SHORT COMMUNICATION

Effect of fertilizer on seed yield of alfalfa under irrigation in Saskatchewan

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Agriculture and Agri-Food Canada, Saskatoon Research Centre, 107 Science Place, Saskatoon, Saskatchewan, Canada S7N 0X2 (e-mail: gossenb@agr.gc.ca). *Centre contribution no. 1573, received 1 August 2003, accepted 2 June 2004.*

Gossen, B. D., Ukrainetz, H. and Soroka, J. J. 2004. **Effect of fertilizer on seed yield of alfalfa under irrigation in Saskatchewan.** Can. J. Plant Sci. **84**: 1105–1108. The impact of fertilizers containing macro- and micro-nutrients on seed production of alfalfa under irrigation in Saskatchewan was assessed. Trials were conducted on a Sutherland clay loam at Saskatoon, SK, from 1986 to 1991, and in a commercial field on Asquith sandy loam near Outlook, SK, from 1990 to 1993. Nutrients (primarily combinations of P, K, S) were applied at establishment (in-row with seed, side-banded, or broadcast and incorporated prior to seeding), and/or broadcast on the soil surface each year. Seed yield at both sites was excellent for the region, and application of fertilizer had little or no impact on yield. At sites with adequate initial soil fertility, as indicated by soil testing, alfalfa may not require added fertilizer to maintain high levels of seed production.

Key words: *Medicago sativa*, lucerne

Gossen, B. D., Ukrainetz, H. et Soroka, J. J. 2004. **Incidence de la fertilisation sur le rendement grainier de la luzerne cultivée sous irrigation en Saskatchewan**. Can. J. Plant Sci. **84**: 1105–1108. Les auteurs ont évalué l'impact des engrais composés d'éléments macro-nutritifs et d'oligo-éléments sur le rendement grainier de la luzerne cultivée sous irrigation en Saskatchewan. Les essais se sont déroulés de 1986 à 1991 sur un loam argileux Sutherland, à Saskatoon (Sask.), et de 1990 à 1993 sur un loam sablonneux Asquith dans un champ commercial près d'Outlook (Sask.). Les éléments nutritifs (essentiellement divers mélanges de P, K et S) ont été appliqués à l'implantation (dans le sillon avec la semence, en bandes ou à la volée avec incorporation avant les semis) ou épandus à la volée sur le sol chaque année. La culture a donné un excellent rendement grainier pour la région aux deux endroits et l'application d'engrais n'a exercé aucune influence ou très peu sur ce rendement. Aux endroits où le sol est assez fertile au départ (tel qu'indiqué par l'analyse), il se peut que la luzerne n'ait pas besoin d'engrais pour donner une grande quantité de semences.

Mots clés: *Medicago sativa*, luzerne

Most of the Canadian alfalfa (*Medicago sativa* L.) seed crop is produced in western Canada (Goplen et al. 1982; Rincker et al. 1988). The area devoted to seed production of alfalfa increased steadily in Saskatchewan in the 1980s and 1990s (Lan 1999), which stimulated interest in factors that limit alfalfa seed production in the province. The current study was part of a larger program to assess constraints to alfalfa seed production under irrigation in this region (Goplen et al.1989; Gossen et al. 1993).

When alfalfa is grown for forage, a large amount of plant material is removed from the field each year. This removal represents a substantial export of plant-available nutrients from the field over the life of the stand (Anonymous 1987; Marble 1988). In addition to nutritional requirements for growth, a high level of available K is required for alfalfa plants to develop sufficient low temperature tolerance to survive the harsh winter environment of the Canadian prairies (Bailey 1983). As a result, alfalfa requires high levels of soil nutrients to maintain plant populations and achieve maximum yields (Anonymous 1982; Goplen et al. 1982). Alfalfa grown for seed may not require the same levels of nutrition as for forage, because export of nutrients from the field is much lower. The deep roots of alfalfa are also able to access nutrients that cannot be reached by shallower-rooted crops. This factor might be especially important on irrigated sites, where the potential for nutrient leaching is higher than on a rain-fed site. The impact of soil fertility on alfalfa seed production under irrigation has not been assessed in detail in the region, so the objective of this study was to determine if soil nutrients were limiting for seed production at two sites under irrigation in Saskatchewan.

A trial to assess the impact of fertilizer application on seed production of alfalfa cv. Beaver was established on a clay loam soil at the Agriculture and Agri-Food Canada Research Farm at Saskatoon, SK, in the spring of 1987. Fertilizer treatments included one treatment where P, K, and S were broadcast and incorporated prior to seeding, and combinations of N, P, K, S, B, and Mo side-banded at seeding or broadcast each spring in the years after establishment. N was applied as ammonium nitrate, P as treblesuperphosphate, K as potassium chloride (where only K was required) or potassium sulphate (where both K and S were required), S as potassium sulphate or sodium sulphate, B as borax, and

[1]*Retired.*

Mo as sodium molybdate. Levels of macro-nutrients in the top 30 cm of soil, based on standard soil tests, were moderately high at the site (41 μg g^{-1} of P, 353 of K, and 15 of S), as were micronutrient levels (0–15 cm = 1.6 μg g^{-1} of B, 1.4 of Cu, 12 of Fe, 4.6 of Mn, 0.8 of Zn; 15–30 cm = 1.1 μg g^{-1} of B, 1.2 of Cu, 15 of Fe, 7.3 of Mn, 1.1 of Zn). Micronutrient levels at this site were assessed after the test was completed, but before additional fertilizer was applied. The plots were seeded at 1 kg seed ha^{-1} using a disk- opener seeder, in a randomized complete-block design with four replicates. Each plot consisted of six 10-m-long rows, with 0.7-m inter-row spacing. Overhead irrigation was applied as required to maintain vigorous plant growth in May and June, using impact sprinklers on risers. Irrigation was applied in 1988 (12 cm) and 1989 (15 cm), but was not required in 1990 and 1991. No irrigation was applied from late June until harvest in any year. Insect pests that attack alfalfa flowers were monitored each year at early bloom, and populations were reduced with an insecticide application if required, prior to release of the pollinators. Alfalfa leafcutting bees [*Megachile rotundata* (Fabricius)] were set out when the plots achieved 50% bloom, usually around Jul. 01, at about 6×10^4 bees ha^{-1}. No visible differences were apparent in stand establishment or plant density among plots, so no assessment of these factors was made in any year. Seed yield was measured each year from 1988 to 1991. At harvest, the plants were allowed to dry after a killing frost, and were direct-harvested using a small-plot combine. Seed was dried, cleaned, and weighed. In 1991, an early snowfall prevented seed harvest in fall. A warm period in early April 1992 melted the snow cover, but the soil remained frozen, which permitted harvest of the seed crop. The test was terminated in the spring of 1992.

A second trial was established on an Asquith fine sandy loam soil on a commercial seed production site near Outlook, SK, in the spring of 1990. Beaver was seeded in 23- and 68-cm row spacings, at seeding rates of 6 and 2 kg ha^{-1}, respectively. Initial soil test levels indicated moderate to high levels of P, high levels of N, K, and S, and acceptable levels of the micronutrients tested (0–15 cm = 8.5 μg g^{-1} NO_3-N, 9 of P, 215 of K, 12 of S, 0.38 of Cu, 9.2. of Fe, 5.4 of Mn, 0.76 of Zn; 15–30 cm = 9 μg g^{-1} of NO_3-N, 12 of S; 30–60 cm = 22 μg g^{-1} NO_3- N, 24 of S). Fertilizer treatments included combinations of P or K broadcast and incorporated before seeding, and N, P, K, or S sideband ed at seeding and/or broadcast on the soil surface annually after establishment (Table 2). Plot layout and planting, and irrigation and bee management were conducted as described previously. About 25 cm of irrigation water was applied in 1990, 5 cm in 1991, and no irrigation was applied in 1992 or 1993, due to above-normal levels of precipitation. Seed yield was measured in 1991–1993 as described previously. Seed produced in 1991 was harvested in the spring of 1992, as at Saskatoon.

Data analysis for each year was conducted using analysis of variance in SAS software (SAS user's guide: Statistics Version 5, 1985, Cary, NC). Data transformation [$\log_{10}$ (Yield)] was assessed, but did not substantially affect the results, so nontransformed data are presented. Variation in mean yield per year was very substantial over the duration of each test, so the data were not combined over years for analysis.

Mean seed yield at Saskatoon varied from 613 kg ha^{-1} in 1988 and 619 kg in 1989, to 267 kg in 1991 (Table 1). There were no differences among treatments in 1988 and 1989. Small differences in yield among some treatments were noted in 1990 and 1991, but there was no clear association between fertilizer amount, composition, or application technique with seed yield. In fact, yield in the control treatment (no fertilizer added) was generally near the top of the range each year. Mean yield declined substantially in 1990 and 1991, but this decline was not ameliorated by addition of fertilizer. However, the variability in seed yield between seasons was strongly related to weather conditions. In 1988 and 1989, conditions were very good for alfalfa seed production under irrigation; warm (above 20°C), dry conditions in July promoted flowering of alfalfa and leafcutting bee activity (Richards 1984). In 1990, cloudy wet weather in early July promoted vegetative growth and inhibited pollinator activity. Warmer, drier weather prevailed late in the flowering period, and seed setting continued well into August. Some of this seed matured, associated with warm weather and no killing frost in September and early October. In 1991, cool wet conditions in July promoted vegetative growth and inhibited bee activity; hot dry weather in August came too late to affect seed set.

At Outlook, seed yields in 1991 and 1992 were good (>500 kg ha^{-1}), but yield dropped to about 100 kg ha^{-1} in 1993 (Table 2). There was no increase in seed yield associated with fertilizer treatment in any year, even though there was a small positive response to P fertilizer in an adjacent forage trial (Gossen et al. 1993). In 1991, cool wet conditions early in the summer promoted vegetative growth and inhibited bee activity. However, it had less impact on this sandy site than on the clay soil at Saskatoon. In 1992, precipitation was above normal and temperatures in July and August were below normal, but yields were fairly good on this site. However, weather conditions during flowering in 1993 were among the coolest and wettest on record, and yields declined dramatically. Many commercial seed producers harvested little or no seed due to a combination of reduced flowering, limited pollinator activity, and losses due to plant disease (Gossen et al. 1994). There was no difference between row spacings of 23 and 68 cm in this trial, possibly due to weather conditions that promoted vegetative growth and reduced flowering of alfalfa.

We conclude that the initial levels of nutrients in the soil at both locations were sufficient to maximize seed production over the duration of the two studies. Yield of alfalfa seed in these trials was high compared to normal production expectations in the region, where mean production at rain-fed sites averages about 150 kg ha^{-1}. The results indicate that soil fertility was not a critical factor limiting alfalfa seed yield at these sites, and that application of fertilizer may not be required for alfalfa seed production on soils with moderate to high levels of soil nutrients over the normal duration of a alfalfa stand grown for seed. These results support the results of a small study conducted on rain-fed sites in Saskatchewan,

Table 1. Effect of timing and amount of fertilizer on seed production of alfalfa cv. Beaver under irrigation at Saskatoon, SK, 1988–1991 (seeded 1987)

Fertilizer and application (kg ha^{-1} of N-P-K-S)	Seed yield (kg ha^{-1})				
	1988	1989	1990	1991	Mean
Broadcast prior to seeding					
0-40-100-25	590	660	340	350	490
Side-banded at seeding					
0-20-50-25	610	590	350	220	440
0-20-50-0	610	520	330	300	440
0-0-50-25	650	700	330	260	480
25-20-50-25	610	590	250	230	420
0-20-50-25[z]	520	630	380	270	450
0-20-50-25[x]	580	630	310	270	450
Broadcast each harvest year					
0-0-50-25	690	730	350	290	520
0-20-50-25	570	530	270	300	420
0-40-50-25	660	610	340	320	480
0-80-50-25	590	670	330	230	460
0-40-0-25	720	750	340	210	500
0-40-50-0	660	550	390	230	460
0-40-50-50	500	520	290	280	400
50-40-50-50	620	670	350	260	470
Control (no fertilizer applied)	640	560	300	270	440
Mean	613	619	327	267	456
$LSD_{0.05}$	NS	NS	72	81	
CV (%)	18	23	16	21	

[z]Boron applied at 2.5 kg ha^{-1}.
[x]Molybdenum applied at 0.16 kg ha^{-1}.
NS = not significant.

Table 2. Effect of fertilizer on seed yield of alfalfa cv. Beaver at two row spacings (23- and 68- cm) under irrigation in a commercial field near Outlook, SK, 1991–1993 (seeded 1990)

Fertilizer applied (kg ha^{-1} of N-P-K-S)		Seed yield (kg ha^{-1})							
		1991		1992		1993		Mean	
Seeding year	Harvest year	23	68	23	68	23	68	23	68
Side-banded									
0-25-0-0	0-50-0-0	540	590	550	510	100	100	400	400
0-25-50-0	0-50-50-0	540	560	560	490	110	110	400	390
0-25-50-25	0-50-50-25	720	470	580	600	100	70	470	380
25-25-50-25	25-50-50-25	640	440	480	460	130	100	420	330
Broadcast									
0-50-0-0	NA	580	450	610	510	80	60	420	340
0-100-0-0	NA	550	430	570	510	60	50	390	330
0-200-0-0	NA	520	540	590	550	90	80	400	390
0-100-100-0	NA	570	580	590	540	160	120	440	410
NA	0-25-50-25	640	450	700	550	180	140	510	380
NA	0-50-50-25	490	490	650	540	110	100	420	380
NA	0-100-50-25	680	480	500	460	120	130	430	360
NA	0-50-50-0	460	500	580	440	90	90	380	340
NA	0-50-0-25	580	490	600	520	200	40	460	380
NA	25-50-50-25	630	600	560	470	50	50	410	70
0-100-100-0	0-50-0-0	570	540	580	560	190	130	450	410
0-100-100-0	0-50-50-25	600	470	590	520	140	100	450	360
Control		550	560	540	480	130	90	410	380
Mean		580	508	578	512	120	98	427	372
$LSD_{0.05}$		129	146	150	132	122	92		
CV (%)		16	20	18	18	72	66		

NA = none applied.

in which there was no increase in seed yield with application of N, P, and S, and inconsistent results with P and Bo (Horton 1991). Research is required to assess the impact of fertilizer in situations where initial soil nutrients levels are low.

We thank W. Reiter, G. Larson, J. Forsberg, J. Bernston, and K. Bassendowski for technical assistance, M. Larson for providing the commercial site, and the Canada-Saskatchewan Prairie Agriculture Water-Based Economic Development Fund for partial funding of the project.

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