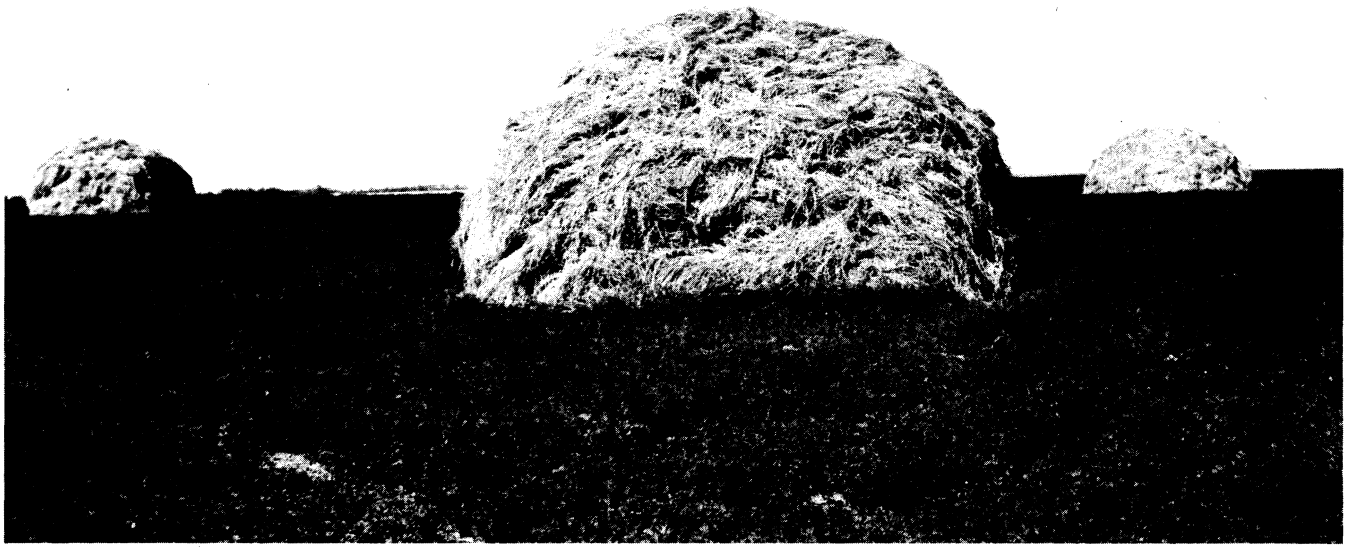


ALFALFA MANAGEMENT IN NORTH DAKOTA

Establishment Method and Seeding Rate Effects

D. W. Meyer

The influence of establishment method and seeding rate in obtaining adequate dryland and irrigated alfalfa stands was studied in several field experiments at Fargo and Oakes, North Dakota. Alfalfa seeded with companion crops and the companion crop harvested as silage generally produced higher seeding-year forage yields, but lower quality forage, than the one or two harvests of alfalfa established with herbicides used for weed control (clear seedings). Companion crops harvested for forage and clear-seeded alfalfa, compared to companion crops harvested for grain, produced similar or greater gross dollar return/acre using January 15, 1978 prices and 1977 comparative yields. Establishing alfalfa with or without a companion crop had little effect on the forage yield during the three years following seeding.

The author acknowledges the valuable assistance of W. E. Norby, project technician, in harvesting and chemical determinations and K. L. Davidson of the Radiation and Metabolism Laboratory for supplying rumen fluid used in the in vitro dry matter disappearance determination.

Dr. Meyer is Associate Professor, Department of Agronomy.

The influence of establishment method and seeding rate in obtaining adequate dryland and irrigated alfalfa stands was studied in several field experiments at Fargo and Oakes, North Dakota. Alfalfa seeded with companion crops and the companion crop harvested as silage generally produced higher seeding-year forage yields, but lower quality forage, than the one or two harvests of alfalfa established with herbicides used for weed control

(clear seedings). Companion crops harvested for forage and clear-seeded alfalfa, compared to companion crops harvested for grain, produced similar or greater gross dollar return/acre using January 15, 1978 prices and 1977 comparative yields. Establishing alfalfa with or without a companion crop had little affect on the forage yield during the three years following seeding.

INTRODUCTION

Establishing a dense, productive stand is the first step in optimum alfalfa management. Proper varietal selection, fertilization to soil test recommendations, optimum harvest frequency, field rotation, and other alfalfa management practices are of little value if adequate stands are not established first.

Companion crops, especially oats, wheat, and flax, are used extensively to facilitate spring alfalfa establishment. Companion crops can provide a harvestable cash crop in the establishment year, reduce weed competition, reduce soil erosion, and provide cover for the legume seedlings. Companion crops, however, compete with underseeded legumes for moisture, light, and soil nutrients, which may result in severe stand reduction or loss. As an alternative, pre- and post-emergent herbicides may be used, following label restrictions, to control weeds in legume seedings where erosion is not a serious problem.

Excellent alfalfa stands have been established in several north central states without a companion crop but using herbicides for weed control (clear seedings) (3, 5, 7, 8, 11). Clear-seeded alfalfa may produce 2 to 5 tons/acre from one to three harvests in the seeding year in high rainfall areas or with irrigation. However, total dry matter yields of forage the seeding year generally are higher when a companion crop is removed early as hay or silage than from clear seedings (3, 8). In addition, forages from companion crops compared to clear seedings generally are lower in forage quality factors including protein percentage, digestibility, and potential intake by livestock.

Five to eight lbs. PLS/acre is the recommended seeding rate on dryland in North Dakota when alfalfa is seeded with a companion crop (1). Clear seedings of alfalfa may require higher seeding rates (12 to 18 lbs. PLS/acre) than alfalfa established with companion crops to obtain maximum forage yields during the establishment year (2, 3, 9). Seeding rates above 6 to 10 lbs. PLS/acre generally have little influence on alfalfa yield after the initial harvest during the establishment year (2, 3, 5, 9, 11). Seeding rates have not affected such forage quality indicators as the leaf to stem ratio, crude protein percentage, cell wall constituents, acid detergent fiber, and acid detergent lignin (9).

Objectives of this research were 1) to determine the influence of the establishment methods (primarily companion crop and clear seedings) and seeding rate on the forage productivity of dryland and irrigated alfalfa in North Dakota, and 2) compare various dryland establishment methods for gross dollar return/acre during the year of alfalfa establishment.

METHODS AND MATERIALS

Dryland

Experiment I was seeded May 5, 1971 at Fargo, ND, on clean, fallowed, Fargo clay soil. Soil analyses prior to seeding indicated 105 lbs. N, 30 lbs. P, and 396 lbs. K per acre and a pH of 8.0. No additional fertilizer was applied. Alfalfa establishment methods were the whole plots and alfalfa seeding rates and varieties were the factorial subplots of a split plot design. Treatments were replicated three times. Establishment methods were a 'Cayuse' oat companion crop drilled at 40 lbs/acre just prior to alfalfa seeding and a clear seeding without weed control. 'Vernal' (a winterhardy, bacterial wilt resistant variety) and 'Saranac' (a moderately winterhardy, bacterial wilt resistant variety) were seeded at 6, 8, 12, 16, and 20 lbs. PLS/acre with and without a companion crop. Seed was hand broadcast, raked in, and the soil packed with a Brillion seeder. The oat companion crop in the soft dough growth stage was removed July 26, 1971 as silage at a three-inch stubble height. The clear seeded alfalfa in the 20 per cent bloom growth stage was harvested at this same time. Weeds in the clear-seeded plots, estimated at less than 10 per cent of the dry matter and not related to treatment, were removed by hand seven days prior to harvest. Below normal August moisture precluded a second harvest. Alfalfa plant density was determined August 16, 1971 on a representative area in each plot. A three-cut system with harvest at or near 10 per cent bloom growth stage and the third harvest before September 1 was used during 1972, 1973, and 1974.

Experiment II was seeded at Fargo, ND, on fallowed, Fargo clay soil. Soil analyses prior to seeding averaged 128 lbs. N, 43 lbs. P, and 460 lbs. K per acre and a pH of 7.3. No fertilizer was applied. The experimental design and alfalfa varieties used were identical to Experiment I. Four replications were used. Establishment methods were a 'Wyndmere' oat companion crop drilled at 32 lbs/acre May 11, 1972 and a clear seeding with 2.5 lbs/acre EPTC (S-ethyl dipropylthiocarbamate) preplant incorporated to a four-inch depth for weed control. Alfalfa in Replication 1 was seeded May 11, 1972 at 6, 8, 10, 12, 16, and 20 lbs. PLS/acre using methods similar to Experiment I, but rain delayed planting of Replications 2, 3, and 4 until May 19. The oat companion crop in the soft dough growth stage was removed July 5, 1972 as silage, leaving a three-inch stubble height. Clear-seeded alfalfa plots were harvested July 18, 1972 at about 10 per cent bloom growth stage. All plots were harvested August 30, 1972 at 10 per cent bloom. A three-cut system similar to Experiment I was employed during 1973, 1974, and 1975.

Experiment III compared several alfalfa establishment methods during the seeding year. Treatments included 1) 'Era' and 'Waldron' wheat, 'Beacon' barley, and 'Kelsey' oat companion crops harvested for grain; 2) Waldron wheat, Beacon barley, and Kelsey oat companion crops harvested for forage; 3) 'Linott' flax as a companion crop with 0, 3, and 6 lbs/acre EPTC fall (October 26, 1976) incorporated; 4) clear-seeded Vernal alfalfa with 0, 6, and 9 lbs/acre EPTC fall incorporated and harvested under a two-cut system; and 5) clear-seeded Vernal alfalfa with 6 lbs/acre EPTC fall incorporated and harvested under a one- and three-cut system. A randomized complete block design with three replications was used. Experiment III was seeded April 26, 1977 at Fargo, ND, on a clean, fallowed, Fargo clay soil. The seeding rates were 75, 55, 48, 55, and 12 lbs. PLS/acre for the wheat, barley, oats, flax, and alfalfa treatments, respectively. All stands were considered good to excellent except flax stands (including the no herbicide treatment) which were considered only fair due to an early season lack of moisture.

Barley and oat companion crops in the hard dough and soft dough growth stages, respectively, were harvested for forage on July 1. The wheat companion crop in the medium dough growth stage was harvested for forage on July 12, 1977. Companion crops were harvested for grain July 21 (barley and oats) and July 28 (wheat). Flax was harvested August 5 when about 10 to 15 per cent boll drop was noted. Alfalfa plots were harvested July 12 at 60 per cent bloom and October 18 in the vegetative growth stage. An additional harvest on August 18 was taken on the three-cut system plots. Grain yields are reported at 12 per cent moisture, forage yields are reported in tons dry matter (DM)/acre. Commodity prices utilized are January 15, 1978 prices reported by the North Dakota Crop and Livestock Reporting Service (6). A 12 per cent harvesting loss was assumed in calculating gross return/acre for forage yields. Samples for quality determination were obtained from all forage treatments. Per cent crude protein was determined by the standard micro-Kjeldahl procedure and *in vitro* dry matter disappearance by the Tilley and Terry (10) method with modification for direct acidification.

Irrigated

Experiment IV was seeded at Oakes, North Dakota on Embden loamy-sand soil which had previously been cropped to a small grain. Soil analyses averaged 21 lbs. N, 16 lbs. P, and 220 lbs. K per acre and a pH of 7.1. Thirty pounds P_2O_5 and 50 lbs. K_2O per acre were broadcast and plowed down. The oat companion crop was fertilized with 200 lbs. N/acre. All plots were fertilized with broadcast applications of 100 lbs. P_2O_5 and 55 lbs. K_2O per acre during the 1973 spring and a 100 lbs. of each fertilizer type during the 1974 spring. The experimental design, replications, and alfalfa varieties used were identical to Experiment II. The alfalfa establishment methods were identical to Experiment II except the oat companion crop was sown at 40 lbs/acre April 28, 1972. Alfalfa was hand broadcast at 8, 12, 16, and 20 lbs. PLS/acre, raked in, and packed. The experiment was irrigated to ensure establishment. Water was applied attempting to maintain tensiometer readings above 50 to 60 per cent field capacity in each year of the experiment. The oat companion crop in the soft dough growth stage was removed July 18, 1972 as silage leaving a three-inch stubble height. The clear-seeded alfalfa was harvested July 18, 1972 at about 20 to 30 per cent bloom. All plots were harvested September 1, 1972 when the alfalfa was at about 10 per cent bloom. A three-cut system similar to Experiment I was utilized during 1973, 1974, and 1975.

RESULTS AND DISCUSSION

Dryland Establishment Methods

An oat companion crop underseeded with alfalfa harvested for silage produced a higher forage yield during the 1971 seeding year than clear-seeded alfalfa at Fargo (Table 1). Below normal August rainfall permitted only a single harvest the seeding year for both establishment methods. Seeding-year forage yields were similar with or without a companion crop when two harvests in the seeding year were obtained in 1972 (Table 2). However, an extremely poor oat silage yield (averaging about 1.0 ton DM/acre compared to a normal 2.5 to 3.5 tons DM/acre at Fargo) as a result of poor tillering from unseasonably warm June temperatures and a reduced seeding rate influenced the comparison among establishment methods.

Alfalfa forage yields during the three years following establishment were similar with or without a companion crop (Tables 1 and 2). Clear-seeded plots produced a slightly higher total forage yield (0.70 tons DM/acre) than plots established with a companion crop in Experiment I (Table 1), but similar yields in Experiment II (Table 2). Similar forage yields were produced by Vernal and Saranac alfalfa varieties on clear-seeded plots and on plots established with companion crops in all years, suggesting that the winterhardiness of the alfalfa variety was not a factor affecting the comparison among establishment methods. Higher forage yields in the seeding year when alfalfa was established with companion crops than with clear seedings and similar forage yields during the years following establishment have been reported in South Dakota (3) and Minnesota (8) also.

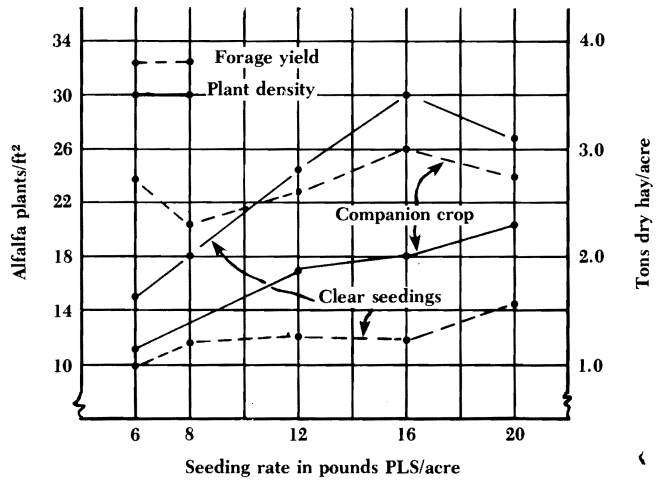
An economic comparison of several alfalfa establishment methods during the seeding year is shown in Table 3. Forage crops gave the highest gross dollar return/acre when January 15, 1978 prices and 1977 comparative yields were used. Beacon barley harvested as silage and clear-seeded alfalfa harvested three times the seeding

year produced the highest gross dollar return/acre. Wheat and barley companion crops harvested for grain produced about the same gross dollar return/acre as clear-seeded alfalfa harvested twice during the seeding year. Rainfall probably will limit much of North Dakota to a single seeding-year harvest on clear-seeded alfalfa stands, which will not generate the gross dollar return/acre of traditional companion crops harvested for grain or forage.

Clear-seeded alfalfa plots produced a higher quality forage than companion crops harvested for forage (Table 4). First-harvest alfalfa hay averaged 68.7 per cent *in vitro* dry matter disappearance compared to the 50 to 60 per cent for the small grain hays. Crude protein percentage averaged 14.8 per cent in the first-harvest alfalfa hay and 9.8 to 13.9 per cent in the small grain hays. The higher quality forage obtained from clear-seeded alfalfa may be an important consideration for livestock producers.

Utilizing flax as the companion crop can help ensure alfalfa stand establishment even in dry years. An experiment similar to that reported in Table 3 was seeded during the very dry 1976 spring at Fargo. Alfalfa stands established with all methods in 1977 appear to be fully productive stands, but clear-seeded and flax companion crop treatments produced the only acceptable alfalfa stands in 1976. Competition from the small grain companion crops in 1976 resulted in complete alfalfa stand loss. Most weed problems in early seeded flax, necessary for best alfalfa establishment and flax productivity, can be controlled effectively with EPTC at recommended rates.

Figure 1. The influence of seeding rate and establishment method on the number of alfalfa plants/ft² on August 16, 1971 and the seeding-year forage fields at Fargo, ND.



Dryland Seeding Rates

Increasing the seeding rate from 6 to 20 lbs. PLS/acre generally increased the alfalfa plant density for both establishment methods (Figure 1). The number of alfalfa plants/ft² ranged from 29 to 66 per cent higher in the clear-seeded plots than in plots established with a companion crop. The percentage of seed producing plants decreased from 43 per cent at 6 lbs. PLS/acre to 22 per cent at 20 lbs. PLS/acre with a companion crop, and 56 and 29 per cent for clear-seeded plots, respectively. All clear-seeded plots except the 20-pound seeding rate produced equal or more plants than the 6 lbs. PLS/acre seeding rate of plots established with a companion crop. However, the number of plants/ft² decreased due to interplant competition more rapidly at high than low seeding rates tending to equalize plant density after 3 to 4 years (3,9).

The alfalfa seeding rate had no significant affect on the forage yield of clear-seeded plots during the establishment year at Fargo (Table 5). Forage yield during the establishment year was not closely associated with number of alfalfa plants per unit area in either establishment method (Figure 1 and Table 5). Forage production of both establishment methods was not affected by the seeding rate during the three years following establishment. Forage yields from Vernal and Saranac alfalfa varieties were similar across seeding rates. There appears to be little justification to seeding dryland alfalfa at seeding rates above 6 lbs. PLS/acre, especially when companion crops are utilized and alfalfa is seeded at the proper depth.

Irrigated Establishment Methods

Irrigated forage yields in the seeding year at Oakes, ND, were the highest from the companion crop establishment of alfalfa (Table 6). The oat companion crop produced 3.70 tons DM/acre and the alfalfa regrowth produced 1.96 tons DM/acre by early September. The clear-seeded alfalfa plots produced 5.01 tons DM/acre. The July harvest produced an exceptionally high yield of 3.14 tons DM/acre; however, wild sunflower, which was not controlled by the EPTC herbicide, contributed an estimated 10 to 15 per cent of this yield. Sixteen alfalfa varieties clear-seeded under irrigation at Oakes in 1976 produced 3.40 tons DM/acre average seeding-year yield, a yield that probably can be obtained more consistently than the five-ton yield. Establishing alfalfa with or without a companion crop had little effect on the forage yield during the three years following establishment.

Clear-seeded alfalfa in early August following removal of a small grain crop is a useful alternative to spring establishment where moisture is plentiful. Alfalfa clear-seeded August 4, 1970 produced comparable 1971

forage yields to alfalfa seeded in early June, and substantially higher forage yields than an oat companion crop and alfalfa regrowth seeded the following spring (Table 7).

Irrigated Seeding Rates

Irrigated alfalfa forage yields increased with seeding rate for both establishment methods during the seeding year (Table 8). Forage yields on clear-seeded plots increased 0.37 tons DM/acre by increasing the seeding rate from 8 to 16 lbs. PLS/acre. However, forage yield was less at the 20 than 8 lbs. PLS/acre seeding rate. Second-harvest alfalfa forage yields on plots established with companion crops were 1.78, 1.97, 2.02, and 2.09 tons DM/acre with the 8, 12, 16, and 20 lbs. PLS/acre seeding rates, respectively, accounting for the significant increase in forage yields with increasing seeding rate.

Seeding rate had little influence on the total alfalfa forage yields during the three years following establishment (Table 8). The alfalfa yield was significantly higher at 16 compared to the 8 lbs. PLS/acre seeding rate in 1973. However, the 16 lbs. PLS/acre seeding rate treatment was significantly lower yielding than the 8 lbs. PLS/acre rate in 1974 when mild winter injury occurred, especially on the moderately-winterhardy Saranac plots.

Sufficient additional irrigated forage production in the establishment year was obtained by increasing the seeding rate from 8 to 16 lbs. PLS/acre to justify the additional seed cost in both clear-seeded plots and in plots established with a companion crop. However, the higher seeding rates also may result in increased winter injury as observed in 1974. Sund and Barrington (9) reported equal total nonstructural carbohydrate levels among seeding rates, but the smaller taproots at higher seeding rates resulted in less grams of carbohydrate available/plant. Higher seeding rates which results in smaller taproots may result in plants more subject to winter injury.

Table 1. Alfalfa forage yield as influenced by establishment method at Fargo, ND, 1971-1974.

Establishment method	Tons of dry forage/acre by harvest year				
	Seeding	1972	1973	1974	1972-74
Companion crop[1]	2.68b[2]	4.92a	4.12a	4.72a	13.76a
Clear seedings	1.25a	5.34a	4.33a	4.78a	14.45b

[1]*Cayuse oats in the soft dough stage was harvested for silage July 26, 1971.*
[2]*Means within a year followed by different letters are significantly different at the 5% probability level.*

Table 2. Alfalfa forage yield as influenced by establishment method at Fargo, ND, 1972-1975.

Establishment method	Tons of dry forage/acre by harvest year				
	Seeding	1973	1974	1975	1972-75
Companion crop[1]	2.39a[2]	3.76a	4.33a	3.90a	11.99a
Clear seedings	2.47a	3.62a	4.31a	4.14a	12.07a

[1]*Wyndmere oats in the soft dough stage was harvested for silage July 5, 1972.*
[2]*Means within a year followed by different letters are significantly different at the 5% probability level.*

Table 3. Comparison of the gross dollar return/acre during the seeding year for several alfalfa establishment methods at Fargo, ND, in 1977.

Establishment method and treatment	Eptam rate lbs/A	Grain yield bu/A	Forage yield tons DM/A	Price[1] on 1-15-78	Gross return $/acre
Grain companion crops					
Era wheat		42.5		$2.75/bu	117
Waldron wheat		41.5		$2.75/bu	114
Beacon barley		66.9		$1.74/bu	116
Kelsey oats		81.9		$1.00/bu	82
Forage companion crops					
Waldron wheat			3.30	$39/ton	129
Beacon barley			3.74	$39/ton	146
Kelsey oats			2.83	$39/ton	110
Flax companion crop					
Linott flax	0	17.6		$4.10/bu	72
Linott flax	3	17.4		$4.10/bu	71
Linott flax	6	18.5		$4.10/bu	76
Clear-seeded Vernal alfalfa[2]					
2-cut system	0		1.82	$48/ton	87
2-cut system	6		2.36	$48/ton	113
2-cut system	9		2.10	$48/ton	100
3-cut system	6		3.01	$48/ton	144
1-cut system	6		1.55	$48/ton	74

[1]*Prices as reported by the North Dakota Crop and Livestock Reporting Service on January 15, 1978 (6).*
[2]*Weed-free forage yields.*

Table 4. Quality of the forage produced during the seeding year for several alfalfa establishment methods at Fargo, ND, in 1977.

Establishment method and treatment	Eptam rate lbs/A	Cutting	Percent IVDMD	T/A digestible forage By cut	T/A digestible forage Total	Percent protein	Pounds protein per acre
Forage companion crops							
Waldron wheat			49.7		1.64	13.83	913
Beacon barley			60.1		2.25	9.79	732
Kelsey oats			55.8		1.58	12.66	717
Clear-seeded Vernal alfalfa							
2-cut system	0	1	65.4	1.25		14.00	
	0	2	54.9[1]	0.44	1.69	15.20[1]	695
2-cut system	6	1	69.4	1.17		15.63	
	6	2	55.4[1]	0.39	1.56	14.92[1]	737
2-cut system	9	1	68.7	1.04		14.88	
	9	2	56.2[1]	0.40	1.44	14.75[1]	661
3-cut system	6	1	69.4	1.19		14.06	
	6	2	74.0	0.88		18.16	
	6	3	64.2	0.32	2.39	24.06	1154
1-cut system	6	1	70.6	1.45	1.45	15.50	637

[1]*IVDMD about 10 units and per cent protein about 5 units lower than anticipated due to a nutritional deficiency which stunted alfalfa growth and caused extensive premature leaf loss.*

Table 5. Alfalfa forage yield as influenced by seeding rate at Fargo, ND.

Seeding rate (lbs/A)	Tons of dry forages/acre: 1971 seeding year CS[1]	1971 seeding year CC[2]	1972 seeding year CS[1]	1972 seeding year CC[3]	3-yr. total by experiment I 1972-74	3-yr. total by experiment II 1973-75
6	1.04	2.73	2.39	2.40	14.04	12.02
8	1.22	2.31	2.47	2.30	14.23	11.94
10	—	—	2.49	2.37	—	12.12
12	1.27	2.66	2.41	2.38	14.08	11.86
16	1.21	3.00	2.56	2.45	14.21	12.07
20	1.51	2.70	2.53	2.43	13.97	12.10
LSD_{05}	NS	NS	NS	NS	NS	NS

[1]*Clear seedings.*
[2]*Companion crop yield reported is primarily oatlage.*
[3]*Companion crop yield reported average 1.4 tons DM/acre oatlage and 0.99 tons DM/acre of alfalfa.*

Table 7. Irrigated alfalfa forage yields as influenced by establishment method at Oakes, ND, 1970-1972.

Establishment method	Tons of dry forage by harvest year	
	1971	1972
Spring seeded (1970)[1]	7.13a[2]	—[3]
Late summer seeded (1970)[4]	7.62a	6.95a
Spring companion crop (1971)[5]	4.02b	7.14a

[1]*Seeded in early June, 1970 without a companion crop. No harvest was taken in 1970.*
[2]*Means within a year followed by different letters are significantly different at the 5% probability level.*
[3]*Abandoned due to damage by pocket gophers.*
[4]*Seeding August 4, 1970 after early removal of a small grain crop.*
[5]*Wyndmere oats seeded April 30, 1971 at 2 bu/acre and harvested in the soft dough stage July 16 as silage. The oatlage yielded 3.38 tons DM/acre and a November 5 alfalfa harvest yielded 0.64 tons DM/acre.*

Table 6. Irrigated alfalfa forage yield as influenced by establishment method at Oakes, ND, 1972-1975.

Establishment method	Tons of dry forage/acre by harvest year				
	Seeding	1973	1974	1975	1973-75
Companion crop[1]	5.66b[2]	5.67a	4.64a	5.24a	15.55a
Clear seedings	5.01a	5.75a	5.00a	5.35a	16.10a

[1]*Wyndmere oats companion crop in the soft dough stage was removed July 18, 1972 as silage. It contributed 3.70 tons DM/acre to the seeding-year's forage yield.*
[2]*Means within a year followed by different letters are significantly different at the 5% probability level.*

Table 8. Irrigated alfalfa forage yield as influenced by seeding rate at Oakes, ND, 1972-1975.

Seeding rate (lbs/A)	Tons of dry forage per acre by harvest year					
	1972 seeding year					
	CS[1]	CC[2]	1973[3]	1974[3]	1975[3]	1973-75
8	4.96b[4]	5.53	5.56b	5.01a	5.35a	15.92a
12	5.04ab	5.53b	5.70ab	4.73b	5.26a	15.69a
16	5.33a	5.86a	5.85a	4.73b	5.31a	15.89a
20	4.70b	5.71ab	5.75ab	4.82ab	5.25a	15.82a

[1]*Clear seedings – Eptam at 2.5 lbs/acre, preplant incorporated, was used for weed control but wild sunflower constituted 10 to 15% of the reported dry matter yields. Two harvests at first flower were taken.*
[2]*Companion crop – Wyndmere oats at the soft dough stage harvested for silage yielded 3.7 tons DM/acre.*
[3]*Average of companion crop and clear seedings since forage yields were similar.*
[4]*Means within a column followed by different letters are significantly different at the 5% probability level.*

LITERATURE CITED

1. Carter, J. F. 1964. **Alfalfa production in North Dakota.** N. Dak. Agric. Exp. Stn. Bull. 448. 48 p.

2. Graffis, D. W., and W. D. Pardee. 1968. **Effect of seeding rates on spring-seeded *Medicago sativa* without companion crops in Illinois.** Agron. Abstr. 44.

3. Krueger, C. R., and L. H. Hansen. 1974. **Establishment method, variety, and seeding rate affect quality and production of alfalfa under dryland and irrigation.** S. Dak. Farm and Home Res. 25(1):10-13.

4. Meyer, D. W. 1975. **Alfalfa management in North Dakota.** N. Dak. Farm Res. 32(6):3-9.

5. Moline, W. J., and L. R. Robinson. 1971. **Effects of herbicides and seeding rates on the production of alfalfa.** Agron J. 63:614-616.

6. Price, J. R. 1978. **Farm reporter.** N. Dak. Crop and Livestock Reporting Service. Fargo.

7. Rohweder, D. A., and R. E. Doersch. 1974. **Methods of legume establishment.** Wis. Coop. Ext. Ser. Cir. A2580.

8. Schmid, A. R., and R. Behrens. 1972. **Herbicides vs oat companion crops for alfalfa establishment.** Agron. J. 64:157-159.

9. Sund, J. M., and G. P. Barrington. 1976. **Alfalfa seeding rates: Their influence on dry matter yield, stand density and survival, root size, and forage quality.** Wis. Res. Bull. R2786.

10. Tilley, J. M. A., and R. A. Terry. 1963. **A two-stage technique for the *in vitro* digestion of forage crops.** J. Brit. Grassl. Soc. 18:104-111.

11. Van Keuren, R. W. 1973. **Alfalfa establishment and seeding rate studies.** Ohio Forage Rep. 58(2):52-54.