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Farming for the Future

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Project Title:

No-Till Establishment of Forage Crops in Grain Stubble: Seed and Herbage Yields in the First-production Year

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ABSTRACT

The project was conducted at two sites near Beaverlodge, Alberta, to demonstrate and evaluate the direct-seeding and subsequent performance of four grasses (smooth brome, red and tall fescue, and timothy) and four legumes (alfalfa, alsike and red clover, and birdsfoot trefoil) on grain stubble, when sown at two seeding rates (200 and 400 seeds per square metre), and with three soil fertility treatments applied after seeding (surface-broadcast granular and soil-injected fluid to supply 20-60-0 kg/ha of nitrogen and phosphate fertilizer, and no fertilizer).

At each of the two sites, the ACRA-Plant V-disc openers, which are designed to handle both no-till and conventional methods of seeding, led to good-to-excellent, no-till, establishment of the eight forage crops in 1993. This occurred in spite of the dry soil conditions during spring and early summer and the wet conditions of July and early August. The early season superiority of the higher seeding density was apparent for each crop but visual differences in crop growth and development among the densities, and among the three soil fertilizer treatments, were no longer evident at the end of the 1993 growing season.

In the first production year, 1994, beneficial responses to nitrogen/phosphorus fertilizer at crop establishment were realized on a more consistent basis for stands grown for seed than for those grown for herbage. Seed yield was increased by about 40% with the application of nitrogen/phosphorus fertilizer in the year of establishment, and the responses to the soil-injection and broadcast methods of application were equal. In spite of the relatively close

proximity of the two sites, herbage production in the first-production year differed considerably and, on average, herbage yield at Site 2 was double that at Site 1. In contrast, seed yield at the two sites was similar. At Site 1, the three most productive crops were birdsfoot trefoil, red clover and smooth bromegrass for herbage, and smooth bromegrass, tall fescue and red fescue for seed. At Site 2, the three most productive crops were red clover, smooth bromegrass and red fescue for herbage, and tall fescue, smooth bromegrass and timothy for seed.

Under the conditions of this project, a seeding density of 200 seeds per square metre was adequate for the no-till establishment of productive seed and herbage stands of the forages. However, the agronomic and environmental requirements differ markedly for seed and herbage production of each crop. Tall fescue was somewhat marginal in its winter hardiness for herbage production in the Peace region but this did not prevent it from producing high-yielding seed crops.

The ACRA-Plant V-Disc Cropmaker openers can be recommended highly for the direct-seeding of a broad range of forage crops on grain stubble in spring, after suppression of weeds and volunteer plants with glyphosate herbicide.

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INTRODUCTION

There is increasing interest in the adoption of no-till and reduced tillage methods of crop establishment in the Peace River region, particularly with annual cereals for grain. Forage crops are, however, important components of most crop rotations in the region because of their beneficial effects on soil structure and health. Therefore, when producers acquire equipment for establishing successive crops without tillage, it may be economically beneficial to select a machine that will perform as well for small-seeded forage crops, which require shallow seeding at low rates, as it does for larger-seeded cereal crops that can withstand deeper seeding at much higher seeding rates.

The objective of the project was to evaluate the success of establishing stands of the principal forage grass and legume crops on grain stubble, using a drill with ACRA-Plant V-Disc Cropmaker openers, to demonstrate no-till cropping technology to more producers, and to document the performance of the forage crops for seed and herbage in their first production year. The 1993 report for this project documented the establishment of the forage crops and this present report documents the crop yields for the first production year.

MATERIALS AND METHODS

Two sites that had been seeded to barley in 1992 were selected for the demonstration; the soil at legal land location SW-2-71-10-W6 (Site 1) was a Dark Grey Solod (loam and clay loam) and that at SE-1-72-10-W6 (Site 2) was a Black Solod (silt loam and clay loam). In early May, 1993, approximately one week before seeding, each site was sprayed with 2.5 l/ha Roundup (356 g/l glyphosate) to suppress or kill any green vegetation.

The drill was a 6-row Hege 1000 fitted with ACRA-Plant V-Disc Cropmaker openers spaced 30 cm apart and set to place the seed about 2 cm deep. These openers are mounted on a parallel-arm, floating-linkage mechanism and have a 38 cm diameter notched disc on either side of a V-slice seeding insert, one disc has 11 notches and the other has 15. This arrangement is designed to provide good soil penetration, a uniform depth of seeding, and minimal plugging regardless of the crop, trash, or soil conditions. The insert slices a clean "V" in the soil directly in front of the seed tube. Each opener has three adjustable springs capable of applying over 100 kg of downward pressure, and the seeding depth for each row can be controlled precisely with a screw-type adjuster on the trailing press-wheel. The openers can be used in conventional and no-till conditions but appropriate press-wheels should be selected for the soil conditions; press-wheels with a "V"-faced rubber tyre (5 cm wide by 33 cm diameter) are recommended for no-till conditions, and ones with a double-ribbed rubber tyre (10 cm wide by 30 cm diameter) are recommended for conventional seedbeds. If necessary, additional weight can be added to the frame of the drill to ensure that the openers penetrate the soil adequately. The soil surface at Site 1 was hard, dry and crusted, and the narrower "V"-faced press-wheels were needed to ensure proper seed placement and coverage. The soil conditions at Site 2 were much more friable and the double-ribbed press-wheels were used because, in a test run, they performed better than the narrower, "V"-faced, press-wheels.

Eight forage crops were included in the demonstration, four grasses and four legumes. The grasses were 'Carlton' smooth bromegrass, 'Mustang' tall fescue, 'Boreal' creeping red fescue, and 'Climax' timothy. The legumes were 'Peace' alfalfa, 'Altaswede' red clover, 'Dawn' alsike clover, and 'Leo' birdsfoot trefoil. The legume seed was inoculated with appropriate *Rhizobium* bacteria just prior to sowing.

The drill was calibrated to sow the seed of each crop at two densities, 200 and 400 viable seeds per square metre (equivalent to two and four million viable seeds per hectare of land). For each crop type, the seeding rates required to achieve these densities were calculated from the actual weight of 1000 seeds, assuming a germination capacity of 80%. The actual seeding rates used at each site are shown in Table 1.

The seeding dates in 1993 were 19th May for Site 1 and 12th May for Site 2. At each site, the eight forages were seeded in adjacent strips of 12 rows, each strip exceeding 120 m in length. The first six rows of each strip were seeded at the lower seeding density on the outward pass of the drill, and the remaining six rows were seeded at the higher density on the return pass. A vacuum cleaner was used to clean the seed box and seeding mechanism of the drill between the seeding of each crop type. The seed rate adjustment on the drill was a Zeromax stepless mechanism, with a microdial control and digital readout for precise duplication of the required settings.

After drilling, the seeded strip of each crop at each site was divided into three 30 m long segments (with 5-10 m pathways between each) to accommodate the application of three fertilizer treatments:

1) None; 2) Surface-broadcast granular fertilizer to provide 20 kg/ha nitrogen (N) and 60 kg/ha phosphate (P_2O_5); and 3) Soil-injected fluid fertilizer to provide the same nutrients as in 2). The granular fertilizer was applied on 27th May by broadcasting 118 kg/ha of a fertilizer (17-51-0) made by mixing monoammonium phosphate (11-51-0) and ammonium nitrate (34.5-0-0) in the ratio of 100:17.4 by weight. The fluid fertilizer (9-27-0) was injected at a rate of 222 kg/ha (155 litres/ha) approximately 5 cm to one side of each crop row to a depth of 5-10 cm with a Cady spoke-wheel injector set at an operating pressure of 35 psi; Site 1 was injected on 1st June and Site 2 on 31st May.

In mid-to-late September 1993, the growth of forage at each site was removed with a flail-type forage harvester at a height of about 10 cm to prepare the crops for overwintering. In early October the grasses received a broadcast application of 200 kg/ha of ammonium nitrate fertilizer (34-0-0) in preparation for production in the 1994 crop season. Prior to this fertilization, soil samples were taken at each site for commercial analysis.

In 1994, herbage and seed yields were determined for each of the 48 treatments (8 crops x 2 seeding rates x 3 fertilizer treatments) at each site. The herbage was harvested on two occasions. At each site, the first cut for the grasses was taken on 20th June and for the legumes on 7th July. The second cut for both grasses and legumes was taken on 26th September at Site 1 and on 15th September at Site 2. An area of 3 square metres per treatment (5 metre length from 2 rows spaced 30 cm apart) was harvested on each occasion for the determination of herbage dry matter yield. The day for seed harvest was determined individually for each crop and was scheduled when the majority of the seed was ripe, but before significant shattering occurred. For seed harvest, an area of 3 square metres per treatment was harvested (10 metre length from one row on a 30 cm spacing). The seed samples were placed in cotton bags and allowed to air-dry prior to threshing. The seed was threshed and cleaned, and its moisture content was determined. The seed yields were corrected to a moisture content of 12%.

RESULTS

The results for the establishment year were reported in in the 1993 project report. Basically, the no-till establishment of all eight forage crops was good-to-excellent in spite of the dry soil conditions during spring and early summer, and the wet conditions of July and August, 1993. By fall, 1993, there were no visual differences in crop growth and/or development among the two seeding densities, or among the three fertilizer treatments. Prior to N fertilization in the fall of 1993, the nutrients in the soil (0-15 cm depth) at Site 1 and Site 2, respectively, were as follows: 12-24 and 16-36 kg/ha nitrate-N, 100-124 and 64-92 kg/ha P_2O_5, 186-206 and 338-508 kg/ha K_2O, and 76-176 and 22-24 kg/ha S.

The precipitation received throughout the two years of this project was about average in the year of establishment, 1993, and 37% greater than average in 1994. The seasonal distribution of the precipitation was far from normal; in both years, precipitation was lower than normal during late winter and spring, and higher than normal during summer (Table 2).

Crop performance

The influence of the main treatment effects on the herbage and seed production from these trials is shown in Table 3. Herbage production at Site 1, at each of the two cuts and annually, was only half that at Site 2 whereas seed yields were similar for the two sites. The application of fertilizer during the establishment year resulted in no consistent responses in herbage production in the first-production year, but did result in a 37-44% increase in average seed yield. In the first production year, both herbage and seed yields were similar for the two seeding densities and, as would be expected, the forage crops differed widely for both their herbage and seed yields (Table 3). There was a statistically significant ($P < 0.1\%$) crop by site interaction for both herbage and seed yield (Table 4). At Site 1, the three most productive crops were birdsfoot trefoil, red clover and smooth bromegrass for herbage, and smooth bromegrass, tall fescue and red fescue for seed. At Site 2, the three most productive crops were red clover, smooth bromegrass and red fescue for herbage, and tall fescue, smooth bromegrass and timothy for seed (Table 4).

There was a statistically significant ($P < 1\%$) crop by fertilizer interaction for the yield of herbage produced in the first-production year which was mediated via a differential yield response in the second cut (Table 5). The response to broadcast or soil-injected application of nitrogen/phosphorus fertilizer at crop establishment was not particularly consistent. In general, second cut and annual herbage production of the grass crops was greater when no fertilizer was applied. The herbage yield of the legume crops was generally increased when the fertilizer was soil-injected but was inconsistently affected when it was broadcast (Table 5).

DISCUSSION

The crop yields realized in this project were not only affected by the simple and combined effects of the treatments but also by the interaction of the treatments with the soil and atmospheric environment at each of the two sites. Because of the relatively close proximity of the two sites, the most significant difference among the two sites was the nature of the soil. The soil at Site 1 was a Dark Grey Solod (loam/clay loam) and that at Site 2 was a Black Solod (silt/clay loam). The differences in soil physical and chemical attributes are responsible presumably for most of the site effects observed in this project. These differences had particularly pronounced effects on the herbage-producing capability of the site, with the Black Solod being considerably more productive than the Dark Grey Solod. In contrast, the differences in the soil characteristics had little effect on the seed-producing capability of the sites. The nature of the crop growth is shown in photographs taken in early May and late July, 1994, at Site 1 (Figure 1) and Site 2 (Figure 2).

As is often the case when comparing widely differing seeding densities or rates for forage crops, virtually no differences in herbage or seed production were attributable to seeding density in this project. In the first-production year, herbage yield responses to the application of nitrogen/phosphorus fertilizer at establishment were somewhat inconclusive, because of the high magnitude of variation and the direction of some of the trends, but seed yields generally responded positively to the fertilizer treatments. Perhaps some of the inconsistent responses are attributable to the natural variation of the soil charcteristics within each site that could not be compensated for in this type of demonstration project.

The results of this project also serve to emphasize that the agronomic and environmental requirements for growing productive forage crops for herbage and seed can differ markedly. For instance, the relatively wet growing season favoured the production of herbage in the second half of the growing season. This suppressed the seed production of the legume forages much more than that of the grasses, because the legumes require the full growing season to mature their seed. Also, although the herbage productivity of tall fescue was relatively low in this project, its seed production was very good. The herbage yield was low because the winter hardiness of tall fescue is marginal for the Peace region, and the plants lacked vigour in the spring of 1994. This was detrimental to the herbage yields at both sites but did not appear to be particularly harmful to the seed-producing capability of tall fescue; it was the second highest seed producer at Site 1 (735 kg/ha) and the highest seed producer at Site 2 (1167 kg/ha).

CONCLUSIONS

1. At each of the two sites, the ACRA-Plant V-disc openers led to good-to-excellent, no-till, establishment of all eight forage crops included in the project, in spite of the dry soil conditions during spring and early summer, and the wet conditions of July and early August of the establishment year.
2. Visual effects of the two seeding densities, 200 and 400 seeds per square metre, were largely masked by the end of the growing

season of the establishment year, in spite of the early season superiority of the higher seeding density. No measurable effects of seeding density were detected in the first-production year for either herbage or seed yield.

3. Differences in crop growth and development among the three soil fertilizer treatments (none, broadcast granular N and P, and soil-injected fluid N and P) were not evident visually in the year of establishment.
4. In the first production year, seed yield was increased by about 40% with the application of nitrogen/phosphorus fertilizer in the year of establishment, and the responses to the soil-injection and broadcast methods of application were equal.
5. In the first-production year, herbage yield of the grass crops was greatest when no fertilizer was applied in the establishment year, but there is no obvious explanation for this negative response. In contrast, herbage yield of the legume crops was generally increased by soil-injection of fertilizer at establishment but no consistent response to the broadcast application was observed.
6. In spite of the relatively close proximity of the two sites, herbage production differed considerably among sites. Overall, herbage yield at Site 2 was double that at Site 1. In contrast, seed yield at the two sites was similar. Red clover and smooth bromegrass were among the best three crops for herbage production at each site, and tall fescue and smooth bromegrass were among the best three crops for seed production at each site.

7. The results of this project serve to emphasize that the agronomic and environmental requirements for growing productive forage crops for herbage and seed can differ markedly.

RECOMMENDATIONS

1. Crop trash should be thoroughly chopped and spread if the succeeding crop is to be established by direct seeding, in order to prevent trash from causing problems during drilling and with subsequent crop emergence.
2. When injecting fluid fertilizers into the soil-root zone, make sure that the formulation of the fertilizer is compatible with the dispensing mechanism of the applicator. The pump used on the Cady spoke-wheel injector requires a clear liquid with no clay carrier to ensure uniform application.
3. The very successful direct-seeding establishment of four grass and four legume crops on grain stubble, at both project sites, indicates that, given suitable drilling equipment and reasonable growing conditions, local producers could expect good results from no-till cropping practices when establishing forages in their crop rotations.
4. The ACRA-Plant V-Disc Cropmaker openers, which have the capability to seed in both conventional and no-till soil conditions, can be recommended highly for direct-seeding a broad range of forage crops on grain stubble in spring, after suppression of weeds and volunteer plants with a herbicide.
5. Under the conditions of this project, a seeding density of 200 seeds per square metre was adequate for the no-till

establishment of productive seed and herbage stands of a broad range of forage crops.

6. Beneficial responses to nitrogen/phosphorus fertilizer at crop establishment can be realized on a more consistent basis for stands grown for seed than for those grown for herbage.
7. Tall fescue may be somewhat marginal in its winter hardiness for herbage production in the Peace region but this does not prevent it from producing high-yielding seed crops. The agronomic and environmental requirements differ markedly for each type of production, seed or herbage.

Figure 1 (on facing page)

Photographs taken at Site 1 in May and July, 1994:

Top:

10th May: Early spring growth of Smooth bromegrass / Tall fescue (left) and Red fescue / Timothy (right).

Second:

10th May: Early spring growth of Alfalfa / Red clover (left) and Alsike clover / Birdsfoot trefoil (right).

Third:

22nd July: Smooth bromegrass / Tall fescue (left) and Red fescue / Timothy (right), with the regrowth after the first cut of herbage in the foreground and the seed crop in the background.

Bottom:

22nd July: Alfalfa / Red clover (left) and Alsike clover / Birdsfoot trefoil (right), with the regrowth after the first cut of herbage in the foreground and the seed crop in the background.

Figure 2 (on facing page)

Photographs taken at Site 2 in May and July, 1994:

Top:

10th May: Early spring growth of Timothy / Red fescue (left) and Tall fescue / Smooth bromegrass (right). In December, 1993, snow was removed from a 3 metre wide strip across the outside of the treatment area. This strip is shown in the foreground of the photographs. Note the relative sensitivity of Tall fescue to the colder conditions.

Second:

10th May: Early spring growth of Birdsfoot trefoil / Alsike clover (left) and Red clover / Alfalfa (right). In December, 1993, snow was removed from a 3 metre wide strip across the outside of the treatment area. This strip is shown in the foreground of the photographs.

Third:

22nd July: Timothy / Red fescue (left) and Tall fescue / Smooth bromegrass (right), with the regrowth after the first cut of herbage in the foreground and the seed crop in the background.

Bottom:

22nd July: Birdsfoot trefoil / Alsike clover (left) and Red clover / Alfalfa (right), with the regrowth after the first cut of herbage in the foreground and the seed crop in the background.

Table 1. Seeding rates for each forage crop and seeding density.

Crop	1000-seed weight (g)	Seeding density (No. seeds per sq. m.)	Seeding rate (kg/ha)[z]
Smooth bromegrass	3.78	200	9.4
		400	18.9
Tall fescue	2.31	200	5.8
		400	11.6
Creeping red fescue	1.17	200	2.9
		400	5.8
Timothy	0.43	200	1.1
		400	2.2
Alfalfa	2.06	200	5.2
		400	10.3
Red clover	1.83	200	4.6
		400	9.2
Alsike clover	0.84	200	2.1
		400	4.2
Birdsfoot trefoil	1.01	200	2.5
		400	5.1

[z] Assuming 80% germination capacity.

Table 2. Growing season precipitation (mm) at Beaverlodge.

Month	1993	1994	Long-term average (66-year)
January	13.6	82.7	32.9
February	5.3	44.4	25.5
March	9.7	2.4	26.1

April	42.4	6.9	20.4
May	15.3	44.3	39.6
June	134.0[z]	125.3	58.4
July	79.4	73.2	61.4
August	81.0	102.8	54.5
September	23.2	43.8	42.8
October	28.7	25.5	28.0
November	12.0	43.3	29.8
December	19.4	25.8	31.3
Annual total	464.0	620.4	453.0

[z] 118.3 mm of this was received from 20-28th June.

Table 3. Predicted means for herbage dry matter (DM) and seed yield (@ 12% moisture) for the main treatment effects, and their statistical significance.

Effect	Level	Herbage DM yield (kg/ha)			Seed yield (kg/ha)
		Cut 1	Cut 2	Annual	
Site	Site 1	2172	1314	3507	540
	Site 2	4278	3029	7293	570
Significance[z]		***	***	***	NS
Fertilizer	None	3188	2569	5802	441
	Broadcast	3227	2020	5230	604
	Inject	3478	2154	5588	635
Significance[z]		NS	**	*	**
Seeding density (seeds/m^2)	200	3212	2266	5464	588
	400	3392	2229	5608	531
Significancez		*	NS	NS	NS
Crop	Smooth bromegrass	4008	2691	6712	1148

Tall fescue	2354	1384	3747	994
Creeping red fescue	3450	2563	5935	686
Timothy	2971	2726	5699	588
Alfalfa	3146	1423	4496	282
Red clover	5373	1553	6863	42
Alsike clover	2796	2625	5380	155
Birdsfoot trefoil	2446	2740	5195	191
Significance[z]	***	***	***	***
Coefficient of variation (%)	22	29	19	34

[z] NS, *, **, *** indicate Not Significant, and significant at a probability of 5%, 1%, and 0.1%, respectively.

Table 4. Predicted means for herbage DM and seed yield (@ 12% moisture) characteristics for which the crop by site interaction was statistically significant (Probability < 0.1%). The coefficient of variation was 22%, 29%, 19%, and 34% for Cut 1, Cut 2, annual herbage DM yield, and seed yield, respectively.

Crop	Site 1				Site 2			
	Herbage DM yield (kg/ha)			Seed yield (kg/ha)	Herbage DM yield (kg/ha)			Seed yield (kg/ha)
	Cut 1	Cut 2	Annual		Cut 1	Cut 2	Annual	
Smooth bromegrass	2683	1419	4050	1367	5208	3822	9123	1002
Tall fescue	1799	524	2362	735	2857	2149	5001	1167
Creeping red fescue	1422	1415	2873	517	5287	3583	8708	799
Timothy	1582	1890	3497	239	4229	3468	7692	820
Alfalfa	2578	311	2891	348	3660	2412	5949	237
Red clover	3765	425	4190	32	7110	2555	9752	48
Alsike clover	1937	1667	3622	–[z]	3574	3476	6972	155
Birdsfoot trefoil	1740	2863	4632	–[z]	3084	2631	5706	191

[z] No harvest because seed shattered during extended period of wet weather.

Table 5. Predicted means for Cut 2 and annual herbage DM yield for which the crop by fertilizer interaction was statistically significant.

	Herbage DM yield (kg/ha)					
	Cut 2			Annual		
	Fertilizer treatment			Fertilizer treatment		
Crop	None	Broadcast	Inject	None	Broadcast	Inject
Smooth bromegrass	3010	2832	2332	6569	7229	6335
Tall fescue	2399	1131	623	5611	2970	2714
Creeping red fescue	3899	1770	2019	6850	4977	6005
Timothy	3284	2544	2348	6293	5723	5098
Alfalfa	1141	1089	2040	4078	3915	5482
Red clover	1289	1357	2012	6065	6706	7595
Alsike clover	2433	2521	2920	5306	4923	5908
Birdsfoot trefoil	2918	2517	2784	5339	4880	5372
Significance[z]		***			**	
Coefficient of variation		29%			19%	

[z] **, *** Interaction significant at a probability of 1%, and 0.1%, respectively.