INFLUENCE OF SOWING DATES ON ESTABLISHMENT OF ALFALFA IN OKLAHOMA

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Finally, to the honor of my beloved father and mother, I dedicate this thesis.

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CHAPTER I

INTRODUCTION

Establishment of new stands of alfalfa (Medicago sativa L.) is often difficult because of many problems faced by the seedlings during the first season.

In Oklahoma alfalfa is usually sown in later summer or early fall to avoid the effects of weed competition and summer drought on small seedlings. Weed problems and dry summer soil conditions are two factors which Oklahoma farmers believe responsible for frequent failure of spring seedings. By planting in the fall, farmers are faced with the possibility of losing new seedlings from drought and winter kill. With the development of new herbicides, weeds are a much less serious problem. If weeds can be eliminated from alfalfa seedings, spring seeding could become an alternative in Oklahoma.

For the purposes of this study, it is assumed that alfalfa sown during the late summer or early fall is more likely to result in a productive stand than spring or mid-fall seedings. The objectives of this study were to determine why this is true and to establish which spring dates are optimum.

CHAPTER II

LITERATURE REVIEW

Both fall and spring seedings of alfalfa (Medicago sativa L.) have many advantages and disadvantages, depending upon the area, because of the influence of climatic conditions on stand establishment.

Alfalfa seeded in fall in California reported by Barnes (1) gave higher yield than spring seeding in the first year. Late September through mid-November are usually acceptable fall dates for most forage productions; however, mid-February through March have been considered the best time for spring seedings. In a 2-year experiment at Woodland, Schoner et al. (30) reported that early to mid-September out-produced late fall or early spring seedings in the year of alfalfa establishment.

Under favorable conditions fall seeding is preferred throughout Kansas. Quick germination and good stands of alfalfa should be obtained, when planting is done immediately following the first good rain in August. Alfalfa should not be planted later than 10 September in northern Kansas or 20 September for the southern part of the state. Spring seeding varies from April to the end of May, but weather conditions and weed competition are two major

factors affecting alfalfa stands in spring (10).

Alfalfa seeding varies from one region to the other. In Arizona (6) early fall seeding is commonly practiced at elevations less than 3000 feet which resulted in high forage yield. Spring and summer seedings must be practiced at higher elevations. Bates (2) at Ardmore, Oklahoma concluded that September to October were the optimum dates of alfalfa sowings.

Smith (32) reported most small seeded forage in northern U. S. are sown during the early spring with a companion crops. This gives forages enough time to become well established before winter. However, summer seedings are usually planted without companion crops but in weed free seedbeds. Early spring plantings of alfalfa in Ohio was recommended to give plants time to become well established before frost (35).

In Michigan, Pulli (27) noted that yields of spring seeded alfalfa in the year of establishment were reduced, if sowing was delayed 3 to 4 weeks after earliest possible seeding dates. In Canada Goplen et al. (9) pointed out that sowing alfalfa in early spring had a good chance for success to become established before weed growth, and finally gave good results. However, summer seedings (mid-August) in the paririe provences had less than a 50% chance of good stand establishment because of drought.

Schmid and Behrens (28), in Minnesota, found that alfalfa grown without companion crops should be planted in

early spring to obtain maximum yield in the year of establishment. Peters and Stritzke (26) pointed out that good stand establishment and higher yields were obtained from early spring sowings in Missouri. In Michigan, Teasar (34) reported that alfalfa sown in spring gave 1.3 t/ha higher yields than summer in first year. Second year yield was the same for spring and summer, but summer seedings out yielded spring by 1.5 and 2.6 t/ha during the 3rd and 4th years respectively.

Good results of alfalfa establishment were obtained from late summer or early autumn sowing in north Caucasus, USSR. However, in north Crimea, early spring seeding of alfalfa without cover crops gave the best establishment (14). Evelyn and Ahmed (7) reported that the best time for sowing alfalfa in Sudan was 15 September, which yielded 5.7 t/ha, while later dates of sowing produced lower yields.

Janson (13) in New Zealand reported that September seeding of alfalfa gave 3.8 and 14.Ø t/ha compared to 2.1 and 11.9 t/ha with sowing in mid-November in the first and second season, respectively. Singh et al. (29) in India showed that highest dry matter and crude protein were obtained from alfalfa sown in mid-October, and lowest in early December.

Moisture is an important factor for a good alfalfa stand establishment. Musgrave and Lowther (23) conducted an experiment over three years in semi-arid regions in north

Otago, New Zealand. A successful stand of alfalfa was obtained only on humid or shady sites or if sowing was followed by rain. The best establishment was obtained in early to mid-August, while later sowing was favored on shady sites. Spring sowings were more successful than autumn sowings for alfalfa establishment for semi-arid to subhumid in north Otago (22).

Kim (15) showed that from 30 March to 10 April were the optimum dates for sowing alfalfa under irrigation in the southern Kzyl area of the USSR, and 10-20 April for central districts. Late spring and especially summer-sowing dates resulted in drastically reduced yields.

Soil temperature usually has an important role on seed germination. Wynn-Williamas (36) indicated that alfalfa germination increased with increase in soil temperature, and was highest in December in New Zealand. Musgrave (20) reported that alfalfa establishment was highest when soil temperature at 10 cm depth reached 3-7^{o} C.

McWilliam et al. (18) found that germination rate of alfalfa increased as temperature increased from 5-30^{o} C. However, Musgrave (21) suggested that optimum temperature for seedling establishment of alfalfa was 6^{o} C, as increased germination at high temperature was offset by subsequent decrease in soil moisture. Taylor et al. (33) concluded that under high temperature (36 to 39 ^{o} C), and low amount of precipitation sowing in July usually failed and decreased stands of alfalfa.

Companion crops are often used to reduce weed competition and to produces a quick crop in the year of establishment. Smith (31), in Wisconsin, showed that oats were usually planted as companion crop with spring seedings. Kust (17), in Wisconsin, reported that the companion crop harvested for forage, when under sown with alfalfa showed the best chance of establishing stand and producing maximum yields in the year of seeding. Hansen and Krueger (11) found that when oats harvested early for grain or forage gave the most weed-free alfalfa during the first year.

Dancik (5) found that oats (Avena sativa L.) as a companion crop gave higher alfalfa yields than barley (Hordeum vulgare L.). Buxton and Wedin (3) showed that alfalfa was less sensitive to inter-species competition than crown vetch (Coronilla varise L.) and birdsfoot (Lotus corniculatus L.), when oats were removed as hay.

Grandfield (10), in Kansas, suggested that the use of oats as a companion crop is sometimes successful. A companion crop does help control weeds in the spring, but it uses soil moisture and plant food needed by alfalfa. Schmid and Behrens (28), in Minnesota, indicated that alfalfa established with oat as a companion crop produced 5.2 t/ha, while alfalfa grown alone gave 4.0 t/ha.

Weeds are occasionally one of the serious problems encountered in alfalfa establishment. A number of scientists (4, 16, 17, 19, 25) indicated that herbicides can

replace companion crops to control weeds, and make two or three harvests of spring sown alfalfa possible during the sowing year.

CHAPTERh III

MATERIALS AND METHODS

Two studies were conducted to determine the effects of three spring and three fall sowing dates on four alfalfa cultivars adapted to the southern plains. The first study was sown in the Cow Creek bottom area of the Agronomy Research Station at Stillwater, Ok. in 1980 on a Port loam soil (fine-silty, mixed, thermic Cumulic Haplustolls). The second study was established in 1981 at the Agronomy Research Station near Perkins, Ok. on a Teller loam soil (fine-loamy, mixed, thermic Udic Argiustolls).

The experimental design was a split plot with four replications at each site. The main plots consisted of the six seeding dates, and subplots were four cultivars ('Arc', 'Baker', 'Riley', and 'Buffalo'). The sowing dates at Stillwater location were 1 March, 1 April, 1 May, 26 August, 22 September, and 20 October, 1980. Seeding dates at the Perkins location (differing slightly from 1980 because of weather and soil conditions) were 6 March, 6 April, 5 May, 26 August, 29 September, and 21 October, 1981. The results of fall seedings at Perkins location are not included in this thesis. The main plots were arranged in a randomized complete block design, and subplots were randomized within

each main plot. Improved statistical analysis of the sowing dates would have resulted if dates had been the subplots within the cultivars as main plots, but arrangement would have been impossible due to having to prepare seed beds six different times.

Subplots (cultivars) were planted at the various seeding dates by two passes with a Carter 5-row belt seeder at 18kg/ha. Rows were 15 cm apart and 5 m long with a space of 40 cm between subplots. One pass was designated for forage yield measurements, while the other area was reserved for destructive measurements, requiring the plants to be uprooted. Lime and fertilizer were applied according to the soil test recommendations. All seeds were inoculated with Rhizobium (Rhizobium meliloti) immediately prior to planting. All plots were irrigated imeediately after seeding to insure germination and emergence. With the exception of this initial irrigation, the study was conducted under dryland conditions. Weeds were controlled mechanically by using hoe or pulled by hand.

The primary observations used to estimate stand establishment were as follows:

1. Number of plants/unit area.
2. Root length at 6 weeks.
3. Shoot length at 6 weeks and during the first spring.
4. Root weight/unit area at 6 weeks and first spring.
5. Shoot weight/unit area at 6 weeks and first spring.

6. Percent ground cover.

7. Dry forage yield.

Number of plants/unit area were counted 2 weeks and 6 weeks after sowing at Stillwater and Perkins, and during the first srping after sowing at Stillwater.

Root length, length of 10 roots were measured from plants dug at 6 weeks of age at Stillwater and Perkins.

Shoot length, height of 10 plants were measured from uprooted samples, 6 weeks at both locations and during the first spring after sowing at Stillwater.

Root dry weights/450 cm^2 were recorded for whole roots at 6 weeks of age from both locations, and for the top 10 cm at first spring from Stillwater.

Shoot dry weights/450 cm^2 were recorded at 6 weeks of age for both locations, and first spring after sowing at Stillwater.

Percent ground covered by alfalfa was recorded during the first spring after sowing at Stillwater, and first fall after sowing at Perkins.

Dry forage yield was measured each time the plants reached bloom stage at both locations.

All data were subjected to F-tests. Duncan's Multiple Range Test at the 0.05 level of probability was used to separate means for planting dates and cultivars.

CHAPTER IV

RESULTS AND DISCUSSION

Stillwater Study

Seedling Growth

Based on the analysis of variance, there were highly significant differences (P=Ø.Ø1) due to the effect of planting dates for number of plants/unit area at 2 weeks, root length, shoot length, dry weight/unit area, and weight/plant at 6 weeks of age. However, no significant difference (P=Ø.Ø5) among cultivar nor planting date X cultivar interaction was detected (Table 1).

In general, fall seedings of alfalfa had higher plant populations than spring seedings at 2 and 6 weeks of age. April seeding resulted in the longest roots and shoots, and produced the heaviest dry weight/m^2 and average weight/plant at 6 weeks of age (Table 2).

Results of the number of plants/m^2 for four alfalfa cultivars at six planting dates are given in Table 2. The counts at 2 weeks indicated maximum emergence, and the counts at 6 weeks represented the results of thinning due to interseedling competition and death of weak seedlings.

The highest emergence (614 plants/m^2) was in the

TABLE 1. ANALYSIS OF VARIANCE FOR THE NUMBER OF PLANTS AT 2 AND 6 WEEKS, ROOT LENGTH, SHOOT LENGTH, DRY WEIGHT/M^2, AND WEIGHT/PLANT AT 6 WEEKS FOR FOUR ALFALFA CULTIVARS AT SIX PLANTING DATES IN 1980 (STILLWATER).

Source of Variation	df	Mean Squares					
		No. of plants/m^2		Root Length	Shoot Length	Dry Weight/m^2	Weight/ Plant
		2 Weeks	6 Weeks				
Replications	3	29,680.80	19,363.30	6.53	24.59	8.94	0.14
Planting Dates	5	316,701.60**	83,718.30	430.42**	5,999.76**	310.87**	6.55**
Error (a)	15	23,962.51	33,283.00	2.92	38.85	14.87	0.15
Cultivars	3	6,844.10	9,387.53	0.67	19.05	4.79	0.05
Date X Cultivar	15	8,629.28	13,928.59	2.16	15.40	3.58	0.05
Error (b)	54	7,584.43	8,923.38	1.74	18.35	5.49	0.01

**Significant at the 0.01 level of probability.

TABLE 2. NUMBER OF PLANTS/M^2 AT 2 AND 6 WEEKS, ROOT LENGTH, SHOOT LENGTH, DRY WEIGHT/M^2 AND WEIGHT/PLANT AT 6 WEEKS FOR FOUR ALFALFA CULTIVARS AT SIX PLANTING DATES IN 1980 (STILLWATER).

	Seedling Growth					
Sowing Date	No. of Plants 2 Weeks	No. of Plants 6 Weeks	Root Length	Shoot Length	Dry Weight/m^2	Weight/ Plant
	----plants/m^2-----		--------cm--------		----------g----------	
1 March	277 c†	207 ab	5.0 d	3.1 d	6.7 c	0.02 d
1 April	258 c	147 b	11.3 a	28.3 a	137.6 a	0.89 a
1 May	249 c	200 b	7.0 c	15.0 b	31.1 c	0.16 cd
26 August	402 b	352 a	10.0 b	16.4 b	71.0 b	0.22 bc
22 September	298 bc	263 ab	7.2 c	9.0 c	79.9 b	0.33 b
20 October	614 a	284 ab	5.1 d	3.5 d	24.4 c	0.08 d

†Within a column values followed by the same letter were not significantly different according to Duncan's Multiple Range Test (p = 0.05).

October seeding, while September, March, April, and May seedings had the lowest plant emergence (Table 2). It is not known why October seeding had more plants/m^2 than other seeding dates, perhaps the lack of high temperature during emergence. Emergence was considered satisfactory for all dates, however, stands from the October, March, April, and May seedings thinned drastically. This initial decline in plant population was apparently due to the onset of adverse conditions (e.g. hot, dry, and cold), which the alfalfa seedlings were not vigorous enough to withstand.

Root and shoot growth measurements at 6 weeks age are presented in Table 2. April seeded alfalfa plants were well established and showed greater top and root growth than plants of other treatments. May, August, and September seedings showed an intermediate root and shoot growth, while October and March seedings were not different and produced the least root and shoot growth. This may be due to low soil temperature, and the environmental conditions that cause the seedlings to be nonvigorous for March and October seedings, in addition to late seeding for October planting.

High soil temperatures and adequate soil moisture content are two factors which favored top and root growth. Top and root growth increased as the temperature and moisture are at the optimum level for plant growth.

Total root and shoot dry weight/unit area and weight/plant were heaviest in April seeding, while October, March, and May seedings gave the lowest weight, according

to Duncan's Multiple Range Test at Ø.Ø5 level of probability (Table 2). This weight is related to the number of plants/unit area, plant size, competition among alfalfa plants, and due to the environmental stress placed on the alfalfa plants.

Adult Plant Growth

There were highly significant differences among planting dates due to the effect of sowing dates for number of plants/unit area, shoot length, dry weight/unit area, weight/plant, and percent ground cover at first spring 1981 after planting. Highly significant differences among cultivars due to the effect of planting dates for number of plants/m^2, shoot length, and percent ground cover were found. There were significant interactions between planting date X cultivar for shoot length and dry weight/unit area (Table 3).

Generally fall seedings gave highest percent ground covered by alfalfa and highest plant population. March, April, May, and August seedings produced the tallest plants. Spring seedings resulted in higher weight/individual plant than fall seedings. March seeding gave highest dry weight/unit area (Table 4).

The counts made during the first spring (1981) after seeding indicated the number of plants which would actually contribute to yield during the first full production year.

TABLE 3. ANALYIS OF VARIANCE FOR NUMBER OF PLANTS/M^2, SHOOT LENGTH, DRY WEIGHT/M^2, WEIGHT/PLANT, AND PERCENT GROUND COVER AT FIRST SPRING (1981) FOR FOUR ALFALFA CULTIVARS AT SIX PLANTING DATES IN 1980 (STILLWATER).

Source of Variation	df	Mean Squares				
		No. of Plants/m^2	Shoot Length	Dry Weight/m^2	Weight/ Plant	% Ground Cover
Replications	3	4,187.93	1,769.68**	1,385.09**	149.64	74.66**
Planting Dates	5	276,086.44**	2,306.33**	9,925.89**	1,357.01**	1,194.42**
Error (a)	15	1,591.38	55.79	155.18	112.35	32.67
Cultivars	3	68,189.03**	62.48**	228.91	101.48	69.56**
Date X Cultivar	15	16,481.37	77.36**	271.61**	44.53	24.20
Error (b)	54	10,105.64	12.53	97.09	57.73	9.89

**Significant at the 0.01 probability level.

TABLE 4. NUMBER OF PLANTS/M^2, SHOOT LENGTH, DRY WEIGHT/M^2, WEIGHT/PLANT, AND PERCENT GROUND COVER AT FIRST SPRING (1981) FOR FOUR ALFALFA CULTIVARS AT SIX PLANTING DATES IN 1980 (STILLWATER).

Sowing Date	No. of Plants	Shoot Length	Dry Weight/m^2	Weight/Plant	Ground Cover
	--plants/m^2--	--cm--	----------g----------		---%---
1 March	135 c†	22.0 a	742 a	9.13 a	47.5 b
1 April	89 c	20.0 a	542 c	9.10 a	46.1 b
1 May	129 c	20.0 a	666 b	9.00 a	45.3 b
26 August	428 a	20.1 a	542 c	2.67 b	87.2 a
22 September	304 b	13.1 b	273 d	1.19 b	82.5 a
20 October	281 b	8.0 c	93 e	0.25 b	75.5 a

†Values followed by the same letter were not significantly different according to Duncan's Multiple Range Test (P = 0.05).

These data show that the plant populations by that period had declined over time at each seeding date except August and September (Table 2). August seeding had 428 plants/m^2, September and October seedings had 304 and 281 plants, respectively. March, April, and May seedings were not significantly different (P=0.05) and had lowest plant density with an average of 118 plants/m^2. Stands of alfalfa generally were satisfactory at all dates. These results are in agreement with those of Schoner et al. (30) who reported 270 plants/m^2 was considered a full stand for a first year planting. However, Fribourg and Strand (8) reported that a population of about 100 plants/m^2 gave a satisfactory stand. Such a stand could be expected to permit the plants to express its productivity during the season following establishment. Higher plant mortality was observed in spring seedings than fall seedings. This mortality began soon after emergence and continued on, which made early fall-seeding superior on spring-seedings.

Densities of Riley and Baker were similar (263 and 260 plants/m^2 respectively), but population of Buffalo and Arc were only 220 and 167 plants/m^2, respectively (Table 5).

The data in Table 4 showed the shoot length at first spring after planting. August, March, April and May seedings were not significantly different at 0.05 probability level with an average of 20.5 cm and had most top growth, while the October seeding had the least top growth. However, September gave an intermediate length.

TABLE 5. NUMBER OF PLANTS/M^2, SHOOT LENGTH, DRY WEIGHT/M^2, AND PERCENT GROUND COVER AT FIRST SPRING (1981) OF FOUR ALFALFA CULTIVARS AT SIX PLANTING DATES IN 1980 (STILLWATER).

Cultivar	No. of Plants	Shoot Length	Dry Weight /m^2	Ground Cover
	--plants/m^2--	---cm--	----g----	---%---
Arc	167 b†	16.7 bc	453 b	58.8 b
Buffalo	220 ab	17.9 a	451 b	60.5 b
Baker	260 a	17.1 ab	520 a	67.9 a
Riley	263 a	16.2 c	484 ab	68.6 a

†Values follwed by the same letter were not significantly different according to Duncan's Mutiple Range Test (P=0.05).

The taller shoots were due to the good development of spring and August seedlings, and the age of these plants were about one year for spring seedings, whereas August seeding was about 7 months old at the time of sampling. October seeding was about 5 months old, and apparently root development was insufficient to allow the plant to grow rapidly in the spring after the temperature began to rise. Good top growth enhances root growth and give the roots a chance to go deeper.

Buffalo had longest shoot length, while Riley was shortest (Table 5). This difference of the top growth was due to the difference in dormancy among cultivars.

The interaction between planting date X cultivar for shoot length is probably due to the difference in dormancy among cultivars, and due to the cold weather for early spring and late fall seedings (Figure 1).

Total root and shoot weight/unit area (Table 4) was highest in March seeding and lowest in October seeding. This is because the March plants were older even though it had few plants, but they were larger. Thus October seeding was youngest and even though it had many plants, they were small.

There was a significant interaction between planting date X cultivar (P=Ø.Ø1) (Figure 2). Arc tended to have the highest dry weight/unit area from spring seedings, but the lowest from fall seedings. On the other hand, Riley plants resulting from spring seedings were relatively small but

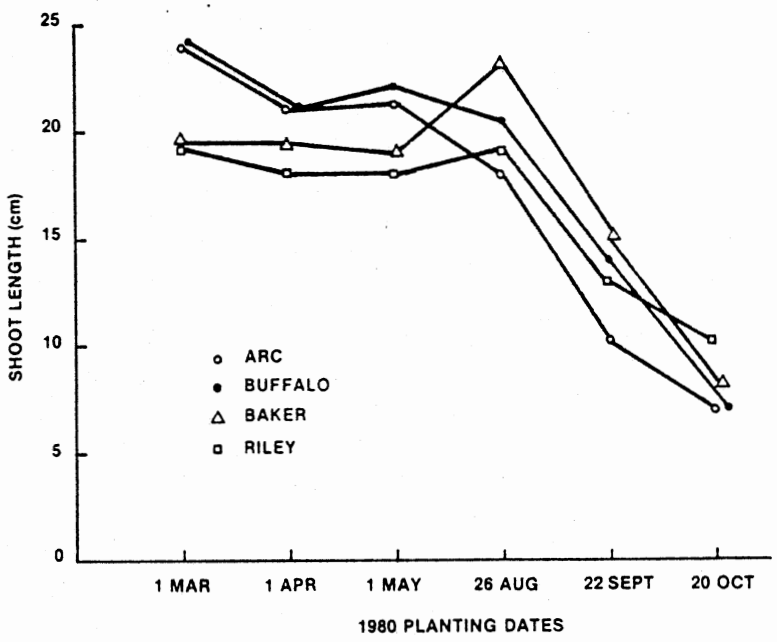

Figure 1. Shoot length at first spring 1981 for four alfalfa cultivars with six planting dates at Stillwater.

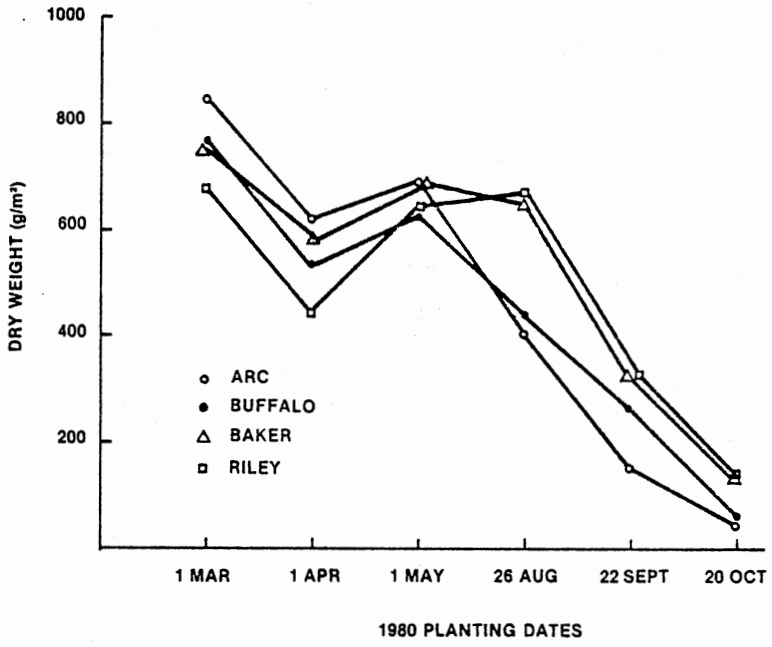

Figure 2. Dry weight/m^2 at first spring 1981 for four alfalfa cultivars with six planting dates at Stillwater.

large from fall seedings.

Duncan's Multiple Range Test at Ø.Ø5 probability level in Table 4 shows that the 3 spring planting dates were not significantly different, and produced higher weight/plant than the 3 fall dates. This was due to the older and larger plant size from spring than fall seedings.

Duncan's Multiple Range Test at 5% probability in Table 4 indicated that the 3 fall seedings were not significantly different and resulted in higher alfalfa stand than the 3 spring seedings. This lower stand from spring seedings may be due to nonvigorous seedlings, which resulted in death of many plants and allowed weed invasion. Spring seedings showed an average of 46% stand which is considered satisfactory plant density score for alfalfa yield. Offutt (24) concluded that minimum plant density score for continued production of high yield was about 55%.

Riley and Baker gave higher stand than Buffalo and Arc (Table 5). This difference is not agronomically important and all cultivars had full stands. Baker and Riley were more dormant at the time of taking these observations, otherwise they might have given same stand.

Forage Production

Highly significant differences were observed due to the effect of planting date among planting dates and cultivars for the forage yield of the first cut, total production of the first year, first cut in 1981, total production in 1981,

and cumulative production of 1980-81. There was highly significant interaction between planting date X cultivar for the yield of the first cut of the year of establishment (Table 6).

March and August seedings produced the highest forage yield in the first cut after sowing. August and September seedings outyielded the other treatments in the first year production. August seeding produced highest forage in the first cut in 1981. March, April, May, and August seedings were not different and produced higher yield than September and October seedings for the total production in 1981, whereas spring seedings produced more forage than fall seedings for the cumulative production in 1980-81 (Table 7). Baker and Riley produced higher forage yield than Buffalo and Arc (Table 8).

First Cut Yield

First forage harvest of spring seedings was recorded in summer 1980, while first cut of fall seedings was made in spring 1981. Even though these harvests were produced in different growing seasons, they are important to compare because these are the comparisons producers make to answer the questions related to the value of spring sowing versus fall sowing.

March and August alfalfa seedings produced 5.1 and 5.5 metric tons/ha, while April and October seedings gave the

TABLE 6. ANALYSIS OF VARIANCE FOR FORAGE PRODUCTION OF FOUR ALFALFA CULTIVARS AT SIX PLANTING DATES 1980-81 (STILLWATER).

Source of Variation	df	Mean Squares				
		First Year Production		Production 1981		Cumulative
		First Cut	Total	First Cut†	Total‡	1980-81
Replications	3	6.12*	40.89**	2.66	41.36*	80.88**
Planting Dates	5	23.77**	347.48**	11.27**	184.49**	1,010.79**
Error (a)	15	1.58	2.26	2.02	8.61	12.16
Cultivars	3	11.79**	28.43**	33.42**	68.75**	88.76**
Date X Cultivar	15	1.16**	3.38	0.42	2.67	2.67
Error (b)	54	0.46	2.42	0.59	4.21	6.12

*, ** Significant at 0.05, and 0.01 probability levels, respectively.

†Yield of first cut of fall vs. first cut in second year of spring seedings.

‡Yield of first year of fall vs. second year of spring seedings.

TABLE 7. FORAGE PRODUCTION FOR FOUR ALFALFA CULTIVARS AT SIX PLANTING DATES 1980-81 (STILLWATER).

Sowing Date	Production Year	First Year Production		Production 1981		No. of Cuts	Cumulative 1980-81
		First Cut	Total	First Cut †	Total #		
		tons/ha					
1 March	1980	5.1 a†	11.1 c	4.5 b	18.9 a	7	29.9 a
1 April	1980	2.5 c	7.9 d	4.5 b	18.5 a	7	26.5 b
1 May	1980	3.9 b	6.5 e	4.3 b	18.2 a	7	24.7 b
26 August	1981	5.5 a	18.6 a	5.5 a	18.6 a	4	18.6 d
22 September	1981	4.1 b	15.2 b	4.1 bc	15.2 b	4	15.2 d
20 October	1981	3.1 c	11.1 c	3.1 c	11.1 c	4	11.1 e

† Within a column values followed by the same letter were not significantly different according to Duncan's Multiple Range Test (P=0.05).

†Yield of first cut of fall vs. first cut in second year of spring seedings.

#Yield of first year of fall vs. second year of spring seedings.

TABLE 8. FORAGE PRODUCTION OF FOUR ALFALFA CULTIVARS AT SIX PLANTING DATES 1980-81 (STILLWATER).

Cultivar	First Year Production		Production 1981		Cumulative
	First Cut	Total	First Cut‡	Total#	1980-81
	tons/ha				
Arc	3.7 b†	10.6 b	3.1 c	14.7 c	18.8 c
Buffalo	3.9 b	11.2 b	3.8 b	16.5 b	20.5 b
Baker	5.2 a	13.9 a	5.3 a	17.5 ab	22.2 a
Riley	4.8 a	13.7 a	5.1 a	18.3 a	22.6 a

† Within a column values follwed by the same letter were not significantly different according to Duncan's Multiple Range Test (P=0.05).

‡Yield of first cut of fall vs. first cut in second year of spring seedings.

#Yield of first year of fall vs. second year of spring seedings.

least forage production (2.5 and 3.1 tons/ha), Table 6 respectively. This lower yield of April and October seedings was attributed to lower plant population density/ m^2 for April seeding, since April sowing had 147 plants/m^2 after 6 weeks of planting (Table 3) which considered is not sufficient to give maximum yield. Jacobs et al (12) reported that maximum yield was not reached until there were 300 plants/m^2 in first cut yield. Smaller plant size in the October seeding also contributed to poor yield.

Baker and Riley produced more dry matter than Arc and Buffalo (Table 8). The lower yield of Arc and Buffalo may be in part due to the lower stand density and spotted alfalfa aphids {Therioaphis maculata (Buckton)} infestation.

The interaction between planting date and cultivar (Figure 3) may be due to the difference in stand establishment and vegetative growth of the cultivars under different seeding dates. All four cultivars were similar when spring sown, but differed when fall sown.

First Cut 1981

Yields of fall seedings at the first cut after sowing, and first cut of the second year (season 1981) of spring seedings are presented in Table 7. A second comparison of interest is the yield of the various dates harvested in the spring 1981. At that point the spring sown plots were 11 to 13 months old while the fall sown were only 6 to 8 months old. August alfalfa planting produced greatest forage

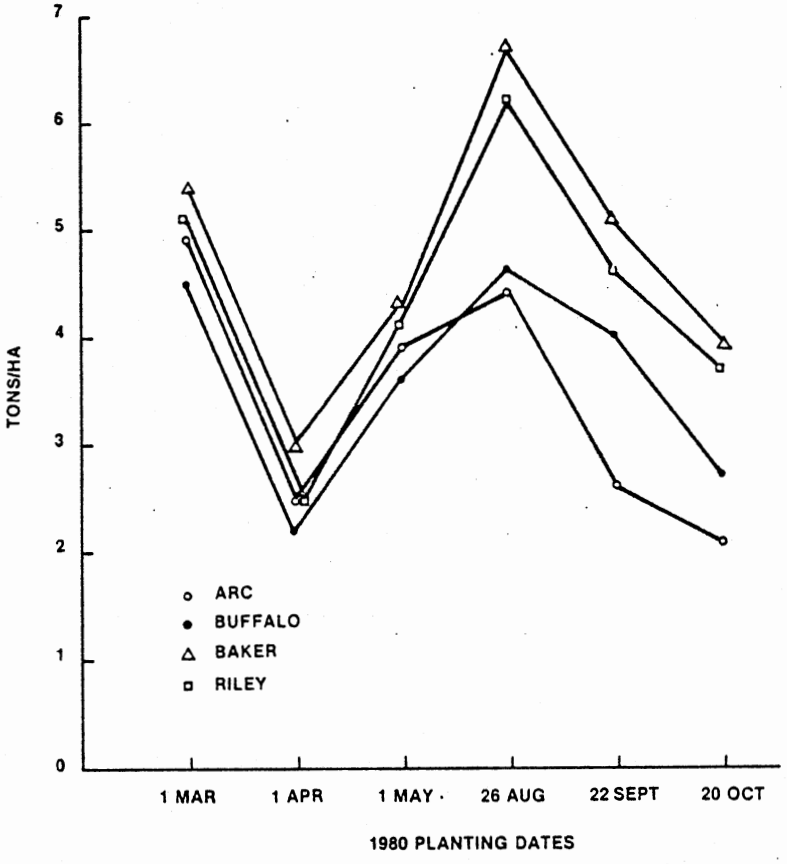

Figure 3. First cut forage yield 1980-81 for four alfalfa cultivar with six planting dates at Stillwater.

yield, while March, April, May, and September were intermediate, and October seeding yielded lowest forage dry matter. For the first harvest the October seeding was harvested 3 weeks later than the other treatments, because of its immature stage of growth when the others were harvested at the 5% to 25% bloom.

The data in Table 8 show that Baker and Riley produced the most forage yield, while Arc produced the least yield. This lower yield was in part due to spotted alfalfa aphids infestation. Arc is not resistant to spotted aphid and showed sever damage during the first cut. Buffalo is less susceptible to spotted aphid and it had slight damage. Baker and Riley are not susceptible to this aphid. Blue alfalfa aphids [Acyrthosiphon kondio (Shinji and Kondo)] and pea aphid [A. pisum (Harris)] were observed at this time but they did not have any noticeable effect on alfalfa plants. However, alfalfa weevil [Hypera pestica (Gyllenhal)] showed slight effect on all cultivars in all treatments.

First Year Production

First-year forage production from March, April, and May seedings of alfalfa was made in season 1980, however August, September, and October seedings' yields were produced in the 1981 season.

August seeding produced highest yield, while May seeding gave the least yield according to Duncan's Multiple range Test (P = 0.05) (Table 7). Early fall seedings of

alfalfa showed considerable advantage over spring and late fall seedings. This higher yield is attributed to the better stand of August and September seedings than other treatments. The influence of stand on yield was greater in the first than in second year after seeding, and is attributed to the ability of alfalfa to partially compensate for the stand by producing more branches/plant.

Total Production 1981

Second year forage production for spring seedings and first year production for fall seedings are presented in Table 7. Duncan's Multiple Range Test (P=Ø.Ø5) Table 7 shows that March, April, May, and August seedings were not significantly different and produce the most forage, while October seeding yielded the least forage. This lower yield attributed to smaller plant size, and lower number of branches in the October seeding than other treatments.

The data in Table 8 show that Riley gave the highest forage yield, Baker and Buffalo gave an intermediate yield, whereas, Arc produced the lowest forage yield. This in part due to the spotted alfalfa aphids during first cut, and lower plant density of Arc than other cultivars.

Total Forage Production

March seeding of alfalfa produced the highest yield, while October seeding gave the lowest yield. Spring

seedings produced more forage yield than fall seedings. This is at least in part due to the number of cuts obtained from each seeding date. March, April, and May seedings produced 29.9, 26.5, and 24.7 tons/ha in 7 cuts during two seasons. August, September, and October produced 18.6, 15.2, and 11.1 tons/ha respectively, in 4 cuts in one season (Table 7). Early fall seedings could have out yielded spring seedings if they planted in fall prior to the spring seedings.

Riley and Baker gave greater yield than Buffalo and Arc (Table 8). This difference in yield may be due to the effect of insect damage and the difference in plant population density.

Perkins Study

Seedling Growth

Based on the analysis of variance there were highly significant differences among planting dates for number of plants/m^2 at 2 and 6 weeks age, shoot length, dry weight/unit area, and weight/plant at 6 weeks of age. Significant differences (P=Ø.Ø5 and Ø.Ø1) among cultivars due to the effect of planting date for number of plants and weight/plant at 6 weeks of age were observed, respectively. However, no signifcant interaction between planting date X cultivar were found (Table 9).

April seeding had more plants/unit area than March and

TABLE 9. AMALYSIS OF VARIANCE FOR NUMBER OF PLANTS AT 2 AND 6 WEEKS, ROOT LENGTH, SHOOT LENGTH, DRY WEIGHT/UNIT AREA, WEIGHT/PLANT, AND PERCENT GROUND COVER FOR FOUR ALFALFA CULTIVARS AT THREE PLANTING DATES IN 1981 (PERKINS).

		Mean Squares						
Source of Variation	df	Number of Plants/m^2 2 Weeks	Number of Plants/m^2 6 Weeks	Root Length	Shoot Length	Dry Weight/ m^2	Weight/ Plant	%Ground Cover
Replications	3	7,483.13	7,647.05	4.69	77.52	13.51	0.11	371.07
Planting Dates	2	27,674.48**	478,484.36**	35.88	3,176.23**	655.09**	1.91**	1,307.81
Error (a)	6	9,282.72	8,733.41	9.18	73.99	10.88	0.07	415.97
Cultivars	3	24,224.97	61,943.89*	4.15	22.21	7.60	0.08**	567.18
Date X Cultivar	6	6,324.14	18,200.69	2.32	1.65	3.64	0.03	103.13
Error (b)	27	9,654.41	11,101.65	2.42	15.96	3.82	0.01	296.24

*, **Significant at 0.05 and 0.01 probability levels, respectively.

May seedings. April and May seedings had taller shoot and heavier weight/plant than March seedings, while April seeding gave highest dry root and shoot weight/m^2 (Table 1Ø). Baker and Riley had more plants/m^2 at 6 weeks of age than Arc and Buffalo. However, Arc produced the highest weight/plant than other cultivars (Table 11).

Results of the number of plants/m^2 for four alfalfa cultivars at three spring planting dates are given in Table 1Ø. Stand counts as an indication of stand establishment were made at 2 weeks and 6 weeks after planting at Perkins location.

Data in Table 1Ø show plant population density was 447, 587, and 277 plants/m^2 planted in March, April, and May, respectively. April seeding of alfalfa gave highest plant density, while May seeding gave lowest plants/unit area. Emergence was relatively high for March and April seedings, however, it was poor in the May seeding. This poor stand may be attributed to the heavy rain following planting which washed out many seeds, in addition, some seedlings failed to penetrate soil surface due to soil crust.

Number of plants/m^2 at 6 weeks age were counted by uprooting 5, 3Ø cm row length in each plot. Average living plants (Table 1Ø) were 453, 552, and 216 plants/m^2 for March, April, and May seedings. This indicates that plants from March and April seedings responded more favorable to the environmental conditions, and gave higher stand density than May seeding. Plant populations at 6 weeks after

TABLE 10. NUMBER OF PLANTS/M^2 AT 2 AND 6 WEEKS, ROOT LENGTH, SHOOT LENGTH, DRY WEIGHT/M^2, AND WEIGHT/PLANT FOR FOUR ALFALFA CULTIVARS AT THREE PLANTING DATES IN 1981 (PERKINS).

	Seedling Growth					
Sowing Date	No. of Plants 2 wks	No. of Plants 6 Wks	Root Length	Shoot Length	Dry Weight /m^2	Weight /Plant
	--plants/m^2--		-----cm------		--------g--------	
6 March	447 b†	453 b	6.8 b	7.4 b	20.0 c	0.05 b
6 April	587 a	552 a	7.7 ab	19.1 a	151.0 a	0.28 a
5 May	227 c	216 c	8.2 a	17.9 a	67.0 b	0.36 a

† Within a column values followed by the same letter were not significantly different according to Duncan's Multiple Range Test (P=0.05).

TABLE 11. NUMBER OF PLANTS/M^2, AND WEIGHT/PLANT AT 6 WEEKS AGE OF FOUR ALFALFA CULTIVARS AT THREE PLANTING DATES IN 1981 (PERKINS).

	Seedling Growth	
Cultivar	No. of Plants at 6 Weeks	Weight/ Plant
	--plants/m^2--	---g---
Arc	330 b†	0.28 a
Buffalo	398 ab	0.19 b
Baker	429 a	0.24 b
Riley	470 a	0.20 b

†Values followed by the same letter were not significantly different according to Duncan's Multiple Range Test (P=0.05).

planting had declined over time at each seeding date except March.

Baker, Riley, and Buffalo had a higher plant density/m^2 than Arc (Table 11). The reason Arc gave least plants/m^2 was not known since this cultivar is adapted to this location.

Percent ground cover was measured during the first fall after planting. Average stand percent from March, April, and May seedings in Perkins gave the same average stand (82%) in August, September, and October seedings in Stillwater study (Table 4). However, March, April, and May spring seeding at Stillwater study gave low stand percent average of 46% when compared with spring seedings stand 82% at Perkins study. This implies that spring seedings season 1981 in Perkins gave more vegetative growth and better stand than spring seedings of season 1980 in Stillwater study, but it cannot be tested statistically because of the experimental design.

April and May seedings resulted in taller top growth than March seeding. Shorter top growth of March seeding may have been due to cool temperatures in March, which delayed the quick growth of seedlings.

The data in Table 10 show that April seeding produced the heaviest dry plants/m^2, while March seedings gave the lighest weight. This lower dry weight has been attributed to the smaller seedling size at the March seeding.

Alfalfa seedlings resulted in higher weight/plant when

planted in April and May than in March (Table 1Ø). This weight is related to the plant size and competition among alfalfa plants.

Duncan's Multiple Range Test (P=Ø.Ø5) in Table 11 shows that Arc gave higher weight/plant than Buffalo, Baker, and Riley cultivas. Arc had fewer plants/m^2 than other cultivars, resulted in larger seedling size and gave higher weight/plant due to less competition among plants in space and nutrients.

Forage Productions

There were highly significant differences due to the effect of three planting dates for the forage yield of the first cut and the first year production (1981). Significant differences (P=Ø.Ø5) were found among cultivars for the first cut and first year production. However, no significant interaction between planting date X cultivar was detected (Table 12).

For the first cut yield March seeding produced the highest forage. However, for the total (of 1981) March and April were not different, but both were higher than May (Table 13). Buffalo, Baker, and Riley were not different and produced higher yield than Arc in the year of establishment (Table 14).

TABLE 12. ANALYSES OF VARIANCE OF FORAGE PRODUCTION FOR FOUR ALFALFA CULTIVARS AT THREE PLANTING DATES IN 1981 (PERKINS).

Source of Variation	df	Mean Squares Forage Production	
		First Cut	First Year
Replications	3	0.04	1.38
Planting Dates	2	29.59**	115.56**
Error (a)	6	0.25	1.79
Cultivars	3	0.39*	1.89*
Date X Cultivar	6	0.14	0.59
Error (b)	27	0.09	0.44

*, **Significant at 0.05 and 0.01 probability levels, respectively.

TABLE 13. FORAGE PRODUCTION FOR FOUR ALFALFA CULTIVARS AT THREE PLANTING DATES IN 1981 (PERKINS).

Sowing Date	First Cut Production	Number of Cuts	First Year Production
	tons/ha		tons/ha
6 March	4.3 a†	3	7.9 a
6 April	3.8 b	3	7.9 a
5 May	1.9 c	2	3.7 b

†Within a column values followed by the same letter were not significantly different according to Duncan's Multiple Range Test (P=0.05).

TABLE 14. FORAGE PRODUCTION OF FOUR ALFALFA CULTIVARS AT THREE PLANTING DATES IN 1981 (PERKINS).

Cultivar	Forage Production	
	First Cut	First Year
	--------tons/ha----------	
Arc	3.1 c†	5.9 b
Buffalo	3.4 ab	6.8 a
Baker	3.5 a	6.6 a
Riley	3.2 ab	6.6 a

†Within a column values followed by the same letter were not significantly different according to Duncan's Multiple Range Test (P=Ø.Ø5).

First Cut Yield

The data in Table 13 show that March seeding gave highest dry matter/ha (4.3 tons/ha), and May seeding produced 1.9 tons/ha, the lowest alfalfa forage yield. The April seeding produced 3.8 tons/ha even though it had highest number of living plants/m^2. This may be attributed to the fact that March seeding had larger plants which were better established than April and May seedings.

The four cultivars, Baker, Buffalo, Riley and Arc, produced 3.5, 3.4, 3.2, and 3.1 tons/ha, respectively (Table 14). This lower yield is due to the lower stand establishment of Arc than other cultivars.

First Year Production

The data in Table 13 show March and April seedings produced the same yield 7.9 tons/ha in 3 cuts, whereas, May seeding gave 3.5 tons/ha in 2 cuts. This low yield was due to the difference in number of cuts obtained, and the poor stand density of May seeding. The number of living plants/m^2 of May seeding were low when compared to March and April seedings, which showed excellent plant density (Table 10).

As can be seen in Table 14, Buffalo, Baker, and Riley were not significantly different and produced an average of 6.7 tons/ha dry matter, while Arc yielded 5.7 tons/ha. This lower yield was due to poorer stand of Arc.

CHAPTER V

SUMMARY AND CONCLUSION

The objectives of this study were to determine why alfalfa sown in late summer or early fall results in more productive stands than spring or mid-fall seedings, and to establish which spring dates are optimum. Two studies were conducted to examine the alfalfa plants response to three spring and three fall sowing dates, using four cultivars. The characters evaluated were number of plants/m^2 at 2 weeks of age, 6 weeks of age, and during first spring, root length, shoot length, total plant weight, and weight/plant at 6 weeks of age and during first spring after planting, stand percentage, and dry forage yield.

Planting dates were significantly different for all characters evaluated except number of plants/m^2 at 6 weeks of age from Stillwater study, and root length at 6 weeks of age and stand percentage from Perkins study. Significant differences among cultivars were observed only for number of plants/m^2, and shoot length during first spring, stand percentage, and dry forage yield at Stillwater study, and number of plants/m^2, weight/plant at 6 weeks of age, and forage dry yield at Perkins study. However, no interaction was found between cultivar and planting date except shoot

length, total plant weight during first spring, and first cut production at Stillwater study.

Fall alfalfa seedings produced higher plant densities and stand percentage than spring seedings first spring after planting in Stillwater study. However, March and April seedings at Perkins gave high plant population density at 6 weeks age when compared to the same seeding dates at Stillwater. Higher plant mortality after emergence was observed in spring seedings than fall seedings, which made early fall superior on spring seedings in Stillwater study. However, it was not obvious in Perkins study.

Root length, shoot length, total plant weight, and weight/plant at 6 weeks age were lower in March and October seedings than other seeding dates at Stillwater, and March seeding at Perkins. During first spring after planting spring seedings produced taller shoot and heavier plants than fall seedlings at Stillwater.

Alfalfa planted in March and August produced highest forage, whereas April and October seedings produced the lowest forage yield the first cut after planting in Stillwater study. However, alfalfa sown on 5 March produced highest yield, while May seeding produced lowest yield in the first cut at Perkins study.

Total forage yield obtained from spring seedings was higher than fall seedings, because of number of cuts obtained from each season. However, average forage yield per harvest was higher when alfalfa sown in early fall and

early spring than late fall and late spring seedings at Stillwater. At Perkins March and April seedings produced nearly the same yield higher than May seeding.

Significant differences among cultivars for plant population density was observed at first spring after planting. Higher plant mortality was observed from Arc than the other cultivars. Baker and Riley were highly dormant and gave better stand percentage than Arc and Buffalo at both studies.

Baker and Riley produced higher forage than Arc and Buffalo in the first cut after planting and the total forage production at Stillwater. However, Arc produced the lowest forage in the first cut and the total forage yield than the other cultivars at Perkins study.

From the above results some conclusions may be summarized as follows:

1. Emergence of all cultivars were relatively high at all planting dates at both studies. However, plant mortality after emergence was higher in spring seedings than fall seedings.
2. Fall seedings of alfalfa showed higher plant density and stand percentage than spring seedings.
3. Alfalfa seeded in early spring and late summer or early fall produced higher forage yield than late spring and late fall in the year of establishment.
4. Forage yield per harvest of early fall seeding was higher than spring and late fall seedings.

5. No difference among cultivars for stand establishment in the first year.
6. Baker and Riley produced higher forage yield than Arc and Buffalo.

To facilitate further studies some suggestions are summarized as follows:

1. For different comparisons, fall alfalfa seedings should be conducted before spring seedings.
2. Both studies should be done in the same locations for best comparisons.
3. This study should be repeated with one cultivar to test planting date of alfalfa.
4. The same experiment should be repeated for two consecutive years, partially irrigated during alfalfa establishment.
5. Root length, shoot length, total plant weight, and weight/plant all the four parameters show the same pattern and are apparently measuring seedling vigor. Therefore, measuring shoot weight/unit area would be adequate.
6. Stand establishment should be determined by counting number of plants/unit area at early stages and number of stems/unit area at older stages of growth for several times.

LITERATURE CITED

1. Barnes, D. 1971. Establishing alfalfa stands. California alfalfa production symposium. Dec. 7-8, 1971. California Agric. Ext. Ser. Freseno, Ca. p. 14.

2. Bates, R. P. 1979. Selecting, growing, and utilizing legumes. Noble Foundation. Ardmore, Ok. Bull. 38.

3. Buxton, . R., and W. F. Wedin. 1970. Establishment of perennial forages. 1 - subsequent yields. Agron. J. 62:93-97.

4. Dancik, J. 1980. The effect of two sowing dates and several sowing rates of lucerne without a companion crop on yield in the establishment year. Herb. Abstracts 50:75.

5. Dancik, J. 1980. Effect of sowing rate, date and method on lucerne yield. Herb. Abstracts 50:23.

6. Dennis, R. E., E. S. Heathman, K. C. Hamilton, M. A. Massengale, M. H. Schonhorst, and R. K. Thompson. 1977. Growing alfalfa in Arizona. Arizona Coop. Ext. Ser. Bull. A16.

7. Evelyn, S. H., and M. S. Ahmed. 1970. 1964-65 Annual report of the Gezira Research Station and substation. Herb. Abstracts 40:99.

8. Fribourg, H. A., and H. S. Strand. 1973. Influence of seeding dates and methods on establishment of small-seeded legumes. Agron. J. 65:804-807.

9. Goplen, B. P., H. Baenziger, L. D. Bailey, A. T. H. Grass, M. R. Hanna, R. Michaud, K. W. Richards, and J. Waddington. 1980. Growing and managing alfalfa in Canada. Information Services, Agriculture Canada Ottawa. K1A0C7, Canada Pub. 1705.

10. Grandfield, C. O. 1951. Alfalfa in Kansas. Kansas Agric Exp. Stn. Bull. 341.

11. Hansen, L. H., and C. R. Krueger. 1973. Effect of establishment method, variety, and seeding rate on the production and quality of alfalfa under dryland and irrigation. Agron J. 65:755-759.

12. Jackobs, J. A., and D. A. Miller. 1973. Performance of alfalfa (Medicago sativa L.) blends consisting of long-and short-lived varieties. Agron. J. 65:222-225.

13. Janson, C. G. 1976. The establishment, management and utilization of lucerne. Herb. Abstracts 46:6.

14. Khar'Kov, G., A. Koval, V. Romantev, and G. Ryzhkovskaya. 1975. Dates and methods of sowing perennial legumes. Herb. Abstracts 45:323.

15. Kim, N. I. 1970. Sowing dates for lucerne in Kzyl-orda provinces. Herb. Abstracts 40:24.

16. Kunelues, H. J. 1974. Effect of weed control and N fertilization at establishment on the growth and nodulation of alfalfa. Agron. J. 66:806-809.

17. Kust, C. A. 1968. Herbicides or oat companion crops for alfalfa establishment and forage yields. Agron J. 60:151-154.

18. McWilliam, J. R., R. J. Clements, and P. M. Dowling. 1970. Some factors influencing the germination and early seedling development of pasture plants. Aust. J. Agric Res. 21:19:32.

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

20. Musgrave, D. J. 1978. Effects of time of sowing on the establishment of oversown legumes. Herb. Abstracts 48:31.

21. Musgrave, D. J. 1978. Time of sowing - effects on the establishment of oversown pasture and site factors in relation to a development programme. Herb. Abstracts 48:260.

22. Musgrave, D. J., J. R. Clare, and W. L. Lowther. 1976. The potential for oversowing lucerne on steep land soils in North and Central Otago. Herb. Abstracts 46:351.

23. Musgrave, D. J., and W. L. Lowther. 1976. Effects of sowing date, inoculation level, and pelleting on the establishment of oversown lucerne. Herb. Abstracts 46:434.

24. Offutt, M. S. 1979. Effect of stand density on yield of alfalfa. Arkansas Farm Res. 28:14.

25. Peters, E. J. 1964. Pre-emergence, preplanting and postemergence herbicides for alfalfa and birdsfoot trefoil. Agron. J. 56:415-419.

26. Peters, E. J., and J. F. Stritzke. 1970. Herbicides and nitrogen fertilizer for the establishment of three varieties of spring-sown alfalfa. Agron. J. 62:259-262.

27. Pulli, S. K. 1975. Yields, root development, CHO reserves and in vito dry matter disappearance of spring-seeded alfalfa (Medicago sativa L.) treated with herbicides and harvested in the year of seeding. Herb. Abstracts 45:426.

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

29. Singh, H. S., C. P. Prasad, and B. Bahadur. 1972. Effect of sowing time on the green fodder yield at different stages of growth in alfalfa (Medicago sativa L.). Indian J. of Agric. Res. 6:89-87.

30. Schoner, C., W. Knipe, and F. Autio. 1979. Alfalfa time of planting. North California alfalfa symposium. Dec. 12-13. 1979. Woodland, Ca.

31. Smith, D. 1968. The establishment and management of alfalfa. Res. Div. College of Agriculture and Life Science. Univ. of Wis. Bull. 542, revised ed. 22 p.

32. Smith, D. 1978. Forage Management in the North. 3rd edition. Kendall Hunt Pub. Com., Dubuque, Iowa. p. 15.

33. Taylor, T. H., E. M. Smith, and W. C. Templeton. 1970. Use of minimum tillage and herbicide for establishing legumes in kentucky bluegrass (Poa protensis L.). swards. Agron. J. 62:761-766.

34. Teasar, M. B. 1978. Yield and persistence of alfalfa (Medicago sativa L.) as affected by rate and date of seeding and annual fertilization. Michigan Agric. Exp. Stn. Rept. 353:5-12.

35. Willard, C. J., L. E. Thatcher, and J. C. Cuther. 1934. Alfalfa in Ohio. Ohio Agric. Exp. Stn. Bull. 547.

36. Wynn-Williams, R. B. 1977. Effect of sowing date on lucerne emergence, survival, nodulation, and early growth. Herb. Abstracts 47:416.

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