Methods for Sod-Seeding of Small-Seeded Legumes and Grasses

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TABLE OF CONTENTS

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INTRODUCTION

The 2.4 million acres of hay harvested in Montana yielded an average of 1.80 tons/A in 1979 (9). Low forage yields are in part the result of hay crops being grown on poor soils. Traditionally, forage crops are planted on less productive land than are small grain and cash crops. Poor management practices such as poor fertility and weed control, ineffective irrigation and poor harvest management also contribute to low yields. Where productive species are present, improved management practices can increase yields substantially.

Low yields often reflect the high percentages of low productive species in pastures and haylands. New and more productive species may need to be introduced to increase forage yields. Complete seedbed preparation for reseeding has often been impractical due to economic considerations, or because the terrain is too wet, rocky or sloping to lend itself to conventional tillage practices. Sod-seeding may allow establishment of forage species without plowing and total sod destruction.

Pasture renovation without complete seedbed preparation has been successful in Australia. Dowling et al. (5) reported that surface sowing of pasture species with the use of herbicides for sod control produced adequate stands. Numerous researchers in the United States have reported successful interseeding when using paraquat [1,l'-dimethyl-4,4'-bipyridinium ion] (4, 8, 12, 15) or glyphosate [N-(phosphonomethyl) glycine] (1, 10, 11, l2) for sod suppression.

Even with the use of herbicides to suppress existing vegetation, many problems have been encountered with direct sod-seeding. Welty et al. (17) observed that in many situations where herbicides provided adequate sod control, forage stand establishment was inadequate. They concluded that factors other than sod control were limiting successful establishment of small-seeded legumes and grasses. Suspected reasons for poor establishment are residual toxicity of non-selective herbicides and/or allelopathic effects of decaying swards on germination, emergence and growth of legumes and grasses.

Herbicide residual effects on germination of various forage species have been investigated. Segura et al. (13) showed that glyphosate sprayed on annual ryegrass (*Lolium multiflorum* Lam.) and red clover (*Trifolium pratense* L.), with or without 0.02 inches of soil cover, reduced germination of both species. However, Moshier et al. (10), reported that glyphosate applied over seed of two alfalfa (*Medicago sativa* L.) cultivars did not reduce germination, but did reduce shoot length of both cultivars. Hurto and Turgeon (6), found that Kentucky bluegrass (*Poapratensis* L.) thatch

Test strip at Northwestern Agricultural Research Center, Kalispell, MT. Sprayed with glyphosate (1.5 lbs. AE/A) and seeded with John Deere drill. Apollo alfalfa, 12 lbs. **PLS/A.**

containing paraquat inhibited perennial ryegrass (*Lolium perenne* L.) establishment, but glyphosate-treated thatch did not.

Toxin release (allelopathy) from decaying pasture swards has also been studied. Toai and Linscott (16) showed that alfalfa seedling development and growth were inhibited by toxins released from dried quackgrass (*Agropyron repens* (L) Beauv.) rhizomes and leaves. The degree of phytotoxicity to alfalfa decreased with time of incubation. Seedling establishment may be enhanced when the application of the non-selective herbicide and sod-seeding are separated in time. (2, 3, 10, 11, 17).

The Montana Agricultural Experiment Station initiated sod-seeding research in 1977 to: 1) evaluate no-till drills; 2) evaluate selective and non-selective herbicides for sod suppression and weed control; 3) determine effect of herbicide timing relative to seeding on establishment and yield; 4) determine fertilizer levels needed to produce optimum stands and yields; 5) determine ability of various legumes and grasses to become established; 6) determine optimum seeding rates for forage species under sod-seeding establishment and 7) determine adaptability of sod-seeding throughout western Montana.

Evaluation of No-Till Drills

Materials and Methods

We compared the John Deere 1500 Powr-till and Melroe 701 No-till drills for forage crop establishment in 1977. The John Deere drill is a three-point hitch mounted, power take-off driven seeder which plants 12 rows spaced 8 inches apart. The Melroe drill is a pull type, triple-disc seeder that plants 15 rows spaced 7 inches apart. Although establishment with the John Deere drill was better than with the Melroe drill, performance of both drills was unsatisfactory in 1977.

In order to obtain adequate forage seedling establishment, a sod-seeding drill must meet three requirements: 1) provide sod penetration, 2) provide seeding depth control and 3) have a packer wheel system that firms soil over seed. The John Deere drill, as secured from factory, met requirements 1 and 2 above, but the packer wheels were not heavy enough to adequately firm soil over seed. The Melroe drill, as secured from factory, lacked depth control and packer wheels. In winter of 1977-78, we installed heavier packer wheels on the John Deere drill. Modifications on the Melroe consisted of added depth bands to the double disc openers and installing several different type packer wheels.

The modified John Deere and Melroe drills were compared in 1978 on an irrigated, orchardgrass (*Dac*

Test strips at Kalispell, MT. Tall fescue sod sprayed with glyphosate (1.5 lbs. AE/A) and seeded with alfalfa (12 lbs. PLS/A) with John Deere drill.

tylis glomerata L.) sod and a wetland, Kentucky bluegrass-orchardgrass-tall fescue (*Festuca arundinacea* Schreb.) sod at Kalispell. Both locations were sprayed with glyphosate at 1.5 lbs acid equivalent/acre (AE/A) on July 6, when the vegetation was 3-6 inches tall, and were seeded with 'Apollo' alfalfa at 12 lbs pure live seed per acre (PLS/A) on July 7.

Results and Discussion

Alfalfa seedling establishment was best for the John Deere drill at both locations (Table 1). Total legume yield, after botanical separation, was significantly greater for the John Deere on the irrigated site in the seeding year; however, the next year yields were similar for both drills. Yield data was not obtained in the seeding year for the wetland site due to poor vigor of alfalfa seedlings because of sod competition. Glyphosate, applied at *1.5* lbs AE/A, did not control the tall fescue. Total legume yields on the wetland site in 1979 were very low because of the fescue competition.

The John Deere drill was successfully modified, whereas the Melroe drill was not.

TABLE 1. ESTABLISHMENT AND YIELD OF APOLLO ALFALFA, WHEN SEEDED WITH TWO NO-TILL DRILLS, AT KALISPELL, MONTANA.

Drill	Seedling Establishment		Alfalfa Yield		Wetland
	Irrigated 1978	Wetland 1978		Irrigated	
			1978	1979	1979
	— *plants/ft²* —			—*tons DM/A*—	
John Deere	25a[1]	43a	2.37a	3.92a	0.75a
Melroe	7b	l6b	1.65b	3.63a	0.64a

[1]Column means followed by a common letter are not significantly different at the 5% probability level according to Duncan's New Multiple Range Test.

Evaluation of Non-Selective Herbicides for Sod Control

Comparison of Glyphosate, Paraquat and Power Tilling

Materials and Methods

On April 4, 1978, glyphosate (1.5 lbs AE/A), paraquat (0.5 lbs active ingredient/acre [Al/A]) and power tilling were used to suppress a cheatgrass (*Bromus tectorum* **L.),** intermediate wheatgrass (*Agropyron intermedium* (Host) Beauv.), tall wheatgrass (*Agropyron elongatum* (Host) Beauv.), and needle-and-thread grass (*Stipa comata* Trin. & Rupr.) sod which was 3 inches tall. The experiment was conducted at Hamilton, Mont. on an overgrazed, native range site with an annual precipitation of 13 inches. On April *5,* 1978, 'Ladak-65' alfalfa was interseeded with the John Deere drill in 16-inch rows at a seeding rate of 6 lbs PLS/A.

Results and Discussion

Glyphosate provided excellent sod control and resulted in better stand establishment than paraquat or power-tilling (Table 2). Weed encroachment in the power-tilled plots was severe. In 1979, alfalfa yields for glyphosate-treated plots were much greater than yields for other suppression treatments. The glyphosate treated plots yielded over 300% more total herbage than the native check. Paraquat and power tilling did not increase yields over the native check.

TABLE 2. EFFECT OF SOD-SUPPRESSION TREATMENT ON ESTABLISHMENT AND YIELD OF LADAK-65 ALFALFA.

Suppression Treatment	Seedling Establishment 1978	Total Herbage Yield 1979	Alfalfa Yield 1979
	- *plants/ft²* -	- *lbs DM/A* -	
Glyphosate	9a[1]	3l85a	2443a
Paraquat	3b	l281b	465b
Power-tilling[2]	2b	l496b	564b
Native check	—	1020b	—

[1]Means within a column followed by a common letter are not significantly different at the 5% probability level according to Duncan's New Multiple Range Test.

[2] Entire plot area was tilled before seeding with the John Deere Drill.

Effect of Paraquat and Clipping on Sod Suppression and Alfalfa Establishment

Materials and Methods

A vigorous, smooth bromegrass (*Bromus inermis* Leyss.) sod that was clipped to 2 inches was sprayed with paraquat (0.75 lbs Al/A) two days before seeding Apollo alfalfa (12 lbs PLS/A) with the John Deere drill on April 18, June 13 and September 13. Three simulated grazing treatments (clippings) were imposed for each seeding date. These simulated grazing treatments included; 1) clipping to 3 inches when grass regrowth reached 6 inches, 2) clipping to 3 inches when grass regrowth reached 12 inches and 3) defer all clipping until after frost.

Results and Discussion

No alfalfa plants emerged from the September seeding due to slug predation. Initial alfalfa emergence on paraquat-treated plots was better than without chemical, particularly for the June 13 seeding date (Table 3). However, stands in the paraquat-treated plots at the time of the second count were drastically reduced due to competition from the smooth bromegrass for both seeding dates. Clipping during the growing season did not enhance establishment. Alfalfa stands in 1979 were too poor to harvest.

TABLE 3. EFFECT OF SIMULATED GRAZING AND PARAQUAT ON ESTABLISHMENT OF APOLLO ALFALFA AT KALISPELL, MONTANA.

		Seeding Date			
		4/18/78		6/13/78	
Herbicide Treatment	Clipping Treatment	First Count 5/22/78	Second Count 6/6/78	First Count 7/3/78	Second Count 7/18/78
		-plants/ft^2-			
Paraquat	6 to 3 in.	20abc[1]	7a	17a	8ab
Paraquat	12 to 3 in.	24a	6a	15a	6abc
Paraquat	Clipped to 3 in. after frost	22ab	8a	l6a	10a
None	6-3in.	15bc	5a	5b	1bc
None	12-3 in.	15bc	4a	2b	0c
None	Clipped to 3 in. after frost	14c	2a	2b	0c

[1]Means within a column followed be a common letter are not significantly different at the 5% probability level according to Duncan's New Multiple Range Test.

Effect of Glyphosate Rate on Establishment and Yield of Apollo Alfalfa

Materials and Methods

In 1978, we sprayed glyphosate, with and without additional non-ionic surfactant (0.5% by volume) on an irrigated, orchardgrass-Kentucky bluegrass sod at three rates (0.75, 1.00 and 2.00 lbs AE/A). The sod was sprayed on three dates (April 12, May 1, and May 18) when the grass was 2-3, 7-8 and 10-14 inches tall, respectively. Apollo alfalfa was seeded (12 lbs PLS/A) with the John Deere drill five days after spraying. Two harvests were obtained in 1978 and three harvests were taken in 1979. Sub-samples were hand separated to determine botanical composition.

Results and Discussion

When vegetation was short (2-3 inches), spraying glyphosate resulted in the best alfalfa seeding establishment (Table 4). When vegetation was 10-14 inches high, establishment was reduced because the drill did not function properly in the tall forage. Stand counts obtained one month prior to those presented in Table 4 showed no differences among any herbicide treatments and the seeded check for each growth stage. However, stand counts presented in Table 4 show differences between the check and glyphosate rates, especially for the third growth stage (10-14 inches). The early plant count date revealed numerous seedlings that were chlorotic and spindly. Some of these plants had died by the time of the second counting.

Alfalfa yields were reduced the year of establishment (1978) when glyphosate was applied to vegetation 10-14 inches tall (Table 5). Similar alfalfa yields were obtained in 1979 regardless of when glyphosate was applied. Even though reduced stands were obtained, when glyphosate was applied to 10 to 14-inch sod, alfalfa plants developed larger crowns and produced equivalent yields.

TABLE 4. EFFECT OF GLYPHOSATE RATE AND SURFACTANT ON ESTABLISHMENT OF APOLLO ALFALFA AT KALISPELL, MONTANA IN 1978.

Herbicide Treatment	Herbicide Rate	Sod Height at Treatment		
		2-3 in.	7-8 in.	10-14 in.
	- lbs AE/A -		*- plants/ft²-*	
Seeded Check	—	28c[1]	29a	4c
Glyphosate	0.75	35ab	29a	23a
Glyphosate + surfactant	0.75	37ab	29a	23a
Glyphosate	1.00	39a	29a	17b
Glyphosate + surfactant	1.00	36ab	28a	2Oab
Glyphosate	2.00	36ab	29a	l8ab
Glyphosate + surfactant	2.00	33b	30a	l8ab
Mean		35a[2]	29a	18b

[1]Treatment means within each growth stage followed by a common letter are not significantly different at the 5¾ probability level according to Duncan's New Multiple Range Test.

[2]Growth stage means followed by a common letter are not significantly different at the 5°lo probability level according to Duncan's New Multiple Range Test.

Leon Welty viewing sod-seeded test plots at Northwestern Agricultural Research Center, Kalispell, MT. Orchardgrass-Kentucky bluegrass sod was sprayed with 1.5 lbs. AE/A of glyphosate and seeded with Apollo alfalfa at rate of 12 lbs. PLS/A with John Deere drill.

In 1978, the addition of surfactant at lower glyphosate rates (0.75 and 1.00 lbs AE/A) increased alfalfa yields when the glyphosate was applied to a 2 to 3-inch tall sod. Generally, higher glyphosate rates applied at the 2 to 3-inch growth stage resulted in greatest alfalfa yields in 1978 and 1979 (Table *5).* The addition of surfactant to glyphosate applied on vegetation 7 to 8 inches tall resulted in increased yields only at the lowest glyphosate rate *(0.75* lb AE/A) in 1978. When vegetation was 10 to 14 inches tall at time of glyphosate application, additional surfactant actually decreased yields at the 0.75 lb AE/A rate in 1978 and 1979. In all years for all growth stages, the absence of glyphosate resulted in drastically reduced yields.

TABLE 5. EFFECT OF GLYPHOSATE RATE SURFACTANT ON YIELD OF APOLLO ALFALFA IN 1978 AND 1979

Herbicide Treatment	Herbicide Rate	Sod Height at Treatment					
		2-3 in.		7-8 in.		10-14 in.	
		1978	1979	1978	1979	1978	1979
	- lbs AE/A-			*-tons alfalfa/A-*			
Seeded Check	—	0.46c[1]	1.38d	0. 15c	1.80d	0.27c	1.49d
Glyphosate	0.75	0.65c	2.73c	2.15b	4.70c	2.16a	5.13abc
Glyphosate + surfactant	0.75	2.08b	4.54b	3.0la	5.91ab	l.66b	4.70bc
Glyphosate	1.00	2.26b	4.27b	2.90a	5.23c	1 .74b	5.17abc
Glyphosate + surfactant	1.00	3.0Sa	4.80b	2.70a	5.32bc	l.49b	4.82bc
Glyphosate	2.00	3.11a	5.98a	2.78a	4.85c	1.72b	5.40ab
Glyphosate + surfactant	2.00	3.19a	6.29a	2.74a	6.48a	1.65b	5.56a
Mean	(1978)	2.11a[2]		2.35a		l.53b	
Mean	(1979)		4.28a[2]		4.90a		4.6la

[1] Means within each column followed by a common letter are not significantly different at the 5% probability level according to Duncan's New Multiple Range Test.

[2] Growth stage means for each year followed by a common letter are not significantly different at the 5% probability level according to Duncan's New Multiple Range Test.

Effect of Timing of Glyphosate Application

Materials and Methods

Apollo alfalfa and ladino clover (*Trifolium repens* L.) were seeded on June 8, 1978 at rates of 12 and 5 lbs PLS/A, respectively, into an irrigated, orchardgrassKentucky bluegrass sod with the John Deere drill. Prior to seeding, glyphosate *(1.5* lbs AE/A) was broadcast sprayed 28, 14, 7 and 1 day before seeding. Legume seedlings emerged per foot of row were counted 41 days after seeding. Two harvests were obtained in the seeding year, 1978, and three harvests were taken in 1979. A subsample was obtained from each plot and separated to determine botanical composition.

On June *15,* 1979, Apollo alfalfa and ladino clover were seeded at rates of 12 and S lbs PLS/A, respectively, into an irrigated, smooth bromegrass sod with the John Deere drill. Glyphosate (1.5 lbs AE/A) was broadcast sprayed 28, 21, 14, 7 and 1 day before seeding and 1 and 7 days after seeding. Number of established legume seedlings was recorded 25 days after seeding.

Results and Discussion

A 14 to 28-day spray-plant interval was needed for good establishment of ladino clover (Table 6). Ladino clover forage yields in 1978 were greatest when spraying and planting were separated by 28 days. However, by 1979, forage yields from plots sprayed 14 days before seeding were equal to those having a 28-day spray-plant interval.

Apollo alfalfa establishment was enhanced as spray-plant interval was increased up to 28 days (Table 7). Apollo forage yields in 1978 and 1979 were increased as the spray-plant interval was increased up to 28 days. The optimum waiting period between spraying and seeding was 28 days for alfalfa and 14 days for ladino clover.

When seeding into smooth bromegrass sod in 1979, a 28-day spray-plant interval was needed for establishment of Apollo alfalfa (Table 8). Ladino clover did not emerge in this study for any spray-plant interval. Poor establishment of ladino clover and reduced alfalfa emergence were most likely associated with slug (*Agriolimax reticulatum* MUller) predation. We observed fewer slugs in the drill furrow for the alfalfa 28-day spray-plant interval treatment than for other treatments. Spraying 28 days prior to seeding allowed sufficient time for grass desiccation which permitted sunlight to penetrate the grass canopy. This, in effect, dried out the furrow and provided a less favorable slug habitat. These results concur with those of Kaimbacher et al. (7). They showed that high snail (*Polygyra cereolus* Muhifeld) populations severely reduce legume stands when sod-seeding in Florida. White clover was more susceptible to loss than red clover or alfalfa which is consistent with our findings.

TABLE 6. EFFECT OF SPRAY-PLANT INTERVAL ON ESTABLISHMENT AND YIELD OF SOD-SEEDED LADINO CLOVER AT KALISPELL, MONTANA.

Interval between Glyphosate Spraying and Planting	Seedling Establishment	Yield[2]	
	1978	1978	1979
-days-	*-plants/ft²-*	*-tons DM/A-*	
28	33a[1]	0.72a	1.56a
14	26b	0.59b	1.62a
7	19c	0.17c	0.91b
1	15c	0.11c	0.58c

[1]Means within a column followed by a common letter are not significantly different at the 5% probability level according to Duncan's New Multiple Range Test.
[2]Total ladino clover yield.

TABLE 7. EFFECT OF SPRAY-PLANT INTERVAL ON ESTABLISHMENT AND YIELD OF SOD-SEEDED APOLLO ALFALFA AT KALISPELL, MONTANA.

Interval between Glyphosate Spraying and Planting	Seedling Establishment	Yield[2]	
	1978	1978	1979
-days-	*-plants/ft²-*	*-tons DM/A-*	
28	31a[1]	1.49a	4.32a
14	24b	1.00b	3.19b
7	17c	0.48c	2.44c
1	14c	0.13d	1.42d

[1]Means within a column followed by a common letter are not significantly different at the 5% probability level according to Duncan's New Multiple Range Test.
[2]Total alfalfa yield.

TABLE 8. EFFECT OF SPRAY-PLANT INTERVAL ON ESTABLISHMENT OF SOD-SEEDED APOLLO ALFALFA AT KALISPELL, MONTANA, IN 1979.

Interval Between Glyphosate Spraying and Planting	Seedling Establishment
- days -	*- plants/ft²-*
28	13a[1]
21	2bc
14	4b
7	4b
1	3bc
-1	1c
-7	1c

[1]Means within a column followed by a common letter are not significantly different at the 5% probability level according to Duncan's New Multiple Range Test.

Evaluation of Glyphosate and Paraquat Under Varying Environments

Materials and Methods

We evaluated two non-selective herbicides in 1979 for sod suppression at 26 off-station trials throughout western Montana. Paraquat was applied at 0.75 lb Al/A, and glyphosate rates were 0.75, 1.5 and 2.25 lbs AE/A. Also, additional surfactant was added to glyphosate to determine if it would increase herbicide effectiveness.

Results and Discussion

Glyphosate provided better sod control than para quat and generally resulted in more vigorous stands. Higher rates of glyphosate gave more complete control of sod than lower rates. The addition of surfactant at low glyphosate rates increased sod suppression. Glyphosate or paraquat did not provide adequate suppression of rushes *(Juncus* spp.), sedges *(Carex* spp.), fescues or creeping foxtail sods. In only one instance were semi-acceptable stands obtained without the use of a herbicide.

Evaluation of Selective Herbicides

One of the major factors limiting success of sod-seeding establishment is competition from weeds that germinate after applying glyphosate. In many cases weed competition has drastically reduced stands and vigor of sod-seeded legumes and grasses. We evaluated other chemicals that could be applied preplant (tank mix with glyphosate) or at time of planting for control of these germinating weeds.

Materials and Methods

Napropamide (2-(α-naphthoxy)-*N*, *N*-diethylprop-rionamide), buthidazole (3-[5-(l,1-dimethylethyl)-1,3,4-thiadiazol-2-yl]-4-hydroxy-l-methyl-2-imidazolidinone) and Stauffer R40244 (1-(*m*-trifluoromethylphenyl)-3-chlor-4-chloromethyl-2-pyrrolidone) were tank mixed with glyphosate (Table 9) and sprayed on an irrigated, orchardgrass-Kentucky bluegrass sod on May 1, 1978, five days before interseeding Apollo alfalfa (12 lbs PLS/A) with the John Deere drill. Granular EPTC (*S*-ethyl dipropylthiocarbamate) was applied with the Apollo alfalfa seed. Status of vegetation at time of spraying was: orchardgrass (4-8 inches high); Kentucky

TABLE 9. EFFECT OF VARIOUS HERBICIDES ON WEED CONTROL, ESTABLISHMENT AND YIELD OF APOLLO ALFALFA AT KALISPELL, MONTANA.

Herbicide Treatment	Herbicide Rate[3]	Alfalfa Establishment 1978	Total Alfalfa Yield 1978	Total Alfalfa Yield 1979	Broadleaved Weed Control 1978
	- lbs/A-	*- seedlings/ft²-*	*-tons DM/A-*		*- seedlings/ft²-*
Glyphosate	1.5	21a[4]	2.45abc	6.68a	L6ab
Glyphosate + EPTC[1]	1.5+ 3.0	l9ab	2.14c	7.07a	17a
Glyphosate + R40244[2]	1.5 + 0.5	20a	2.78a	6.83a	1c
Glyphosate + napropamide[2]	1.5+ 2.0	22a	2.29bc	6.54ab	12b
Glyphosate + buthidazole[2]	1.5+ 0.5	10c	2.76a	5.76b	1c
Glyphosate + R40244 + buthidazole	1.5+ 0.5+ 2.0	19ab	2.80a	6.86a	3c
Glyphosate + buthidazole + napropamide	1.5+ 0.5+ 2.0	13bc	2.68ab	6.42ab	4c
Seeded Check	0.0	17ab	0.04d	0.81c	—

[1] Granular mixed with seed.
[2] Tank mix.
[3] Glyphosate expressed as AE and other other herbicides expressed as AI.
[4] Means within a column followed by a common letter are not significantly different at the 5% probability level according to Duncan's New Multiple Range Test.

bluegrass (3 inches high); and dandelion (*Taraxacum officinale* Weber) [7 inches in diameter]. Stand evaluations were made in 1978. Two forage harvests were obtained in 1978 and three in 1979.

Results and Discussion

Two herbicides, R40244 and buthidazole, provided excellent control of broadleaved weeds germinating from seed (Table 9). However, buthidazole also reduced alfalfa stands. Alfalfa emergence for the seeded check was equal to the best chemical treatments; however, plants were dwarfed and spindly. All herbicide treatments produced much greater legume yields than the seeded check in 1978 and 1979. In 1978, plots sprayed with buthidazole produced the greatest yields even though stands were reduced by that chemical.

Determination of Fertilizer Requirement

Materials and Methods

The Melroe drill was used to interseed 12 lbs PLS/A of Apollo alfalfa and 15 lbs PLS/A of 'Regar' meadow bromegrass (*Bromus biebersteinii* Roem. & Schult.) into an irrigated, orchardgrass-Kentucky bluegrass sod and a wetland, fescue-Kentucky bluegrass-orchardgrass sod. Eleven lbs/A of N and *55* lbs/A of P_2O, were drilled with seed of both species. Glyphosate at 1.5 lbs AE/A was applied in 20-inch bands perpendicular to direction of seeding at the irrigated site and as a broadcast treatment at the wetland site. The wetland site was sprayed May 12 and seeded May 19, 1978 and the irrigated site was sprayed June 28 and seeded July 7, 1978.

Results and Discussion

Use of N and P fertilizers reduced both Apollo and Regar stands on the irrigated site and Apollo stands (for the first plant count) on the wetland site (Table 10). Forage yields were not obtained in 1979 at either location because stands and vigor for both species were poor due to excessive competition from the perennial sods.

TABLE 10. EFFECT OF N AND P ON ESTABLISHMENT OF SOD-SEEDED APOLLO ALFALFA AND REGAR MEADOW BROMEGRASS AT AN IRRIGATED AND WETLAND SITE AT KALISPELL, MONTANA IN 1978.

Fertilizer Treatment		Date of Count	Irrigated		Wetland	
			Apollo	Regar	Apollo	Regar
- lbs/A -			- plants/ft^2 -			
N	P_2O_5					
11	55	8/1/78	3b[1]	3b	9b	8a
0	0	8/1/78	11a	10a	l5a	9a
11	55	8/22/78	6b[1]	4a	7a	9a
0	0	8/22/78	15a	9a	8a	9a

[1]Means within a column for each date of counting followed by a common letter are not significantly different at the 5% probability level according to Duncan's New Multiple Range Test.

Control of Slugs (*Agriolimax Reticulatum* MÜller)

Materials and Methods

Incidence of slugs in other experiments precipitated this study to evaluate selected granular chemicals to control slugs. Three chemicals; Mesurol [3,5-di-methyl-4-(methylthio) phenol methylcarbamate], metaldehyde (polymer of acetaldehyde), and Furadan (2,3-dihydro-2,2-dimethyl-7-benzofuranyl methylcar-bamate) were applied with Apollo alfalfa (12 lbs PLS/A) using the John Deere drill on August 16 and 30 and September 12, 1979. One week before seeding, glyphosate was broadcast sprayed to the irrigated, orchardgrass sod at 1.5 lbs AE/A.

Results and Discussion

Late plantings resulted in reduced stands in 1979 and lower alfalfa yields in 1980 (Table 11). Alfalfa

TABLE 11. EFFECT OF PLANTING DATE ON EMERGENCE AND YIELD OF SOD-SEEDED APOLLO ALFALFA AT KALISPELL, MONTANA.[1]

Seeding Date	Seedling Establishment 1979	Alfalfa Yield 1980
	- plants/ft^2-	*-tons DM/A-*
8/16/79	51a[2]	1.34a
8/30/79	22b	0.75b
9/12/79	9c	0.46c

[1]Values averaged across planting dates.

[2]Means within a column followed by a common letter are not significantly different at the 5% probability level according to Duncan's New Multiple Range Test.

TABLE 12. EFFECT OF CHEMICAL TREATMENT ON EMERGENCE AND YIELD OF SOD-SEEDED APOLLO ALFALFA AT KALISPELL, MONTANA.[1]

Chemical Treatment	Chemical Rate	Seedling Establishment 1979	Alfalfa Yield 1980
	- lbs product/A-	*- plants/ft²-*	*-tons DM/A-*
Check	0	22b[2]	0.85ab
Mesurol	44	32a	0.81b
Metaldehyde	291	30a	1.lla
Furadan	24	26ab	0.63b

[1]Values averaged across planting dates.
[2]Means within a column followed by a common letter are not significantly different at the 5% probability level according to Duncan's New Multiple Range Test.

seedling establishment was increased when Mesurol and metaldehyde were used for slug control (Table 12). In 1980, higher alfalfa yields were obtained from plots treated with metaldehyde than from plots treated with Furadan or Mesurol. None of the chemical treatments resulted in more alfalfa production than the non-treated check in 1980. Slug predation was evident for all seeding dates, but was highest in plots established on September 12, 1979.

Evaluation of Species Establishment

Materials and Methods

Establishment evaluations for various species were obtained in three separate experiments conducted in 1978 and 1979. Ladino clover and Apollo alfalfa were interseeded with the John Deere drill. Glyphosate (1.5 lbs AE/A) was broadcast sprayed on an irrigated, orchardgrass-Kentucky bluegrass sod before seeding in 1978 and on an irrigated, smooth bromegrass sod before seeding in 1979.

In the third experiment, we seeded Apollo alfalfa and 'Potomac' orchardgrass with the John Deere drill in 1978. The irrigated, smooth bromegrass sod was sprayed in 20-inch bands with glyphosate at a rate of 1.5 lbs AE/A (actual rate in bands) one week prior to seeding.

Field near Greenough MT. Sprayed with glyphosate 1.5 lbs AE/A and seeded with alfalfa and orchardgrass with the John Deere drill.

TABLE 15. EFFECT OF SEEDING RATE ON ESTABLISHMENT AND YIELD OF SOD-SEEDED APOLLO ALFALFA AND POTOMAC ORCHARDGRASS AT KALISPELL, MONTANA.

	Irrigated			Wetland	
	Seedling Establishment	Seeded Crop Yield		Seedling Establishment	Seeded Crop Yield
Seeding Rate	1978	1978[1]	1979[2]	1978	1979[1]
- lbs PLS/A -	*- plants/ft^2 -*	*- tons DM/A -*		*- plants/ft^2 -*	*- tons DM/A -*
		Apollo Alfalfa			
7	13c[3]	0.30a	1.94c	19c	0.76a
14	32b	0.51a	2.93b	36b	0.65a
21	54a	0.40a	3.56a	56a	0.84a
		Potomac Orchardgrass			
4	14c[3]	0.04a	1.10b	14b	--
8	26b	0.17a	2.27a	22ab	--
12	41a	0.16a	2.60a	28a	--

[1] One harvest.
[2] Total of two harvests.
[3] Means within a column for each species followed by a common letter are not significantly different at the 5% probability level according to Duncan's New Multiple Range Test

Off Station Demonstration Trials

Materials and Methods

In 1980, eight locations varying in size from 5 to 14 acres were sprayed with 1.5 lbs AE/A of glyphosate and sod-seeded with the John Deere drill. Seeding was delayed from 3-5 weeks after spraying.

Results and Discussion

Excellent stands were obtained at all locations but one. Evaluations made in 1981 indicated that 7 of the 8 locations had very vigorous stands.

Excellent stands in 1980 can be attributed to three factors: 1) above normal precipitation during the establishment period; 2) separation of spraying and seeding; and 3) adequate performance of the John Deere drill. No truly wetland sites (comprised of rushes and sedges) were seeded in 1980 because chemical suppression of these species has been ineffective. However, excellent establishment of

Sod-seeding Tour — Helmsville, MT. Viewing old hay field sprayed with glyphosate (1.5 lbs AE/A) and seeded with Ladak-65 alfalfa (12 lbs. PLS/A) with John Deere drill.

wetland species was obtained at three locations in 1979 even though herbicides were not effective. We seeded into the wetland sods in late August after rushes and sedges had become less competitive. Unfortunately, tall fescue and reed canarygrass were drowned out the following spring. If water had been withheld in the spring of 1980, we feel confident that stands would not have been lost.

Cost of Establishment

A comparison between conventional and sod-seeding establishment costs is presented in Table 16. This information was compiled by Dr. Ronald Delaney, University of Wyoming. Conventional tillage costs were determined for a farm located in the Big Horn Basin, Northcentral Wyoming. Where similar tillage operations are used, this information should be applicable to Montana producers.

Minimum tillage establishment costs vary with amount of acres being interseeded each year. Per acre costs decrease as the number of interseeded acres increase because the initial purchase price of the drill is spread out over more acres. Total cost of establishing forage crops would be less for sod-seeding than for conventional establishment. Additional costs that may have to be added to conventional establishment would be 1) rock picking costs if rocks were overturned during the plowing operation and 2) additional herbicide costs if a perennial weed (quackgrass) had to be sprayed with glyphosate.

TABLE 16. ESTABLISHMENT COSTS – CONVENTIONAL VS SOD-SEEDING.[1]

	100 A/yr.	200 A/yr.
Sod-Seeding	cost/A	
John Deere Drill[2]	$15.02	$ 8.56
Tractor[3]	3.07	3.07
Spray (application $3.50/A + Roundup at 2 qt/A @ $78/gal.)	42.50	42.50
Total	$60.59	$54.13

Conventional[4]	Cost/A
Plow	$13.87
Disk (twice)	13.86
Roller harrow	5.70
Level	6.36
Drill	8.76
Spray (applications $3.50/Z & Eptam 3.5 pt./A @ $25.44/gal.)	14.63
Total	$63.18

[1] Costs shown exclude seed, fertilizer and land.
[2] Assume drill cost $10,500 with a 15 year life and travels at 4 mi/hr.
[3] Assume 70 hp diesel tractor used 350 hrs./yr. with a 12 yr. life.
[4] Conventional costs are based on a 480 acre farm. Each item of machinery was assumed to be used on the following number of acres/year to arrive at cost/acre. Plow-320 acres, disk-200 acres, roller harrow-l280 acres, level-560 acres, and drill-195 acres. Conventional tillage cost will depend on the specific tillage operations and the number of each used by individual producers. (Information taken from "Costs of Producing Crops, Worland Area, Wyoming 1981-82" Bul. 644R-Dec., 1981)

CONCLUSIONS

Drill Evaluation

A sod-seeding drill must meet three requirements to function properly in sod: 1) provide sod penetration; 2) provide seeding depth control; and 3) have an adequate packer wheel system. After we modified the John Deere packer wheels, the drill met the three above requirements and functioned well. The Melroe drill performed unsatisfactorily, even after modification.

A sprayer attachment that fits on the John Deere drill, so spraying and seeding can be accomplished in one operation, may be purchased. We do not recommend spraying and seeding in one operation because the cutter wheels on the drill stir up dust which contacts sprayed foliage and deactivates the herbicide.

Herbicides for Sod Control

The use of a non-selective herbicide to control competing sod is critical. Generally, glyphosate suppressed competing sod longer than paraquat and resulted in better legume and grass establishment.

Generally, higher rates (1.5 lbs AE/A and greater) of glyphosate provided better sod control. The addition of non-ionic surfactant increased activity of glyphosate at rates of 0.75 lb AE/A.

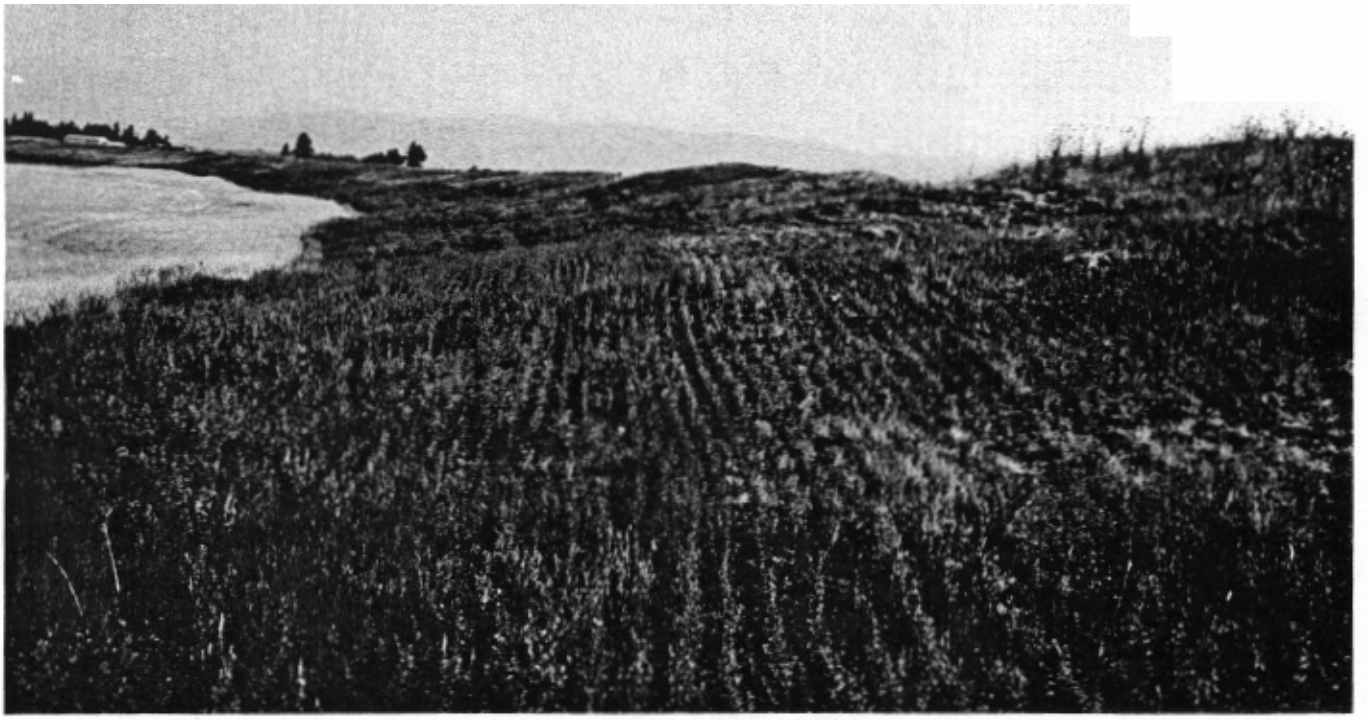
Glyphosate should be applied when vegetation is 6-8 inches tall and actively growing. If cattle droppings are prevelant, the sod should be harrowed prior to applying glyphosate so good herbicide-foliage contact can be assured.

Timing of Glyphosate Application

Some decaying grass and broadleaved weeds give off toxins harmful to interseeded legumes and grasses (allelopathy). A separation between spraying of sod with glyphosate and interseeding forage species allows time for toxin dissipation. In studies at Kalispell, optimum spray-plant interval for alfalfa was 28 days, and for ladino clover was 14 days.

In order to sod-seed dryland areas in early spring it may be necessary to apply glyphosate to green and actively growing vegetation in fall. It has been our experience that glyphosate applied at time of first killing

Sandy side-hill near Kalispell, MT. Sprayed with glyphosate (1.5 lbs. AE/A) and seeded with Ladak-65 alfalfa (10 lbs PLS/A) with John Deere drill.



frost can provide more effectivie control of hard to kill species (fescues and creeping foxtail) than glyphosate applied in late spring or early summer. Glyphosate applied on green vegetation at time of frost or shortly thereafter is translocated through the plant very effectively to below ground plant parts as the plant prepares for over-wintering.

Determination of Fertilizer Requirement of Sod-Seeded Forages

Application of fertilizer with seed, when planting with a no-till drill, reduced emergence of forage species at Kalispell. We recommend applying fertilizers after successful stand establishment.

Most Easily Established Species

Species selection is a major determinant to the success of sod-seeding establishment. Alfalfa and pubescent wheatgrass established better than crested wheatgrass and Russian wildrye under dryland conditions. Alfalfa and orchardgrass established better than ladino clover and meadow bromegrass on irrigated, well drained locations. However, ladino clover and meadow bromegrass stands were acceptable in some instances. Tall fescue and reed canarygrass established better than Garrison creeping foxtail and alsike clover under wetland conditions.

Evaluation of Seeding Rates

When seeding with the John Deere 1500 Powr-till drill, seeding rates should be 1.5 times greater than those used for conventional establishment. The cutter wheel action of the John Deere drill throws some seed out of the furrow, thus losing seed to soil contact.

Site Selection

Success of sod-seeding has been very good under dryland conditions where competition is not too severe and on competitive, irrigated, well drained sites. Success has been limited on very wet sites where rushes and sedges dominate the sward because these species are resistant to glyphosate.

Successful establishment has been achieved at wetland sites by seeding in late August when the rushes and sedges have lost their competitive edge. However, stands were lost the next spring due to standing water. We feel success can be achieved in these areas if spring water can be controlled.

Cost of Establishment

Data compiled by researchers at the University of Wyoming showed that establishment costs for sod-seeding was less than that for conventional seeding. Presumably, the same relationship will apply to western Montana.

Results and Discussion

Establishment in 1978 was similar for ladino clover and alfalfa (Table 13). However, alfalfa was more vigorous and yielded more forage than ladino clover the seeding year and the year following seeding. In the 1979 seeding, ladino clover did not emerge, whereas alfalfa stands were adequate.

In the third experiment, establishment and subsequent forage yield was significantly greater for Apollo alfalfa than for Potomac orchardgrass (Table 14).

Many legume and grass species were evaluated for establishment throughout western Montana in 1979. Alfalfa and pubescent wheatgrass [*Agropyron trichophorum* (Link) Richt.] established better than crested wheatgrass [*Agropyron desertorum* (Fisch. ex Link) Schult.] and Russian wildrye (*Elymus junceus* Fisch.) under dryland conditions. Alfalfa and orchard-grass established better than ladino clover and meadow bromegrass on irrigated, well drained sites. Tall fescue and reed canarygrass (*Phalaris arundinacea* L.) established better than 'Garrison' creeping foxtail (*Alopecurus arundinaceus* Poir) and alsike clover (*Tnfolium hybnidum L.*) under wetland conditions.

TABLE 13. ESTABLISHMENT AND YIELD OF TWO SOD-SEEDED LEGUMES AT KALISPELL, MONTANA.

Species	Seedling Establishment	Legume Yield 1978[1]	Legume Yield 1979[2]
	-plants/ft²-	*-tons DM/A-*	
Apollo alfalfa	22a[3]	0.77a	2.84a
Ladino clover	23a	0.40b	1.16b

[1] Total of two harvests.

[2] Total of three harvests.

[3] Means within a column followed by a common letter are not significantly different at the 5% probability level according to Duncan's New Multiple Range Test.

TABLE 14. ESTABLISHMENT AND YIELD OF SOD-SEEDED APOLLO ALFALFA AND POTOMAC ORCHARDGRASS AT KALISPELL, MONTANA.

Species	Seedling	Legume Yield 1978[1]	Legume Yield 1979[2]
	-plants/ft²-	*-tons DM/A-*	
Apollo alfalfa	33a[3]	0.40a	2.81a
Ladino clover	27b	0.12b	1.99b

[1] One harvest.

[2] Total of three harvests.

[3]Means within a column followed by a common letter are not significantly different at the 5% probability level according to Duncan's New Multiple Range Test.

Evaluation of Seeding Rates

Materials and Methods

We interseeded Apollo alfalfa and Potomac orchardgrass with the John Deere drill in 1978 at three seeding rates into a wetland, tall fescue sod and an irrigated, smooth bromegrass sod. Orchardgrass was seeded at 4, 8 and 12 lbs PLS/A and alfalfa at 7, 14 and 21 lbs PLS/A. The wetland site was broadcast sprayed *(1.5* lbs AE/A) and the irrigated site was band sprayed (1.5 lbs AE/A in bands) with glyphosate one week prior to seeding July 7.

Results and Discussion

The number of alfalfa and orchardgrass seedlings increased as seeding rates increased at both the wetland and irrigated sites (Table 15). In the year after seeding
on the irrigated site, high seeding rates resulted in greatest yields for both species. Yields of both species on the wetland site were very low because glyphosate did not control the fescue sod.

The cutter wheel action of the John Deere 1500 Powr-till drill throws seed out of the furrow and onto the berm; thus not all of the seed comes into contact with the soil. This is probably the reason seeding rates need to be at least 1.5 times greater for sod-seeding as compared to conventional establishment. These findings are consistent with research conducted in Minnesota. Sheaffer and Swanson (14) concluded that legume seeding rates for sod-seeding should be higher than for conventional seeding when grass competition is high.

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