15 percent higher when grown on legume (alfalfa) compared to nonlegume land for three crops following the legume.

The stage of maturity at which a green-manure crop is incorporated affects the amount of nitrogen and soil moisture available to the subsequent crop (7). Sweetclover plowed early (vegetative) or at the bud stage as a green-manure crop had similar levels of nitrate-nitrogen in the soil while sweetclover harvested for hay had only 81 percent of the nitrate-nitrogen found in a green-manure treatment.

The objective of experiments reported here was to evaluate sweetclover as a green manure or forage crop at two maturity stages and their effect on subsequent crop productivity and quality at Streeter and Prosper, ND.

METHODS AND MATERIALS

Experiments were initiated at the Central Grassland Station at Streeter in 1981 and 1982. Madrid sweetclover was established with a Butte (1981) or Len (1982) hard red spring wheat companion crop. An excellent stand of sweetclover was obtained. Wheat grain was harvested in mid-August at a 12-inch stubble height and the excess straw was removed.

Eleven cropping systems including two checks (continuous wheat and a traditional wheat-fallow) and nine sweetclover systems were established in 1982. The nine sweetclover systems included three treatments: hayed with traditional fallow thereafter, hayed with chemical fallow (chemfallow) thereafter, and green manuring; each treatment was initiated at three growth stages on second-year-growth sweetclover. Growth stages selected were early bud, mid bloom (two weeks after mid bud), and full bloom (four weeks after early bud). Hayed treatments were cut at a 1- to 3-inch stubble height at the appropriate growth stage and all forage removed. Hayed, traditional-fallow treatments were plowed when weed growth was well initiated at four to six weeks after hay harvest. Hayed, chemfallow treatments were not tilled but had weeds controlled with an application of glyphosate at 0.33 pounds actual ingredient per acre at the same time corresponding hayed traditional-fallow treatments were plowed. The green-manured treatments were plowed two weeks after clipping at the appropriate maturity stage. All above-ground forage was incorporated. The experimental design was a randomized complete block with three replicates.

To evaluate grain yield as influenced by cropping system treatment, Len wheat was seeded at 70 pounds per acre in late April 1983 after three passes with a field cultivator for seedbed preparation. Phosphorus fertilizer was applied at 50 pounds per acre to all treatments prior to cultivation. Continuous wheat and wheat-fallow plots received 100 pounds of nitrogen per acre as ammonium nitrate broadcast shortly after wheat emergence. The sweetclover system plots received no nitrogen fertilizer. Weeds were not a problem with only isolated plants of wild sunflower, wild

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mustard, and wild oats observed. Grain was harvested from an 80 square foot area in mid August. Grain samples were dried, cleaned, and weighed. Grain yields were expressed at 12 percent moisture. Grain yields were not reported for each maturity level but were averaged across maturities since they were not significantly different. Excess straw was removed from all plots, but an 8- to 10-inch stubble height was left standing to accumulate snow.

Residual effects of legumes in a rotation were evaluated in 1984. Precipitation in the fall of 1983 was below normal but March through April 1984 precipitation was nearly three inches above normal. The 1984 wheat crop was seeded at 75 pounds per acre in mid April. All other methods were similar to 1983. Ammonium nitrate at 0, 50, and 100 pounds nitrogen per acre was applied to each cropping-system treatment and replicated at least twice within each treatment in 1984. Each 1984 grain yield of the unfertilized treatment had 30 to 36 observations per mean. The field design was a split plot with the cropping-system treatments the main plots and nitrogen rates with subplots.

The new North Dakota Agricultural Experiment Station near Prosper was chosen for the second environment after a second experiment was lost at Streeter in 1983. Common sweetclover was seeded in a clean wheat stubble in mid August. An excellent stand was obtained except where chaff rows from small grain harvest thinned the stand. Adequate sweetclover growth occurred at this late seeding date to allow the crop to survive the mild winter of 1983-84.

Five sweetclover cropping systems were initiated in 1984 on early and late bloom, second-year-growth sweetclover. The treatments included: 1) green manure (all above-ground residue plowed down) with traditional fallow, 2) green manure with chemfallow, 3) hayed, stubble rototilled with traditional fallow thereafter, 4) hayed, rototilled, chemfallow, and 5) hayed, no stubble incorporation, chemfallow. Traditional fallow of sweetclover treatments consisted of one pass with a field cultivator for weed control. One application of glyphosate at 0.25 pounds per acre for weed control constituted chemfallow. Three checks, continuous wheat, traditional fallow (cultivated three times), and chemfallow (sprayed twice), also were included for a total of 13 treatments. The continuous wheat treatment in 1984 was seeded to Len wheat at 75 pounds per acre and fertilized with 100 pounds nitrogen per acre. Trifluralin at 0.5 pounds per acre was applied preemergent and lightly incorporated into the soil surface for weed control. Grain was harvested in late August, the straw removed, and the 10-inch stubble rototilled in early October. The field design was a randomized complete block with four replicates.

Seedbed preparation in 1985 was a double pass with a field cultivator. Len wheat and Hazen barley were seeded across all 1984 treatments at 70 and 60 pounds per acre, respectively, in early 1985. Resultant stands were excellent. Shortly after wheat and barley emergence all treatments were split with three nitrogen rates (0, 50, and 100 pounds of nitrogen per acre as ammonium nitrate). Weeds were controlled with 0.75 pounds per acre trifluralin applied preemergent and 2,4-D applied postemergent at 1.0 pound per acre. Barley and wheat grains were harvested from 80 square feet with a Hege plot combine, dried, cleaned, and weighed. Grain yields were determined and expressed on a 12 percent moisture basis. Grain yields were not reported for each maturity level but were averaged across maturities since they were not significantly different. Protein concentration in the grain was determined on an Infraanalyzer 400 and expressed on a dry matter basis. Straw protein was determined by the Kjeltec method.

Len wheat and hazen barley were seeded with a Haybuster no-till drill across all 1984 treatments at 75 and 48 pounds per acre, respectively, in May 1986. The no-till drill was used to maintain the same plots as in 1985. Resulting wheat stands were adequate, but barley stands were very poor. The 10-inch barley rows were split with a second pass of the no-till drill seeding another 48 pounds per acre 10 days after the first seeding. Phosphorus at 17 pounds per acre was deep-banded and 34 pounds per acre was banded 2 inches to the side and 2 inches below the seed at planting. The same nitrogen treatments applied to each plot in 1985 were applied preemergent to each plot in 1986. Broadleaf weeds emerging at planting were controlled with 2,4-D at 1 pound per acre. Grassy weeds were controlled with diclofop at 1 pound per acre applied at the three-leaf stage of wheat. Late emerging broadleaf weeds were controlled with dinoseb at 1.25 pounds per acre. All other methods were similar to 1985.

Soil nitrate-nitrogen to a 2-foot depth was sampled in all cropping system treatments during fall 1982 and spring 1984 at Streeter and just prior to planting in 1985 and 1986 at Prosper. Soil samples were taken from the unfertilized treatment in the second crop year. Nitrate-nitrogen was determined on all samples by the NDSU Soil Testing Lab.

RESULTS AND DISCUSSION

Forage and N yield

Forage yield, N concentration, and above-ground N yield as influenced by maturity stage in sweetclover are presented in Table 1. Forage yield increased with increasing maturity at Streeter. The lack of maturity effect at Prosper was not anticipated but was probably due to the lack of root development on the late-seeded sweetclover or environmental conditions which delayed maturity effects. Nitrogen concentration in sweetclover forage averaged 2.6 to 2.8 percent except at the full-bloom growth stage at Streeter. Nitrogen incorporated into the soil from above-ground material ranged from 89 to 114 pounds per acre. Nitrogen concentration in the root system was not determined, but it should contribute an additional 50 to 75 pounds nitrogen per acre based on fall root samples of first-year growth of sweetclover (6). These data suggest that an early incorporation of a second-year, green-manured sweetclover crop should be practiced to conserve soil moisture since little additional nitrogen was available at full-bloom maturity stage.

Soil nitrate-nitrogen

Soil nitrate-nitrogen level in November 1982 at Streeter was higher in green-manured sweetclover plots than in untilled hayed or fallowed plots (Table 2). The continuous wheat plots had a higher nitrate-nitrogen level than anticipated, which may have been due to the previous year's fertilization practice. All sweetclover and fallow treatments had substantially higher nitrate-nitrogen levels in the soil than the continuous wheat treatment in the spring following treatment initiation at Prosper. The fallow treatment was higher in nitrate-nitrogen than the green-manured and hayed sweetclover treatments. Green-manured treatments had higher soil nitrate-nitrogen levels than hayed treatments. Chemfallow sweetclover treatments generally had lower soil nitrate-nitrogen levels than traditional fallow treatments except the hayed, plowed, chemfallow treatment. Sweetclover treatments were higher in soil nitrate-nitrogen than fallow and continuous wheat treatments beginning the second crop year (1984) at Streeter, but soil nitrate-nitrogen levels were similar among treatments at Prosper (1986).

Table 1. Forage yield, nitrogen (N) concentration, and above-ground N yield as affected by maturity stage of sweetclover at Streeter (1982) and Prosper (1984), ND.

	Streeter				Prosper			
Sweetclover growth stage	**Harvest date**	**Forage yield**	**N conc†**	**N yield**	**Harvest date**	**Forage yield**	**N conc**	**N yield**
		tons/A	%	lb/A		tons/A	%	lb/A
Early bud	6-11	1.64	2.64	89	—	—	—	—
Early to mid bloom	6-24	2.04	2.57	105	6-18	1.62	2.79	90
Full bloom	7-8	2.95	1.94	114	6-28	1.72	2.76	95
LSD (0.05)		0.21	0.43	NS		NS	NS	NS
CV (%)		10.1	18.2	25.5		7.5	5.1	6.7

†conc = concentration on dry matter basis; (N × 6.25 = protein)

Table 2. Soil nitrate-nitrogen level in a 2-foot soil profile at Streeter and Prosper, ND as influenced by cropping system.

	Soil nitrate-nitrogen by location			
	Streeter		Prosper†	
Cropping system	**11-8-82**	**5-16-84**	**5-2-85**	**5-7-86**
	lb/A			
Continuous wheat	40	56	47	84
Fallow	33	57	138	62
Chemfallow	—	—	73	63
Green-manured sweetclover				
a. Plowed, fallow	46	69	114	68
b. Plowed, chemfallow	—	—	110	76
Hayed sweetclover				
a. Plowed, fallow	38	77	92	79
b. Plowed, chemfallow	—	—	107	71
c. Untilled, chemfallow	32	81	79	94
LSD (0.05)	9	17	27	NS
CV (%)	26	25	29	30

†The Prosper location was rotatilled instead of plowed.

Grain yield - Streeter

Grain yields from fallow fertilized with 100 pound nitrogen per acre and unfertilized green-manured and hayed sweetclover treatments were similar but superior to a continuous wheat fertilized with 100 pounds nitrogen per acre (Table 3). Leaf diseases were not evident on the continuous wheat. These data suggest that moisture, not nitrogen, was limiting grain yield and that the shorter fallow period of the green-manured or hayed treatments was adequate to conserve moisture equivalent to conventional fallow. The nearly five inches of precipitation in October 1982 probably explains part of the moisture effect.

Untilled, chemfallow, hayed plots exhibited typical nitrogen deficiency symptoms whereas plowed, fallow plots did not (Table 3). This indicates that organic nitrogen found

Table 3. Wheat grain yield by cropping system at Streeter, ND in 1983.

Cropping system (1982)	**Grain yield (bu/A)**
Continuous wheat + 100 lb N/A	22.2
Fallow + 100 lb N/A	29.8
Green-manured sweetclover	30.7
Hayed sweetclover	
a. Plowed, fallow	30.5
b. Untilled, chemfallow	19.8
LSD (0.05)	7.7
CV (%)	29.1

in the sweetclover root system was unavailable to the wheat plant in this treatment. Apparently, some tillage after hay harvest is necessary to initiate decomposition of the root system and release of the organic nitrogen. This suggests that a no-till green-manuring system that does not incorporate the above-ground organic residues into the soil would be ineffective, at least for the next cropping year.

The fall sampling for soil nitrate-nitrogen did not adequately test available nitrogen of green-manured or hayed sweetclover treatments for subsequent crop productivity (Tables 2 and 3). Apparently, nitrogen in the above-ground forage or root system was not adequately decomposed to be detected as nitrate-nitrogen in the soil test. The amount of nitrogen available to the subsequent crop will depend on the amount of organic nitrogen incorporated, the time incorporation occurs, and environmental conditions which increase decomposition of plant refuse and organic nitrogen release in soils.

Wheat grain yields at Streeter in 1984, the second year after sweetclover was included in the cropping sequence, are presented in Table 4. Wheat grown on 1983 fallow fertilized with 100 pounds nitrogen per acre was the highest yielding treatment (44 bushels per acre) in 1984. A typical response to increasing nitrogen fertilization on low nitrate-nitrogen testing soil (Table 2) was found in the 1983 fallow and continuous wheat treatments (Table 4). Continuous wheat plots fertilized with 100 pounds nitrogen per acre, second-crop wheat (fallow in 1982) and green-manured sweetclover treatments fertilized with 50 or 100 pounds nitrogen per acre, and unfertilized or fertilized, hayed sweetclover treatments were similar in grain yield to the unfertilized 1983 fallow treatment.

Residual effects of including legumes in a crop rotation can best be evaluated by comparing yields of sweetclover treatments to the second-crop wheat (1982 fallow treatment) since moisture differences are removed (Table 4). Unfertilized, hayed sweetclover treatments had grain yields equivalent to the second-crop wheat (1982 fallow) with 100 pounds nitrogen per acre. Fertilizer additions to the hayed treatments had little effect on the grain yields, indicating that moisture and not lack of nitrogen was limiting the yield.

Table 4. Wheat grain yields in 1984 by cropping system the second year after treatments were imposed at Streeter, ND.

Cropping system		Nitrogen rate (lb/A) in 1984		
1982	**1983**	**0**	**50**	**100**
		-Grain yield (bu/A) @12% moisture-		
Continuous wheat	Wheat	14	25	27
Fallow	Wheat	21	27	30
Green-manured sweetclover	Wheat	25	30	31
Hayed sweetclover				
a. Plowed, fallow	Wheat	29	32	33
b. Untilled, Chemfallow	Wheat	31	33	32
Wheat	Fallow	29	39	44
LSD (0.05)		5	7	9
CV (%)		21.5	19.7	22.6

Unfertilized, green-manured treatments produced grain yields equivalent to 50 pounds nitrogen per acre on second-crop wheat. These data suggest that including a legume in the rotation was equivalent to 50 to 100 pounds nitrogen per acre two years after its inclusion when grain yields were less than 35 bushels per acre.

Why second-crop grain yields of the green-manured treatment were lower than hayed treatments, especially in hayed, fallowed treatments, is unclear. Green manuring incorporated 90 to 110 pounds per acre more nitrogen than the root system alone (Table 2), yet unfertilized grain yields were higher from hayed than green-manured treatments (Table 4). One possible explanation is that organic nitrogen in the root system is released faster than that in the coarse, woody stem of sweetclover. If this is the case, then green-manured treatments may increase crop productivity the third year after inclusion as reported by Bailey (2) in Canada and Stoa and Zubriski (12) at Fargo.

Grain yields - Prosper

Wheat and barley grain yields as affected by the cropping system at Prosper are presented in Table 5. Wheat and barley grain yields grown on wheatland exhibited the typical response to increasing nitrogen rate. Wheat and barley grain yields were increased 75 and 50 percent, respectively, with fertilizer application compared to the unfertilized checks. Tanspot leaf disease was extensive at the two to three-leaf stage on continuous wheat plots, but apparently grain yields were not affected substantially. Grain yields of unfertilized fallow or chemfallow treatments were similar to a 100 pounds nitrogen per acre application on previous wheatland for both crops. Fertilized chemfallow barley treatments tended to produce higher grain yields than fertilized fallow, indicating that tillage of the fallow may have lowered available moisture.

Unfertilized grain yields of hayed sweetclover treatments of both crops generally were equal to unfertilized fallow (Table 5). Unfertilized grain yields of green-manured sweetclover treatments of both crops generally were equal to grain yields of fertilized (50 pounds nitrogen per acre) fallow. Likewise, fertilized (50 pounds nitrogen per acre) grain yields of hayed sweetclover treatments of both crops generally were equal to fertilized fallow, and fertilized (50 pounds nitrogen per acre) grain yields of green-manured treatments were equal to grain yields of fertilized (100 pounds nitrogen per acre) fallow. Fertilized or unfertilized grain yields of either crop have been only slightly less from hayed than green-manured sweetclover treatments. Little difference in grain yields were found among plowed fallow or chemfallow treatments and among plowed or untilled chemfallow treatments in either crop.

Results at Prosper (Table 5) and Streeter (Table 3) were similar (except untilled chemfallow) in that green-manured or hayed sweetclover treatments produced unfertilized grain yields at least equivalent to fallow and in some cases higher than fallow. Since the 1985 and 1986 federal farm program permitted grazing or haying of set-aside acreage, the hayed treatment with 1.6 to 2.0 tons per acre forage yield (Table 1) and the additional organic nitrogen contained in the root system would have produced the greatest economic return to producers. Meyer (8) and Badaruddin and Meyer (3) have reported that other legumes such as alfalfa and hairy vetch harvested for hay or green-manured had subsequent first-year crop productivity equivalent to sweetclover and fallow.

Grain yields at Prosper (Table 5) did not correlate well with soil nitrate-nitrogen levels (Table 2) determined at plan-

Table 5. Wheat and barley grain yields in 1985 by 1984 cropping system at Prosper, ND.

	Len wheat†			Hazen barley		
	Nitrogen rate (lb/A)			Nitrogen rate (lb/A)		
Cropping system in 1984	0	50	100	0	50	100
	Grain yield (bu/A) @ 12% moisture					
Wheat + 100 lb N/A	32	52	56	58	74	87
Fallow	58	62	65	87	95	96
Chemfallow	54	62	69	83	100	109
Green-manured sweetclover						
a. Plowed, fallow	63	68	66	95	98	100
b. Plowed, chemfallow	61	67	65	92	98	99
Hayed sweetclover						
a. Plowed, fallow	62	62	65	88	91	96
b. Plowed, chemfallow	57	57	67	89	94	99
c. Untilled, chemfallow	56	61	64	86	92	95
LSD (0.05)	5.3	8.2	NS	13.1	9.5	11.5
CV (%)	5.5	7.8	7.9	10.7	7.1	8.2

†Tanspot leaf disease was extensive at the 2 to 3 leaf stage on all wheat on wheat plots.

ting. Chemfallow and all hayed untilled treatments produced unfertilized barley or wheat grain yields similar to fallow when soil nitrate-nitrogen test indicated nearly 60 pounds per acre more in fallow treatments.

Little residual effects from including a legume in the rotation were found on barley grain yields at Prosper in 1986 (Table 6). No-till barley stands obtained in 1986 were poor, which may have accounted for the small residual effect. Another reason might be that the high grain yields obtained in 1985 utilized most of the available nitrogen from the previous legume crop. Nitrogen removed in the grain (Table 7) alone would account for most of the nitrogen incorporated (Table 1) in above-ground material. However, it is unclear why more of a residual response was not detected in the green-manured treatments at either location. The strong second-year response at Streeter may have been due to the relatively low yield in 1983 removing only a part of the available nitrogen compared to the higher 1985 yields at Prosper. Wheat grain yields in 1986 at Prosper were not reported because severe scab infection occurred, which reduced grain yields to less than 20 bushels per acre masking any residual legume effects.

Grain protein

Grain protein concentration of barley and wheat was increaed by including sweetclover in the rotation compared to fertilized (100 pounds nitrogen per acre) wheat and barley at Prosper in 1985 (Table 8). Generally, hayed sweetclover treatments had grain protein concentrations equal to fallow at the same fertility level while green-manured treatments were equal to fallow with an additional 50 pounds nitrogen per acre. Grain protein concentration of chemfallow treatments generally was less than fallow treatments, but protein concentration of chemfallow hayed or green-manured sweetclover treatments was equal to the similar treatment fallowed. These data suggest that including a legume like sweetclover in cropping sequences helps maintain or improve grain protein percentage.

CONCLUSIONS

Including sweetclover as a hay or green-manured crop generally increased grain yields of the subsequent wheat and barley crop compared to a fertilized continuous wheat or maintained grain yields equal to fallow in these experiments. Including the legume also maintains or improves grain protein percentage compared to continuous wheat or fallow. Other advantages of including the legume in cropping sequences include: 1) reduced wind and water erosion

Table 6. Hazen barley grain yield in 1986 by cropping system the second year after treatments imposed at Prosper, ND.

	Nitrogen rate (lb/A)		
Cropping system in 1984	0	50	100
	-Grain yield (bu/A) @12% moisture-		
Wheat + 100 lb N/A	34	54	62
Fallow	33	53	61
Chemfallow	28	50	55
Green-manured sweetclover			
a. Plowed, fallow	39	52	61
b. Plowed, chemfallow	38	54	55
Hayed sweetclover			
a. Plowed, fallow	35	51	55
b. Plowed, chemfallow	40	56	55
c. Untilled, chemfallow	32	53	55
LSD (0.05)	8	NS	6
CV (%)	15.7	13.7	6.5

Table 7. Nitrogen removed in wheat and barley grain in 1985 by cropping system in 1984 at Prosper, ND.

	Len wheat			Hazen barley		
	Nitrogen rate (lb/A)			Nitrogen rate (lb/A		
Cropping system in 1984	0	50	100	0	50	100
	lb/A					
Wheat + 100 lb N/A	34	54	58	40	53	66
Fallow	66	78	90	71	77	80
Chemfallow	56	71	83	61	82	89
Green-manured sweetclover						
a. Plowed, fallow	82	89	92	78	88	92
b. Plowed, chemfallow	82	89	95	76	85	92
Hayed sweetclover						
a. Plowed, fallow	73	80	88	69	76	84
b. Plowed, chemfallow	70	77	93	75	77	89
c. Untilled, chemfallow	63	79	87	65	73	81
LSD (0.05)	9	10	12	16	12	13
CV (%)	8.7	9.1	9.4	16.0	10.4	10.7

Table 8. Grain protein concentration of wheat and barley in 1985 by cropping system in 1984 at Prosper, ND.

	Len wheat			Hazen barley		
	Nitrogen rate (lb/A)			Nitrogen rate (lb/A		
Cropping system in 1984	0	50	100	0	50	100
	Percent protein, dry matter basis					
Wheat + 100 lb N/A	12.1	12.3	12.8	8.9	9.2	9.9
Fallow	13.4	14.6	15.5	10.5	10.6	10.8
Chemfallow	12.6	13.7	14.6	9.5	10.8	10.6
Green-manured sweetclover						
a. Plowed, fallow	14.9	15.6	16.0	10.7	11.6	11.4
b. Plowed, chemfallow	14.6	15.4	16.1	10.8	11.2	11.3
Hayed sweetclover						
a. Plowed, fallow	13.7	14.9	15.8	10.2	10.9	10.8
b. Plowed, chemfallow	14.2	15.0	15.8	10.9	10.6	11.0
c. Untilled, chemfallow	13.4	14.6	15.5	9.8	10.3	10.4
LSD (0.05)	0.8	1.0	0.6	1.2	1.1	0.9
CV (%)	4.0	4.5	2.7	7.9	6.9	5.6

since a crop canopy would be maintained on the land an additional 10 months, 2) reduction in the annual variation in forage supply by allowing a hay harvest in dry years when hay is short and high priced and use as a green-manure crop in wet years when hay is abundant and cheap, 3) greater flexibility for producers to take advantage of constantly changing government programs which have allowed hay harvest or grazing on set-aside acreage, and 4) potentially reduced production cost from an organic nitrogen source and reduced tillage cost compared to conventional fallow.

The major disadvantage of including a legume in a cropping sequence would be excess moisture utilization by the legume crop reducing subsequent crop productivity. Seed costs of some legumes are expensive and can be prohibitive, but sweetclover seed is relatively cheap at $4.20 per acre (6 pounds per acre at $0.70 per pound). Including hayed or green-manured sweetclover in the rotation replaced the need for at least 100 pounds nitrogen per acre in the subsequent crop(s), which would reduce nitrogen fertilizer cost by $15 per acre. In addition, livestock producers could harvest an additional $60 to $80 per acre of hay. More years and locations should be evaluated before sweetclover in the rotation can be recommended as a general practice. However, since government programs require set-aside acreage, including a legume on set-aside acreage in place of fallow appears to be a viable option worth considering in high moisture areas of North Dakota.

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