NO-TILL ESTABLISHMENT OF ALFALFA

By

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CHAPTER I

INTRODUCTION

Alfalfa (*Medicago sativa* L.) is a drought tolerant forage crop that is well adapted to the environmental conditions of Oklahoma. Currently, alfalfa occupies some 160,000 ha in Oklahoma with an average annual forage producation of 6,500 kg/ha. There is potential for increasing this acreage by directly seeding alfalfa into either bermudagrass [*Cynodon dactylon* (L.) Pers.] sod or wheat (*Triticum aestivum* L.) stubble. It has been estimated that there are 1.8 million ha of bermudagrass sod and approximately 3.2 million ha of wheat.

Alfalfa has the highest feeding value of all commonly grown hay crops and produces more protein per ha than any other crop for livestock. Alfalfa also has the ability to fix its own nitrogen, thus eliminating the need for high cost nitrogen fertilizers. Despite these benefits, Oklahoma producers have been reluctant to increase plantings of alfalfa because of the cost of seedbed preparation and the possibilities of seedling failure.

Traditionally, tillage has always been considered an essential component of any successful alfalfa establishment program. However, establishment of alfalfa plants on sandy soil has been a problem with conventional seedbed preparation since soil crusting, drying, and wind damage often results. This, along with increasing energy costs, has resulted in a growing interest in no-till systems. One barrier restricting

the development of no-till alfalfa establishment programs has been the availability of effective herbicides. Another barrier has been the lack of suitable no-till drills. Eight field experiments were initiated in 1981 and 1982 to: 1) evaluate the effectiveness of various herbicides for sod suppression and weed control, 2) examine the feasibility of direct seeding of alfalfa into bermudagrass sod in order to produce a bermudagrass-alfalfa mixture, and 3) determine the possibility of establishing alfalfa without tillage into wheat stubble on sandy soils.

CHAPTER II

LITERATURE REVIEW

No-till systems depend upon herbicides for vegetation control. Weed competition can easily cause seedling failure since the seeds of alfalfa and other small seeded legumes are not very competitive (18, 24, 33). It has been reported that competition of weeds can reduce root, crown, and shoot growth of alfalfa seedlings (15, 34, 35). Competition for soil moisture may be a major reason for seedling failure (36), however, Gist and Mott (15) reported that reduction of alfalfa shoot and root growth was due at least in part to shading by the weeds. Groya (16) demonstrated that when shading of alfalfa seedlings by Kentucky bluegrass (Poa pratensis L.) and smooth bromegrass (Bromus inermis Leyss) was eliminated, high soil moisture levels resulted in increased alfalfa yields. Weeds can also reduce the protein content of alfalfa hay (8).

The competitiveness of small seeded legumes may be dependent on the seeding method. Taylor (36) demonstrated that placement of alfalfa seed into the soil instead of on the soil surface doubled stands and increased plant size. Mueller (27) observed that drilling ladino clover (Trifolium repens L.) versus surface placement resulted in 2.5 to 4.0 times as many seedlings initially established and 1000-2000 kg/ha more forage yield during the first season.

Vegetation Control Before Seeding

There have been many reports concerning the use of herbicides as sod suppressants prior to alfalfa seeding into sod. Most of these reports dealt with the use of paraquat (1, 1-dimehtyl-4, 4-bipyridinium ion) and glyphosate [N-(Phosphonomethyl) glycine] as sod suppressants prior to seeding. No literature was found pertaining to vegetation control for the establishment of alfalfa into small grains. Results with paraquat have been somewhat variable. Faix (11) found paraquat to give excellent suppression of a tall fescue (Festuca arundinacea Schreb.) - orchardgrass (Dactylis glomerata L.) sod. Coates (6) also reported a 14 to 18% increase in alfalfa forage yield when paraquat was used to suppress a bromegrass-quackgrass (Agraopyron repens L.) sod. Peters and Zaprzalka (30) however, reported that control of an orchardgrass-quackgrass sod using paraquat was relatively poor. Welty (44) also observed that paraquat was ineffective for suppression of high density sods.

Results of sod suppression by glyphosate have been more consistent. Tesar (37) reported glyphosate to be as effective in suppression of a quackgrass sod as the accepted plow-till procedure. Campbell (5) also reported excellent suppression of a predominately grass sod with glyphosate. Faix (11) reported that glyphosate provided excellent suppression of a tall fescue-orchardgrass sod. Anderson and Delaney (1) also reported glyphosate to provide excellent sod suppression resulting in successful legume establishment into intermountain hay meadows.

Factors other than sod control may be limiting successful establishment of small seeded legumes since there are many instances where although glyphosate has provided adequate sod control, stand establishment has

been inadequate (44). Researchers have investigated the influence of herbicides on the germination of various forage species. Germination of alfalfa and red clover, (Trifolium pratense L.) was not affected when 1.10 kg/ha of paraquat was applied directly to the seeds but germination of Kentucky bluegrass and perennial ryegrass (Lolium perenne L.) was severely reduced (2). A protecting layer of soil approximately 0.64 cm thick was effective in protecting the seeds from the effect of paraquat. Klingman (22) reported that paraquat sprayed directly onto the seeds on the soil surface prevented germination of Kentucky bluegrass, tall fescue and red fescue (Festuca rubra L.) whereas glyphosate did not. Glyphosate sprayed at 4 kg/ha on ryegrass (Lolium multiflorum Lam.) and at 2 kg/ha on red clover (Trifolium pratense L.), with or without 5 mm of soil cover reduced germination of both species (35). However, germination of two alfalfa cultivars grown in petri dishes was not significantly reduced by a 10^{-5} M concentration of glyphosate but growth of shoot length of both cultivars was reduced (26). The effect of thatch, which contained residues of paraquat and glyphosate, on establishment of perennial ryegrass has also been investigated (20). Kentucky bluegrass thatch containing paraquat inhibited perennial ryegrass establishment, but glyphosate treated thatch did not.

The possiblilty of soil activity of paraquat and glyphosate has been investigated. Phytotoxic residues were recorded on peat soils sprayed with 1 - 2 kg/ha of paraquat (41). Watkin (42) observed that the residual activity of paraquat (after the minimum phytotoxic dose was reached) on a sandy soil increased almost linearily from the lowest to the highest dose applied. Contrary to these reports, other researchers (4, 43) have reported paraquat and diquat to adsorb approximately the

cation exchange capacity of Na-montmorillonite and Na-kaolinite. Hance (17) proposed that the low phytotoxicity of soil applied glyphosate was due to a combination of moderate absorption and the low intrinsic activity of the compound when made available to the root system.

A delay in planting may be necessary for maximum establishment of alfalfa after sod control. Moshier and Penner (26) recommended a 3 day delay in planting after spraying glyphosate. Campbell (5) from Australia concluded that a time period of 10 days before seeding was needed for grasses and 20 days for alfalfa. Mueller-Warrant and Koch (28) reported significantly better stands of alfalfa with a 19 day waiting period compared to only a 5 day interval after spraying with glyphosate. Faix (12) concluded that a glyphosate treatment applied 1 month in advance of seeding resulted in an increase in establishment of alfalfa. No information was found concerning what effect a delay in planting after paraquat applications would have on alfalfa establishment. This enhanced establishment of alfalfa with delayed planting may be due to a decrease in the level of phytotoxic substances released from decaying vegetation. Toai and Linscott (38) demonstrated that development and growth of alfalfa seedlings was inhibited by toxins released from dried quackgrass rhizomes and leaves. Also a Missouri researcher (Luu, Kien Truong. 1979, unpublished data) has found that tall fescue releases allelopathic substances that inhibit germination of small seeded legumes.

Vegetation and Insect Control After Seeding

Numerous reports (7, 18, 21, 23, 24, 25, 31, 34, 40) substantiated that increased alfalfa stands and yields resulted when weeds were controlled during the seeding year. Dawson (9) demonstrated that EPTC

(S-ethyl dipropylthiocarbamate) can be applied directly in the row with alfalfa seed to control grass weeds selectively in a band about the crop row. It was further demonstrated that such control can be achieved by mixing alfalfa seed with EPTC-treated clay granules of the size of alfalfa seed and seeding the mixture with tractor-mounted conventional seeders. Nichols and Peters (29) reported that although fall applied pronamide [3, 5-dichloro (N-1, 1-dimethyl-2-propynly) benzamide] treatments reduced perennial grasses, there was a subsequent release of perennial broadleaf weeds which competed with the seeded legumes. Literature dealing with the use of 2, 4-DB [4-(2, 4-dichlorophenoxy) butyric acid] to control broad-leaved weeds in seedling alfalfa has been previously reviewed (32). Pendimenthalin [N-(1-ethylopropyl)-3, 4-dimethyl-2, 6-dinitrobenzenamine] applied preemergence in no-till sod seeding has been more effective for control of grassy weeds than other dinitroanaline herbicides but it reduces the size and number of alfalfa seedlings (14). Application of both pendimethalin and methazole [2-(3, 4-dichlorophenyl) - methyl-1, 2, 4-oxadiazolidine-3, 5-dione] in advance of seeding the alfalfa may improve the safety to alfalfa while maintaining sufficient residual activity to control germinating weeds (14).

Insects can be a major reason for the poor performance of no-till alfalfa seedlings (10). Vough (39) demonstrated that alfalfa plant populations and seedling weight were markedly increased when carbofuran (2, 3-dihydro-2, 2-dimenthyl-7-benzofuranol methylcarbamate) was placed in the row with the seed. Also, other reports (14, 30, 39) have observed carbofuran treatment not only increased the number of alfalfa plants, but also caused a significant increase of alfalfa forage production. Faix (13) also noted increased alfalfa establishment with carbofuran, however, alfalfa yields the following year were not improved.

CHAPTER III

MATERIALS AND METHODS

Eight field experiments were initiated in 1981 and 1982 to determine the effectiveness of various herbicides for vegetation control prior to no-till seeding of alfalfa. Three of these experiments were established in bermudagrass (var. Midland) sod and will be referred to as BG-I, BG-II, and BG-III. The other five experiments were seeded into wheat stubble and will be referred to as WS-I, WS-II, WS-III, WS-IV, and WS-V. Alfalfa variety WL-318 (3) was seeded at a rate of 18 kg/ha for all three bermudagrass experiments and WS-I. Alfalfa variety WL-318 was seeded at a rate of 11 kg/ha for the remaining experiments. Details of experimental areas and treatment rates and dates for all experiments are listed in Table 1. Rainfall data for the experiments are listed in Table 2.

Bermudagrass Experiments

Experiment BG-I was located on the Agronomy Research Station at Perkins, OK, and Experiments BG-II and BG-III were located 4 miles northeast of Perry, OK. Both studies at Perry were conducted on a Port silt loam soil while the bermudagrass study at Perkins was on a Zaneis loam soil (Table 1).

A randomized complete block statistical design with four replications was used for all three experiments. The plot size for all studies was 8.2 x 12.2 m. Applications of carbofuran (1.10 kg/ha) and paraquat

Table 1. Soil characteristics, soil fertility, and treatment information for eight field experiments.

Experiments	Soil Series	Soil Texture	Soil Classification	pH	ECCE Lime Applied	Plot Size	Alfalfa Seeding Rate	Treatment Date	Carrier Volume
					(kg/ha)	(m^2)	(kg/ha)		(l/ha)
Bermudagrass Experiments[a]									
BG-I (Perkins)	Zaneis	loam	Udic Argiustolls	5.9	0	100	18	Sept. 8, 1981	234
BG-II (Perry)	Port	silt loam	Cumulic Haplustolls	6.8	4,480	100	18	Sept. 10, 1981	234
BG-III (Perry)	Port	silt loam	Cumulic Haplustolls	6.8	4,480	100	18	Sept. 10, 1981	234
Wheat Stubble Experiments[b]									
WS-I (Mangum)	Meno	fine sandy loam	Aquic Arenic Haplustalfs	6.2	0	100	18	Aug. 20, 1982	234
WS-II (Mangum)	Meno	fine sandy loam	Aquic Arenic Haplustalfs	5.3	1,568	100	11	Sept. 4, 1982	234
WS-III (Perkins)	Dougherty	fine sandy loam	Arenic Haplustalfs	5.4	1,568	34	11	Sept. 1, 1982	187
WS-IV (Mangum)	Meno	fine sandy loam	Aquic Arenic Haplustalfs	5.6	1,568	30	11		
Pre-harvest								May 19, 1982	187
Post-harvest								July 8, 1982	187
WS-V (Perkins)	Dougherty	fine sandy loam	Arenic Haplustalfs	5.4	1,568	30	11		
Pre-harvest								May 7, 1982	187
Post-harvest								June 30, 1982	187

[a] Pronamide treatments were applied to BG-II and BG-III on February 23, 1982, to control little barley.

[b] Oryzalin was applied prior to wheat harvest for WS-I and WS-II on April 7, 1981, and May 19, 1982, respectively; oryzalin and paraquat were sprayed after wheat harvest on July 7, 1982, for WS-III; pronamide was applied on Oct. 31, 1982, on WS-II to control volunteer wheat. Severe grasshopper infestation resulted in reseeding of WS-III and WS-V on Oct. 14, 1982 and then the entire experiments including borders were sprayed with carbofuran for grasshopper control.

Table 2. Rainfall data from three locations in Oklahoma.

Month	Mangum			Perkins			Perry	
	1981	1982	1983	1981	1982	1983	1981	1982
	(cm)							
January	0.43	3.10	2.67	0.13	6.22	1.78	0.10	3.78
February	1.37	0.86	5.36	2.59	4.42	9.88	2.57	4.47
March	6.65	4.98	6.48	4.22	3.48	8.61	6.96	4.01
April	9.75	1.30		2.67	5.99		1.88	5.69
May	9.91	19.46		17.58	37.06		15.98	26.34
June	13.03	27.79		11.48	13.41		5.49	9.40
July	4.67	5.94		12.42	9.42		13.79	3.76
August	7.52	0.28		12.85	0.84		6.65	1.88
September	1.32	6.58		4.90	2.24		7.75	2.39
October	8.97	0.51		9.88	2.31		9.04	1.42
November	4.75	5.18		10.26	7.67		7.57	7.04
December	0.53	0.00		0.48	9.27		0.36	5.13
TOTAL	68.90	75.98		89.46	102.33		78.14	75.31

(0.55 kg/ha) both alone and in combination at the time of seeding were evaluated in these experiments. Pronamide (1.10 kg/ha) was applied to BG-II and BG-III to control little barley (Hordeum jubatum L.). The effect of seeding method (drilled vs. broadcast) was also evaluated.

A Melroe 701 no-till drill with 16 cm row spacing was used for the drilled alfalfa and a Cyclone whirlybird seeder was used for seeding the broadcast plots. The bermudagrass was harvested for hay just preceding the initiation of the studies and sod was apprximately 5 cm tall at the time of seeding. All pesticides were applied with a tractor-mounted sprayer calibrated to deliver 234 l/ha (Table 1). All experimental data from BG-I was analyzed using orthogonal comparisons. Experimental data of drill seeded plots from BG-II and BG-III were analyzed as a 2 x 4 factorial and broadcast seeded plots were compared to drilled plots using orthogonal comparisons.

Experiment BG-I

Treatments were applied and alfalfa was seeded on September 8, 1981. A soil test reported the study area to be deficient of 2688 kilograms ECCE lime per hectare and 35 kilograms P_2O_5 per hectare. Rainfall was adequate for emergence since more than 20 cm of rainfall occurred on this dryland site during the 2 month period after seeding. Alfalfa plant counts were taken randomly from each plot on October 6, and December 12, 1981, by using four-(15 x 91 cm) quadrats on broadcast seeded plots and by four-(1 meter) strips on drilled plots. Top growth of 25 plants were harvested on December 12, 1981, to determine alfalfa vigor. On February 15, 1982, an attempt to overcome the phosphate deficiency was made by soil injecting 198 kg/ha of 10-34-0 fertilizer.

A cool season weed problem never resulted so the post weed control treatment of pronamide was not applied. No harvest data was taken at this site.

Experiment BG-II

A soil test indicated 132 kg/ha of P, 405 kg/ha of K, and 4 kg/ha of NO_3-N at this site. The soil pH was 6.8 and 4,480 kilograms ECCE lime per hectare was applied on August 18, 1981 to ensure a favorable pH for alfalfa seedlings. Pesticide treatments were applied and alfalfa was seeded on September 10, 1981 (Table 1). Two days after planting, 5.4 cm of rain fell on this dryland site.

Alfalfa plant populations for BG-II was determined on October 1, and December 8, 1981 using the same procedure as described for BG-I. Also on December 8, 1981 alfalfa vigor in the various plots was determined by sampling the topgrowth from 25 plants. Pronamide treatments were applied with a compressed air bicycle sprayer on February 23, 1982 to control little barley. Malathion [O,O-dimethyl-S-1, 2-di (ethoxy-carbamyl) ethylphosphoro dithioate] was aerially sprayed over the entire experiment at a rate of 1.4 kg/ha on March 28, and April 7, 1982 to control alfalfa blue aphid (Acyrthosiphon kondoi Shinji) and alfalfa weevil (Hypera postica Gyllenhal). Yield estimates were taken for the first and third cutting in early May and late July respectively. Estimates were made by clipping the forage from three-(1.0 x 0.5 cm) quadrats randomly selected from each plot. Alfalfa was in the pre-bud stage at the time of both harvests. The samples were then dried and weighed to determine dry matter production.

Experiment BG-III

Experiment BG-III was located in the same field as BG-II, however, BG-III was located under an overhead irrigation system which provided supplemental watering. Experiment BG-III was irrigated as needed to avoid moisture stress to alfalfa seedlings. Experiment BG-III was seeded and pesticide treatments applied on September 10, 1981 (Table 1). Soil fertility levels and liming procedures were the same as BG-II.

Alfalfa plant populations for BG-III was determined on October 1, and December 8, 1981 using the same procedure described for BG-I. Also on December 8, 1981 alfalfa vigor in the various plots was determined by sampling the topgrowth from 25 plants. Pronamide and malathion treatments were applied using the same procedures described for BG-II. Yield data was also taken as described for BG-II.

Wheat Stubble Experiments

Experiments WS-I, WS-II, and WS-IV were located on the Agronomy Research Station at Mangum, OK and Experiments WS-III and WS-V were located on the Agronomy Research Station at Perkins, OK. The three experiments at Mangum were conducted on a Meno fine sandy loam and the two experiments at Perkins were conducted on a Dougherty fine sandy loam (Table 1).

A randomized complete block statistical design with four replications was used in all five experiments. See Table 1 for plot sizes of individual experiements. Two different strategies were utilized for the wheat stubble experiments. In Experiments WS-I, WS-II, and WS-III, oryzalin (3,5-dinitro-N^4-N^4-dipropylsulfanilamide) was used for summer weed control followed by paraquat and carbofuran treatments both alone

and in combination at the time of seeding.

In Experiments WS-IV and WS-V, various herbicides were evaluated for summer weed control. Oryzalin and pendimethalin were compared alone as pre-harvest treatments and in combinations with paraquat and glyphosate as post-harvest applications. Additional post-harvest treatments included paraquat alone, glyphosate alone, mixtures of cyanazine [2-[[4-chloro-6-(ethylamino)-s-triazin-2-yl] amino]-2-methylpropionitrile], terbutryn [2-(tert-butylamino)-4-(ethylamino)-6-(methylthio)-s-triazine], and alachlor [2-chloro-2', 6'diethyl-N-(methoxymethyl) acetanilide] as mixtures with glyphosate and a cultivated check.

A Melroe 701 no-till drill with 16 cm row spacing was used for the drilled alfalfa in WS-I. The other wheat stubble experiments were seeded using a Tye no-till drill with 25 cm row spacing. A Cyclone whirlybird seeder was used for seeding the broadcast plots. Wheat was harvested for grain for Experiments WS-I, WS-II, and WS-IV. Wheat was grazed and mowed for Experiments WS-III and WS-V. The height of the wheat stubble in all experiments at the time of alfalfa seeding was approximately 15 cm. Pesticides were applied with a tractor-mounted sprayer calibrated to deliver 234 l/ha for Experiments WS-I and WS-II (Table 1). All other pesticides were applied using a hand-held CO_2 sprayer calibrated to deliver 187 l/ha. All experiments except WS-I were surface fertilized and limed according to standard soil test recommendations. The recommended liming (2,688 kilograms ECCE lime per hectare) was never applied on Experiment WS-I. All experimental data was subjected to statistical analysis and F tests at the 5% level of significance were used to compare treatment effects. When the F-tests were significant, the least significant differences at the 5% level of

significance were used to compare treatment effects. Treatment means of WS-II were analyzed using orthogonal comparisons.

Experiment WS-I

A pre-harvest oryzalin treatment (1.10 kg/ha) was applied on April 7, 1981. Pesticide treatments were applied and alfalfa was seeded on August 20, 1981. The entire area was infested with a heavy stand of leaf flower (Phyllanthus abnormis Baillon) at the time of seeding. Alfalfa plant counts were taken randomly on September 22, and December 3, 1981, from each plot by using four-(15 x 91 cm) quadrats in broadcast seeded plots and by four-(1 meter) strips in drilled plots. Topgrowth of 25 plants were harvested on December 3, 1981 to determine alfalfa vigor. Carbofuran (0.55 kg/ha) was then sprayed across the entire area on March 23, 1982 to control alfalfa weevil. Forage yield was estimated by clipping the forage from two-(1.0 x 0.5 m) quadrats randomly selected from each plot on May 20, 1982.

Experiment WS-II

A pre-harvest oryzalin (1.10 kg/ha) treatment was applied on May 19, 1982. Pesticide treatments were sprayed and alfalfa was seeded on September 4, 1982. The experimental area of WS-II at the time of seeding was uniformly infested with volunteer wheat. Plant counts for WS-II were taken on October 31, 1982 and March 9 1983 using the same procedure described for WS-I. Pronamide (1.10 kg/ha) was applied on October 31, 1982 to control the severe infestation of volunteer wheat. Forage yield was taken on May 17, 1983 as described for WS-I.

Experiment WS-III

A mixture of oryzalin (1.10 kg/ha) and paraquat (0.55 kg/ha) was sprayed after wheat harvest on July 7, 1982. Pesticides were applied and alfalfa was seeded on September 1, 1982. A large population of grasshoppers (Melanoplus spp.) existed in an adjacent fenceline and as a result the experiment had to be reseeded on October 14, 1982 after the grasshoppers were controlled with carbofuran (1.10 kg/ha). A dense canopy of dead crabgrass (Digitaria sp.) was present across the entire area at the time of the second planting. Alfalfa plant populations were determined on November 8, December 6, 1982 and March 31, 1983 using the procedure described for WS-I. Forage yields were estimated on May 16, 1983 using the methods discussed for WS-I.

Experiment WS-IV

Pre-harvest treatments were applied on May 19, 1982. Post-harvest treatments were applied on July 8, 1982. The entire area was infested with crabgrass and volunteer wheat at the July 8 date. Alfalfa was seeded on September 4, 1982. Plant counts were then taken on October 31, 1981 and March 9, 1983 by counting the number of alfalfa plants from three-(1 meter) strips randomly selected from each plot. Visual estimates of summer weed control were taken September 2, 1982. No alfalfa yields were taken from this experiment since results were confounded due to the severe infestation of volunteer wheat.

Experiment WS-V

Pre-harvest treatments were applied on May 7, 1982. Post-harvest treatments were applied on June 30, 1982. Crabgrass was the predominant

weed at this location. Soil moisture was determined gravimetrically on August 24, 1982 to a depth of 15 cm for each treatment. Alfalfa was planted on September 1, 1982; however, due to a high population of grasshoppers, the area was replanted on October 14, 1982 and the entire area sprayed with 1.10 kg/ha of carbofuran. Alfalfa plant densities were determined on November 8, December 6, 1982 and March 31, 1983 using the procedure described for WS-IV. Visual estimates for summer weed control were then taken on August 23, 1982. Alfalfa yield was determined on May 16, 1983 by clipping the forage from two-(1.0x0.5 m) quadrats randomly selected from each plot.

CHAPTER IV

RESULTS AND DISCUSSION

Bermudagrass Experiments

Experiment BG-I

None of the treatments had a significant effect on plant stand or plant weight at the 5% level when comparing all treatments but orthogonal comparisons of some of the factors indicates that there may be some real differences (Table 3). At the October count there was a trend of having more plants in drilled and pesticide treated plots. However, by December 12, 1981 results were different and there were significantly more plants in broadcast seeded plots (361 plant/m^2) than drill seeded plots (251 plants/m^2). The earlier emergence of plants in the drilled plots is probably the major reason for the larger plants in the drilled plots on December 12, 1981. However, plants were very small even in drill seeded plots (0.65 g/25 plants) despite the fact that over 20 cm of precipitation (Table 2) had fallen during the 2 month period after seeding. Injecting 198 kg/ha of 10-34-0 fertilizer on February 15, 1982 resulted in no beneficial effect on alfalfa growth. Lack of seedling vigor may be due excess soil acidity since the recommended liming (2,688 kilograms ECCE lime per hectare) was never applied. Alfalfa plants were not competitive enough to compete with the bermudagrass when it started growing in April, and as a result, no alfalfa plants could be found in the plots by harvest time in early May.

Table 3. Effect of pesticides and seeding method on alfalfa populations and vigor on a dryland site - Experiment BG-I.

Treatment					
			Plant counts		Plant weight[c]
Pesticide[a]	Seeding[b] Method	Rate	Oct. 6, 1981	Dec. 12, 1982	Dec. 12, 1981
		(kg/ha)	(Plants/m²)		(gms/25 plants)
Carbofuran	Drill	1.10	172	253	---
Paraquat	Drill	0.55	195	252	---
Carbofuran + paraquat	Drill	1.10 + 0.55	202	266	0.7
Carbofuran + paraquat	Broadcast	1.10 + 0.55	138	313	0.4
Untreated control	Drill	0.00	128	236	0.6
Untreated control	Broadcast	0.00	119	408	0.3
LSD (0.05)			NS	NS	NS
Orthogonal comparisons					
Drill vs Broadcast			165 vs 129	251 vs 361	0.65 vs 0.35
(Significance level)			(.14)	(.02)	(.02)
Pesticide vs No Pesticide			170 vs 124	290 vs 322	0.55 vs 0.45
(Significance level)			(.07)	(>.25)	(.21)
Drill vs Broadcast x Pesticide vs No Pesticide			161 x 133	337 x 275	0.50 x 0.50
(Significance level)			(.25)	(.19)	(>.25)
Carbofuran vs Paraquat			172 vs 195	253 vs 252	----
(Significance level)			(>.25)	(>.25)	

[a]All pesticides applied just before planting. Surfactant X-77 was added to all paraquat treatments at a concentration of 473 ml per 379 L tank mix.
[b]Alfalfa was seeded on September 8, 1981 at a rate of 18 kg/ha.
[c]Plants harvested at ground level.

Experiment BG-II

The most significant result in this experiment was the significant increase in early establishment of alfalfa attributed to vegetation control with paraquat (Table 4). There were only 56 plants/m^2 in the untreated drill plots and this compared to 139 plants/m^2 when vegetation was controlled at seeding with paraquat. However, there were no significant differences in plant weights on December 8, 1981 among any of the treatments.

Table 4. Effect of preplant pesticides and seeding method on alfalfa populations and vigor on a fertile dryland site - Experiment BG-II.

Treatment					
	Seeding[b]		Plant counts		Plant weight[c]
Pesticide[a]	Method	Rate	Oct. 1, 1981	Dec. 8, 1981	Dec. 8, 1981
		(kg/ha)	(plants/m^2)		(gms/25 plants)
Carbofuran	Drill	1.10	55	113	---
Paraquat	Drill	0.55	139	194	---
Carbofuran + paraquat	Drill	1.10 + 0.55	128	176	2.6
Carbofuran + paraquat	Broadcast	1.10 + 0.55	156	159	2.2
Untreated control	Drill	0.00	56	121	1.9
Untreated control	Broadcast	0.00	53	114	1.7
LSD (0.05)			54	NS	NS
Orthogonal comparisons					
Drill vs Broadcast			92 vs 105	149 vs 137	2.25 vs 1.95
(Significance level)			(> .25)	(> .25)	(> .25)
Pesticide vs No Pesticide			142 vs 55	168 vs 118	2.40 vs 1.80
(Significance level)			(< .005)	(.06)	(.22)
Drill vs Broadcast x Pesticide vs No Pesticide			91 vs 106	145 vs 140	2.15 vs 2.05
(Significance level)			(> .25)	(> .25)	(> .25)
Carbofuran vs Paraquat			55 vs 139	113 vs 194	---
(Significance level)			(< .005)	(.02)	

[a]All pesticides applied just before planting; X-77 surfactant was added to all paraquat treatments at a concentration of 473 ml per 379 L tank mix.
[b]Alfalfa was seeded on September 10, 1981 at a rate of 18 kg/ha.
[c]Plants harvested at ground level.

A factorial comparison of main effects indicated that paraquat and pronamide treatments had a significant effect on forage production at first harvest (Table 5). There were no interactions between preplant pesticide treatments and the postemergence pronamide treatment, consequently, only the means of the main effects are listed in Table 5. Alfalfa production at the May harvest was greatest in those plots treated with paraquat (677 kg/ha). The post emergence application of pronamide also significantly reduced grass production. Control of grasses by pronamide treatments also resulted in decreased total production. However, alfalfa forage production at the July harvest was significantly increased in plots treated with pronamide (875 kg/ha versus 663 kg/ha in plots not treated). Total production was also greater at July harvest in those plots treated with pronamide. Results indicated that the two seeding methods (drilled vs. broadcast) were comparable in this experiment.

Experiment BG-III

The most significant effect in this experiment was the large increase in plants in the drilled plots at the October count (Table 6). Alfalfa plant populations were also higher on October 1, 1981 in plots treated with carbofuran + paraquat (232 plants/m^2) than those not treated (154 plants/m^2). However, there were no significant differences in plant counts due to any of the treatments by the December 8, 1981 sampling date. Plant vigor was also determined on December 8, 1981 and there were no significant differences due to any of the treatments. Lack of significant differences among treatments must be attributed to the supplemental watering since differences did exist in the adjacent dryland experiment. Insect problems never developed during the establishment period, thus carbofuran treatments were not necessary.

Table 5. Effect of preplant and postemergence pesticides and seeding method on alfalfa and grass yields at a fertile dryland site - Experiment BG-II.

Treatment			Forage Yield[c]					
Pesticide[a]	Seeding Method[b]	Rate	ALF	GRS[d]	TOT	ALF	BG	TOT
			May 7, 1982			July 23, 1982		
Means of treatments		(kg/ha)	(kg/ha)					
Carbofuran	Drill	1.10	275	652	927	685	253	938
Carbofuran; pronamide	Drill	1.10; 1.10	290	130	420	990	280	1270
Paraquat	Drill	0.55	580	452	1032	658	173	831
Paraquat; pronamide	Drill	0.55; 1.10	774	180	954	838	318	1156
Carbofuran; paraquat	Drill	1.10 + 0.55	645	444	1089	650	223	873
Carbofuran + paraquat	Broadcast	1.10 + 0.55	500	465	965	688	328	1016
(Carbofuran + paraquat); pronamide	Drill	(1.10 + 0.55); 1.10	460	233	693	728	423	1151
Pronamide	Drill	1.10	465	195	660	945	288	1233
Untreated control	Drill	0.00	190	680	870	660	345	1005
Untreated control	Broadcast	0.00	232	469	701	733	393	1126
LSD (0.05)			NS	NS	310	219	NS	242
Means of pesticide (preplant) main effects								
Carbofuran	Drill		283	391	674	838	267	1104
Paraquat	Drill		677	316	993	748	246	994
Carbofuran + paraquat	Drill		553	339	891	689	323	1012
Untreated control	Drill		328	438	765	803	317	1119
LSD (0.05)			272	NS	219	NS	NS	NS
Means of pronamide (postemergence) main effects								
No Pronamide	Drill		423	557	980	663	249	912
Pronamide	Drill		497	185	682	875	327	1203
LSD (0.05)			NS	211	155	109	NS	121
Orthogonal comparisons								
Drill vs Broadcast (Significance level)			418 vs 366 (> .25)	562 vs 467 (> .25)	980 vs 833 (.17)	655 vs 711 (> .25)	384 vs 361 (> .25)	939 vs 1071 (> .25)

[a]Preplant pesticides were applied just before seeding; pronamide was applied postemergence on Feb. 23, 1982; X-77 surfactant was added to all paraquat treatments at a concentration of 473 ml per 379 L tank mix.

[b]Alfalfa was seeded on September 10, 1981 at a rate of 18 kg/ha; Drill seeded plots were analyzes as a 2x4 factorial; broadcast seeded plots were compared using orthogonal comparisons.

[c]ALF=alfalfa; GRS=grass; BG=bermudagrass; TOT=total

[d]Consisted of little barley and bermudagrass.

Table 6. Effect of preplant pesticides and seeding method on alfalfa populations and vigor on a fertile irrigated site - Experiment BG-III.

Treatment			Plant counts		Plant weight[c]
Pesticide[a]	Seeding[b] Method	Rate	Oct. 1, 1981	Dec. 8, 1981	Dec. 8, 1981
		(kg/ha)	(Plants/m²)		(gms/25 plants)
Carbofuran	Drill	1.10	261	256	4.4
Paraquat	Drill	0.55	284	205	4.6
Carbofuran + paraquat	Drill	1.10 + 0.55	267	248	4.0
Carbofuran + paraquat	Broadcast	1.10 + 0.55	197	289	3.6
Untreated control	Drill	0.00	211	208	4.4
Untreated control	Broadcast	0.00	97	303	3.9
LSD (0.05)			88	NS	NS
Orthogonal comparisons					
Drill vs Broadcast			239 vs 147	228 vs 296	4.20 vs 3.75
(Significance level)			(.008)	(0.67)	(.22)
Pesticide vs No Pesticide			232 vs 154	269 vs 256	3.80 vs 4.15
(Significance level)			(.021)	(>.25)	(>.25)
Drill vs Broadcast x Pesticide vs No Pesticide			182 vs 204	276 vs 249	3.95 vs 3.95
(Significance level)			(>.25)	(>.25)	(>.25)
Cabofuran vs Paraquat			261 vs 284	256 vs 205	4.4 vs 4.6
(Significance level)			(>.25)	(>.25)	(>.25)

[a]All pesticides applied just before planting; X-77 surfactant was added to all paraquat treatments at a concentration of 473 ml per 379 L tank mix.
[b]Alfalfa was seeded on September 10, 1981 at a rate of 18 kg/ha.
[c]Plants harvested at ground level.

There were no significant differences in forage yields among treatments at either harvest (Table 7). There was no interaction between preplant pesticide treatments and the postemergence pronamide treatment, consequently, only the means of the main effects are listed in Table 7. Pronamide treatments had a tendency to lower grass production at first harvest, but the decreases were not significant. Maximum alfalfa yield for May harvest was 1,828 kg/ha for carbofuran treatment and for July harvest was 1,448 kg/ha for the untreated control (drill seeded).

Wheat Stubble Experiments

Experiment WS-I

The best emergence of alfalfa plants by September 22, 1981 (150 plants/m^2) resulted in drilled plots treated with carbofuran and paraquat (Table 8). Control of vegetation at seeding with paraquat was very important. There were 31 plants/m^2 in the plots treated with only carbofuran and this compares to 81 plants/m^2 where only paraquat was used at the time of drilling. The difference was even more striking by the December 3, 1981, sampling. There were still 81 plants/m^2 in the paraquat treated plots and this compared to only 6 plants/m^2 left in the carbofuran treated plots. There was also a significant size difference of alfalfa seedlings in paraquat and nonparaquat treated plots. For example, the weight of 25 plants was greater than 13 g in all paraquat treated plots and only 1.2 g on untreated drill plots. The advantage of paraquat was primarily attributed to the control of leaf flower. The rainfall following seeding was very low (2.6 cm for the 45 days following planting) and the growing leaf flower essentially was too competitive for the seedling alfalfa.

Table 7. Effect of preplant and postemergence pesticides and seeding method on alfalfa and grass yields at a fertile irrigated site - Experiment BG-III.

Treatment			Forage Yield[c]					
Pesticide[a]	Seeding Method[b]	Rate	ALF	GRS[d]	TOT	ALF	BG	TOT
			May 5, 1982			July 22, 1982		
Means of treatments		(kg/ha)	(kg/ha)					
Carbofuran	Drill	1.10	1828	497	2325	1140	323	1463
Carbofuran;pronamide	Drill	1.10; 1.10	1804	148	1952	1070	275	1345
Paraquat	Drill	0.55	1602	192	1794	1403	393	1796
Paraquat; pronamide	Drill	0.55; 1.10	1444	180	1624	1145	285	1430
Carbofuran + paraquat	Drill	1.10 + 0.55	1506	432	1938	1190	360	1550
Carbofuran + paraquat	Broadcast	1.10 + 0.55	1738	172	1910	745	425	1170
(Carbofuran + paraquat); pronamide	Drill	(1.10 + 0.55); 1.10	1586	197	1783	1153	648	1801
Pronamide	Drill	1.10	1476	223	1699	1088	310	1398
Untreated control	Drill	0.00	1511	148	1659	1448	323	1771
Untreated control	Broadcast	0.00	1564	640	2204	1443	273	1716
LSD (0.05)			NS	NS	NS	NS	NS	NS
Means of pesticide (preplant) main effects								
Carbofuran	Drill		1816	323	2139	1105	299	1404
Paraquat	Drill		1523	186	1709	1274	339	1613
Carbofuran + paraquat	Drill		1546	315	1861	1172	504	1676
Untreated control	Drill		1494	186	1679	1268	317	1585
LSD (0.05)			NS	NS	NS	NS	NS	NS
Means of pronamide (postemergence) main effects								
No Pronamide	Drill		1612	317	1929	1295	350	1645
Pronamide	Drill		1578	187	1765	1114	380	1494
LSD (0.05)			NS	NS	NS	NS	NS	NS
Orthogonal comparisons								
Drill vs Broadcast (Significance level)			1509 vs 1651 (>.25)	290 vs 406 (>.25)	1799 vs 2057 (.23)	1319 vs 1094 (.24)	342 vs 349 (>.25)	1661 vs 1443 (.23)

[a]Preplant pesticides were applied just before seeding; pronamide was applied postemergence on Feb. 23, 1982; X-77 surfactant was added to all paraquat treatments at a concentration of 473 ml per 379 L tank mix.

[b]Alfalfa was seeded on September 10, 1981 at a rate of 18 kg/ha; Drill seeded plots were analyzed as a 2x4 factorial; broadcast seeded plots were compared using orthogonal comparisons.

[c]ALF=alfalfa; GRS=grass; BG=bermudagrass; TOT=total.

[d]Consisted of little barley and bermudagrass.

Table 8. Effects of pesticides and seeding method on alfalfa populations, vigor and yield for Experiment WS-I.

Treatment			Plant counts		Plant weight[d]	Forage Yield[e]		
Pesticide[b]	Seeding[c] Method	Rate	Sept. 22, 1981	Dec. 3, 1981	Dec. 3, 1981	ALF	WD[f]	TOT
						May 20, 1982		
		(kg/ha)	(Plants/m²)		(gms/25 plants)	(kg/ha)		
Carbofuran	Drill	1.10	31	6	0.8	135	512	647
Paraquat	Drill	0.55	81	81	13.0	1591	465	2056
Carbofuran + paraquat	Drill	1.10 + 0.55	150	88	14.2	1794	160	1954
Carbofuran + paraquat	Broadcast	1.10 + 0.55	75	50	13.1	1966	273	2239
Untreated control	Drill	0.00	31	13	1.2	188	437	625
Untreated control	Broadcast	0.00	13	0	0.0	254	550	804
LSD (0.05)			38	13	3.0	727	NS	860

[a]Entire area received a 1.10 kg/ha rate of oryzalin prior to wheat harvest on April 7, 1981.
[b]All pesticides were applied just before planting. Surfactant X-77 was added to all paraquat treatments at a concentration of 473 ml per 379 tank mix.
[c]Alfalfa was seeded on August 20, 1981 at a rate of 18 kg/ha.
[d]Plants harvested at ground level.
[e]ALF=alfalfa; WD=weed; TOT=total.
[f]Horseweed (40%), Cutleaf primrose (50%), and volunteer wheat (10%).

First harvest forage yields are also listed in Table 8. Alfalfa production from plots treated with paraquat was significantly better than non-paraquat treated plots. Alfalfa forage production ranged from a high of 1966 kg/ha in broadcast seeded plots treated with carbofuran and paraquat to a low of 135 kg/ha in carbofuran treated plots. Although plant counts were higher in drill seeded plots, there were no significant differences in forage production due to the seeding method.

Experiment WS-II

There were no significant differences (Significance level =.05) in alfalfa plant counts due to treatment on October 31, 1982 (Table 9). Alfalfa plant populations estimated a second time on March 9, 1983 also resulted in no significant differences among treatments. By this time, however, the number of alfalfa seedlings fell an average of 36 plants/m^2. A slight decrease in population could be expected due to competition among alfalfa seedlings, however, a decline of this extreme might be attributed to moisture stress. Only 5.8 cm of precipitation had fallen between September 17, 1982 and January 1, 1983.

There were no significant differences in alfalfa forage production (Table 9) due to treatment. Even the highest yield (228 kg/ha) from plots treated with carbofuran and paraquat drill seeded was very low due to inadequate rainfall during the establishment period.

Experiment WS-III

Plant counts were taken on three dates and the resulting plant populations are given in Table 10. Paraquat treatments significantly increased alfalfa plant counts for drilled plots on all three dates. The

Table 9. Effect of pesticides and seeding method on alfalfa populations and yield - Experiment WS-II.[a]

Treatment			Plant counts		Forage Yield[d]			
Pesticide[b]	Seeding[c] Method	Rate	Oct. 31, 1982	March, 9 1983	ALF	MUS	WHT	TOT
					May 17, 1983			
		(kg/ha)	(Plants/m²)		(kg/ha)			
Carbofuran	Drill	1.10	74	44	219	873	34	1126
Paraquat	Drill	0.55	66	31	72	846	0	918
Carbofuran + paraquat	Drill	1.10 + 0.55	59	41	228	647	0	875
Carbofuran + paraquat	Broadcast	1.10 + 0.55	91	41	141	770	82	993
Untreated control	Drill	0.00	59	33	148	935	0	1083
Untreated control	Broadcast	0.00	83	28	15	612	0	627
LSD (0.05)			NS	NS	NS	NS	NS	NS
Orthogonal comparisons								
Drill vs Broadcast			59 vs 87	37 vs 35	188 vs 78	791 vs 691	0 vs 41	979 vs 810
(Significance level)			(.092)	(.23)	(.15)	(>.25)	(>.25)	(>.25)
Pesticide vs No Pesticide			75 vs 71	41 vs 31	185 vs 82	709 vs 774	41 vs 0	934 vs 855
(Significance level)			(>.25)	(>.25)	(.18)	(>.25)	(>.25)	(>.25)
Drill vs Broadcast x Pesticide vs No Pesticide			71 vs 75	35 vs 37	122 vs 145	630 vs 853	0 vs 41	751 vs 1038
(Significance level)			(>.25)	(>.25)	(>.25)	(.23)	(>.25)	(.11)
Carbofuran vs Paraquat			74 vs 66	44 vs 31	219 vs 72	873 vs 846	34 vs 0	1126 vs 918
(Significance level)			(>.25)	(>.25)	(.18)	(>.25)	(>.25)	(>.25)

[a] Entire area was sprayed before wheat harvest with 1.10 kg/ha of oryzalin on May 19, 1982.
[b] All pesticides were applied just before planting; X-77 surfactant was added to all paraquat treatments at a concentration of 473 ml per 379 L tank mix; Pronamide was applied to all plots at a rate of 1.10 kg/ha on October 31, 1982.
[c] Alfalfa was seeded on September 4, 1982 at a rate of 11 kg/ha.
[d] ALF=alfalfa; MUS=mustard; WHT=wheat; TOT=total.

Table 10. Effects of pesticides and seeding method on alfalfa populations and yield Experiment WS-III.[a]

Treatment			Plant counts			Forage Yield[d]			
Pesticide[b]	Seeding[c] Method	Rate	Nov. 8, 1982	Dec. 6, 1982	March 31, 1983	ALF	WHT	MUS	TOT
						May 16, 1983			
		(kg/ha)	(Plants/m²)			(kg/ha)			
Carbofuran	Drill	1.10	20	20	8	47	108	135	290
Paraquat	Drill	0.55	48	44	28	680	246	255	1181
Carbofuran + paraquat	Drill	1.10 + 0.55	36	28	20	342	194	171	707
Carbofuran + paraquat	Broadcast	1.10 + 0.55	4	4	0	0	97	210	307
Untreated control	Drill	0.00	12	4	0	5	140	88	233
Untreated control	Broadcast	0.00	8	8	4	0	84	249	333
LSD (0.05)			16	16	16	402	NS	NS	NS

[a]Entire area was sprayed with 1.10 and 0.55 kg/ha or oryzalin and paraquat respectively on July 7, 1982, after wheat harvest.

[b]All pesticides were applied just before planting; X-77 surfactant was added to all paraquat treatments at a concentration of 473 ml per 379 L tank mix.

[c]Alfalfa was seeded on September 1, 1981 at a rate of 11 kg/ha, however, due to severe insect pressure the area was replanted on Oct. 14, 1982 and sprayed with 1.10 kg/ha of carbofuran.

[d]ALF=alfalfa; WHT=wheat; MUS=mustard; TOT=total.

reason for poor performance in broadcast seeded plots might be attributed to the thick crabrass cover. Paraquat controlled crabgrass but there was sufficient canopy to prevent broadcast seeded alfalfa from coming in direct contact with the soil surface. Plant counts averaged over the three dates for the carbofuran + paraquat (drill seeded) and the carbofuran + paraquat (broadcast seeded) treatments were 28 and 3 plants/m^2, respectively.

Alfalfa yield ranged from a high of 680 kg/ha in drill seeded plots treated with paraquat to zero production in broadcast seeded plots. Alfalfa yield in the drill seeded untreated control plots was only 5 kg/ha. There were no significant differences among treatments in the forage production of wheat, mustard, and total yield.

Experiment WS-IV

Oryzalin applied pre-harvest and glyphosate alone and in combination with other preemergence herbicides applied post-harvest were the only treatments adequately controlling crabgrass (Table 11). Treatments with paraquat averaged 36% crabgrass control as compared to 91% control for comparable glyphosate treatments. Additions of residual herbicides (cyanazine, terbutryn, and alachlor) to glyphosate were not necessary since crabgrass control with mixtures was not better than glyphosate alone. Plots which received a pre-harvest oryzalin treatment contained significantly more plants on October 31, 1982 than did plots receiving a pendimethalin treatment, 60 versus 12 plants/m^2 respectively. There was also a trend for higher alfalfa populations in plots treated with glyphosate than those treated with paraquat and this attributed to the better crabgrass control. The only significant difference, however,

Table 11. Effects of various herbicides on summer weed control and alfalfa populations for Experiment WS-IV.[a]

Treatments	Rate	Crabgrass Control	Plant counts	
		Sept. 2, 1982	Oct. 31, 1982	March 9, 1983
Pre-harvest[b]	(kg/ha)	(%)	(Plants/m²)	
Oryzalin	1.10	98	60	24
Pendimethalin	1.10	44	12	0
Post-harvest[c]				
Paraquat	0.55	46	8	4
Paraquat + oryzalin	0.55 + 1.10	31	48	8
Paraquat + pendimethalin	0.55 + 1.10	30	24	0
Glyphosate	0.55	84	32	16
Glyphosate + oryzalin	0.55 + 1.10	92	96	28
Glyphosate + pendimethalin	0.55 + 1.10	96	52	4
Glyphosate + cyanazine	0.55 + 2.20	84	36	8
Glyphosate + terbutryn	0.55 + 2.20	89	56	12
Glyphosate + alachlor	0.55 + 2.20	95	40	8
Tillage control	0.00	40	4	0
Untreated control	0.00	0	0	0
LSD(0.05)		23	36	12

[a]Alfalfa seeded on September 4, 1982, at a rate of 11 kg/ha.
[b]Applied before wheat harvest on May 19, 1982.
[c]Applied after wheat harvest on July 8, 1982; X-77 surfactant was added to all paraquat treatments at a concentration of 473 ml per 379 L tank mix.

occurred in plots treated with glyphosate and oryzalin (96 plants/m^2) versus paraquat and oryzalin (48 plants/m^2). Plants counts taken on March 9, 1983 demonstrated the adverse effect drought had on alfalfa establishment (5.8 cm of precipitation between September 17, 1982 and January 1, 1983). Between October 31, 1982 and March 9, 1983 alfalfa populations declined an average of 28 plants/m^2. By March 9, 1983 all treatments (except oryzalin alone and in mixture with glyphosate) had less than 20 plants/m^2. Alfalfa plant population continued to decline and by May 16, 1983 essentially no alfalfa plants could be found in any of the plots.

Experiment WS-V

Visual estimates for summer weed control data are listed in Table 12. Crabgrass control with pre-harvest treatments of oryzalin (97%) and pendimethalin (75%) were not significantly different. Crabgrass control from post-harvest paraquat treatments averaged 38% compared to 90% control for glyphosate treatments. Additions of residual herbicides (cyanazine, terbutryn, and alachlor) to glyphosate were not necessary since crabgrass control with mixtures were no better than glyphosate alone. Both pre-harvest treatments failed to control broadleaf weeds which consisted of blackeyed susan (*Rudbeckia serotina* Nutt.), horseweed [*Conyza canadensis* (L.) Cronq.], and trailing wild bean [*Strophostyles helvola* (L.) E11.]. All post-harvest treatments including tillage resulted in excellent control of these broadleaf weeds.

Alfalfa population densities were determined at 3 dates and are listed in Table 13. There were no significant differences in plant counts between the two pre-harvest treatments. Plant counts when aver-

Table 12. Visual estimates of summer weed control for Experiment WS-V.

Treatments	Rate	Weed Control CG	BES	HW	WB
		Aug. 24, 1982			
	(kg/ha)	(%)			
Pre-harvest[a]					
Oryzalin	1.10	97	0	0	0
Pendimethalin	1.10	75	0	0	0
Post-harvest[b]					
Paraquat	0.55	38	99	99	97
Paraquat + oryzalin	0.55 + 1.10	43	99	99	99
Paraquat + pendimethalin	0.55 + 1.10	55	99	99	99
Glyphosate	0.55	90	96	99	93
Glyphosate + oryzalin	0.55 + 1.10	99	85	98	99
Glyphosate + pendimethalin	0.55 + 1.10	93	93	99	99
Glyphosate + cyanazine	0.55 + 2.20	86	99	99	96
Glyphosate + terbutryn	0.55 + 2.20	93	99	99	98
Glyphosate + alachlor	0.55 + 2.20	98	98	99	99
Tillage control	0.00	90	98	93	95
Untreated control		0	0	0	0
LSD (0.05)		30	28	27	20

[a] Applied before wheat harvest on May 7, 1982.

[b] Applied after wheat harvest on June 30, 1982; X-77 surfactant was added to all paraquat treatments at a concentration of 473 ml per 379 L tank mix.

[c] CG=crabgrass; BES=blackeyedsusan; HW=horseweed; WB=trailing wild bean.

Table 13. Treatment effect on alfalfa population, % soil moisture and yield for Experiment WS-V.[a]

Treatments	Rate	Plant counts			Soil[d] Moisture	Forage Yield[e]			
		Nov. 8, 1982	Dec. 6, 1982	March 31, 1983	Aug. 24, 1982	ALF	WHT	MUS	TOT
						May 16, 1983			
Pre-harvest[b]	(kg/ha)	(Plants/m²)			(g/g)	(kg/ha)			
Oryzalin	1.10	32	28	32	1.8	377	444	284	1105
Pendimethalin	1.10	44	16	24	1.0	251	292	90	633
Post-harvest[c]									
Paraquat	0.55	20	8	12	2.1	124	95	184	403
Paraquat + oryzalin	0.55 + 1.10	44	24	20	2.4	456	174	118	748
Paraquat + pendimethalin	0.55 + 1.10	40	32	28	3.1	662	171	95	928
Glyphosate	0.55	36	24	20	3.7	384	375	81	840
Glyphosate + oryzalin	0.55 + 1.10	68	60	44	5.1	1057	390	533	1980
Glyphosate + pendimethalin	0.55 + 1.10	48	36	32	4.2	1173	587	145	1905
Glyphosate + cyanazine	0.55 + 2.20	40	36	36	4.2	952	397	109	1458
Glyphosate + terbutryn	0.55 + 2.20	60	44	32	5.1	755	1022	387	2164
Glyphosate + alachlor	0.55 + 2.20	48	40	32	5.2	777	670	125	1572
Tillage control	0.00	32	40	32	4.3	501	984	262	1747
Untreated cotrol	0.00	20	20	4	1.0	29	92	152	273
LSD (0.05)		24	24	16	1.9	621	533	NS	926

[a]Alfalfa seeded on September 1, 1982 at a rate of 11 kg/ha, however, due to severe insect pressure the area was replanted on Oct. 14, 1982 and sprayed with 1.10 kg/ha of carbofuran.
[b]Applied before wheat harvest on May 7, 1982.
[c]Applied after wheat harvest on June 30, 1982; X-77 surfactant was added to all paraquat treatments at a concentration of 473 ml per 379 L tank mix.
[d]To a depth of 15 cm.
[e]ALF=alfalfa; WHT=wheat; MUS=mustard; TOT=total.

aged across the three dates were 31 and 28 plants/m^2 for the oryzalin and pendimethalin treatments respectively. There were also no significant differences in soil moisture (Table 13) between the two pre-harvest treatments.

There were no significant differences in alfalfa plant popluations between post-harvest treatments of paraquat and glyphosate alone. However, alfalfa plant counts were significantly higher with glyphosate + oryzalin treatment than with a paraquat + oryzalin treatment at all three dates. Mixtures of glyphosate with terbutryn or alachlor when compared to glyphosate alone resulted in no significant differences in plant counts at the March 31 1983 date. On the same date, plant counts for glyphosate + cyznazine (36 plants/m^2) mixture were significantly higher than the glyphosate (20 plants/m^2) treatment. There was satisfactory alfalfa establishment (32 plants/m^2) in the tillage plots but not in the untreated control which had only 4 plants/m^2. Alfalfa forage production in plots treated only with pre-harvest treatments of oryzalin (377 kg/ha) and pendimenthalin (251 kg/ha) was poor. Alfalfa production from plots treated with post-harvest treatments of paraquat (124 kg/ha) and glyphosate (384 kg/ha) was also not adequate. The highest alfalfa yield of 1173 kg/ha were obtained from plots treated with a mixture of glyphosate and pendimethalin. The untreated control yielded only 29 kg/ha of alfalfa.

CHAPTER V

CONCLUSIONS

Field experiments were conducted to establish alfalfa without tillage into bermudagrass sod and wheat stubble. Several herbicides were evaluated for summer weed control in wheat stubble and paraquat and carbofuran were evaluated at seeding to determine their effect on alfalfa establishment and consequent yields in both bermudagrass sod and wheat stubble.

Direct seeding of alfalfa into bermudagrass appeared to only have limited application. Although it was possible to get emergence and early establishment of alfalfa in all the experiments, resulting survival and growth was very marginal in the two dryland sites. Competition for soil water was the major limiting factor since there was significant production of alfalfa with irrigation. At this irrigated site, however, paraquat and carbofuran treatments applied both alone and in combination at the time of seeding had no significant effect on alfalfa production. Earlier establishment of alfalfa resulted with drilling but final emergence was similar to broadcast seedlings.

Both summer weed control and pest control at seeding were evaluated in the wheat stubble experiments. Oryzalin for summer weed control followed by paraquat and carbofuran treatments at the time of seeding were tested in three of the experiments. Pre-harvest oryzalin treatments demonstrated excellent control of the summer weedy grasses, provided the

herbicide was applied and activated before the weeds emerged. Paraquat treatments at seeding resulted in significant increases in alfalfa establishment and the best yields were usually from paraquat treated plots. Use of carbofuran for insect control had no effect on alfalfa establishment in any of the experiments. Grasshoppers completely destroyed the stand in two experiments and the alfalfa had to be reseeded. In the other experiments no serious insect problems ever developed. Drill and broadcast seeding methods were comparible when weeds were adequately controlled during the summer but drilling had a definite advantage if much vegetation was growing at seeding.

Comparison of herbicides for summer weed control indicated that pre-harvest treatments of oryzalin gave good control of crabgrass. Glyphosate treatments resulted in excellent crabgrass control while paraquat treatments caused only temporary control. Although paraquat was successful in burning back the topgrowth, it failed to kill the roots of the crabgrass plants and regrowth resulted. Consequently, soil moisture contents were higher in plots sprayed with glyphosate thean with paraquat. The highest alfalfa populations were recorded in plots treated with a mixture of glyphosate and oryzalin.

Several important factors need to be considered in no-till seeding of alfalfa. Most important would be vegetation control and control of insect pests. However, in addition, field drainage, soil pH, and soil fertility are very important. This means that field leveling, liming, and fertility programs for no-till seeding into wheat stubble needs to be corrected before the wheat crop is planted (one year ahead of the alfalfa seeding).

LITERATURE CITED

1. Anderson, R.L., and R.H. Delaney, 1979. Interseeding of legume and grass species into intermountain hay meadows. Agron. Abstr. p. 98.

2. Appleby, A.P. and R.G. Brenchley. 1968. Influence of paraquat on seed germination. Weed Sci. 16:484-485.

3. Beard, D.F., and I.I. Kawaguchi. 1977. Registration of WL-311 and WL-318 alfalfa cultivars. Crop Sci. 18:523.

4. Burns, I.G., M.H.B. Hayes and M. Stacey. 1973. Some physiochemical interactions of paraquat with soil organic materials and model compounds. I. Effect of temperature, lime and adsorbate degredation on paraquat adsorption. Weed Res. 13:67-78.

5. Campbell, M.H. 1976. Effect of timing of glyphosate and 2,2-DPA application on establishment of surface-sown pasture species. Australian Journal of Exp. Agricult. and Anim. Husb. 16:491-499.

6. Coates, D.M. D.W. Koch, J.R. Mitchell, and J.B. Holler. 1981. Use of herbicides in minimum tillage to improve alfalfa composition and feeding value. Proc. of the Northeast. Weed Sci. Soc. 35:75.

7. Cope, W.A., T.W. Waldrop, D.S. Chamblee, and W.M. Lewis. 1973. Evaluation of herbicides in the establishment of alfalfa, ladino white clover, and crownvetch. Agron. J. 65:820-824.

8. Cords, H.P. 193. Weeds and alfalfa hay quality. Weed Sci. 21:400-401.

9. Dawson, J.H. 1980. Selective weed control from EPTC applied with seed of alfalfa (Medicago sativa). Weed Sci. 28: 607-611.

10. Dowling, P.M., and D.L. Linscott. 1981. Effect of chemicals on the establishment of direct planted alfalfa. Proc. of the North East Weed Sci. Soc. 35:42-43.

11. Faix, J.J., G.E. McKibben, C.J. Kaiser, and F.W. Slife. 1976. Sod suppressants and pre-emerge herbicides for sod seeded alfalfa. Dixon Springs Agricultural Center. 4:83-84.

12. Faix, J.J., D.W. Graffis, and C.J. Kaiser. 1979. Conventional and zero-till planted alfalfa with varios pesticides. Dixon Springs Agricultural Center. 7:117-123.

13. Faix, J.J., C.J. Kaiser, and D.W. Graffis. 1980. Evaluation of pesticides for improving alfalfa establishment in conventional and no-till sod planting. Dixon Springs Agricultural Center. 8:104-109.

14. Faix, J.J., C.J. Kaiser, and M.E. Farris. 1980. Insect and weed control in no-till alfalfa establishment. Dixon Springs Agricultural Center. 8:34-38.

15. Gist, G.R., and G.O. Mott. 1957. Some effects of light intensity, temperature, and soil moisture on the growth of alfalfa, red clover, and birdsfoot trefoil seedlings. Agron. J. 49:33-36.

16. Groya, F.L. and C.C. Sheaffer. 1980. Effect of moisture and competition on sod-seeded alfalfa. Agron. Abs. p.99.

17. Hance, R.J. 1976. Adsorption of glyphosate by soils. Pestic. Sci. 7:363-366.

18. Hanson, C.H. 1972. Alfalfa Si. and Technol. American Soc. of Agron. Inc., Madison Wis.

19. Harvey, R.G., D.A. Rohweder, and R.S. Fawcett. 1976. Susceptibility of alfalfa cultivars to triazine herbicides. Agron. J. 68:632-634.

20. Hurto, K.A. and A.J. Turgeon. 1979. Effect of thatch on residual activity of nonselective herbicides used in trufgrass renovation. Agron. J. 71:66-71.

21. Kerkin, A.J. and R.A. Peters. 1957. Herbicidal effectiveness of 2,4-DB, MCPB, Nebruon, and other herbicides as measured by weed control and yields of seedling alfalfa and birdsfoot trefoil. Proc. N. East. Weed Contr. Conf. 11:128-138.

22. Klingman, D.L. and J.J. Murray. 1976. Germination of seeds of trufgrasses as affected by glyphosate and paraquat. Weed Sci. 24:191-193.

23. Lee, W.O. 1959. Pre-plant soil-incorporated herbicides for control of annual weeds in the establishment of alfalfa, birdsfoot trefoil, and red clover. West. Weed Contr. Conf. Res. Prog. Rep. 29.

24. McCarty, M.K. and P.F. Sand. 1958. Chemical weed control in seedling alfalfa. I. Control of weedy grasses. Weeds. 6:152-160.

25. McCarty, M.K. and P.F. Sand. 1961. Chemical weed control in seedling alfalfa III. Effects of some herbicides on five varieties. Weeds. 9:15-19.

26. Moshier, L. and D. Penner. 1978. Use of glyphosate in sod seeded alfalfa establishment. Weed Sci. 26:163-166.

27. Mueller, J.P. and D.S. Chamblee. 1980. Late winter-early spring establishment of perennial legumes in a tall fescue sward. Agron. Abs. p. 103.

28. Mueller-Warrant, G.W. and D.W. Koch. 1980. Establishment of alfalfa by conventional and minimum-tillage seeding techniques in a quackgrass-dominant sward. Agron. J. 72:884-889.

29. Nichols, R.L. and R.A. Peters. 1980. Effect of timing and herbicides on the no-tillage establishment of red clover, alfalfa and birdsfoot trefoil. Proc. Northeast. Weed Sci. Soc. 34:91.

30. Peters, R.A. and J. Zaprzalka. 1981. Impace of carbofuran treatment on no-tillage alfalfa establishment. Proc. of Northeast. Weed Sci. Soc. 35:76.

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

32. Sand, Paul F., and McCarty, M.K. 1959. Chemical weed control in seedling alfalfa. II. Control of broad-leaved weeds. Weeds 7:317-323.

33. Santelmann, P.W., E.O. Burt, and C.J. Willard. 1956. The use of herbicides in establishing legume seedlings. Weeds 4:156-163.

34. Schreiber, M.M. 1960. Pre-emergence herbicides on alfalfa and birdsfoot refoil. Weeds 8:291-299.

35. Segura, J., S.W. Bingham, and C.L. Foy. 1978. Phytotoxicity of glyphosate to Italina ryegrass (Lolium multiflorum and red clover (Trifolium pratense). Weed Sci. 26:32-36.

36. Taylor, T.H., E.M. Smith & W.C. Templeton, Jr. 1969. Use of minimum tillage and herbicide for establishing legumes in Kentucky Bluegrass (Poa pratensis L.) swards. Agron. J. 61:761-766.

37. Tesar, M.B. 1977. Establishment of alfalfa on a quackgrass sod in northern Michigan. Res. Report of the Agric. Exp. Stat. of Mich. State Univ. 47:148-156.

38. Toai, T.V. and D.L. Linscott. 1979. Phytotoxic effect of decaying quackgrass (Agropyron repens) residues. Weed Sci. 27:595-598.

39. Vough, L.R. 1980. Influence of insecticides and fertilizers on no-tillage establishment of alfalfa. The Agronomist. University of Maryland. pp. 3-4.

40. Wakefield, R.C. and N. Skaland. 1965. Effects of seeding rate and chemical weed control on establishment and subsequent growth of alfalfa (Meidcago sativa L.) and birdsfoot trefoil (Lotus corniculatus L.). Agron. J. 57:547-550.

41. Watkin, E.M. and G.R. Sagar. 1971. Residual activity of paraquat in soils-I. Weed Res. 11:1-11.

42. _____ and _____. 1971. Residual activity of paraquat in soils-II. Weed Res. 11:247-256.

43. Weber, J.B. and S.B. Weed. 1968. Adsorption and desorption of diquat, paraquat and prometone by montmorillonite and kaolinite clay materials. Soil Sci. Sco. Am. Proc. 32:485-487.

44. Welty, L.E., R.L. Anderson, R.H. Delaney, and P.F. Hensleigh. 1981. Glyphosate timing effects on establishment of sod-seeded legumes and grasses. Agron. J. 73:813-817.

VITA 2

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