WEED MANAGEMENT IN PEDIGREED ALFALFA SEED PRODUCTION

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by Mark S. Goodwin

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ABSTRACT

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Weed Management in Pedigreed Alfalfa Seed Production.
Major Professor: Dr. I.N. Morrison.

The effects of wheat, canola and flax companion crops on weed growth and alfalfa seedling establishment were evaluated in trials conducted at Portage la Prairie during 1982 and 1983. Compared to flax or canola, wheat suppressed the weeds most. All three companion crops reduced the amount of light available to underseeded alfalfa and depleted soil moisture more rapidly than when no companion was used. The effects exerted by the companion crops reduced dry matter production of alfalfa seedlings by more than 95%. Alfalfa which was established with a companion crop was slower to regrow and flowered later in the season after establishment. However, alfalfa established with a companion crop did not yield significantly less seed than alfalfa grown without a companion crop.

The distributions and densities of weed species in pedigreed alfalfa seed fields were measured throughout the province in a weed survey conducted during June and July 1983. In the surveyed fields, perennial weeds including quackgrass, Canada thistle and sow-thistle were the most abundant species. Annual weeds including wild mustard, wild

buckwheat and wild oats were present in over one-third of fields. American dragonhead and nightflowering catchfly were found in 30 and 21% of the surveyed fields, respectively.

Responses to a mailed grower questionnaire indicated that almost half of the producers did not use herbicides in established alfalfa seed fields. Of the fields that were treated with herbicides, many were sprayed with non-recommended treatments, predominantly 2,4-DB.

Herbicide screening trials conducted at Portage la Prairie indicated that established alfalfa had acceptable tolerance to 2,4-DB at 1.0 and 1.4 kg/ha applied up until the crop was 60 cm in height. Alfalfa was also tolerant to post-emergence applications of metribuzin at 0.2 and 0.4 kg/ha, bentazon at 1.0 and 2.0 kg/ha and bromoxynil at 0.3 and 0.6 kg/ha. Dormant applications of metribuzin at 1.0 and 2.0 kg/ha, simazine at 1.1 kg/ha, terbacil at 0.7 and 1.1 kg/ha and pronamide at 0.5 and 0.7 kg/ha did not cause injury or reductions in seed yield in treated plots.

Adequate control of nightflowering catchfly seedlings in the 4-leaf stage was obtained with post-emergence applications of bromoxynil at 0.6 kg/ha and metribuzin at 0.4 kg/ha. American dragonhead rosettes were controlled by the same treatments and with dormant applications of metribuzin at 2.0 kg/ha.

FOREWORD

This thesis is written in manuscript style. All manuscripts were prepared in accordance with the format specified by the Canadian Journal of Plant Science.

CHAPTER I

INTRODUCTION

Alfalfa (*Medicago sativa*) is one of the world's principal forage crops, occupying approximately 13 million hectares in North America and 33 million hectares globally (Walton 1983). Its rapid growth, high protein content and capacity for nitrogen fixation make it highly desirable as a component of hayfields and pastures (Dawson and Harvey 1981).

The crop's usefulness in forage production creates demand for forage seed. Seed production in Canada has risen steadily to meet this demand. Although the country is traditionally a net importer of alfalfa seed, Canadian producers may soon grow enough alfalfa seed to supply domestic needs (Table 1).

Successful production of pedigreed alfalfa seed requires a high degree of weed management. Growers must maintain clean fields in compliance with the Canada Seeds Act, which sets limits on quantities of weed seeds harvested with alfalfa seed. Pedigreed alfalfa seed fields must pass government inspections to obtain premium prices paid for certified or foundation seed.

Table 1. Exports and Imports of Alfalfa Seed in Canada (1972-1982)[1]

Year	Imported	Exported	Net Imported
	------------------'000 kg	----------------------	
1972	2662	79	2577
1973	2774	43	2689
1974	3159	280	2889
1975	2277	275	1998
1976	2275	233	2038
1977	2243	68	2358
1978	2569	145	2554
1979	2764	266	2498
1980	2843	129	2714
1981	2322	112	2210
1982	1392	715	676

[1]From E. von Graevenitz. Plant Products and Quarantine Division, Agriculture Canada (Winnipeg).

Efforts to control weeds in alfalfa grown for seed centre on the use of a combination of companion cropping and herbicide use during the seedling year, and herbicide use alone in subsequent years. Other weed management practices, such as tillage or crop rotations, are not feasible due to the perennial nature of the crop.

Companion cropping involves planting a cereal or oilseed crop along with newly planted alfalfa. The practice suppresses weed growth but undoubtedly exerts competitive pressure on alfalfa seedlings. As well, the presence of the second crop will limit the selection of herbicides to those to which both crops are tolerant.

Few herbicides are recommended for use in established alfalfa. There are no recommendations for control of many serious weeds such as Canada thistle (*Cirsium arvense*) and yellow sweet clover (*Melilotus* spp.). Labourious hand-roguing is the only means of removing some species from the crop.

In this thesis, three areas relating to weed management in alfalfa seed fields were addressed. Firstly, the effects of three companion crops on weed growth, herbicide choices and alfalfa seedling growth were evaluated. Secondly, the distribution and densities of major weeds throughout alfalfa seed fields in Manitoba was quantified through a combination of field surveys, weed counts and grower questionnaires. And thirdly, several post-emergence and dormant-applied herbicides were assessed for weed control efficacy in established alfalfa. Of particular interest was their potential to control American dragonhead (*Dracocephala parviflora*) and nightflowering catchfly (*Silene noctiflora*).

CHAPTER II

LITERATURE REVIEW

Weed management in alfalfa seed fields can be separated into two distinct phases: 1) management of weeds in seedling stands, where the crop is not highly competitive and where annual weeds predominate and 2) management of weeds in established stands, where alfalfa is vigourously competitive and perennial weeds are more of a problem.

Weed Control in Seedling Stands of Alfalfa

Competitive Effects of Weeds in Seedling Alfalfa

Alfalfa seedlings grow more slowly than many common annual crops. Maximum relative growth rate of alfalfa seedlings was 0.7 g/g/week in an outdoor study in Montana (Cooper 1966), considerably lower than maximum relative growth rates of 2.4 g/g/week and 2.2 g/g/week found in buckwheat (*Fagopyron esculentum*) and sunflower (*Helianthus annuus*), respectively, in a field study in Britain (Blackman and Wilson 1951).

Weed growth decreases stand densities of seedling alfalfa. In Nebraska, competition from green and yellow foxtail (*Setaria viridis* and *S. lutescens*), barnyard grass

(*Echinochloa crusgalli*), lamb's-quarters (*Chenopodium album*) and redroot pigweed (*Amaranthus retroflexus*) reduced populations of five varieties of alfalfa (McCarty and Sand 1961). Stand densities of 'Buffalo', 'Grimm', 'Ladak', 'Ranger' and 'Vernal' in weedy checks were 85% of those in handweeded plots and 81% of those in plots treated with dalapon (2,2-dichloropropionic acid) and 2,4-DB (4-(2,4-dichlorophenoxy-butyric acid). In a later experiment in Washington State involving a similar weed spectrum, the stand density was 47 plants/6m row under weed-free conditions compared to only 32 plants/6m row when a dense population of mixed weed species was present (Dawson and Rincker 1982).

Development of individual alfalfa seedlings is retarded by weed competition. Seedlings grown with heavy populations of redroot pigweed (*Amaranthus retroflexus*), lamb's-quarters (*Chenopodium album*), lady's thumb (*Polygonum persicaria*) and green foxtail (*Setaria viridis*) attained crown sizes only 50% of those of alfalfa grown in weed-free plots (Wakefield and Skaland 1965). Barnyard grass at a density of 510 culms/m2 reduced the mean number of stems per alfalfa seedling to 3.4/plant, compared to 8.1/plant under weed-free conditions (Dawson and Rincker 1982).

Effects of weed competition in seedling alfalfa on second year seed yield are not well documented. In regions where seed production is possible during the seedling year, weeds reduce seed set of alfalfa. A study in Washington state showed that the seed yield of irrigated alfalfa was 820 kg/ha under weed-free conditions and only 45 kg/ha in weedy plots containing an average of 22 culms/m row barnyard grass, 16 plants/m row lamb's-quarters and 1 plant/m row pigweed species (Dawson and Rincker 1982).

Many researchers have examined individual factors involved in competition between weeds and alfalfa seedlings (Pritchett and Nelson 1952, Cooper 1964, McKee 1962). Under weedy conditions, light and moisture become the major limiting factors when fields are adequately fertilized (Dawson and Harvey 1981).

Shading causes etiolation and decreased root:shoot ratios in affected alfalfa seedlings (Pritchett and Nelson 1951, Cooper 1966). The latter effect may decrease the plant's ability to take up moisture and nutrients (Donald 1958). Development of nodules is also affected by reductions in light intensity. Pritchett and Nelson (1951) found no nodules on alfalfa seedlings grown under light equivalent to 10% sunlight. McKee (1962) estimated that the light required for adequate nodulation of 'Vernal' alfalfa was 50% of full sunlight.

Few studies have examined soil moisture competition between weeds and alfalfa. Water is highly mobile in soils and because of this depletion begins sooner than with other soil growth factors (Trenbath 1979). Alfalfa requires considerable moisture for good growth. Up to 1500 kg of water per kilogram of alfalfa dry matter is required compared to 1380 kg for wheat and 720 kg for sugar beets (Byerly 1982). Krogman and Hobbs (1965) found that the daily use of water in alfalfa fields ranged from 1.3-9.1 mm/day. Daigger et al. (1970) found that 11.4 cm soil water was required to produce one ton of alfalfa dry matter. Chamblee (1958) calculated that soil moisture levels under alfalfa reached the wilting point down to 90 cm depths on 36% of days in a dry year. Other workers have recorded suboptimal growth and dry matter production of alfalfa under moisture stress (Lehman et al. 1968, Sammis 1980, Donovan and Meek 1983).

Soil moisture extraction by individual weeds was detailed by Davis et al. (1964). Single kochia (*Kochia scoparia*), cocklebur (*Xanthium pensylvanicum*) and crabgrass (*Digitaria sanguinalis*) plants extracted up to 54.5 kg/m3 of soil water at radii of 0.6 m from their central stems.

Chemical Control of Weeds in Seedlings Stands of Alfalfa

Previous herbicide screening trials have shown that many annual broadleaf and grassy weeds in seedling alfalfa are easily controlled through herbicide use. Current recommendations for Manitoba include two broadleaf weed herbicides and seven grasskillers in newly-planted alfalfa (Manitoba Agriculture 1984).

Early work by Friesen (1960) showed that 2,4-DB (4(2,4-dichlorophenoxy)butyric acid) provided 90% control of lamb's-quarters, stinkweed (Thlaspi arvense) and Canada thistle (Cirsium arvense) topgrowth without adversely affecting development of alfalfa seedlings. In the same trial, MCPA ((4-chloro-o-tolyl)oxy) acetic acid) sprayed at 130 g a.i./ha controlled lamb's-quarters, hemp nettle (Galeopsis tetrahit) and stinkweed, but the treated plots yielded slightly less alfalfa dry matter than those treated with 2,4-DB. Both chemicals are currently registered for broad spectrum broadleaf weed control in seedling alfalfa in Manitoba. However, MCPA, can be used only when a flax companion crop is present and is restricted to low rates because of the marginal tolerance of alfalfa to the chemical (Manitoba Agriculture 1984).

Testing of pre-plant incorporated grasskillers showed that EPTC (S-ethyldipropyl thiocarbamate) and triallate (S-(2,3,3-trichloroallyl) diisopropyl thiocarbamate) were safe to use in seedling stands (Goplen and Ashford 1966, Carder and Elliot 1967). Subsequent tests in Western Canada indicated that post-emergence treatments of asulam (methylsulfanyl carbamate) (Howe and Wilson 1975) or diclofop (2-(4-(2,4-dichlorophenoxy) phenoxy propanoic acid) (Moyer 1978) gave excellent control of wild oats, with the latter chemical also effectively controlling green foxtail. All four grasskillers are currently registered in Manitoba for use in seedling alfalfa (Manitoba Agriculture 1984).

Companion Cropping as a Means of Weed Control in Seedling Stands of Alfalfa

Early work on the advantages and disadvantages of legume establishment with a companion crop centered on the effects of the practice on forage yields and quality (Kust 1968, Schmid and Berens 1972, Temme et al. 1979). The weeds, companion crop and alfalfa were all considered to have intrinsic value as livestock feed, and thus contributed to total forage yield.

In seed production, weeds have no value, and while companion crops provide saleable yield, their value must be weighed against possible losses in alfalfa seed yield in the second year. Few workers have studied companion cropping in these contexts.

Effects on Weed Growth. Companion crops reduced weed populations in seedling legume populations of broadleaf weeds to between 15% and 40% of those found in weedy checks (Klebesadel and Smith 1960, Buxton and Wedin 1970a, Peters 1960). In Wisconsin, oats sown at 77 kg/ha and harvested at maturity reduced the dry matter production of weeds to 25% of that found in treatments where the oats were removed early in the season (Klebesadel and Smith 1960). The authors did not report the weed species involved. In the same year, Peters (1960) obtained similar results with oat companions sown at 52 kg/ha. Dry matter production of lambsquarters and redroot pigweed in alfalfa plots seeded with an oat companion was only 14% of that found in clear-seeded alfalfa. The dry matter of yellow foxtail was suppressed to 50% of that found in clear-seeded controls by the same treatment.

In a more recent study, Waddington (1983) obtained less clear results. In an experiment initiated in 1975, dry matter harvested from alfalfa seeded without a wheat companion contained 2% weedy material compared to 27% weedy material in plots seeded with a wheat companion. However, in stands initiated the following year, weedy growth comprised 42% of harvested dry matter from plots seeded without a companion crop compared to 9% in plots seeded with a wheat companion. The weed species present in the trials were not reported. No explanation for the contrasting results was included in the paper. However, the author reported that in 1975, hot weather in July stressed both the companion crop and the alfalfa. This may have decreased crop competition and allowed a greater ingress of weeds later in the season.

The relative degree of weed suppression is dependent on the competitiveness of the chosen companion crop. Janson and Knight (1973) rated five companion crops in terms of their ability to suppress weeds. Wheat, peas and corn suppressed weeds better than flax or barley. Higher seeding rates of all five companion crops suppressed weed growth better than lower rates. Wynn-Williams (1976) and Briggs and

Harrison (1953) both obtained better weed suppression with barley companions than did Janson and Knight (1973), ranking barley higher than wheat, buckwheat or soybeans. Kilcher and Heinrichs (1960) also found barley to be more competitive than wheat or oat companions in studies at Swift Current.

Crop variety may also influence the degree of weed suppression attained by companion crops. In an experiment comparing two different oat genotypes at similar seeding rates, a species with more erect leaves and a less dense canopy (*Avena sativa* L. 237-89) allowed greater ingress of weeds than another oat species (*Avena byzantium* A. 465) with a more dense canopy.

Effects on Alfalfa Seedling Development. Companion crops also suppress the growth of undersown alfalfa. Bula et al. (1968) reported decreased stand densities, topgrowth dry matter production and root weight of alfalfa when grown with oats. In another study, the presence of barley or wheat companions reduced stem growth and thickness and internode length of alfalfa seedlings (Wynn-Williams 1976). Cooper and Ferguson (1964) showed that vertical and lateral root development of alfalfa seedlings were retarded when a barley companion was utilized. Similar results were obtained by Buxton and Wedin (1970b), with the dry weight of alfalfa roots under an oat companion crop attaining only 67% of that measured in clear-seeded controls. A reduction in root growth would undoubtedly impede alfalfa's ability to take up nutrients and would leave seedlings prone to drought stress in lighter soils where moisture deficits occur.

Some evidence suggests that lower seeding rates have less adverse effects than high seeding rates on undersown alfalfa. In one study, alfalfa dry matter production under barley sown at 56 kg/ha was twice that observed under barley sown at 112 kg/ha (Wynn-Williams 1975c). Supporting evidence was reported in work conducted in Saskatchewan by Kilcher and Heinrichs (1960). They determined that establishment of alfalfa/bromegrass mixtures was better with companion crops sown in 30 cm spacings than with higher seeding rates sown at 12 cm spacings.

Other workers disagree with the premise that lower seeding rates enhance the growth of alfalfa seedlings. They suggest that any decrease in competitiveness of the companion crop is more likely to be exploited by weed species than the alfalfa seedlings (Smith et al. 1956, Bula et al. 1954, Wynn-Williams 1976c). Bula et al. (1954) found that decreasing the seeding rate of oats from 228 kg/ha to 19 kg/ha did not result in an increase in the vigor of the alfalfa seedlings because of the presence of more weed growth at the lower seedings rates. In a recent experiment at Melfort, half the recommended seeding rate of a wheat (50 kg/ha) did not yield less grain than the full rate and forage establishment was not enhanced by the lower rate (Waddington and Bittman 1983).

Light Interception by Companion Crops. Interception of light can be significant in companion cropping. Buxton (1970a) measured 85-99.9% reductions in photosynthetically active radiation (PAR) through an oat canopy. Klebesadel and Smith (1960) reported similar results with the same crop. Cooper and Ferguson (1964) determined that barley reduced PAR penetration to alfalfa seedlings by 89% in mornings and 22% at noon. Flanagan and Washko (1950) found that light reductions within small-grain companions was positively correlated with culm numbers, stem height and above-ground dry matter production of the crop.

Janson and Knight (1973) assessed the importance of "total shading effect", a measure combining the intensity of shading with the duration of shading through the season. Flax allowed more light penetration to underseeded alfalfa than barley, but shaded the alfalfa seedlings for a longer period, resulting in poor legume development. Barley allowed more light penetration in mid-to-late season as its leaves senesced, while light levels remained moderately low in flax late into the season.

All of the above-mentioned light measurements were restricted to wavelengths between 400 and 700 nm, the approximate range of photosynthetically active radiation. Restricting measurements to these wavelengths does not permit an assessment of the effects of canopy interception of longer wavelength radiation on underseeded alfalfa. Transpiration rates and leaf heating of alfalfa are probably affected by near infrared radiation, as factor which would be altered with the use of companion crops (Allen et al. 1976). Consequently, broader wavelengths should also be measured using a pyranometric sensor in experiments involving companion cropping of alfalfa.

Effects of Companion Cropping on Soil Moisture Availability. Little work has been done on the effects of companion cropping on the availability of soil moisture to alfalfa seedlings. Janson and Knight (1973) found no significant differences in soil moisture between alfalfa plots seeded with or without a companion crop. Measurements were taken only in the top 10 cm of soil, however, and other authors suggest that differences would not be seen at shallow depths (Klebesadel and Smith 1960, Cooper and Ferguson 1964).

Klebesadel and Smith (1959) found that fall- and spring-sown companions depleted available soil moisture well into the subsoil on a silt loam. In work at Madison, Wisconsin, timed removal of oat companion crops at four stages of maturity showed that moisture depletion was slower in treatments where oats were harvested at early stages than when the companion was allowed to grow to maturity (Klebesadel and Smith 1960). Differences among treatments were similar at all soil depths down to 60 cm.

Irrigation did not benefit alfalfa growth when companion crops were used in a study conducted in New Zealand, (Janson and Knight 1973). In fact, irrigation decreased the seedling vigour of the undersown legume by increasing the growth rate of the companion crop. This resulted in thinner stands and lower herbage yields of alfalfa in irrigated plots than in non-irrigated plots.

Effects of Seedling Year Companion Cropping on Second Year Alfalfa Development. Of importance to alfalfa seed producers are the effects of seedling year competition from companion crops on seed production in subsequent years. The bulk of published research in this area reports on the effects of companion cropping on second year hay production. Effects of the practice on alfalfa seed yields are not documented in the available literature. Herbage production of alfalfa in the year after seeding was not affected by companion cropping in trials in Wisconsin (Klebesadel and Smith 1960) and Minnesota (Schmid and Behrens 1972). However, Buxton (1970a) recorded large reductions in second season stand densities at Ames, Iowa, following the use of oat companions in the seedling year. In Quebec, Genest and Steppler (1973) reported slight reductions in second-year dry matter yields of alfalfa which had been companion cropped with oats and barley, but no reductions in yields when wheat was used as a companion.

Tossell and Fulkerson (1960) at Guelph, Ontario, noted reduced herbage yields in the first cut of hay harvested in the season following companion cropping, but measured no yield differences in subsequent cuts.

Waddington and Bittman (1983) speculated that carry over of competitive stress into the second season of alfalfa production may be dependent on regional climactic factors. They stated that in areas where companion crops can be harvested in mid-summer, good growing conditions prior to winter may allow some recovery of the under-seeded alfalfa. The authors' own work suggests that in regions where companion crops are harvested later, alfalfa seedlings have insufficient time between harvest and winter to catch up to alfalfa seedlings grown alone.

WEED CONTROL IN ESTABLISHED STANDS

Effects of Weeds in Established Stands

Although alfalfa is generally quite vigourous once established, weeds may still affect growth and development of the crop. Aggressive perennials such as quackgrass (*Agropyron repens*) and Canada thistle compete with alfalfa and can reduce stand longevity (Fawcett et al. 1978). Thin stands and wide row spacings nesessary for maximum seed production also allow annual weeds to grow. Weed blossoms may attract pollinators away from alfalfa flowers, thus decreasing seed yields (Dawson and Rincker 1982).

The quality of harvested seed is decreased by the presence of weed seeds. Removal of these weed seeds increases production costs (Pederson et al. 1972).

CHEMICAL CONTROL OF WEEDS IN ESTABLISHED STANDS

Postemergence Herbicides

Only two post-emergence herbicides are registered for use in established alfalfa. Both barban and asulam are recommended for wild oat control.

No post-emergence herbicides are available for broadleaf weed control. However, recent tolerance tests show that several non-recommended chemicals may be used for selective weed control in established stands without adversely affecting seed yield.

2,4-DB controls a wide variety of broadleaf weeds in seedling stands. When used in established stands, initial injury to alfalfa can be severe and reductions in seed yield can occur (Pchajek 1983). However, another study showed that recovery is rapid and seed yields are not adversely affected (Moyer 1981).

Bromoxynil (3,5-dibromo-4-hydroxybenzonitrile) is a contact herbicide used to control broadleaf weeds such as wild buckwheat, wild mustard and nightflowering catchfly, weeds that are not controlled by 2,4-DB. Ratings from a screening trial showed that alfalfa exhibits some tolerance to bromoxynil (Todd 1982).

Metribuzin (4-amino-6-tert-butyl 3-methylthio)-as triazin-5(5H)-one) is a triazine herbicide and is also effective in controlling some 2,4-DB-resistant weeds. Hemp nettle, mustard species and some species of Polygonums are controlled at early leaf stages with 0.2 to 0.4 kg/ha metribuzin. Application at these rates caused no depression in seed yields in tests in Manitoba (Todd 1982). The treatment is registered for use in alfalfa seed fields in Alberta and eastern Canada.

Bentazon (3-isopropyl-lH-2,1,3 - benzothiadiazin 4-(3H)-one,2,2-dioxide) is currently recommended for use in several leguminous crops such as fababeans, snapbeans, peas and soybeans. The chemical controls a wide spectrum of annual broadleaf weeds including lambsquarters, wild mustard and smartweed. Crop tolerance tests in Manitoba showed no effects on seed yield from 1.0 and 2.0 kg/ha rates of bentazon (Pchajek and Bourrier 1981).

Dormant-applied Chemicals

Simazine (2-chloro-4,6-bis (ethylamino)-a-triazine) controls several annual grasses as well as wild buckwheat, smartweed, clover, lambsquarters and nightflowering catchfly. Application is restricted to the fall, after alfalfa growth has ceased.

Terbacil (3-tert-butyl-5-chloro-6 methyluracil) can be used for control of mustard species, sow thistle and some annual grasses. Suppression of dandelions and quackgrass occurs frequently. Crop tolerance of alfalfa is acceptable (Esau and Reesor 1978) and application may be made either in fall after freeze-up, or in the spring prior to thaw.

Pronamide (3,5-dichloro(N-1,1-dimethyl-2-propynyl) benzamide) controls annuals such as foxtail barley (Hordeum jubatum), volunteer cereals and wild oats as well as perennial grasses. Previous trials have shown good tolerance of alfalfa to the chemical (Waddington 1974, Esau and Reesor 1978). Application is restricted to the fall prior to freeze-up.

Recent work has shown that established alfalfa exhibits good tolerance to metribuzin applied at high rates as a dormant spray (Darwent and MacKenzie 1980, Moyer 1982). Waddington (1980) observed that metribuzin applied as a dormant spray caused early season yellowing of alfalfa but no reductions in seed production. Metribuzin controls many annual broadleaf weeds, including wild mustard and certain Polygonum species.

NIGHTFLOWERING CATCHFLY AND AMERICAN DRAGONHEAD IN ALFALFA SEED PRODUCTION

Nightflowering catchfly and American dragonhead are serious adulterants of alfalfa seed. Cleaning of crops containing these weed seeds is costly and may result in the loss of some alfalfa seed. The presence of both species in pedigreed seed is restricted by the Canada Seeds Act (1977) (Table 2).

Nightflowering Catchfly in Alfalfa Seed Production

Nightflowering catchfly, also known as sticky cockle, is an annual or winter annual distributed throughout much of Canada (Frankton and Mulligan 1977). Thomas (1981) ranked it as the tenth most abundant weed in Manitoba grain crops. The stems of nightflowering catchfly are up to 60 cm in height and hairy. The leaves are opposite, ovate and extremely sticky. The flowers have white or pink petals with sepals joined in a rounded, 10-veined calyx. Flowering occurs in late summer and in early fall. Nightflowering catchfly seed is similar in size and weight to alfalfa seed making them difficult to separate (McNeill 1980). A complete description of the biology of nightflowering catchfly was reported by McNeill (1980).

Chemical control of nightflowering catchfly in alfalfa has been achieved with preplant incorporated herbicides such as trifluralin (trifluro-2,6-dinitro-N,N-dipropyl-p-toluidine),benefin(N-butyl-N-ethyl- , , -trifluro-2,6-dinitro-p-toluidine), benefin and EPTC. Post-emergence chemicals such as bromoxynil, chloroxynil and MCPB (4-((4-chloro-o-tolyl)oxy)butyric acid) have also been used effectively. (Nelson and Johnson 1978, Billett and Strilchuk 1978, McNeill 1980).

American Dragonhead in Alfalfa

Little information is available on the biology or control of American dragonhead. A biennial member of the Mint family, the weed is most commonly found in the Prairie Provinces in forage fields and native grassland. Stems are 4-sided and erect with opposite leaves. Flowers are purplish and are borne in dense terminal spikes. Four seeds are produced in each flower by summer (Budd 1977).

No chemicals are recommended for American dragonhead control in established alfalfa. The fact that it germinates late in the summer and overwinters as a rosette makes seedling control using post-emergence broadleaf weed herbicides difficult. Control of rosettes was achieved at Stead, Manitoba, by applications of metribuzin at 0.2 and 0.4 kg a.i./ha, and with bromoxynil at 0.3 and 0.6 kg a.i./ha, (Todd 1982). Suppression of growth was obtained with 2,4-DB/asulam tank mixes in the same trial. However, in trials at Arborg neither metribuzin nor 2,4-DB gave acceptable results in American dragonhead (Pchajek 1981).

Table 2. Maximum Numbers of Nightflowering Catchfly and American Dragonhead Seed in Certified Alfalfa Seed.[1]

Class	Maximum Numbers Nightflowering Catchfly Seeds	Maximum Numbers American Dragonhead Seeds
	------- no./25 g Alfalfa Seed	--------------
Foundation #1	1	10
Foundation #2	2	75
Certified #1	1	10
Certified #2	2	75

[1]From Canada Seeds Regulations of the Canada Seeds Act.

CHAPTER III

THE EFFECTS OF COMPANION CROPPING ON WEED GROWTH AND ALFALFA ESTABLISHMENT IN ALFALFA SEED PRODUCTION

INTRODUCTION

Producers of alfalfa seed often plant cereal or oilseed companion crops with new seedings of alfalfa. This allows them to obtain saleable yields during the year of alfalfa establishment, when no alfalfa seed is expected.

The use of a companion crop can limit chemical methods of weed control. The choice of herbicides compatible with seedling alfalfa may be limited because of poor tolerance of the companion crop. On the other hand, the added competition imposed on weeds by the companion crop may enhance weed control. Seeded alone, alfalfa seedlings impose little competitive stress on weeds. A competitive, fast growing companion crop may serve to augment chemical usage for weed supression.

Companion crops also compete with alfalfa seedlings. In previous studies, companion crops have been shown to compete for growth factors to such a degree that growth and development of alfalfa were strongly suppressed during the seedling year. (Bula et al. 1968, Cooper and Ferguson

1964, Wynn-Williams 1976). Most workers agree, however, that alfalfa rapidly recovers from this suppression during its second season of growth, with no noticeable lowering of herbage yields (Buxton and Wedin 1970, Janson and Knight 1973). Effects of companion cropping on second-year alfalfa seed yields are not well-documented.

The present study was conducted to examine the effects of three companion crops on weed and alfalfa growth in seedling stands of alfalfa. Companion crops were evaluated for their ability to suppress broadleaf and grassy weeds. The effectiveness of herbicide combinations compatible within each companion crop was examined for suitability of control of common annual weeds. Assessments were made of the effects of the companion crops on light and moisture availability to alfalfa seedlings. Growth and development of alfalfa during both seedling and second year were measured.

MATERIALS AND METHODS

Trials were conducted in 1982 and 1983 on a well-drained clay loam (25% sand, 44% silt, 31% clay) at Portage la Prairie, Manitoba. The 1982 trial was established on a field previously sown to barley. The 1983 trial was carried out on land which was sown to fall rye the preceding season. Both sites were fertilized with ammonium phosphate fertilizer (11-55-0) broadcast at a rate of 108 kg/ha. Immediately following fertilizer application, the fields were disced twice to a depth of 15 cm and harrowed.

Experiments in both years were arranged in a split-plot design with four replicates. Seed of green foxtail (Setaria viridis), wild oats, (Avena fatua), redroot pigweed (Amaranthus retroflexus), lamb's-quarters (Chenopodium album) and nightflowering catchfly (Silene noctiflora) was hand broadcast over all replicates and harrowed in. The companion crops, included canola (var. "Regent"), sown at 3.5 kg/ha, flax (var. "Dufferin") sown at 19 kg/ha and wheat (var. "Neepawa") sown at 50 kg/ha. These were seeded into 8.4 m by 5.0 m main plots using a double disc seeder on May 19, 1982 and on May 24, 1983. In the 1983 trial, plot sizes were increased to 8.4 m by 7.5 m in order to obtain larger yield samples. One plot per replicate was not seeded with a companion crop. This treatment will hereafter be referred to as a clear-seeded control. Granular carbofuran (Furadan) was mixed with the canola at a rate of 5 kg/ha to prevent early season flea beetle damage.

Companion crop treatments were subdivided into three 2.8 m by 5.0 m subplots and cross-seeded with four rows of alfalfa (Medicago media Pers. var. 'Beaver') inoculated heavily with a dry commercial rhizobial culture (Rhizobium meliloti). Seeding was accomplished with a six-belt plot seeder on the same day as the companion crops were seeded. The depth of seeding was approximately 1 cm. The seeding rate was 1.5 kg/ha in 1982 and 1.1 kg/ha in 1983. The two outer rows were spaced 60 cm from the two inner rows which were set 30 cm apart.

Weed control subtreatments were applied to subplots within each companion crop treatment and included a weedy check, a handweeded treatment and a herbicide treatment.

Herbicide treatments were chosen on the basis of tolerance of crop combinations within each treatment, efficacy of weed control and spectrum of weeds controlled. Only chemicals recommended by Manitoba Agriculture were considered for inclusion in the trial. All rates are expressed as active ingredients. Herbicides used in wheat and the clear-seeded treatments were diclofop (190 g/L emulsifiable concentrate) (2-(4-(2,4-dichlorophenoxy) phenoxy) propanoic acid) applied at 0.7 kg/ha, followed four days later by 2,4-DB (400 g/L emulsifiable concentrate) (4-2(2,4-dichlorophenoxybutyric acid) at 1.2 kg/ha. Flax was treated with diclofop at 0.7 kg/ha, followed with a sequential application of MCPA (400 g/L emulsifiable concentrate) (((4-chloro-o-toly)oxyl)acetic acid) at 0.35 kg/ha. Canola was treated with diclofop at 0.7 kg/ha. No post-emergence broadleaf weed herbicide was used in the canola since none was recommended for the weed spectrum present in the plots.

The herbicides were applied with a bicycle sprayer. The spray volume was 149 L/ha and the chemicals were applied with Teejet 8001 stainless steel nozzle tips at 200 KPa pressure on the mornings of June 14 and 24 in the 1982 experiment and on June 7 and 11 in the 1983 trial.

Weed Control Assessments

Weeds were sampled from 1 m^2 quadrats taken in each of the subplots during the third week of July in both the 1982 and 1983 experiments. Counts were made of the principal species present. Dry weights were measured for each weed species after oven drying at 80°C for 72 hours.

Water Usage Measurements

Soil moisture was measured in each subplot in two replicates during the 1983 experiment. Weekly measurements were made of volumetric water content using a Troxler CM neutron probe placed in 5 cm-diameter aluminum access tubes sunk 120 cm into the centre of each subplot. Measurements were taken on medium count settings at 40 cm, 60 cm and 80 cm soil depths. Analysis of variance was performed on water content data, using a split-split plot design with companion crops as main treatments, weed control regimes as subtreatments and weekly water usage as sub-subtreatments.

Light Penetration to Alfalfa Seedlings

Penetration of solar radiation (400nm-1100nm) to alfalfa seedings was measured on July 6 in the 1982 experiment using a Li-Cor LI-185A light meter with a pyranometric sensor. Four readings were taken at random points throughout each plot at the level of the uppermost leaves of the alfalfa seedlings. In 1983, similar light measurements were made on a weekly basis from the time of crop emergence until harvest.

Alfalfa Development and Seed Yield

Dry matter production of alfalfa seedlings was measured by clipping 1 m row samples from each subplot in the third week of July in both 1982 and 1983. In the experiment established in 1982, dry weights of another 1 m row sample were measured the following spring on June 11, 1983.

In 1983, the 1982-seeded alfalfa was continuously handweeded. Dimethoate (Cygon) was applied as an overall spray for control of lygus bugs (*Lygus* spp.), adelphocoris (*Adelphocoris* spp.) and aphids (*Aphis* spp.) on July 1, 1983. Leafcutter bees (*Megachile rotundata*) were released onto the site on July 15, 1983, at a stocking rate of 80,000 bees/ha to permit maximum pollination of the crop site. Bees were removed from the site on August 15, 1983. The plots were cut with a swather and harvested on September 20, 1983, using a Hege plot combine. Pods were then press-rolled between continuous roller belts to thresh intact pods and the seed samples were screened. The samples were weighed and the results analyzed using analysis of variance and least significant differences procedures.

RESULTS

Weed Control Assessments

The total density of broadleaf weeds was approximately the same in both years, but there were fewer species in 1982 than in 1983 (Table 3). Densities of grassy weeds in

Table 3. Broadleaf Weed Growth in Companion Crop/Herbicide Treatment Combinations in 1982 and 1983.

Treatment	Redroot Pigweed		Lamb's-quarters		N. F. Catchfly		Total Broad-Leaf Weeds	
	Density	D.M.	Density	D.M.	Density	D.M.	Density	D.M.
	(no./m^2)	(g/m^2)	(no./m^2)	(g/m^2)	(no./m^2)	(g/m^2)	(no./m^2)	(g/m^2)
1982								
Clear-seeded chem[2]	12	18	1	2	-	-	11	28
Clear-seeded weedy	20	90	47	199	-	-	67	299
Flax chem	64	152	4	5	-	-	69	157
Flax weedy	24	74	19	137	-	-	41	211
Canola chem	16	61	56	256	-	-	73	317
Canola weedy	8	43	34	188	-	-	41	224
Wheat chem	1	4	1	3	-	-	2	7
Wheat weedy	11	39	11	80	-	-	22	118
LSD (0.05)[1]	35	75	28	86	-	-	34	96
1983								
Clear-seeded chem	6	13	1	9	68	80	75	102
Clear seeded weedy	11	62	8	164	35	100	54	326
Flax chem	4	6	3	8	50	64	57	78
Flax weedy	7	76	11	187	32	26	50	290
Canola chem	10	307	3	29	6	2	19	339
Canola weedy	17	205	5	107	24	18	48	345
Wheat chem	2	2	1	5	29	3	22	10
Wheat weedy	4	10	15	140	31	26	51	178
LSD (0.05)[1]	9	60	78	93	10	30	18	140

[1]LSD (0.05) is used for column comparisons.

[2]Chemicals used in clear-seeded and wheat treatments were 2,4-DB at 1.2 kg/ha and diclofop at 0.7 kg/ha, in flax treatments MCPA at 0.35 kg/ha and diclofop at 0.7 kg/ha, in canola diclofop at 0.7 kg/ha.

the 1983 experiment were only about half those of the 1982 study (Table 4). In 1982, the principal weed species were redroot pigweed, lamb's-quarters, green foxtail and wild oats. In 1983, the principal species were redroot pigweed, lamsquarters, green foxtail and nightflowering catchfly.

The mean summer temperature during the 1982 experiment was 1°C less than the 30-year average (Appendix 1). Temperatures during May, June, July and August, 1983, averaged 0.75°C higher than the 30-year average. Total precipitation during May, June, July and August, 1982, was 191 mm less than the 30-year average and, in 1983, 431 mm less than the 30-year average (Appendix 1).

Because of the differences in weed spectra, weed density and environmental conditions, data for the two years was not combined for analysis of weed or crop growth.

Effects of Companion Cropping on Weed Growth.

Significant interactions occurred between cropping treatments and weed control subtreatments in both years. As a result, weed suppression due to crop competition could not be assessed on the basis of treatment means. Instead, weed growth in weedy check sub-plots within wheat-, flax-, canola- and clear-seeded treatments was compared.

Table 4. Grassy Weed Growth in Companion Crop/Herbicide Treatment Combinations in 1982 and 1983.

Treatment	Wild Oats		Green Foxtail		Total Grassy Weeds	
	Density	D.M.	Density	D.M.	Density	D.M.
	(no./m^2)	(g/m^2)	(no./m^2)	(g/m^2)	(no./m^2)	(g/m^2)
1982						
Clear-seeded chem	2	7	33	50	33	81
Clear-seeded weedy	57	172	112	228	169	387
Flax chem	11	28	6	9	17	37
Flax weedy	62	179	139	236	200	453
Canola chem	0	0	3	4	4	17
Canola weedy	41	123	73	150	115	273
Wheat chem	0	0	4	4	4	3
Wheat weedy	17	69	42	71	58	146
LSD (0.05)[1]	14	42	34	42	30	68
1983						
Clear-seeded chem	-	-	18	80	-	-
Clear seeded chem	-	-	25	63	-	-
Flax chem	-	-	1	1	-	-
Flax weedy	-	-	9	21	-	-
Canola chem	-	-	0	0	-	-
Canola weedy	-	-	12	206	-	-
Wheat chem	-	-	0	0	-	-
Wheat weedy	-	-	13	83	-	-
LSD (0.05)[1]	-	-	15	24	-	-

[1]LSD (0.05) is used for column comparisons.

[2]Chemicals used in clear-seeded and wheat treatments were 2,4-DB at 1.2 kg/ha and diclofop at 0.7 kg/ha, in flax treatments MCPA at 0.35 kg/ha and diclofop at 0.7 kg/ha, in canola diclofop at 0.7 kg/ha.

In comparing weedy checks, the wheat companion suppressed dry matter production of redroot pigweed and lambsquarters by more than 50% in 1982, but did not significantly reduce growth of either weed in 1983 (Table 3). The wheat also reduced dry matter production of nightflowering catchfly, suppressing the weed by 74% in 1983. Densities of the three broadleaf weed species were not reduced by the presence of the wheat in either year (Table 3).

The wheat also reduced the growth of grassy weeds. In 1982, the dry matter of wild oats and green foxtail was reduced by 60 and 68%, respectively, while densities of the two weeds were lowered by 71 and 62%, respectively (Table 4).

Canola and flax were less effective than the wheat in suppressing broadleaf weed growth. Although both companion crops suppressed dry matter production of nightflowering catchfly by more than 70%, neither reduced the dry matter or densities of total broadleaf weeds in either 1982 or 1983 (Table 3).

Dry matter and density of grassy weeds were reduced by over 60% in canola treatments in 1982 but were unaffected by the presence of the crop in 1983. The flax companions did not reduce total growth of grassy weeds in either year (Table 4).

(ii) Efficacy of herbicides in companion crops.

Satisfactory chemical control of broadleaf weeds was attained with some chemical treatments, but not with others. The use of 2,4-DB in both clear-seeded plots and in plots seeded with wheat provided better control of redroot pigweed and lamb's-quarters than any other treatment in both years (Table 3). Control was slightly better when the 2,4-DB was used in conjunction with the wheat companion.

When 2,4-DB was used in clear-seeded plots, night-flowering cachfly initially suffered damage but recovered. In fact, spraying 2,4-DB exacerbated nightflowering catchfly infestations by removing competing weedy vegetation in the clear-seeded plots. However, when 2,4-DB was used in plots with a wheat companion crop, the nightflowering catchfly plants did not recover as rapidly as those in clear-seeded plots and good control of nightflowering catchfly was attained (Table 3). None of the plants went to seed.

MCPA provided poor control of redroot pigweed in flax in both years. (Table 3). In 1982, the sub-plots treated with MCPA contained more redroot pigweed than the weedy checks. Lamb's-quarters control with MCPA exceeded 95% in both 1982 and 1983 (Table 3). The chemical was ineffective in controlling nightflowering catchfly (Table 3).

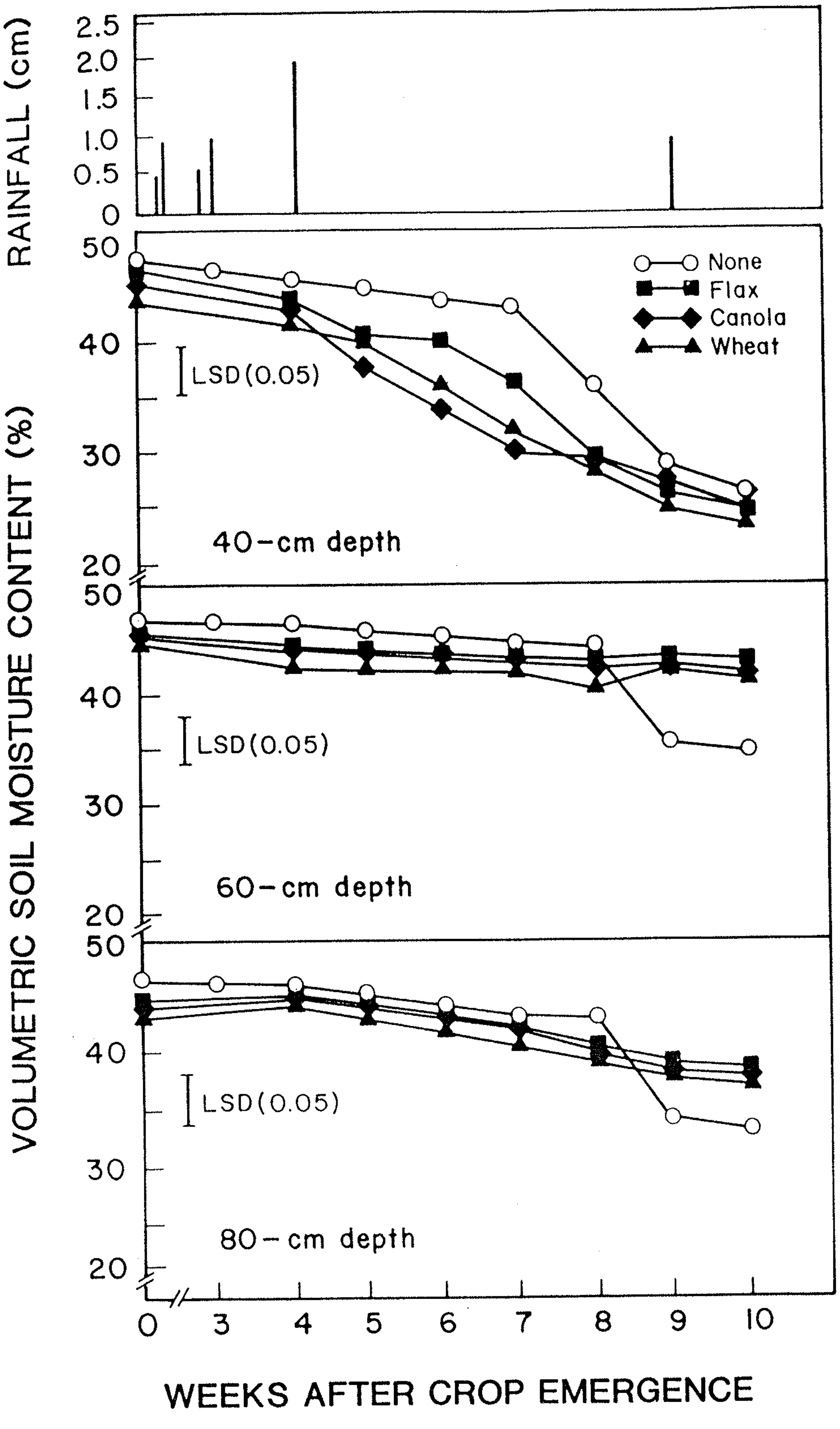
The lack of recommended post-emergence herbicides for broadleaf weed control in alfalfa planted with the canola companion crop led to unacceptably high populations of broadleaf weeds in both years. In fact, the dry matter of broadleaf weeds in subplots treated with diclofop was higher than in unsprayed subplots (Table 3). Diclofop effectively controlled grassy weeds in the flax, wheat and canola, and in the clear-seeded plots in both 1982 and 1983. However, the dry matter and density of green foxtail was slightly lower when diclofop was sprayed on the plots sown to a companion crop compared to the clear-seeded controls.

Effects of Companion Cropping and Weed Control Methods on Soil Moisture.

Volumetric soil moisture content at depths of 40, 60 and 80 cm ranged from 45 to 50% at seeding time. Soil moisture levels declined over the season at all depths, with the largest decline occurring in the upper layer (Figure 1).

Water depletion patterns at all depths were similar among all companion crop treatments during the first four weeks following crop emergence. During the period from the fifth to seventh week after emergence, soil moisture levels at the 40 cm depth in plots with companion crops fell below those of plots with no companion crop (Figure 1). By the seventh week after emergence, the soil water content of the clear-seeded controls was 42% compared to 37, 32 and 30% for flax-, canola- and wheat-seeded treatments, respectively.

In the plots with companion crops, the soil moisture content declined less rapidly in the two weeks prior to


RAINFALL (cm)
2.5
2.0
1.5
1.0
0.5
0
VOLUMETRIC SOIL MOISTURE CONTENT (%)
50
40
30
20
None
Flax
Canola
Wheat
LSD(0.05)
40-cm depth
60-cm depth
80-cm depth
0
3
4
5
6
7
8
9
10
WEEKS AFTER CROP EMERGENCE

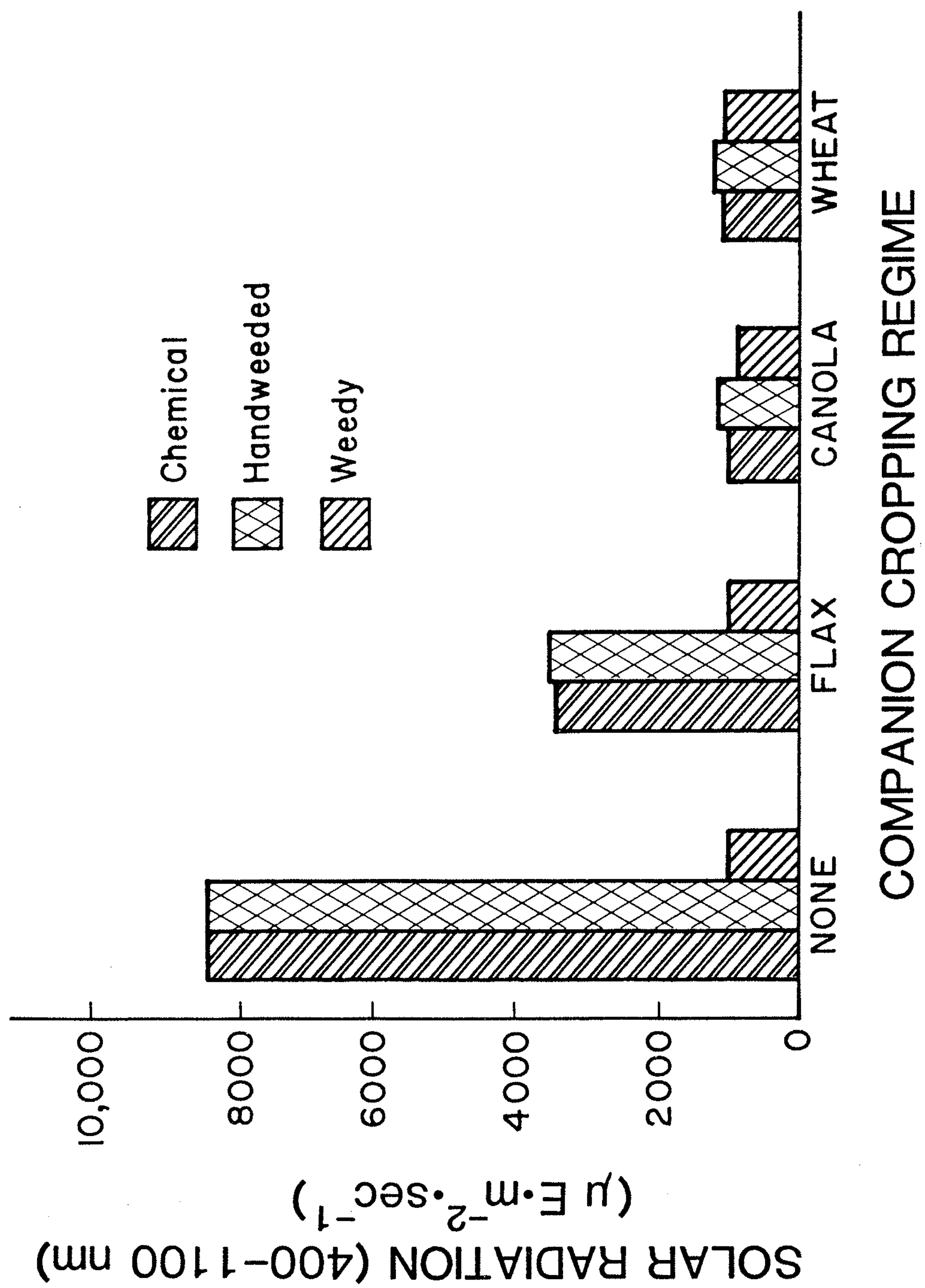
harvest compared to in the previous weeks. The soil water content at the 40 cm depth in clear-seeded plots declined steeply from 42.5% to 27.5% in the last four weeks. Alfalfa plants in these plots were large and healthy and undoubtedly were consuming larger amounts of water than the plants in the companion-cropped plots. As a result, water consumption was also increased at the 60 and 80 cm depths as well (Figure 1). Neither alfalfa nor any of the companion crops exhibited outward signs of drought stress or wilting in 1983, despite the very low amount of precipitation in July and August (Figure 1).

Effects of Companion Cropping and Weed Control on Light Penetration to Alfalfa Seedlings.

Companion cropping sharply reduced penetration of solar radiation to alfalfa seedlings in 1982 (Figure 2). In weed-free subplots, light penetration to alfalfa seedlings at canopy closure (July 17) was reduced to 35% of full sunlight by the flax companion crop. Also in weed-free subplots, canola and wheat companions reduced light infiltration to the alfalfa understory to 11% and 14% of full sunlight, respectively.

Weedy growth reduced light penetration to less than 12% of full sunlight in the flax and the clear-seeded controls. Weeds did not reduce light penetration significantly below levels found in weed-free subplots within wheat and

Figure 2. The effects of companion crops on the penetration of solar radiation to alfalfa seedlings (1982).


SOLAR RADIATION (400–1100 nm)
(μ E•m^{-2}•sec^{-1})
10,000
8000
6000
4000
2000
0
NONE
FLAX
CANOLA
WHEAT
COMPANION CROPPING REGIME
Chemical
Handweeded
Weedy

canola treatments, probably because of the decrease in weed growth in those treatments due to crop competition.

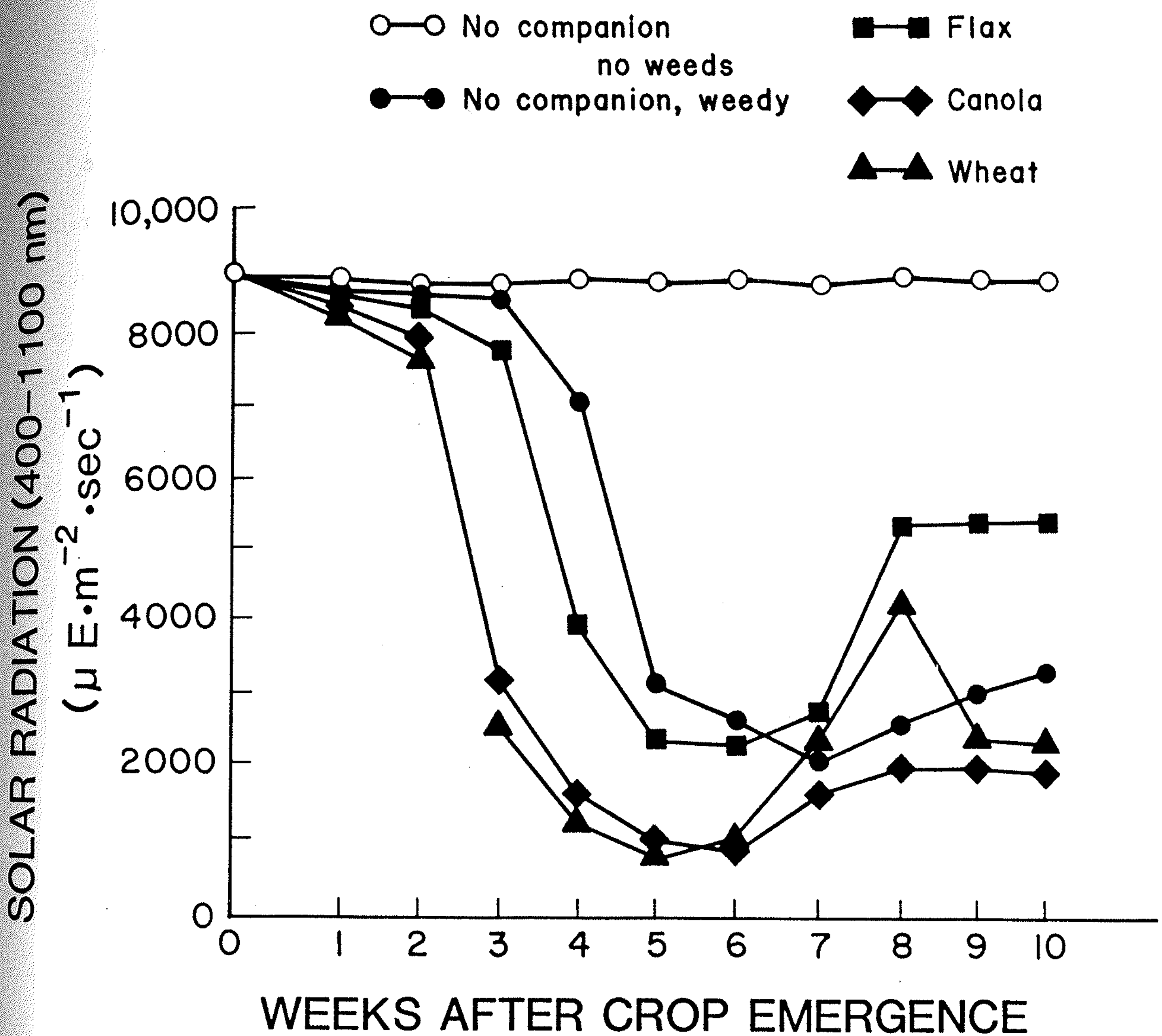
In 1983, sharp reductions in solar irradiance occurred within the companion crops (Figure 3). During early July, light penetration to alfalfa seedlings dropped rapidly in plots sown to either canola or wheat. This corresponded to a time of rapid stem elongation in the companion crops. In the flax, light reductions over time were less than in canola or wheat but more than in the weedy, clear-seeded plots. By mid-July, six weeks after seeding, weed growth in the weedy check subplots of the clear-seeded plots restricted light penetration to the same degree as the companion crops.

The greatest light reductions occurred on July 6 in all companion crops, with wheat and canola both reducing light penetration to alfalfa seedlings to only 9% of full sunlight. In contrast, flax reduced light penetration to 25% of full sunlight. The greatest light reduction for clear-seeded, weedy checks occurred two weeks later (July 13-21). In these plots, irradiance was reduced to 28% of full sunlight.

Crop Growth During Seedling Year of Alfalfa

Yields of companion crops were affected by weed control subtreatments. Weeds depressed yields of flax the most, but yields of canola and wheat were also considerably

Figure 3. The effects of companion crops on light penetration to alfalfa seedlings over a season (1983).



No companion no weeds
No companion, weedy
Flax
Canola
Wheat
SOLAR RADIATION (400–1100 nm) (μ E·m^{-2}·sec^{-1})
10,000
8000
6000
4000
2000
0
0
1
2
3
4
5
6
7
8
9
10
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lower in the weedy subplots than in the weed-free subplots (Table 5). Higher yields of flax and wheat were obtained in the herbicide-treated subplots within flax and wheat, but canola yields were not depressed because of the presence of high populations of uncontrolled broadleaf weeds.

In 1982, an analysis of dry matter production of alfalfa seedlings showed that significant interactions occurred between companion crop treatments and weed control subtreatments. As a result, seedling growth of alfalfa could not be assessed on the basis of treatment means. This interaction did not occur in the 1983 trial, where weed control subtreatments did not have any significant effects on alfalfa seedling growth. Differing results between the two years' experiments were probably due to the sparser weed densities encountered in 1983.

Alfalfa growth in plots seeded with flax, canola or wheat was strongly suppressed in both 1982 and 1983 experiments (Table 6). The alfalfa plants sown with canola and wheat were etiolated, only 20 to 25 cm tall, and had few leaves. Seedlings in flax treatments were slightly more vigorous, approximately 50 cm tall in both years, and had more leaves than the seedlings undersown to canola or wheat. Some of the alfalfa plants in flax treatments flowered during the seedling years. Nevertheless, dry matter production of alfalfa seedlings in the flax plots was not significantly higher than in the canola or wheat (Table 6). By mid-July,

Table 5. Yields of Companion Crops Under Various Weed Control Regimes in 1982 and 1983.

Treatment	1982 yield	1983 yield
	(g/m²)	
Flax Weedy	33	22
Flax Chem	145	156
Flax Handweeded	184	217
LSD (0.05)[1]	51	59
Canola Weedy	46	181
Canola Chem	93	185
Canola Handweeded	174	204
LSD (0.05)[1]	38	43
Wheat Weedy	321	398
Wheat Chem	451	438
Wheat Handweeded	476	417
LSD (0.05)[1]	47	39

[1]LSD (0.05) is used for comparison within treatments.

Table 6. Seedling Growth of Alfalfa Under Various Companion Crop Regimes.

Treatment	Dry Matter of Alfalfa	
	1982	1983
	(g/m)	
Clear-Seeded Chem	32.6	170.5
Clear-Seeded Handweeded	39.7	173.8
Clear-Seeded Weedy	1.4	120.5
Flax Chem	1.7	10.9
Flax Handweeded	3.7	21.1
Flax Weedy	0.4	20.5
Canola Chem	1.0	4.3
Canola Handweeded	1.2	4.1
Canola Weedy	0.4	3.1
Wheat Chem	0.3	2.1
Wheat Handweeded	5.6	3.5
Wheat Weedy	1.0	0.9
LSD (0.05)[1]	9.3	33.4

[1]LSD (0.05) is used for column comparisons

alfalfa seedlings in all three companion crops had attained less than one-tenth the dry matter measured in clear-seeded plots in both 1982 and 1983. The dry matter production of alfalfa seedlings in plots sown with a companion crop ranged from 0.7 to 1.5 g/m row in the two years. In contrast, dry matter production of alfalfa seedlings in the clear-seeded hand-weeded plots averaged 39.7 g/m row in 1982 and 170 g/m row in 1983 (Table 6). Neither handweeding nor herbicide treatments resulted in increased vigor of alfalfa seedlings when companion crops were used.

In plots with no companion crop, both handweeded and chemically-treated sub-plots contained more vigorous alfalfa seedlings than the weedy sub-plots (Table 6). In 1982, hand-weeded sub-plots contained 32.6 to 39.7 g/m row alfalfa dry matter whereas weedy checks contained only 1.4 g/m row. This reduction was similar to the reduction in the companion-cropped plots. In 1983, reductions of alfalfa vigor in weedy checks within clear-seeded plots were not as large as those caused by companion cropping in 1983 (Table 6). This was due to lower populations of weeds in that year.

Alfalfa Development During the Year After Seeding

Flax, canola, and wheat depressed second season regrowth of 1982-established alfalfa to the same level (Table 7). Alfalfa clipped on June 11, 1983, from plots which had

Table 7. Second Season Development of Alfalfa Following Seedling Year Companion Cropping.

Treatment	Dry Matter in Early Spring 1983	Seed Yield 1983
	----(g/m row)----	----(g/m^2)----
Clear-Seeding Chem	121	44.7
Clear-Seeding Handweeded	139	42.9
Clear-Seeding Weedy	69	44.1
Flax Chem	61	47.4
Flax Handweeded	73	46.7
Flax Weedy	73	32.6
Canola Chem	54	45.0
Canola Handweeded	73	46.0
Canola Weedy	54	22.7
Wheat Chem	72	58.1
Wheat Handweeded	49	43.9
Wheat Weedy	57	24.5
LSD (0.05)[1]	34	18.3

[1]LSD (0.05) is used for column comparisons.

been companion cropped weighed 50 to 79 g/m row compared to 120 to 140 g/m row in clear-seeded controls where handweeding or herbicides were employed. In weedy sub-plots of clear-seeded controls, regrowth of alfalfa seedlings was depressed to approximately the same level as in plots where companion crops had been used.

Differences between treatments in spring recovery were less noticeable as the season progressed. By mid-summer, the vegetative growth in all plots was healthy, with no distinguishable set-back of alfalfa occurring in plots that had been companion cropped the preceding season. Flowering of alfalfa plants occurred 8-10 days later in plots that had been companion cropped the previous season and in weedy checks of clear-seeded plots, compared to weeded sub-plots of clear-seeded treatments.

Reductions in seed yield of the alfalfa established in 1982 occurred only in plots which had been companion-cropped without weed control (Table 7). Seed yield in these plots was consistently 12-15 g/m^2 lower than seed yield in clear-seeded plots or in companion-cropped plots in which weeds were controlled either through hand-roguing or through use of chemicals.

DISCUSSION

In this study, the choice of herbicide treatments recommended within the various companion crops was more important than the potential of the crops to suppress weeds. In no case did crop competition result in more than a 55% suppression of mixed weed populations (Tables 3 and 4). Acceptable weed control within the three companion crops was attained only in the herbicide-treated subplots. Some chemicals gave well over 90% control of weeds (Tables 3 and 4).

Large differences occurred in the effectiveness of the herbicide treatments used in each of the companion crops. Control of the weed spectrum present in these experiments was generally better in wheat than in canola or flax, largely because of the greater effectiveness of 2,4-DB compared to the herbicides used in the other crops (Table 3). 2,4-DB gave 90% control of broadleaf weeds in the wheat, compared to only 50% control attained by MCPA in flax and no control in canola due to the lack of any broadleaf weed herbicide in that crop.

In most cases, the yields of the companion crops were enhanced in the herbicide-treated plots but chemical application did not enhance the development of the alfalfa seedlings. While the yields of the three companion crops were up to 90% higher in handweeded or chemically-treated subplots than in weedy subplots (Table 5), growth of the alfalfa seedlings was similar regardless of the presence or absence of weed control (Table 6). This indicates that companion crops effectively exploited the growth resources made available by the removal of weeds and competed with the undersown alfalfa as heavily as when weeds were allowed to remain in the companion crop.

The use of herbicides in combination with a companion crop, as opposed to the use of herbicides alone without a companion crop, provided two advantages. Firstly, the companion crops suppressed weeds that germinated after a post-emergence chemical was applied. Control of green foxtail exceeded 90% in both years' experiments when diclofop was applied in the three companion crops but was only 80% and 0% in 1982 and 1983, respectively, when it was used in clear-seeded plots (Table 6). Secondly, the companion crops suppressed nightflowering catchfly, a weed that is fairly tolerant to 2,4-DB. Within clear-seeded plots, nightflowering catchfly was injured from 2,4-DB treatments but the weed recovered rapidly and grew vigourously in these plots, primarily because the other competing broadleaf weeds were killed. However, in plots where the same chemical was used in wheat the nightflowering catchfly did not recover from the 2,4-DB treatments, probably because of the additional competitive stress imposed by the crop. Dry matter production in 2,4-DB-treated subplots of wheat was only one-third of that measured in 2,4-DB-treated subplots with no companion (Table

3). Nightflowering catchfly plants that survived in the wheat were stunted and failed to flower by harvest.

Greater light penetration and greater moisture availability in the flax compared to in the wheat and canola (Figures 1 and 2) did not result in significantly higher dry matter production of underseeded alfalfa than that measured in either of wheat or canola (Table 6). The lack of response to less competitive companion crops has been noted in other experiments (Smith et al. 1956, Bula et al. 1954, Wynn-Williams 1976c). Bula et al. (1954) suggested that the less competitive companion crops allowed for more vigourous weed growth rather than increased growth of alfalfa. This clearly is not the case in this study, since when comparing between the weed-free subplots within the three companion crops, there were no differences in alfalfa dry matter production. The reasons for the lack of response of alfalfa to companion cropping with the less competitive crops are not immediately apparent.

Some workers maintain that the overwintering ability of alfalfa seedlings is correlated with the degree of seedling development attained prior to the onset of winter (Steponkus 1978). If this is so, alfalfa seedlings grown with companion crops may have been vulnerable to winterkill, since these plants were, by the onset of winter, far less advanced than alfalfa in clear-seeded plots.

In contrast, the risk of winterkill in companion-cropped plots may have been minimized by the presence of cereal or oilseed crop stubble left to act as a trap for insulating snow. Previous work has shown that the presence of stubble has a beneficial effect on overwintering capability and spring regeneration of alfalfa (Kilcher and Heinrichs 1960).

The reduced seed yield of alfalfa in the second year in plots which were established with a companion crop but without weed control, indicate that simultaneous competition from weeds and companion crops affected seed yield, whereas either factor alone did not (Table 7). The apparent additive effects of competition on alfalfa seed yields were not correlated with the total mass of vegetation competing with alfalfa seedlings. It is possible that the reduced seed yields in these plots were due to weeds germinating later in the spring in the establishment year and continuing to grow late into the season after the companion crops were mature. This would result in a lengthening of the duration of competition with the alfalfa seedlings and could account for the lower seed yields.

The similarity of alfalfa seed yields between clear-seeded plots and companion cropped plots in which weeds were controlled indicates that it is possible to utilize companion crops in establishing seedling alfalfa without reducing alfalfa seed yields. On this soil type, and under the environmental conditions of 1982 and 1983, companion cropping of alfalfa did not reduce second season yields of alfalfa seed. In commercial production, this would have allowed the advantage of saleable yields in seedling year without the disadvantage of reduced yields of alfalfa seed the following year. Assessment of the practice on a wider scale is necessary to determine if the same result would be obtained in other years and on other soil types.

None of the three companion crops in this experiment allowed significantly better growth of alfalfa than the others, despite the differences in the relative competitive ability of flax, canola and wheat. The principal criterion in choosing one of the three companion crops, then, is the potential economic return of the companion. Since the efficiency of weed control within the companion crops has a great effect on companion crop yield, the efficiency and cost of the recommended herbicides must also be considered.

CHAPTER IV

WEED SURVEYS OF ALFALFA SEED FIELDS

INTRODUCTION

Past weed surveys in Manitoba have been useful in quantifying the extent and distribution of weed problems in cultivated land (Thomas 1979a and 1981). In these surveys, data from province-wide weed counts and grower questionnaires were summarized to provide information on species distributions and densities and on weed control practices employed by growers.

No similar survey has been conducted in alfalfa seed fields in the province. Quantification of weed problems and assessments of control practices would give indications as to the prevalence of common weed species as well as the potential for improvements in control methods.

MATERIALS AND METHODS

The numbers and locations of established, certified seed fields in Manitoba were determined prior to the survey by summarizing 1982 applications for field registration made to the Plant Products and Quarantine Division of Agriculture Canada (Winnipeg). A list of fields compiled from these records provided a data base for sample planning of a field survey and the mailing of grower questionnaires.

Field Survey

Distribution of sampling through the province was determined by stratifying fields into 4 regions based on edaphic and geographic considerations. The 4 regions were designated as 1) Interlake, 2) Parklands 3) Southcentral, and 4) Southeast regions (Figure 4). Thirty six percent of the fields within each region were chosen at random. In total, 77 of the 211 fields catalogued were sampled.

Sampling began June 12, 1983 and ended July 10, 1983. Counts were taken in 1 m2 quadrats at 20 equispaced points along a "W"- pattern walked through the field as previously described by Thomas (1981) (Figure 5). Density counts were recorded for all species in the quadrat in a chart form (Figure 6). In the case of perennial grasses, numbers of culms were counted. In quadrats where the density of culms was greater than could be reasonably counted and recorded, density of the species was recorded as being greater than 100 culms/m2. Unidentified species were catalogued and pressed for later identification. Each species was evaluated in terms of 1) percentage of fields in which the weed occurred, 2) uniformity of infestations within each field, 3) average density of infestations and 4) relative abundance of the species. Relative abundance is a derived value

Figure 4. Stratification of the survey of alfalfa seed fields in Manitoba.

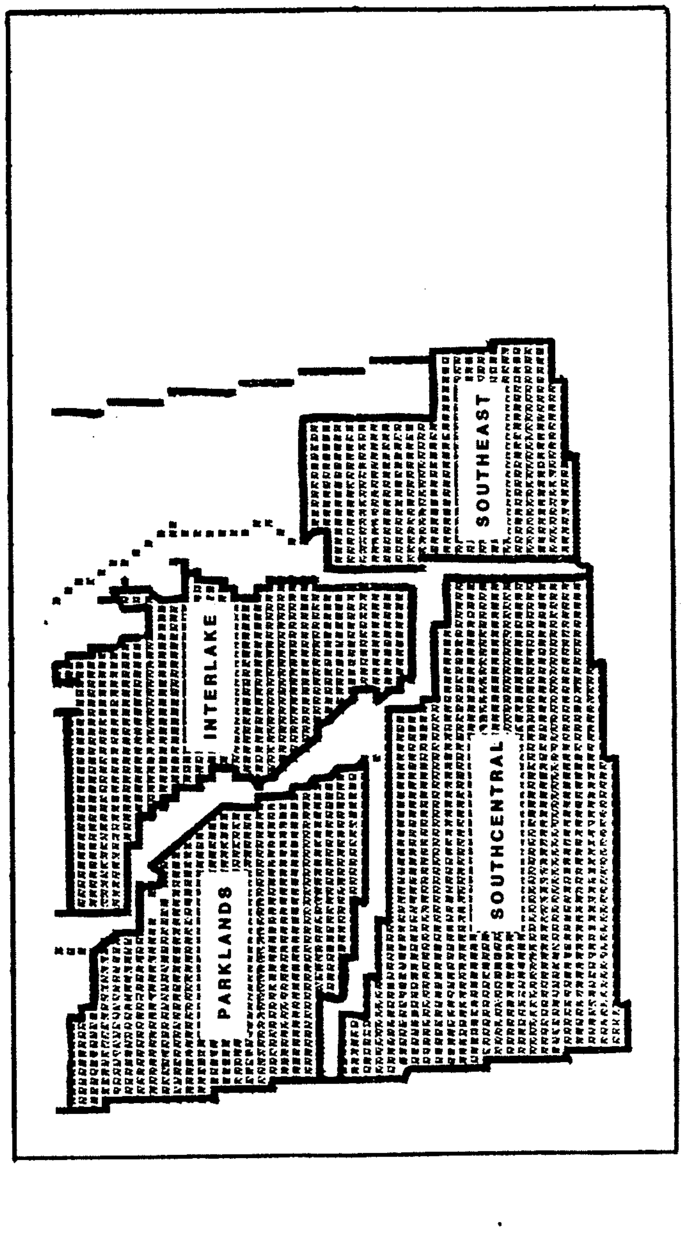

SOUTHEAST
INTERLAKE
SOUTHCENTRAL
PARKLANDS

Figure 5. Sampling pattern through individual fields on the survey of alfalfa seed fields

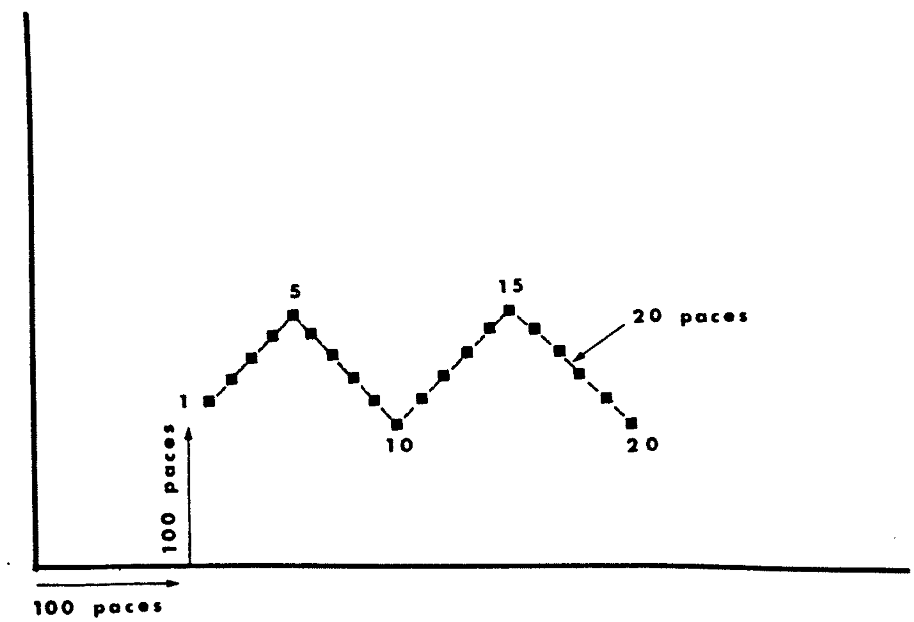

5
15
20 paces
1
10
20
100 paces
100 paces

Figure 6. Recording charts used for weed counts in the survey of alfalfa seed fields.

Municipal.	Twp	Range	E-W	Section	Quarter	Stop	Year	Day	Month	Crop	Region	Ag Rep	Weed	Crop
1 2 3	4 5	6 7	8	9 10	11 12	13 14	15 16	17 18	19 20	21 22 23	24	25 26	27 28	29 30

Species	Code	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Green foxtail	1271																				
Wild buckwheat	1097																				
Wild mustard	1496																				
Wild oats	1509																				
Redroot pigweed	1529																				
Lamb's-quarters	1420																				
Canada thistle	1693																				
Sow-thistle	1644																				
Stinkweed	1672																				
Smartweed	1626																				
No weeds	9999																				

31 35 43 51 59 67 7

calculated from frequency, density and uniformity data. The method of calculation is described in Figure 7. Data for each species was summarized on both a provincial and a regional basis, using a computer program developed for weed surveys at the Regina Research Station of Agriculture Canada.

Grower Questionnaires

A two-page questionnaire (Appendix 2) was mailed to all of the 123 growers listed in the 1982 field registration records. The questionnaire consisted of 13 questions asking for details of general production practices and weed control methods employed by growers in their alfalfa seed fields. One questionnaire was provided for each field registered by the grower the previous year, with an additional questionnaire provided in case of a shortfall.

One question required respondents to indicate what their five worst weeds were in descending order of importance, both during the year the stand was established and during the remainder of the stand's life. Each species was evaluated in terms of 1) frequency of mention and 2) a severity score. Severity scores for weeds were calculated by assigning values to individual species based on how high the grower ranked the weed. A weed ranked first was scored with a value of 5, second was scored with a 4, third with a 3, fourth with a 2, and fifth a 1. Scores for each species were then summed to obtain a unitless representation of the

Figure 7. Method of calculation of relative abundance.

Relative frequency for species k (RF_k)=

$$\frac{\text{frequency value of species k}}{\text{sum of frequency values for all species}} \times 100$$

Relative field uniformity for species k (RU_k)=

$$\frac{\text{field uniformity value of species k}}{\text{sum of field uniformity values for all species}} \times 100$$

Relative mean field density for species k (RD_k)=

$$\frac{\text{mean field density value of species k}}{\text{sum of mean field density values for all species}} \times 100$$

Relative abundance for species k (RA_k)=

$$RF_k + RU_k + RD_k$$

severity of each weed species relative to others mentioned by the producers.

Several steps were taken to maximize the response rate of the survey. Self-addressed, stamped return envelopes were included in the package. A letter appealing for cooperation and promising a summary of results was mailed in the same envelope (Appendix 3). Recipients who had not responded within 90 days were sent a reminder stressing the importance of the study and the possibility of information arising that would be of direct benefit to the industry.

Responses were tabulated and results categorized both in terms of total area and numbers of fields. Questions left unanswered or answered ambiguously were categorized as having no response.

RESULTS

Field Survey

Fifty-nine species, including 6 perennial grasses, 4 annual grasses, 17 perennial or biennial broadleaf weed species and 32 annual broadleaf weeds were recorded in the survey (Table 8). Ten species occurred in 30% or more of fields. Specific information on the regional breakdown of weed species in the survey is included in Appendix 4.

The three most common weeds in the survey were perennials. Quackgrass (*Agropyron repens*), Canada thistle (*Cirsium arvense*) and dandelion (*Taraxacum officinale*)

Table 8. All species found during the survey of 77 alfalfa fields. Species are ranked by the relative abundance value.

	SPECIES	FREQUENCY	FIELD UNIFORMITY (ALL FIELDS)	FIELD DENSITY (ALL FIELDS)	FIELD DENSITY (OCCURRENCE FIELDS)	RELATIVE ABUNDANCE
		(%)	(%)	(#/m^2)	(#/m^2)	
1.	Quack grass	64.9	21.5	15.2+	23.4+	61.2+
2.	Dandelion	79.2	28.2	1.1	1.4	24.8
3.	Canada thistle	77.9	26.6	1.3	1.6	24.4
4.	Poa spp.	28.6	6.3	5.1+	18.6+	20.8+
5.	Sow-thistle spp.	57.1	15.1	1.3	2.3	17.0
6.	Wild buckwheat	50.6	14.9	0.7	1.5	14.6
7.	Wild mustard	48.1	13.8	0.9	1.8	14.1
8.	Wild oats	39.0	9.5	0.9	2.3	11.3
9.	Narrow-leaved hawk's-beard	29.9	9.6	0.8	2.9	10.1
10.	Bromus spp.	16.9	3.1	2.0+	11.7+	9.0+
11.	American dragonhead	36.4	7.7	0.2	0.6	8.2
12.	Timothy	13.0	2.5	1.5+	11.7+	7.0+
13.	American vetch	29.9	4.9	0.1	0.5	6.0
14.	Lamb's-quarters	27.3	4.9	0.2	0.9	5.9
15.	Plantain spp.	22.1	4.2	0.2	1.0	5.0
16.	Stinkweed	22.1	4.0	0.2	1.0	4.9
17.	Sweet clover (white and yellow)	26.0	3.6	0.1	0.5	4.9
18.	Hemp-nettle	16.8	3.3	0.3	1.5	4.1
19.	Smartweed (annual) spp.	24.7	2.6	0.1	0.3	4.1
20.	Field horsetail	19.4	3.2	0.2	0.8	4.1

Table 8. (continued)

SPECIES	FREQUENCY	FIELD UNIFORMITY (ALL FIELDS)	FIELD DENSITY (ALL FIELDS)	FIELD DENSITY (OCCURRENCE FIELDS)	RELATIVE ABUNDANCE
	(%)	(%)	(#/m^2)	(#/m^2)	
21. Night-flowering catchfly	15.6	2.6	0.3	1.7	3.7
22. Green foxtail	18.2	2.0	0.2	1.4	3.6
23. Flixweed	13.0	2.3	0.1	1.0	2.9
24. Kochia	7.8	1.4	0.4	5.1	2.9
25. Canada goldenrod	11.7	2.3	0.1	0.8	2.6
26. White clover	14.3	1.7	0.1	0.2	2.4
27. Rough cinquefoil	9.1	2.0	0.1	0.5	2.0
28. Northern bedstraw	9.1	0.9	0.1	0.3	1.3
29. Absinth	7.8	1.4	0.1	0.3	1.6
30. Shepherd's-purse	7.8	1.2	0.1	0.6	1.5
31. White cockle	7.8	0.6	0.1	0.1	1.2
32. Annual fleabane	6.5	0.8	0.1	0.4	1.1
33. Hare's-ear mustard	3.9	1.1	0.1	1.2	1.1
34. Rye	1.3	0.3	0.3	19.8	1.0
35. Canada anemone	5.2	0.6	0.1	0.3	0.9
36. Red clover	6.5	0.4	0.1	0.1	0.9
37. Cleavers spp.	2.6	0.5	0.1	3.0	0.7
38. Foxtail barley	5.2	0.3	0.1	0.1	0.7
39. Yellow evening-primrose	1.3	0.6	0.1	4.0	0.6
40. Annual bluegrass	2.6	0.2	0.1	2.4	0.6

Table 8. (continued)

SPECIES	FREQUENCY	FIELD UNIFORMITY (ALL FIELDS)	FIELD DENSITY (ALL FIELDS)	FIELD DENSITY (OCCURRENCE FIELDS)	RELATIVE ABUNDANCE
	(%)	(%)	(#/m^2)	(#/m^2)	
41. Redroot pigweed	2.6	0.5	0.1	0.5	0.5
42. Wood's rose	2.6	0.3	0.1	0.2	0.5
43. Scentless chamomile	1.3	0.6	0.1	0.8	0.4
44. Water-parsnip	1.3	0.6	0.1	0.7	0.4
45. Alsike clover	1.3	0.5	0.1	0.6	0.4
46. Yarrow	1.3	0.3	0.1	0.5	0.3
47. Stork's-bill	1.3	0.3	0.1	0.4	0.3
48. Pineappleweed	1.3	0.2	0.1	0.9	0.3
49. Bluebur	1.3	0.2	0.1	0.2	0.2
50. Dock	1.3	0.2	0.1	0.2	0.2
51. Wormseed mustard	1.3	0.1	0.1	0.6	0.2
52. Bird's-foot trefoil	1.3	0.1	0.1	0.1	0.2
53. Pygmyflower	1.3	0.1	0.1	0.1	0.2
54. Biennial wormwood	1.3	0.1	0.1	0.1	0.2
55. Milkweed spp.	1.3	0.1	0.1	0.3	0.2
56. Purslane	1.3	0.1	0.1	0.2	0.2
57. Cocklebur	1.3	0.1	0.1	0.1	0.2
58. Common pepper-grass	1.3	0.1	0.1	0.1	0.2

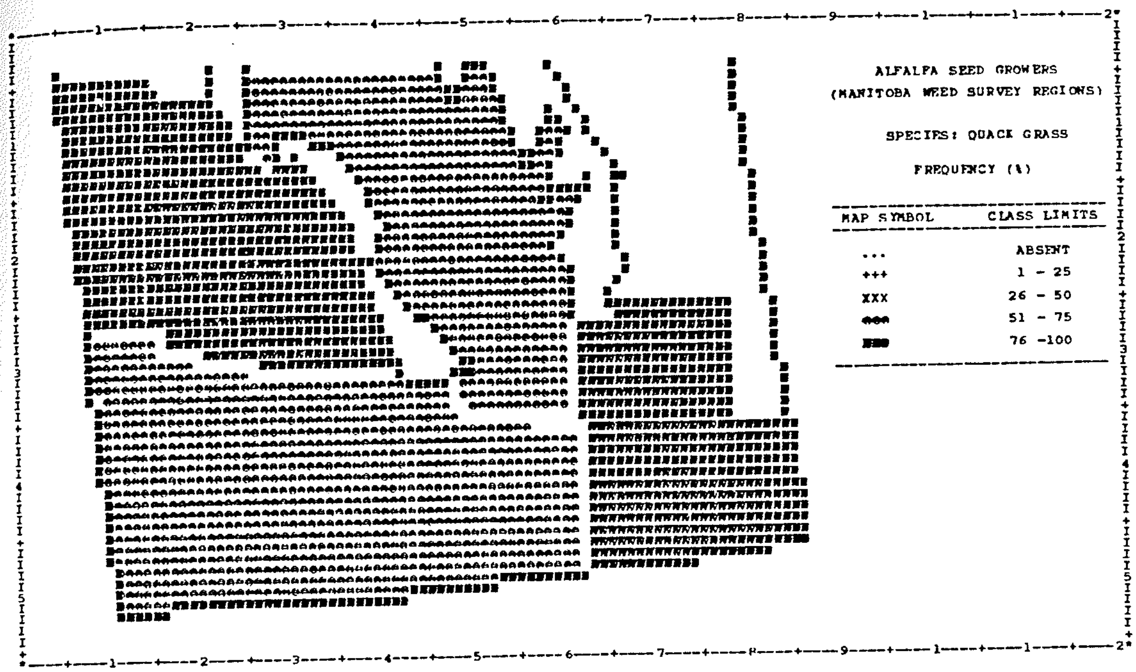
infested 65%, 79% and 78% of the fields, respectively (Table 1). Dandelion and quackgrass were evenly distributed throughout all four regions (Figures 8 and 9). Canada thistle also occurred throughout the province but was less abundant in the Parklands Region, with frequency of infested fields being only three-quarters of the provincial average and densities in occurrence fields approximately one-half those found in other regions (Figure 10).

Five other weeds were present in more than 30% of fields surveyed. Wild buckwheat (_Convulvulus arvensis_), wild mustard (_Sinapsis arvensis_), wild oats (_Avena fatua_), narrow-leaved hawk's-beard (_Crepis tectorum_) and American dragonhead (_Dracocephala parviflora_) occurred at average densities ranging from one to three plants/m^2 (Table 8). American dragonhead, wild buckwheat and wild oats were 1.5 to 3 times as abundant in the Parklands Region as the provincial average (Figures 11 to 13). The abundance of wild mustard in the two southern regions was 3 to 5 times greater than in the two more northerly regions (Figure 14). Narrow-leaved hawk's-beard infested only 17% of fields in the Southeast Region, compared to between 33 and 38% of the fields in the other three regions (Figure 15). Distributions and densities of bluegrass (_Poa_ spp.), sow-thistle (_Sonchus_ spp.) and bromegrass (_Bromus_ spp.) are depicted in Figures 16 to 18.

Grower Questionnaires

Although aspects of general field management were included in the questionnaire, only the responses pertaining

Figure 8. Distribution and densities of quackgrass through Manitoba. (1983 Field Survey)


ALFALFA SEED GROWERS
(MANITOBA WEED SURVEY REGIONS)
SPECIES: QUACK GRASS
FREQUENCY (%)
MAP SYMBOL CLASS LIMITS
... ABSENT
+++ 1 - 25
XXX 26 - 50
51 - 75
76 -100

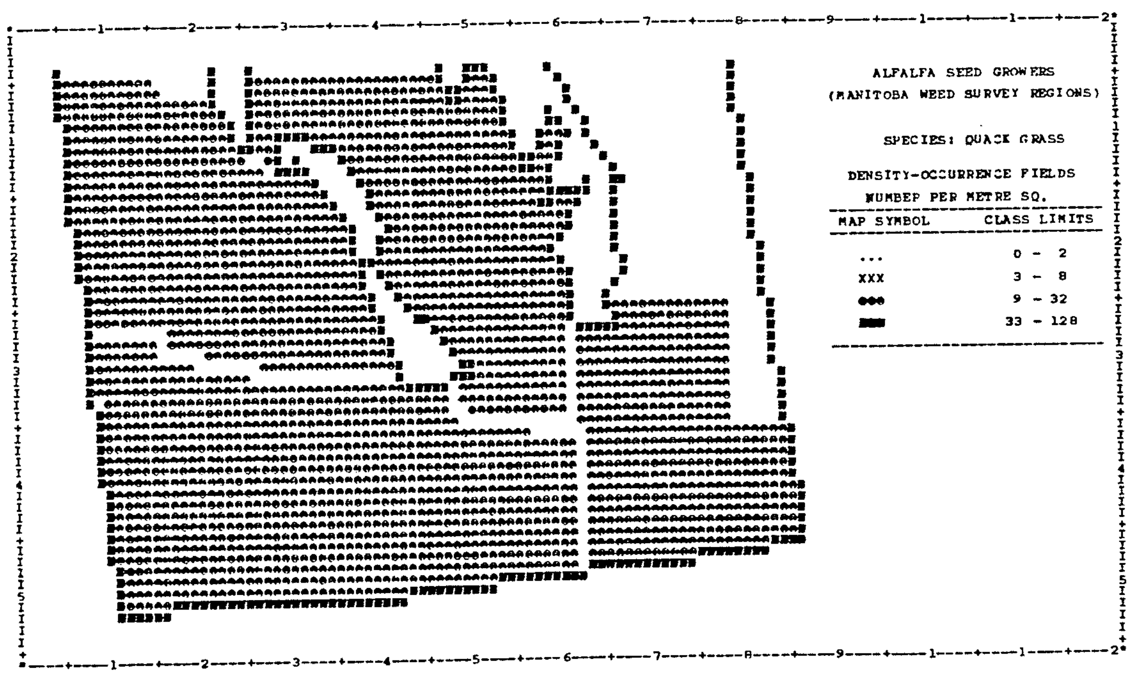
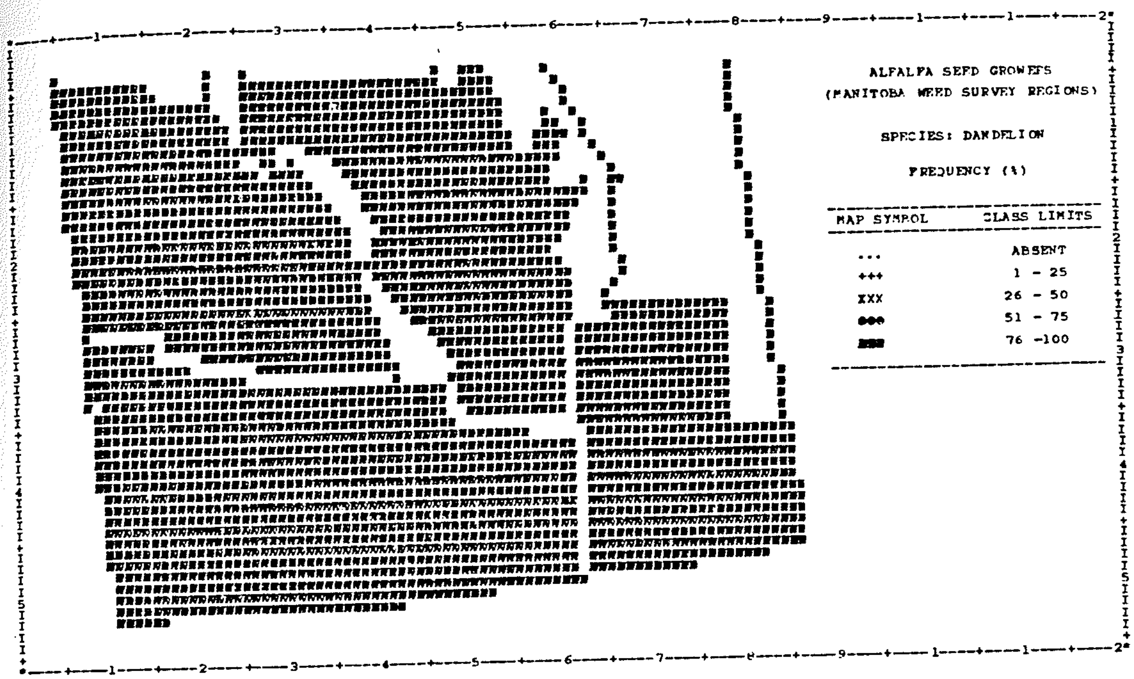

ALFALFA SEED GROWERS
(MANITOBA WEED SURVEY REGIONS)
SPECIES: QUACK GRASS
DENSITY-OCCURRENCE FIELDS
NUMBER PER METRE SQ.
MAP SYMBOL CLASS LIMITS
... 0 - 2
XXX 3 - 8
9 - 32
33 - 128

Figure 9. Distribution and densities of dandelion through Manitoba. (1983 Field Survey)


ALFALFA SEED GROWERS
(MANITOBA WEED SURVEY REGIONS)
SPECIES: DANDELION
FREQUENCY (%)
MAP SYMBOL
CLASS LIMITS
...
ABSENT
+++
1 - 25
XXX
26 - 50
51 - 75
76 -100

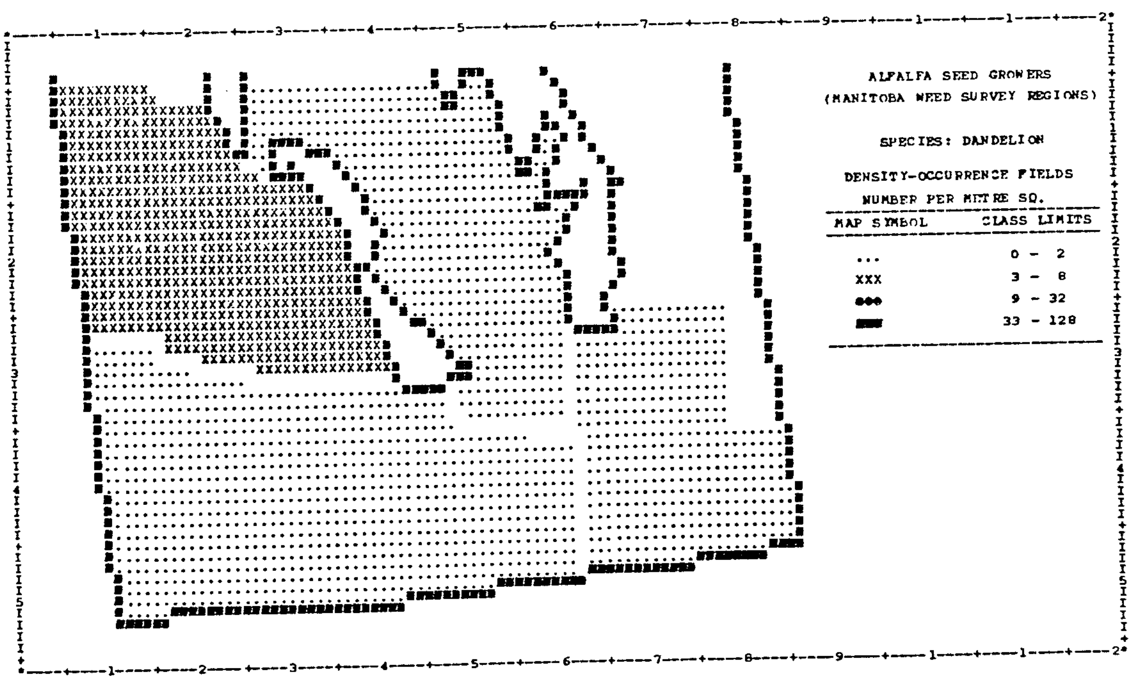
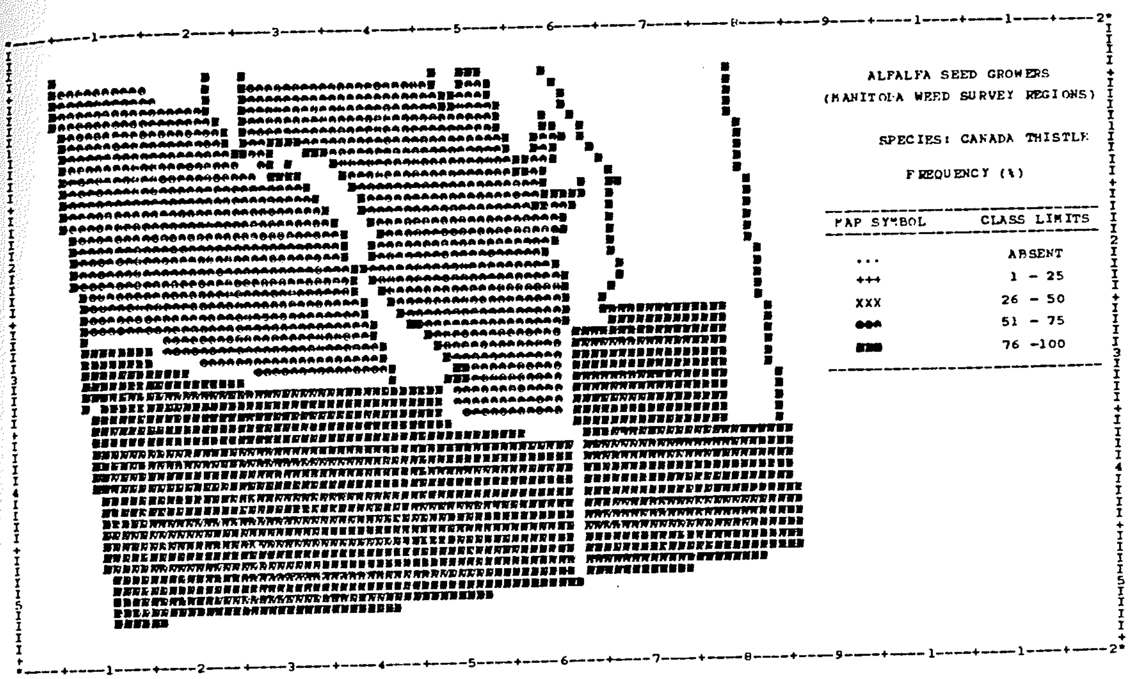

ALFALFA SEED GROWERS
(MANITOBA WEED SURVEY REGIONS)
SPECIES: DANDELION
DENSITY-OCCURRENCE FIELDS
NUMBER PER METRE SQ.
MAP SYMBOL
CLASS LIMITS
...
0 - 2
XXX
3 - 8
9 - 32
33 - 128

Figure 10. Distribution and densities of Canada thistle through Manitoba. (1983 Field Survey)


ALFALFA SEED GROWERS
(MANITOBA WEED SURVEY REGIONS)
SPECIES: CANADA THISTLE
FREQUENCY (%)
MAP SYMBOL
CLASS LIMITS
...
ABSENT
+++
1 - 25
XXX
26 - 50
51 - 75
76 -100

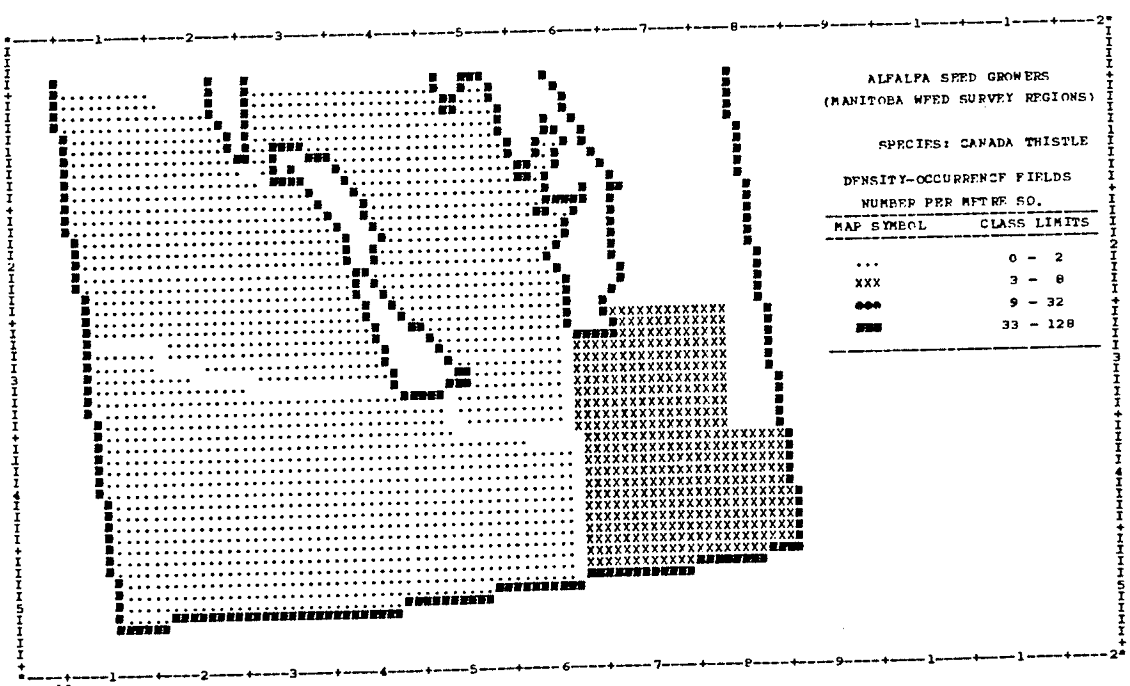
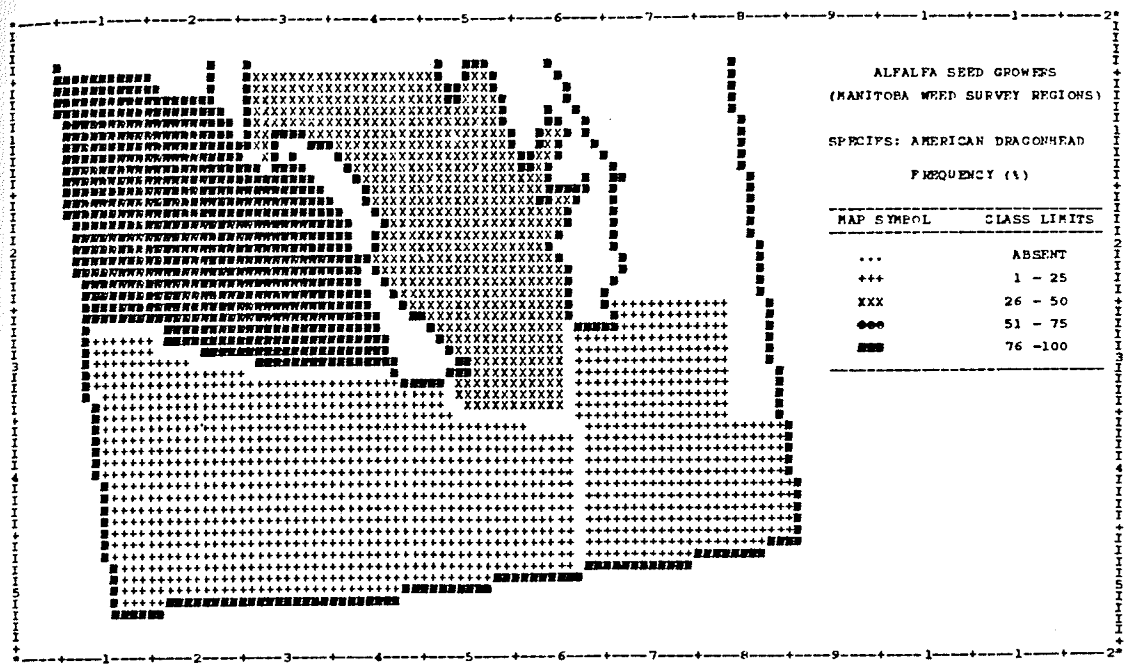

ALFALFA SEED GROWERS
(MANITOBA WEED SURVEY REGIONS)
SPECIES: CANADA THISTLE
DENSITY-OCCURRENCE FIELDS
NUMBER PER METRE SQ.
MAP SYMBOL
CLASS LIMITS
...
0 - 2
XXX
3 - 8
9 - 32
33 - 128

Figure 11. Distribution and densities of American dragonhead through Manitoba. (1983 Field Survey)


ALFALFA SEED GROWERS
(MANITOBA WEED SURVEY REGIONS)
SPECIES: AMERICAN DRAGONHEAD
FREQUENCY (%)
MAP SYMBOL
CLASS LIMITS
...
ABSENT
+++
1 - 25
XXX
26 - 50
51 - 75
76 -100

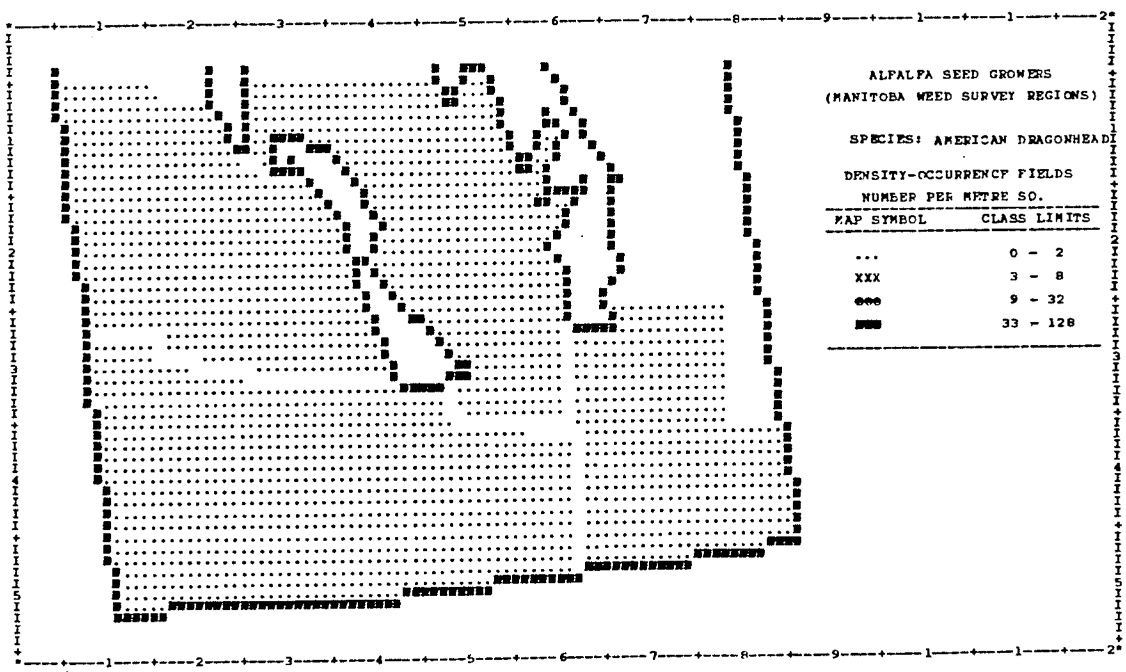
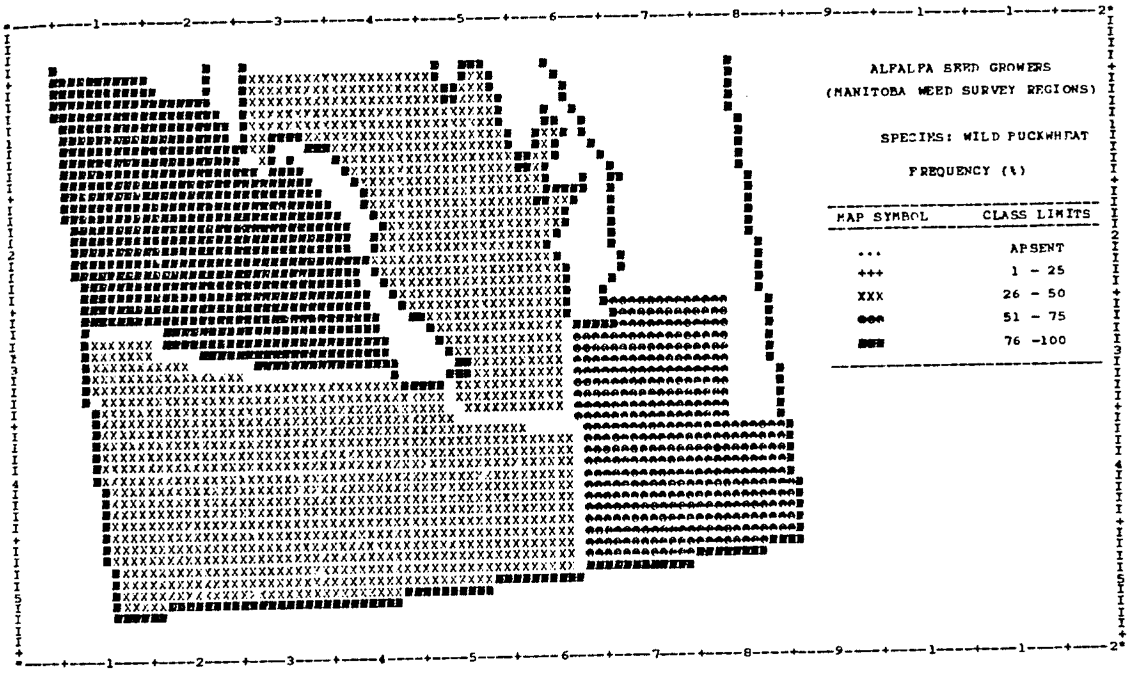

ALFALFA SEED GROWERS
(MANITOBA WEED SURVEY REGIONS)
SPECIES: AMERICAN DRAGONHEAD
DENSITY-OCCURRENCE FIELDS
NUMBER PER METRE SQ.
MAP SYMBOL
CLASS LIMITS
...
0 - 2
XXX
3 - 8
9 - 32
33 - 128

Figure 12. Distribution and densities of wild buckwheat through Manitoba. (1983 Field Survey)


ALFALFA SEED GROWERS
(MANITOBA WEED SURVEY REGIONS)
SPECIES: WILD BUCKWHEAT
FREQUENCY (%)
MAP SYMBOL
CLASS LIMITS
...
ABSENT
+++
1 - 25
XXX
26 - 50
51 - 75
76 -100

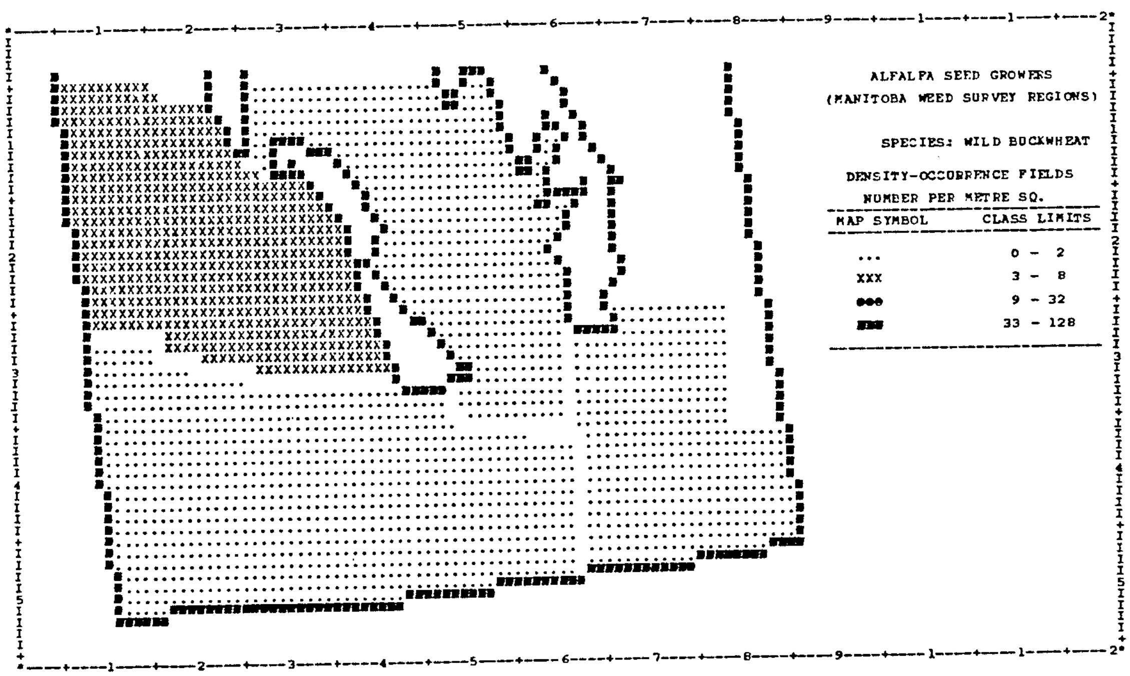
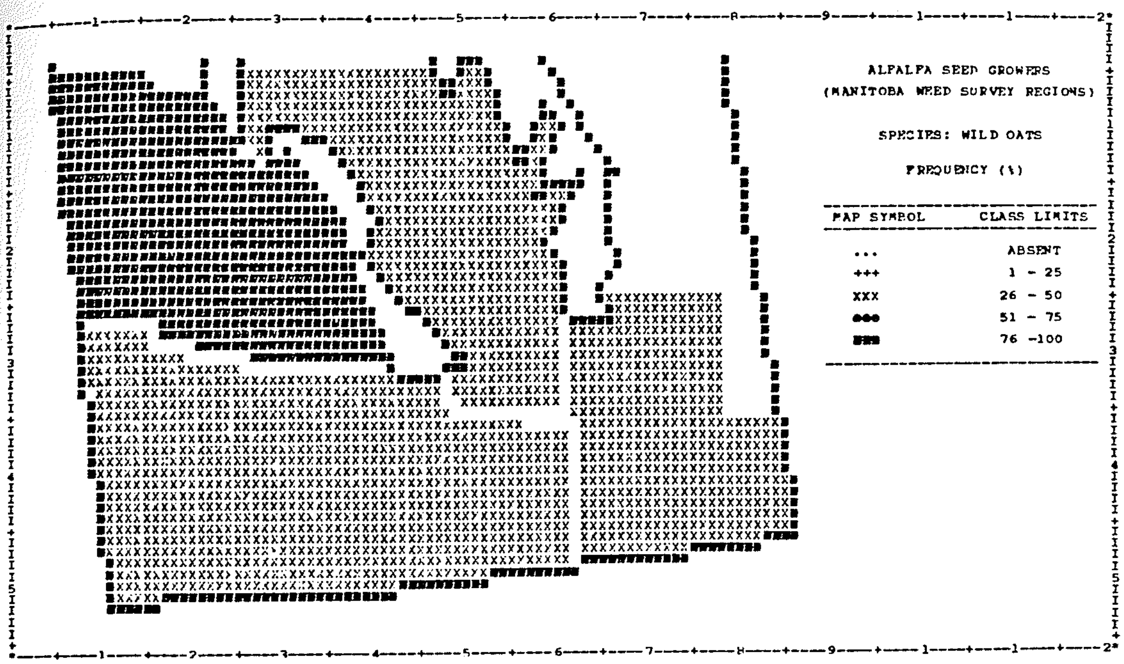

ALFALFA SEED GROWERS
(MANITOBA WEED SURVEY REGIONS)
SPECIES: WILD BUCKWHEAT
DENSITY-OCCURRENCE FIELDS
NUMBER PER METRE SQ.
MAP SYMBOL
CLASS LIMITS
...
0 - 2
XXX
3 - 8
9 - 32
33 - 128

Figure 13. Distribution and densities of wild oats through Manitoba. (1983 Field Survey)


ALFALFA SEED GROWERS
(MANITOBA WEED SURVEY REGIONS)
SPECIES: WILD OATS
FREQUENCY (%)
MAP SYMBOL CLASS LIMITS
... ABSENT
+++ 1 - 25
XXX 26 - 50
51 - 75
76 -100

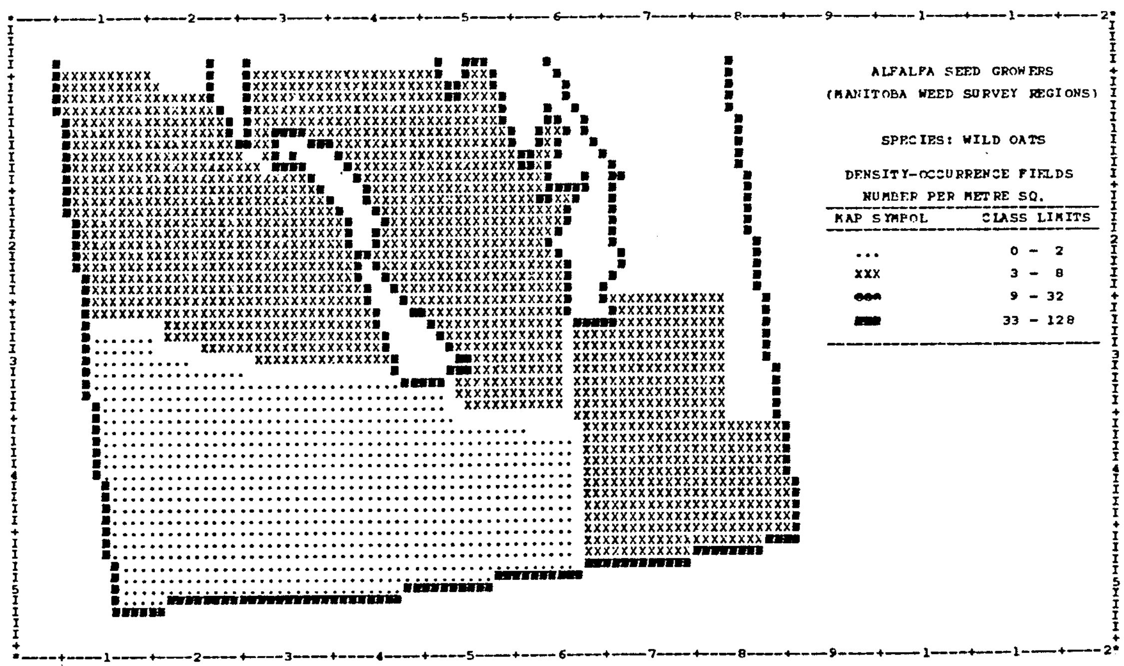
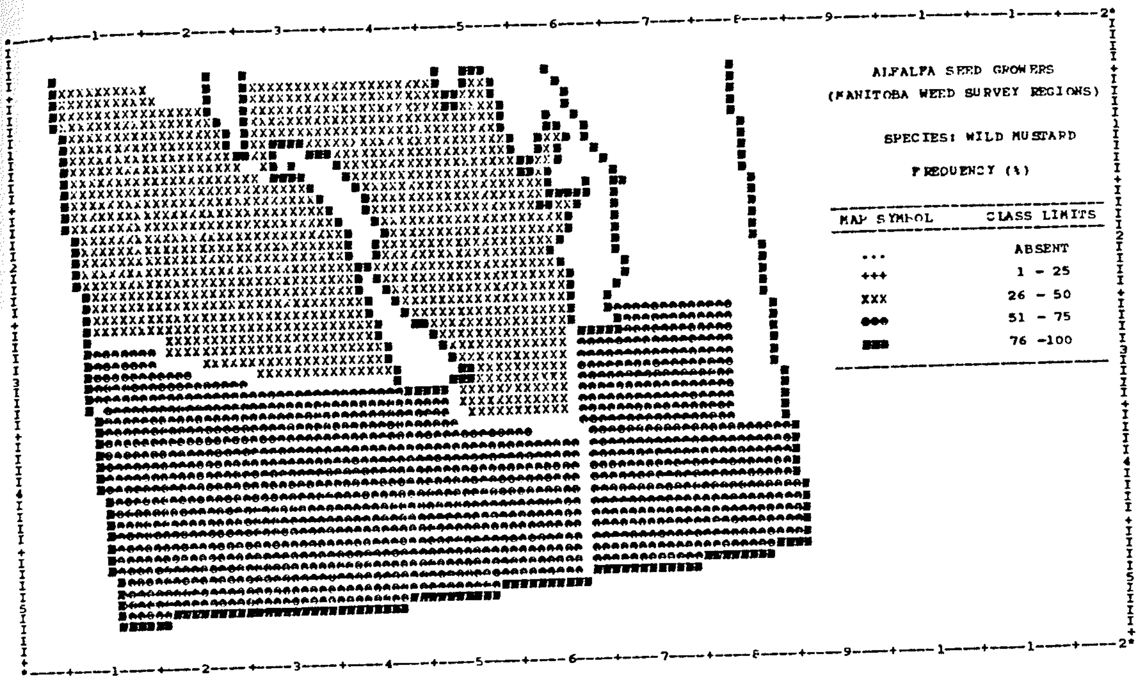

ALFALFA SEED GROWERS
(MANITOBA WEED SURVEY REGIONS)
SPECIES: WILD OATS
DENSITY-OCCURRENCE FIELDS
NUMBER PER METRE SQ.
MAP SYMBOL CLASS LIMITS
... 0 - 2
XXX 3 - 8
9 - 32
33 - 128

Figure 14. Distribution and densities of wild mustard through Manitoba. (1983 Field Survey)


ALFALFA SEED GROWERS
(MANITOBA WEED SURVEY REGIONS)
SPECIES: WILD MUSTARD
FREQUENCY (%)
MAP SYMBOL CLASS LIMITS
... ABSENT
+++ 1 - 25
XXX 26 - 50
51 - 75
76 -100

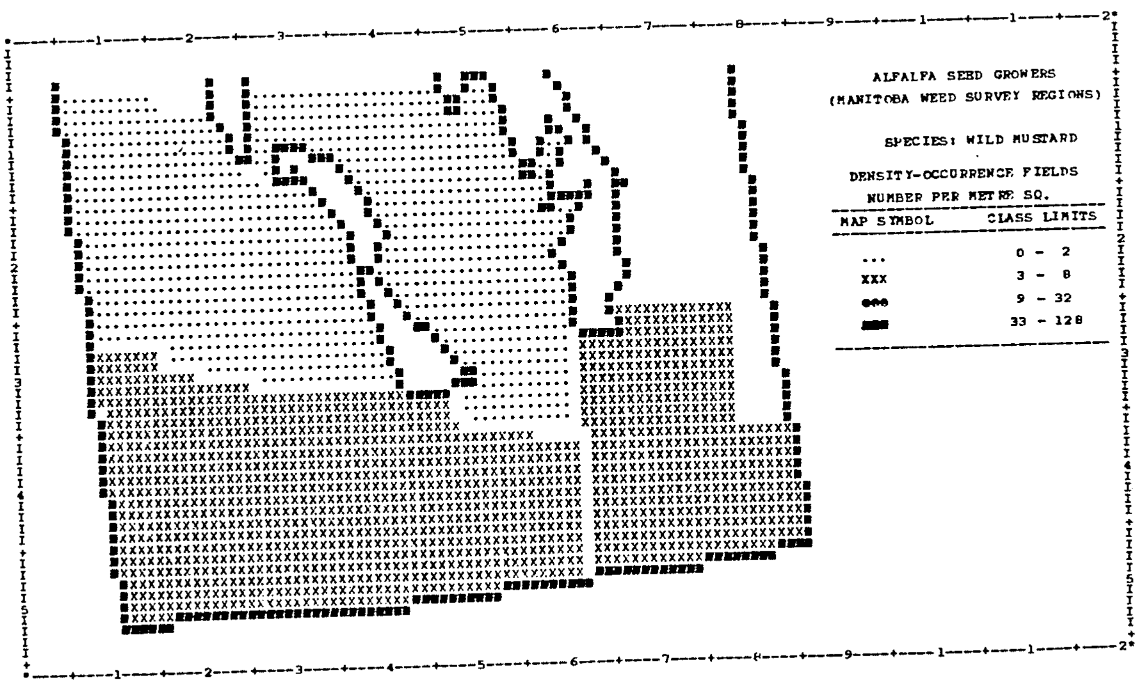
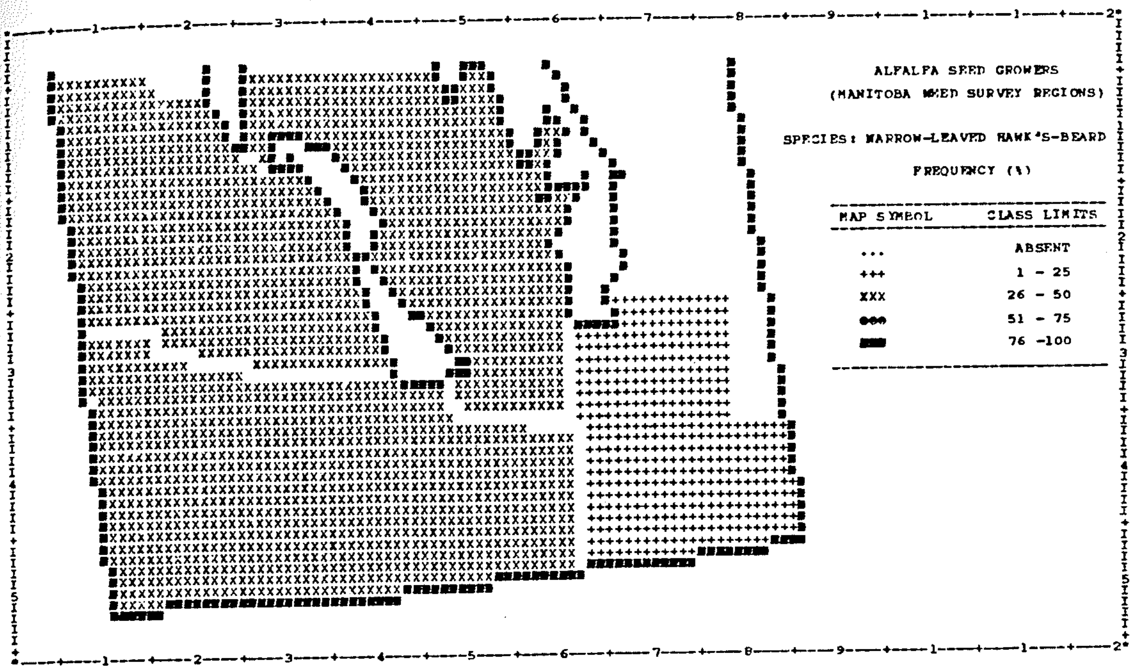

ALFALFA SEED GROWERS
(MANITOBA WEED SURVEY REGIONS)
SPECIES: WILD MUSTARD
DENSITY-OCCURRENCE FIELDS
NUMBER PER METRE SQ.
MAP SYMBOL CLASS LIMITS
... 0 - 2
XXX 3 - 8
9 - 32
33 - 128

Figure 15. Distribution and densities of narrow-leaved hawk's-beard through Manitoba. (1983 Field Survey)


ALFALFA SEED GROWERS
(MANITOBA WEED SURVEY REGIONS)
SPECIES: NARROW-LEAVED HAWK'S-BEARD
FREQUENCY (%)
MAP SYMBOL
CLASS LIMITS
ABSENT
1 - 25
26 - 50
51 - 75
76 -100

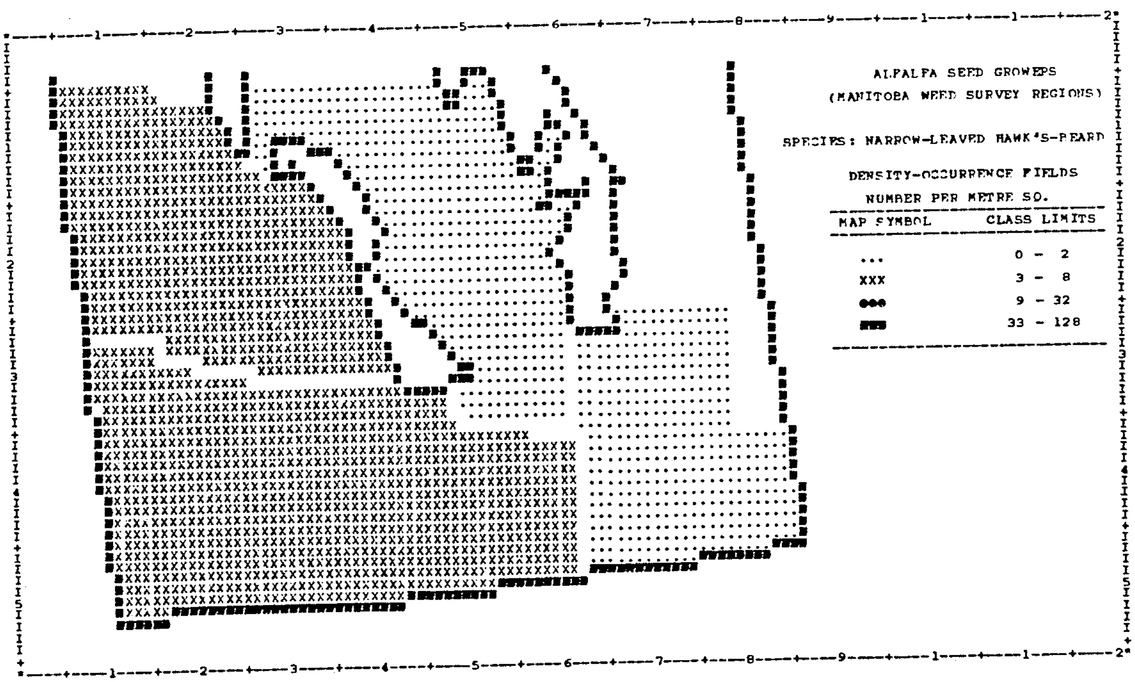
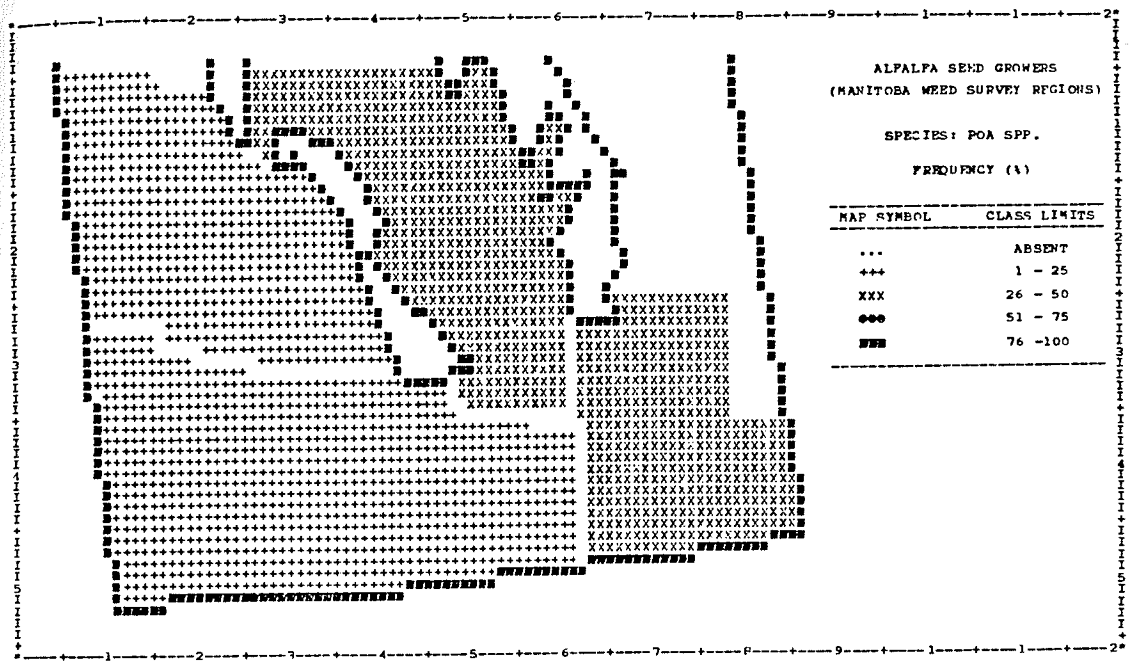

ALFALFA SEED GROWERS
(MANITOBA WEED SURVEY REGIONS)
SPECIES: NARROW-LEAVED HAWK'S-BEARD
DENSITY-OCCURRENCE FIELDS
NUMBER PER METRE SQ.
MAP SYMBOL
CLASS LIMITS
0 - 2
3 - 8
9 - 32
33 - 128

Figure 16. Distribution and densities of *Poa* spp. through Manitoba. (1983 Field Survey)


ALFALFA SEED GROWERS
(MANITOBA WEED SURVEY REGIONS)
SPECIES: POA SPP.
FREQUENCY (%)
MAP SYMBOL CLASS LIMITS
... ABSENT
+++ 1 - 25
XXX 26 - 50
51 - 75
76 -100

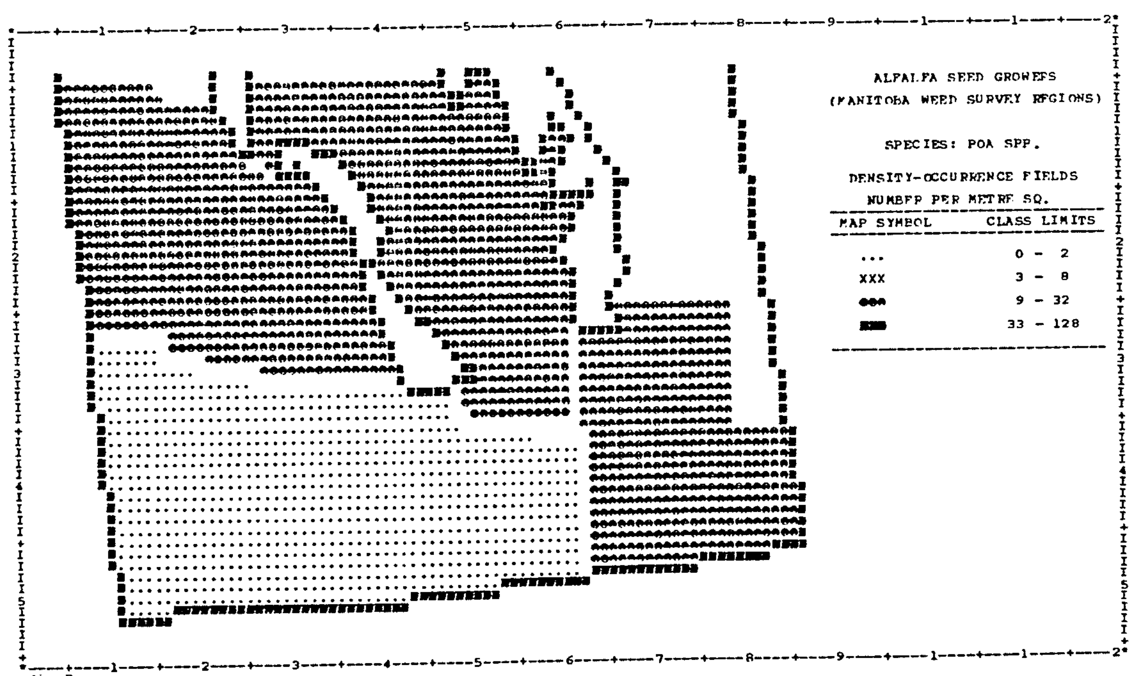
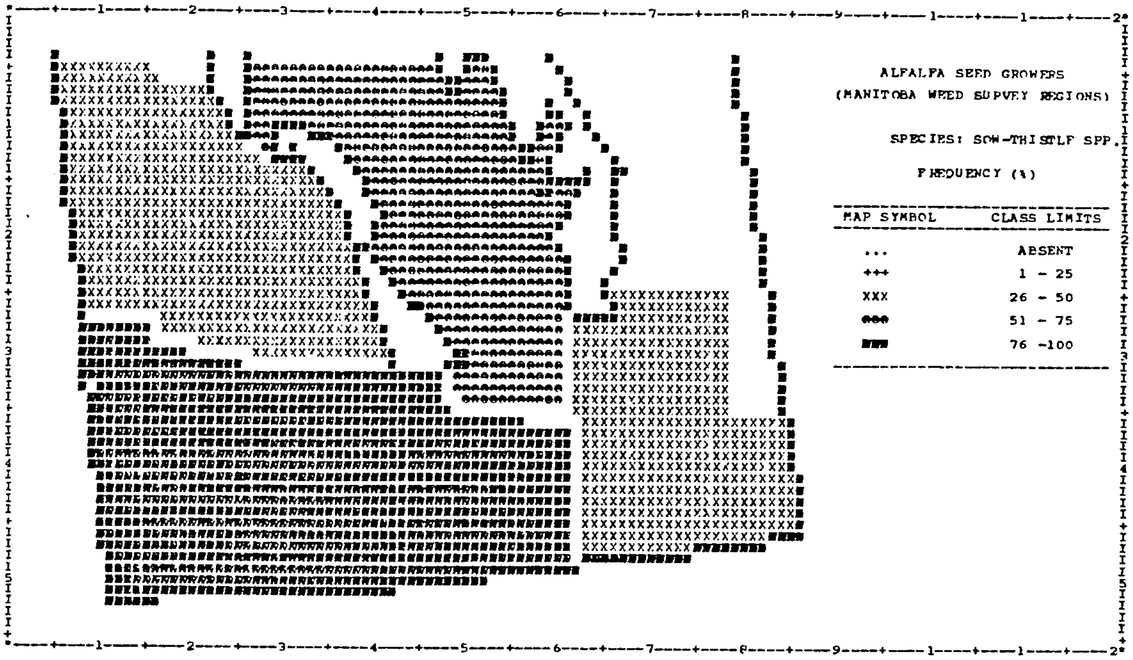

ALFALFA SEED GROWERS
(MANITOBA WEED SURVEY REGIONS)
SPECIES: POA SPP.
DENSITY-OCCURRENCE FIELDS
NUMBER PER METRE SQ.
MAP SYMBOL CLASS LIMITS
... 0 - 2
XXX 3 - 8
9 - 32
33 - 128

Figure 17. Distribution and densities of Sow-Thistle through Manitoba. (1983 Field Survey).


ALFALFA SEED GROWERS
(MANITOBA WEED SURVEY REGIONS)
SPECIES: SOW-THISTLE SPP.
FREQUENCY (%)
MAP SYMBOL CLASS LIMITS
... ABSENT
+++ 1 - 25
XXX 26 - 50
@@@ 51 - 75
■■■ 76 -100

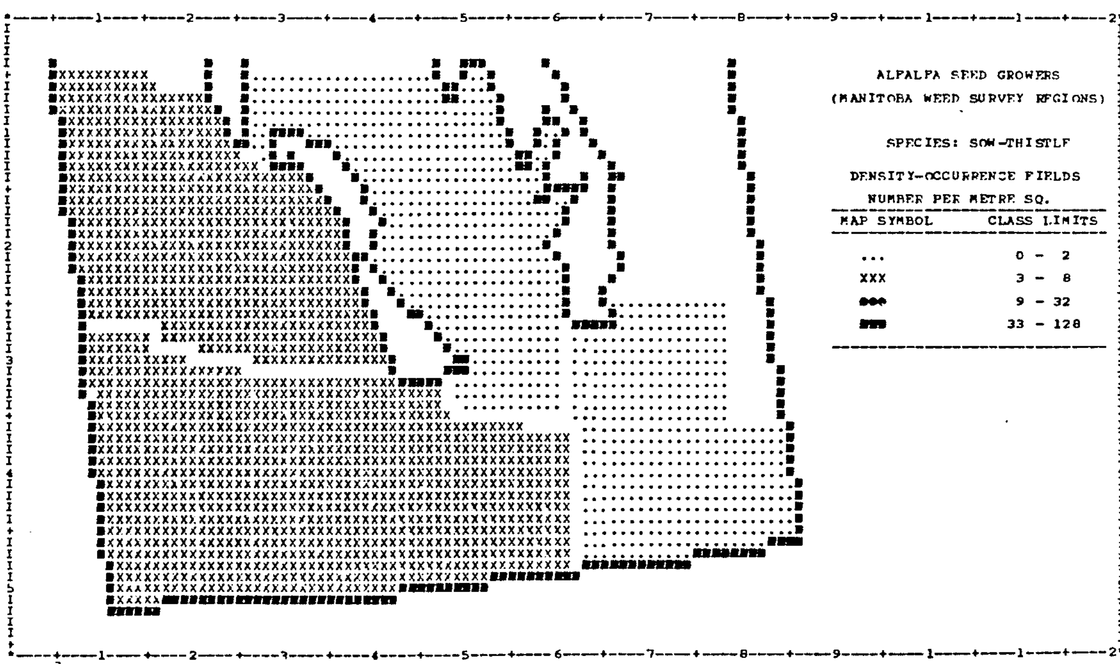
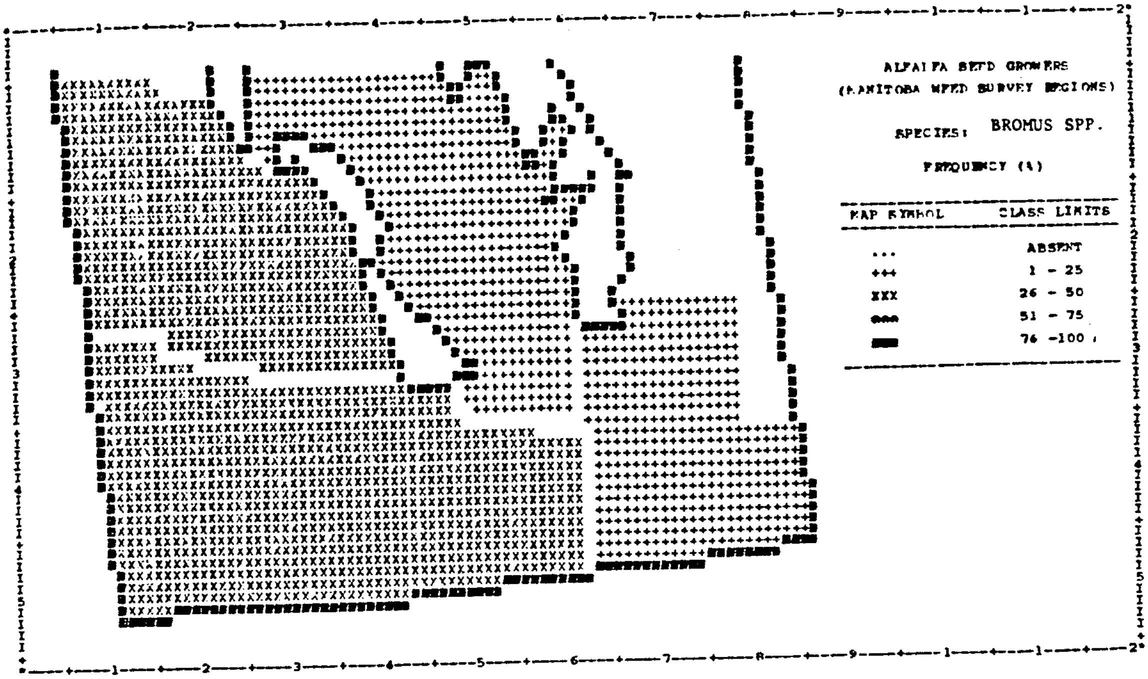
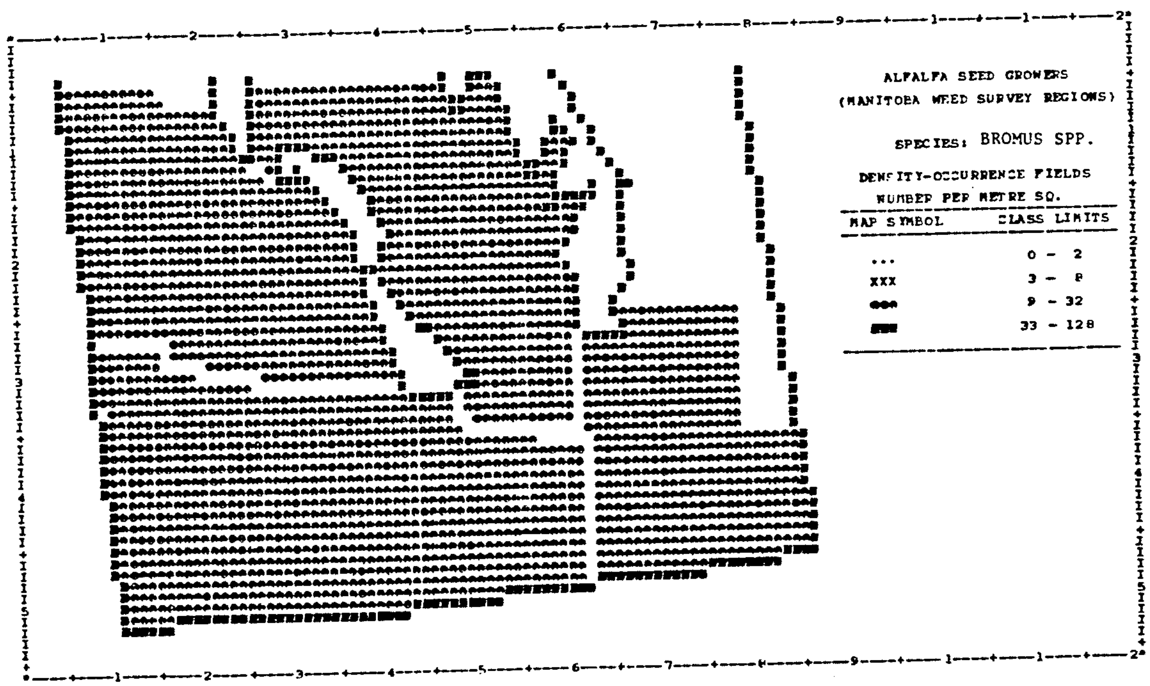

ALFALFA SEED GROWERS
(MANITOBA WEED SURVEY REGIONS)
SPECIES: SOW-THISTLE
DENSITY-OCCURRENCE FIELDS
NUMBER PER METRE SQ.
MAP SYMBOL CLASS LIMITS
... 0 - 2
XXX 3 - 8
@@@ 9 - 32
■■■ 33 - 128

Figure 18. Distribution and densities of *Bromus* spp. through Manitoba. (1983 Field Survey).


ALFALFA SEED GROWERS
(MANITOBA WEED SURVEY REGIONS)
SPECIES: BROMUS SPP.
FREQUENCY (%)
MAP SYMBOL CLASS LIMITS
... ABSENT
+++ 1 - 25
XXX 26 - 50
51 - 75
76 -100


ALFALFA SEED GROWERS
(MANITOBA WEED SURVEY REGIONS)
SPECIES: BROMUS SPP.
DENSITY-OCCURRENCE FIELDS
NUMBER PER METRE SQ.
MAP SYMBOL CLASS LIMITS
... 0 - 2
XXX 3 - 8
9 - 32
33 - 128

directly to weed management are reported in this chapter. Other data appear in Appendix 5.

Over 60% of alfalfa seed growers returned completed questionnaires detailing the cropping history of 131 fields, totalling 1728 hectares, or 71% of the province's total production area (Appendix 5, Table 1). Response rates between the four regions were statistically similar (Appendix 5, Table 2). Thirty-three weeds were listed by growers as being troublesome in the seedling year. Only 4 species were considered troublesome in 30% or more of fields (Table 9).

Growers' rankings of problem weeds in seedling alfalfa reflect early concerns of producers over the prevalence of perennial weeds. Canada thistle and quackgrass were ranked as the first and fourth most troublesome weed species, respectively. Two annuals, wild oats and wild mustard were also listed as troublesome in more than 30% of fields (Table 10).

In established alfalfa fields, quackgrass and Canada thistle were the most troublesome weeds. Both species were considered problems in over two-thirds of the established fields and attained severity scores three to four times that of sweet clover (Melilotus spp.) and dandelion, the third and fourth most frequently mentioned weeds (Table 10). Wild oats and wild mustard were mentioned somewhat less frequently but were still considered problems in 18 and 16% of the fields, respectively.

Cropping histories of the 123 fields indicate that a large number of fields are established without the use of

Table 9. Weed Species Perceived as Problems in Seedling Stands of Alfalfa.

Weed	Frequency Mentioned		Severity Score[1]
	No. of fields	% of fields	
Canada thistle	68	51.9	237
Wild oats	57	43.5	102
Wild mustard	54	41.2	204
Quackgrass	42	32.1	146
Green foxtail	31	23.7	100
American dragonhead	27	20.6	67
Stinkweed	26	19.8	70
Sweet clover	21	16.3	76
Wild buckwheat	21	16.3	61
Sow thistle	20	15.3	63
Lamb's-quarters	14	10.7	32
Lady's thumb	11	8.4	37
Night-flowering catchfly	10	7.6	30
Narrow-leaved hawk's beard	9	6.9	29
Dandelion	8	6.1	16
Redroot pigweed	7	5.7	25
Hemp nettle	7	5.7	28
White cockle	4	3.3	17
Red clover	4	3.3	14
Bromegrass	4	3.3	6
Timothy	2	1.6	4
Flax	2	1.6	3
Native grasses	2	1.6	2
Cow cockle	2	1.5	8
Shepherd's purse	1	0.8	3
Russian pigweed	1	0.8	5
Canola	1	0.8	4
Reed canarygrass	1	0.8	4
Alsike clover	1	0.8	4
Kochia	1	0.8	4
Mallow	1	0.8	1
Milkweed	1	0.8	2
Foxtail barley	1	0.8	4
No response	2	1.6	-
No weeds	6	5.3	-

[1]Maximum possible severity score = 615.

Table 10. Weed Species Perceived as Problems in Established Stands of Alfalfa.

Weed	Frequency Mentioned		Severity Score[1]
	No. of fields	% of fields	
Quackgrass	84	65.0	343
Canada thistle	83	63.4	366
Sweet clover	34	27.6	227
Dandelion	32	24.4	84
Wild oats	24	18.3	68
Wild mustard	22	16.8	68
Sow thistle	19	13.8	70
American dragonhead	17	13.8	51
Narrow-leaved Hawk's beard	11	8.9	33
Stinkweed	10	8.1	27
Night-flowering catchfly	9	7.3	32
Bromegrass	9	7.3	24
Green foxtail	9	7.3	31
Hemp nettle	7	5.7	23
Lady's thumb	7	5.7	18
Red clover	6	4.6	27
Wild buckwheat	5	3.8	13
Timothy	5	3.8	9
R. cinquefoil	4	3.3	16
Poa spp.	4	3.3	16
Chamomile	4	3.3	16
Flixweed	4	3.3	15
Alsike clover	4	3.3	14
Native grasses	4	3.3	14
Milkweed	4	3.3	7
Cow cockle	3	2.5	5
Sheperds purse	2	1.6	4
Biennial wormwood	2	1.6	7
Absinthe	1	0.8	5
Russian pigweed	1	0.8	5
Bladder campion	1	0.8	4
Goldenrod	1	0.8	4
Reed canarygrass	1	0.8	4
Bedstraw	1	0.8	4
Yarrow	1	0.8	4
White clover	1	0.8	3
Lamb's-quarters	1	0.8	2
Foxtail barley	1	0.8	2
Curled dock	1	0.8	1

[1]Maximum possible severity score = 615.

herbicides. Only 52% of the fields were treated with a broadleaf weed herbicide during the seedling year, while only 55% were treated with grasskillers (Table 11). Twenty-six percent of fields detailed in the questionnaire responses were established without the use of any herbicides. A similar pattern was noted in established alfalfa, where over one-third of the fields were not sprayed for weeds during the period 1979-83 (Table 12). The use of non-recommended herbicides was prevalent in established alfalfa seed fields. 2,4-DB (4-(2,4-diclorphenoxy) butyric acid), a treatment not recommended for use in established alfalfa, was used by 43% of growers. Sethoxydim (2-[1-(ethoxyimino)butyl]5-[2-(ethylthio)-propyl]3-hydroxy 2-cyclohexen 1-one), fluazifop (+butyl 2-(4-[5-(trifluoromethyl)-2-pyridinyl]oxy)phenoxy) propanoate) and diclofop (2-[4-(2,4-dichlorophenoxy)phenoxy] propanoic acid) also non-recommended treatments at the time of the survey, were used by 15% of producers (Table 12).

The dormant-applied herbicides terbacil (3-tert-butyl 5-chloro-5 methyluracil) and simazine (2-chloro-4,6bis (ethylamino)-S-triazine) were used relatively little. Only 16% or alfalfa seed fields were treated with one of the two chemicals (Table 12).

DISCUSSION

Comparison of the numbers and types of weed species found in established alfalfa seed fields with those recorded

Table 11. Herbicide Use in Seedling Alfalfa Seed Fields in Manitoba in (1979-83).

Chemical	Extent of Use			
	Fields		Hectares	
	(no.)	(%)	(no.)	(%)
Broadleaf Weed Herbicides				
MCPA	29	22	447	26
2,4-DB	21	16	282	16
Trifluralin	17	13	272	15
Niclofen	1	1	6	1
Grasskillers				
Diclofop	17	12	219	13
EPTC	13	10	265	15
Asulam	10	8	113	7
Triallate	6	5	110	7
TCA	4	3	40	2
Propanil	1	1	48	3
Barban	1	1	10	1
Dalapon	1	1	8	1
Difenzoquat	1	1	6	1
Dormant-Applied Herbicides				
Simazine	2	2	20	1
Terbacil	1	1	10	1
No Herbicies	36	27	446	26

Table 12. Herbicide Use in Established Alfalfa Seed Fields in Manitoba in (1979-83).

Chemical	Extent of Use: Fields (no.)	Fields (%)	Hectares (no.)	Hectares (%)
Broadleaf Weed Herbicides				
2,4-DB	56	43	770	45
MCPA	2	2	66	4
Bromoxynil + MCPA	1	1	2	-
Grasskillers				
Asulam	35	27	563	33
Sethoxydim	12	9	251	15
Fluazifop	6	5	152	9
Diclofop	1	1	1	-
TCA	1	1	2	-
Dalapon				-
Dormant-Applied Herbicides				
Terbacil (fall)	13	10	104	6
Terbacil (spring)	2	2	14	1
Simazine	6	5	81	5
No Herbicides	45	34	532	31

in the 1981 Weed Survey of Cultivated Land in Manitoba, shows two major differences between the weed spectra found in the two surveys. Firstly, dominant weed species in alfalfa seed fields were perennials, with Canada thistle, quackgrass and dandelion found in a large majority of fields. This was not so in the cereal and oilseed field survey, where 7 of the 10 most common weeds were annuals (Thomas 1981). This shift towards dominance of the weed spectrum to perennial species is no doubt due to the lack of cultural weed control practices, including mowing and tillage, in alfalfa seed production.

Secondly, densities of all weeds except quackgrass and narrow-leaved hawk's-beard were lower in alfalfa seed fields than in the annual field crops. Densities of annual weeds in occurrence fields was 4 to 19 times higher in cereal or oilseed fields in the 1981 cultivated land survey than in the 1983 survey of alfalfa seed fields. Perennial weeds also occurred at slightly lower densities in alfalfa seed fields, althought their distribution through the province's fields was more widespread. The lower weed densities in alfalfa fields may be due to the greater competitive ability of established alfalfa than that of annual crops.

Only three species of weeds were noted in the alfalfa seed survey which were not present in the survey of cultivated land. These were included Canada goldenrod (Solidago canadensis), Canada anemone (Anemone canadensis) and yellow evening primrose (Denothora biennis). These species were found in only a few samples.

Rankings of troublesome weeds taken from growers' responses to questionnaires correspond closely with abundance rankings compiled from the weed counts, indicating a high level of grower awareness as to the relative seriousness of common weed problems (Table 13). Growers' rankings departed significantly from abundance rankings with three species, namely sweet clover, American dragonhead, and nightflowering catchfly (Silene noctiflora). Growers considered these species as being more troublesome than the abundance data appeared to warrant. However, all three weeds produce seed which is difficult to remove from alfalfa seed, and thus are economic problems even at low densities.

Herbicide use in alfalfa seed production as determined by questionnaire results was considerably less common than that reported in cereal and oilseed surveys (Thomas 1979b). Unsprayed areas of flax, canola, wheat and barley in the survey of cultivated land were only 1.4%, 8.6%, 3.0% and 4.2%, respectively, whereas 34% of the area seeded to alfalfa was not sprayed.

One possible reason for the relatively low frequency of herbicide use in alfalfa seed production may be the lack of effectiveness of recommended weedkillers in controlling the weeds commonly growing in alfalfa seed fields. Only three of the eight most common weeds occurring in established alfalfa are readily controlled with recommended chemicals. These are wild oats, controlled by asulam, and wild buckwheat

Table 13. Comparison of the Importance of Weeds as Ranked by Relative Abundance and by Growers' Response to Questionnaires.

Weed	Rankings: Relative Abundance	Rankings: Grower's
Quack grass	1	1
Dandelion	2	4
Canada thistle	3	2
Poa spp.	4	20
Sow-thistle spp.	5	7
Wild buckwheat	6	17
Wild mustard	7	6
Wild oats	8	5
Harrow-leaved hawk's-beard	9	9
Smooth brome	10	12
American dragonhead	11	8
Timothy	12	18
American vetch	13	-
Lamb's-quarters	14	37
Plantain spp.	15	-
Stinkweed	16	10
Sweet clover (white & yellow)	17	3
Hemp-nettle	18	14
Smartweed (annual) spp.	19	15
Field horsetail	20	-
Night-flowering catchfly	21	11
Green foxtail	22	13
Flixweed	23	-
Kochia	24	-

and wild mustard, controlled by terbacil. The frequent use of non-recommended herbicides, chiefly 2,4-DB, indicates the need for additional chemical recommendations in the crop.

Growers are employing cultural methods of weed control to compensate for a lack of chemical recommendations. Companion cropping was used in more than three-quarters of the fields established since 1978 (Table 14). Seeding rates and row spacings of alfalfa tended towards producing heavier stands of alfalfa than is recommended for maximal seed production (Tables 15 and 16). Both practices would increase crop competition in the field with the companion crop being effective in the seedling year and the heavier alfalfa stands suppressing weeds in subsequent years.

Table 14. Use of Companion Crops by Alfalfa Seed Growers in Manitoba.

Practice	Extent of Use: Fields (no.)	Fields (%)	Hectares (no.)	Hectares (%)
No Companion	31	24	322	19
Flax	37	27	612	29
Wheat	27	21	357	23
Canola	10	8	129	9
Oats	11	9	88	6
Barley	10	6	95	4
Wheat + Oats	1	1	60	4
Canaryseed	1	1	48	3
Buckwheat	1	1	6	-
Sunflowers	1	1	2	-

Table 15. Seeding Rates Used by Alfalfa Seed Growers in Manitoba.

Seeding Rate (kg/ha)	Extent of Use: Fields (no.)	Fields (%)	Hectares (no.)	Hectares (%)
0.50	9	7	111	6
0.75	15	11	242	14
1.00	17	13	320	19
1.25	10	8	85	6
1.50	17	13	213	12
1.75	7	6	82	5
2.00	32	26	406	23
>2.00	22	19	229	13

Table 16. Row Spacing Used by Alfalfa Seed Growers in Manitoba.

Row Spacing (cm)	Extent of Use			
	Fields		Hectares	
	(no.)	(%)	(no.)	(%)
15	11	9	183	11
30	16	13	215	12
45	14	11	165	10
60	21	17	115	7
75	8	7	197	11
100	4	3	37	2

CHAPTER V

HERBICIDES FOR ESTABLISHED ALFALFA SEED FIELDS

INTRODUCTION

The selection of herbicides recommended for use in Manitoba in established alfalfa seed fields is limited, with only three treatments recommended for selective broadleaf weed control. Terbacil (3-tert-butyl-5-chloro-6-methyluracil) and simazine (2-chloro-4,6-bis (ethylamino)-5-triazine) control several broadleaf weeds when sprayed during the dormancy period of alfalfa. 2,4-DB (4-(2,4-dichlorophenoxy) butyric acid) is also recommended at 0.6 kg/ha in a tank-mixture with asulam (methyl sulfanilylcarbamate). Broadleaf weeds controlled by this mixture include wild mustard (*Sinapsis arvensis*), wild buckwheat (*Polygonum convulvulus*), lady's thumb (*Polygonum persicaria*) and stinkweed (*Thlaspi arvense*) (Manitoba Agriculture 1984).

Two weeds that are not easily controlled in alfalfa seed fields are nightflowering catchfly (*Silene noctiflora*) and American dragonhead (*Dracocephala parviflora*). Night-flowering catchfly is an annual or winter annual identifiable by its sticky, opposite leaves and white-petalled flowers. American dragonhead is a biennial or annual member of the

Mint Family with opposite leaves, square stems and a distinctive large terminal spike of purple flowers. Both species are classified as noxious weeds and, as such, are subject to the regulations of the Canada Seeds Act (1977). According to the Act, if seed of either species is present in the harvested crop seed in numbers exceeding specified tolerance levels, specialized seed cleaning operations must be carried out, thereby increasing costs of production.

No post-emergence herbicides are currently recommended for either nightflowering catchfly or American dragonhead control in established alfalfa. However, bromoxynil (3,5-dibromo-4-hydroxybenzonitrile) is recommended in Alberta for the control of nightflowering catchfly in forage grasses (Alberta Agriculture 1982). Recent screening trials indicate that bromoxynil and metribuzin (4-amino-6-tert-butyl-3-(methylthio-as-triazine-5(4H)-one) control American dragonhead without causing serious damage to alfalfa (Todd 1982).

Although simazine and terbacil are recommended for nightflowering catchfly control in established alfalfa (Manitoba Agriculture 1984), the potential for controlling American dragonhead with these and other dormant-applied chemicals has not been examined.

In this study trials were conducted during the fall of 1982 and in the spring of 1983 to evaluate the effectiveness of several post-emergence and dormant-applied herbicides in controlling nightflowering catchfly and American dragonhead. During the same period, the tolerance of established alfalfa to various post-emergence and dormant-applied chemicals was assessed.

MATERIALS AND METHODS

Trials were established in the spring of 1981 and 1982 on a well-drained clay loam at the Plant Science Research Station near Portage la Prairie, Manitoba. All fields were fertilized with 180 kg/ha of ammonium phosphate (11:55:0) disced twice to a depth of 15 cm and then harrowed. Alfalfa (Medicago media Pers. 'Beaver') was heavily inoculated with commerical rhizobium culture (Rhizobium meliloti) and then seeded with a belt seeder at a rate of 1.1 kg/ha into 2.8 m by 5.0 m plots, with four rows per plot. The two outer rows were spaced 60 cm from the two inner rows. The two inner rows were 30 cm apart. During the seedling year sequential applications of diclofop (190 g/L emulsifiable concentrate (EC)) (2-[4-(2,4-dichlorophenoxy) phenoxy] propanoic acid) at 0.7 kg/ha, followed five days later by 2,4-DB (400 g/L, EC) at 1.2 kg/ha, were applied to control weeds. In the autumn of the establishment year the plots were swathed and the vegetative growth removed from the field to facilitate spraying operations in the following spring.

Tolerance of Alfalfa to Post-Emergence Broadleaf Weed Herbicides.

Two trials of alfalfa, one established in 1981 and the other in 1982, were sprayed with several post-emergence herbicides in their second year of growth. Treatments were applied in a randomized complete block design with 4 replicates. 2,4-DB was sprayed at 1.0 and 1.4 kg/ha when the crop reached heights of 20, 40 and 60 cm. Spraying dates were May 18, May 27 and June 7 in 1982 and June 3, June 11 and June 17 in 1983. Bromoxynil (227 g/L, EC) at 0.3 and 0.6 kg/ha, metribuzin (500 g/L, flowable) at 0.2 and 0.4 kg/ha and bentazon (480 g/L, solution) at 1.0 and 2.0 kg/ha were applied to the alfalfa when it reached 60 cm in height. All applications were made with a bicycle sprayer in a water volume of 149 L/ha at a pressure of 276 kPa, except in the case of bentazon treatments, in which case water volumes were 221 L/ha. Two plots per replicate were left unsprayed as controls. Tolerance ratings were taken ten days and six weeks after the treatments were applied. The ratings were based on a 0 to 9 scale (Table 17) where 0 represents complete death of the crop and 9 represents no observable injury. Plots were kept weed-free for the remainder of the season by handweeding or hoeing. An overall treatment of dimethoate (Cygon) at 0.2 kg/ha was applied on June 18 in 1982 and June 21 in 1983 to control aphids (<u>Aphis</u> spp.), adelphocoris bugs (<u>Adelphocoris</u> spp.) and lygus bugs (<u>Lygus</u> spp.). Leafcutter bees (<u>Megachile rotundata</u>) were placed on the eastern side of the trials at a stocking rate of 80,000 bees/ha when the alfalfa stands were at about 10% bloom stage. Bees were left in the fields throughout flowering to obtain maximum seed

Table 17. Rating Scales Used in Assessments of Weed Control and Crop Tolerance.

Rating Scale	
Weed Control	Crop Tolerance
9* complete control	9* complete tolerance
8* excellent control	8* possible effect
7* good control	7* slight effect
6 fair control	6 definite effect
5 poor control	5 severe effect
4 moderate injury	4 severe effect
3 definite effect	3 severe effect
2 slight effect	2 severe effect
1 possible effect	1 severe effect
0 no effect	0 complete kill

*Commercially acceptable.

production. On September 18, 1982 and September 16, 1983, the alfalfa was swathed and then combined using a Hege plot combine. Seed harvests were weighed and analyzed for treatment differences using Duncan's multiple range test (P=0.05).

Post-Emergence Herbicides for Nightflowering Catchfly and American Dragonhead in Established Alfalfa.

In the spring of 1983, alfalfa seeded the previous spring was sprayed with various post-emergence herbicides to evaluate their potential for controlling nightflowering catchfly and American dragonhead. Seed of both species was raked into the plots, the American dragonhead in June of the seeding year and the nightflowering catchfly in May, 1983. Applications of bromoxynil at 0.3 and 0.6 kg/ha, metribuzin at 0.2 and 0.4 kg/ha and bentazon at 1.0 and 2.0 kg/ha were made to the plots on June 9 as the crop reached 30 cm in height. At the time of treatment, nightflowering catchfly was in the 4- to 6-leaf stage, and American dragonhead rosettes had 8 to 10 leaves. The experiment was arranged in a randomized complete block design with 4 replicates. Herbicides were applied with a bicycle sprayer in 115 L/ha water volume except in the case of bentazon, where water volume was 221 L/ha. Weed control was evaluated for each species using a 0 to 9 scale, where 0 represents no control and 9 represents complete control (Table 17). Crop tolerance was also rated on a 0 to 9 scale as previously described.

Tolerance of Established Alfalfa to Spring- and Fall- Applied Dormant Herbicides.

Tolerance of two-and three-year-old-alfalfa stands to spring and fall applications of dormant-applied herbicides was assessed in 1983. Chemicals were applied to the trial in a split plot design, with herbicides assigned to the main plots and season of application to the subplots. Treatments were replicated 4 times. Terbacil (80% wettable powder) at 0.7 and 1.2 kg/ha, metribuzin (600 g/L, flowable formulation) at 1.0 and 2.0 kg/ha, simazine (90% water dispersible granules) at 1.1 and 2.2 kg/ha and pronamide (50% wettable powder) at 0.5 and 0.7 kg/ha were applied in the fall of 1982, just prior to freeze-up, and in the spring of 1983, just prior to thaw. Applications were made with a bicycle sprayer in a spray volume of 110 L/ha. Tolerance ratings were made in late June of 1983 and were based on the 0 to 9 scale previously described. Weeds were handpulled or hoed from all plots throughout the season. In September, the alfalfa was swathed and the seed harvested using a Hege plot combine. Seed from each plot was weighed and the results analyzed for yield differences at both treatment and subtreatment levels, using Duncan's multiple range test (P=0.05) when applicable.

Control of American Dragonhead in Established Alfalfa Using Dormant-Applied Herbicides.

In 1983, the efficacy of spring- and fall-applied dormant herbicides for control of American dragonhead was assessed. Seed of American dragonhead was raked into the trial in June 1982. Dormant-applied chemicals were sprayed onto the plots as described previously for the tolerance tests. Treatments included terbacil at 0.7 and 1.2 kg/ha, metribuzin at 1.0 and 2.0 kg/ha and simazine at 1.1 kg/ha. Terbacil and metribuzin treatments were applied in the fall of 1982, after freeze-up, and in the spring of 1983. Simazine was applied only in the fall of 1982. One plot per replicate was left unsprayed as a weedy check. Tolerance of alfalfa was rated on the 0 to 9 scale described previously. In September of 1983, American dragonhead rosettes were counted in one randomly selected 1 m^2 area within each plot. Differences in American dragonhead densities resulting from the chemical treatments were tested for significance and the means compared using Duncan's multiple range test (P=0.05).

RESULTS

Tolerance of Alfalfa to Post-Emergence Broadleaf Weed Herbicides.

All herbicides initially caused damage to alfalfa plants in both years (Table 18). Bromoxynil, bentazon and metribuzin scorched the leaf margins at all rates applied, and 2,4-DB induced severe epinasty. Plants rapidly outgrew these symptoms in both years and appeared healthy by mid-season. No setback in flowering or flower deformities were noticed in any of the treatments.

Average seed yields varied considerably from treatment to treatment in both years, with yields ranging from

Table 18. Tolerance of Established Alfalfa to Post-Emergence Broadleaf Weed Herbicides.

Treatment	Rate (kg/ha)	Crop Height (cm)	Visual Crop Injury Ratings[1] 10 days after treatment	6 weeks after treatment	Alfalfa Seed Yield (g/m^2) 1982	1983
Control	-	-	9	9	22.9	38.7 ab
2,4-DB	1.0	20	6	9	22.3	32.9 abc
2,4-DB	1.4	20	6	9	28.8	27.7 c
2,4-DB	1.0	40	6	9	21.6	40.8 ab
2,4-DB	1.4	40	5	8	18.1	35.8 abc
2,4-DB	1.0	60	6	9	16.3	35.9 abc
2,4-DB	1.4	60	5	9	19.8	41.8 a
Bentazon	1.0	60	6	8	21.8	31.5 bc
Bentazon	2.0	60	7	8	23.3	39.8 ab
Bromoxynil	0.3	60	5	8	21.6	32.9 abc
Bromoxynil	0.6	60	5	8	19.0	35.8 abc
Metribuzin	0.2	60	6	9	26.3	32.1 abc
Metribuzin	0.4	60	5	8	19.3	36.2 abc
Control	-	-	9	9	19.3 (NSD)	38.7 ab

[1]Tolerance ratings were assessed on a 0-9 scale with 0 = complete kill or the crop and 9 = complete tolerance of the crop.

[2]Values followd by the same letter are not significantly different according to Duncan's multiple range test (P=0.05).

15 to 27 g/m^2 in 1982 and from 27 to 42 g/m^2 in 1983. However, differences between treatments were not statistically significant in 1982. In 1983, only the plots treated with bentazon at 1.0 kg/ha and 2,4-DB at 1.4 kg/ha (early application) yielded significantly less than the control plots, with seed yields reduced by 18% and 28% respectively.

Post-Emergence Herbicides for Nightflowering Catchfly and American Dragonhead in Established Alfalfa

Bromoxynil at 0.6 kg/ha and metribuzin at 0.4 kg/ha provided good control of nightflowering catchfly seedlings (Table 19). However, control was reduced when the seedlings were past the 4-leaf stage. Plants sprayed with the lower rates of bromoxynil or metribuzin and plants which had advanced to the 6-leaf stage were damaged by the treatments but recovered later in the season. Bentazon did not provide acceptable control of nightflowering catchfly at either 1.0 or 2.0 kg/ha.

The higher rates of both bromoxynil and metribuzin controlled American dragonhead seedlings and rosettes (Table 2). Metribuzin was slightly more damaging to the more advanced weeds than was bromoxynil. Bentazon was ineffective in controlling American dragonhead at either rate.

A heavy crop canopy intercepted much of the applied chemicals, thereby reducing control of both species within rows and between the two narrowly spaced centre rows.

Table 19. Control of American Dragonhead and Nightflowering Catchfly with Post-Emergence Herbicides in Established Alfalfa.

Treatment	Rate (kg/ha)	Visual Injury Ratings[1]		Weed Control Ratings[1]	
		10 days after treatment	6 weeks after treatment	American dragonhead	Nightflowering catchfly
Control	-	9	9	0	0
Bromoxynil	0.30	6	9	6	7
Bromoxynil	0.45	6	9	6	7
Bromoxynil	0.60	6	9	8	8
Metribuzin	0.20	6	9	4	7
Metribuzin	0.30	6	9	4	7
Metribuzin	0.40	5	9	8	8
Bentazon	1.0	6	8	4	5
Bentazon	2.0	6	8	5	6

[1]Weed control and crop tolerance were assessed on a 0-9 scale with 0 = no control of the weed and complete death of the crop and 9 = complete control of the weed and complete tolerance of the crop.

Tolerance of Established Alfalfa to Spring- and Fall-Applied Dormant Herbicides

None of the herbicides appeared to retard vegetative growth or to delay flowering of either two- or three-year-old alfalfa. In the two-year-old stand, seed yields in the sprayed plots were as high as those obtained in the hand-weeded controls (Table 20). Seed yields in the three-year-old stand were higher in the sprayed plots than in the unsprayed plots possibly due to high densities of kochia which occurred in control plots despite efforts to handweed them. No differences in alfalfa seed yields occurred between fall and spring treatments.

Control of American Dragonhead in Established Alfalfa Using Dormant-Applied Herbicides

Both spring and fall applications of metribuzin at 2.0 kg/ha provided 90% control of American dragonhead (Table 21). Control was reduced to between 60 and 80% when rates of 1.0 kg/ha metribuzin were used. Regardless of the time of application, neither terbacil nor simazine provided better than 40% control of American dragonhead rosettes.

DISCUSSION

In these experiments, 2,4-DB was used in established alfalfa at rates of 1.0 kg/ha and at three growth stages up until the crop was 60 cm in height without causing yield losses (Table 18). While good tolerance of alfalfa to 2,4-DB has been noted by other workers (Waddington 1982, Moyer

Table 20. Tolerance of Two- and Three-year-old Alfalfa Stands to Spring - and Fall-Applied Dormant Herbicides.

Treatment	Rate (kg/ha)	Alfalfa Seed Yields (g/m^2)[1]	
		2 year old stands	3 year old stands
Control	-	34.8	20.1 c
Terbacil	0.7	37.4	24.7 ab
Terbacil	1.2	35.7	26.2 a
Pronamide	0.5	37.4	19.3 c
Pronamide	0.7	35.7	21.8 ab
Simazine	1.1	35.9	25.2 ab
Metribuzin	2.0	41.3	22.9 abc
		(NSD)	

[1]Values followed by the same letter are not significantly different according to Duncan's multiple range test (P=0.05).

Table 21. Dormant-Applied Herbicides for American Dragonhead Control in Established Alfalfa.

Treatment	Rate (kg/ha)	Application Date	Alfalfa Tolerance Ratings 4 Weeks After Emergence[1]	Density of Rosettes of American Dragonhead[2]
Weedy	-	-	9.0	22.0 a
Simazine	1.1	01/11/82	9.0	19.4 ab
Terbacil	0.7	01/11/82	8.8	14.3 ab
Terbacil	0.7	05/04/83	8.9	17.6 ab
Terbacil	1.2	01/11/82	9.0	16.3 ab
Terbacil	1.2	05/04/83	9.0	13.0 ab
Metribuzin	1.0	01/11/82	8.8	4.5 ab
Metribuzin	1.0	05/04/83	8.8	8.9 ab
Metribuzin	2.0	01/11/82	8.9	2.3 b
Metribuzin	2.0	05/05/83	8.8	2.1 b

[1]Tolerance ratings were assessed on a 0-9 scale with 0 = complete kill of the crop and 9 = complete tolerance of the crop.

1981), reductions in alfalfa seed yields noted by Pchajek (1983) indicated that crop recovery is not always satisfactory. Hence 2,4-DB sprayed at 1.0 to 1.4 kg/ha cannot be recommended for field use without further testing.

Tolerance of alfalfa to applications of 2,4-DB at early or later stages of crop growth was not significantly different than controls (Table 1). This was also observed by Moyer (1981) in Lethbridge. However, Pchajek (1983) indicated that reductions in alfalfa seed yields were greater when 2,4-DB was applied at later stages of crop growth. Current recommendations in Manitoba caution against using 2,4-DB once the alfalfa is taller than 15 cm (Manitoba Agriculture 1984). Although 2,4-DB did not reduce alfalfa seed yields even at advanced growth stages, further testing should be undertaken to determine if the treatment is safe under different environmental or soil conditions.

Neither bromoxynil nor metribuzin at 0.6 and 0.4 kg/ha, respectively, reduced alfalfa seed yields and both would be useful for controlling nightflowering catchfly and American dragonhead rosettes (Tables 18 and 19). These treatments must be applied at an early date, when the alfalfa plants do not shield the weeds from the spray. However, application of post-emergence chemicals in early spring would miss late-germinating seedlings of both species. This would be a particular disadvantage in attaining control of American dragonhead seedlings since many of the seeds of this species do not germinate until mid-summer.

There were no visible damage symptoms or reductions in seed yield in alfalfa sprayed with any of the dormant-applied chemicals (Table 20). Differences in tolerance of the alfalfa to spring versus fall applications of terbacil, pronamide, simazine and metribuzin were not significant. Therefore, the choice of season for application of the chemicals may be made solely on the basis of weed control efficacy. Terbacil, pronamide and metribuzin are more effective when adequate soil moisture is present to move the chemicals into the soil. Fall application would therefore be preferred, since the melting of snow in the spring would probably enhance the movement and effectiveness of these herbicides.

The dormant applications of metribuzin proved useful in controlling American dragonhead (Table 21). The residual soil activity of the chemical allowed control of American dragonhead seedlings germinating late in the season. Metribuzin is currently recommended for use in Alberta at 1.0 kg/ha in established alfalfa grown under irrigation and may be a useful treatment in Manitoba.

The results of the trials undertaken indicate that a number of post-emergence and dormant-applied herbicides could be recommended for use in alfalfa seed fields. Two treatments which would be of particular value in control of nightflowering catchfly and American dragonhead would be bromoxynil at 0.6 kg/ha applied post-emergence, and metribuzin at 2.0 kg/ha applied during dormancy of the alfalfa. The latter treatment was tested only for American dragonhead control.

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APPENDIX 1

Climatological Data
Portage la Prairie, Manitoba
1982 and 1983

Appendix Table 1. Maximum, Minimum and Mean Temperatures, and Precipitation for the Growing Season at Portage la Prairie. (1982).

Date	May		June		July		August	
	Mean Temp.[1] (°C)	Precip.[2] (mm)	Mean Temp.[1] (°C)	Precip.[2] (mm)	Mean Temp.[1] (°C)	Precip.[2] (mm)	Mean Temp.[1] (°C)	Precip.[2] (mm)
1	12.0		8.8		18.1		16.3	
2	17.2		8.7		20.7		19.2	
3	22.0		14.7		23.4	10.4	22.2	
4	14.8		17.4		22.8		20.4	
5	11.0		20.0	21.6	22.5	5.3	19.7	
6	5.6	1.3	14.3		18.2		23.2	
7	4.3		8.7	3.8	16.0		20.4	3.8
8	3.6	1.3	5.8		16.8	0.3	16.0	
9	8.0		11.9		19.9		13.4	
10	6.9	11.2	14.3		20.3	3.8	13.6	
11	10.7		12.6		20.0		16.8	
12	9.7		14.2	0.8	21.7	6.1	17.2	1.3
13	12.9		17.2		17.7	0.3	20.9	
14	15.1		15.0		17.2		22.6	23.4
15	11.0	10.7	13.4		24.0	20.3	19.3	
16	12.0		16.6		20.4		18.7	
17	11.0	7.6	10.1		17.4		20.4	2.0
18	11.9		13.7		16.6	25.7	22.8	0.8
19	10.7		13.1	6.9	19.7		19.9	
20	12.8		14.4		20.1		18.8	
21	13.3		13.9		17.8		18.8	17.3
22	15.4		13.7	0.8	17.5	4.6	17.2	
23	15.9		20.1		21.8		15.4	
24	16.5		12.9		22.6		14.7	0.3
25	17.6		13.7		11.6		8.8	
26	20.5		19.0	0.9	20.1	34.5	8.4	
27	20.1		17.1		20.5		8.2	
18	17.2		15.8		19.9	43.2	12.8	
29	13.8		13.0		17.7		12.7	
30	11.6		14.1		19.6		10.8	
31	7.4				23.0		16.4	
A	12.7	32.1	13.9	35.2	19.8	154.5	17.0	48.9
B	12.2	81%	- 2.7	79%	0.0	192%	- 1.6	60%

A = Monthly Total

B = Departure from normal

[1]From CFB Portage la Prairie

[2]From Plant Science Field Station, Portage la Prairie

Appendix Table 2. Maximum, minimum and mean temperatures, and precipitation for the growing season (1983).

Date	May		June		July		August	
	Mean Temp. (°C)	Precip. (mm)	Mean Temp. (°C)	Precip. (mm)	Mean Temp. (°C)	Precip. (mm)	Mean Temp. (°C)	Precip. (mm)
1	6.8		12.0		18.7		23.7	4.0
2	9.9		15.3		17.3		25.7	
3	3.9		12.9		21.2		26.6	
4	2.4		8.4	4.0	13.1	22.0	31.4	
5	7.1		9.9		13.0		23.9	
6	5.8		13.5		23.1		26.5	
7	4.5		15.5	1.0	24.3		23.6	
8	9.5		15.5		24.8		19.4	
9	15.3		18.4		24.6		22.4	
10	14.8		24.8		26.1		24.6	
11	1.6		25.1		20.4		20.6	
12	1.3		22.9		23.4		24.2	
13	1.4		15.3		25.5		21.1	
14	- 3.0		16.1	5.2	25.3		23.3	
15	- 1.6		9.9	15.0	27.3		23.7	
16	3.8	11.0	5.7		21.1		20.4	1.1
17	12.8		17.3		20.8		24.5	
18	13.8		18.0		21.1		25.9	
19	5.9	18.1	19.2		23.0		18.5	
20	8.1		20.0	6.0	25.1		12.6	
21	13.5		19.6		25.3		19.1	
22	11.4		19.6	10.0	23.6		18.3	26.3
23	13.3		19.1		19.9		19.9	
24	6.9	3.0	21.6		19.6		22.1	9.0
25	9.8		22.4		22.6		24.0	
26	17.2		17.2		24.6		27.8	
27	15.5		16.2		25.4		23.5	
18	12.3		18.9		24.3		23.4	
29	10.6		16.3		21.5		23.2	
30	11.3		15.9		21.7		22.3	
31	10.9				22.2		26.4	4.0
A	8.3	32.1	16.9	41.2	22.2	22.0	22.7	44.4
B	- 2.9	71%	0.1	93%	2.0	30%	3.9	55%

A = Monthly Total

B = Departure from normal

[1]From CFB Portage la Prairie

[2]From Plant Science Field Station, Portage la Prairie

APPENDIX 2

Grower's Questionnaire

ALFALFA SEED PRODUCERS SURVEY 1983

Name ______________________________

Field ________ of ________ fields

Municipality______ Township______ Range______ Meridian______ Section______

I. GENERAL INFORMATION

1. Variety of alfalfa ____________________ Number of hectares ______________
   Year seeded ________.

2. Seeded in rows ( ) or broadcast ( ). What was seeding rate? ____________
   If rows, what spacing was used? Don't remember ( ). Spacing was _________

3. Is seed to be sold as breeder seed ( ), foundation ( ) or certified ( ).

4. Was field established with a companion crop? Yes ( ) No ( ). If yes, what crop was used? ____________________ Seeding rate of companion crop? Don't remember ( ). Seeding rate was ________________.

5. Was inoculum applied with alfalfa seed? Yes ( ) No ( ). If yes, was it applied as dry powder ( ), slurry ( ), granular ( )?

6. How was field pollinated in 1982? Own bees ( ), contractor ( ), natural pollinators ( ). What stocking rate of bees was used? Don't remember ( ). Stocking rate was ____________________.

II. WEED CONTROL INFORMATION

7. What do you consider to have been your most troublesome weeds <u>during the year of establishment</u> of this field? Don't remember ( ) Specify weeds with the most important one(s) first. Refer to the attached list for weeds.
   1. ______________________________
   2. ______________________________
   3. ______________________________
   4. ______________________________
   5. ______________________________

8. What do you consider to be your most troublesome weeds at the present time? List up to 5 with the most serious ones first.
   1. ______________________________
   2. ______________________________
   3. ______________________________
   4. ______________________________
   5. ______________________________

9. Were herbicides used during year of establishment? Yes ( ) No ( ). If yes, what herbicides?

   Name of Herbicide

   ____

   ____

   ____

10. Were herbicides used since year of establishment? Yes ( ) No ( ). What herbicides were used.

Year	Name of Herbicide	Fall or Spring Applied
1983	______________________	__________
	______________________	__________
1982	______________________	__________
	______________________	__________
1981	______________________	__________
	______________________	__________
1980	______________________	__________
	______________________	__________
1979	______________________	__________
	______________________	__________

11. Was a desiccant applied during 1982 harvest? Yes ( ) No ( ).

12. Were insecticides applied in 1982? Yes ( ) No ( ). Name of insecticide(s) ______________________. Target pest(s) ______________________ ______________________.

13. ADDITIONAL COMMENTS, UNUSUAL FEATURES OF THIS FIELD.

APPENDIX 3

Letters Accompanying the Grower's Questionnaire

June 14, 1983

The Department of Plant Science at the University of Manitoba is currently undertaking a research project on weed control in alfalfa seed production. The project is being carried out by Mark Goodwin, a graduate student working under my supervision. In addition to his plot experiments, Mark is conducting a survey among alfalfa seed producers to find out their views about what the main weed problems are in alfalfa seed production and what management practices are being used to combat these weeds. The information will be included in Mark's thesis and will provide a useful basis for planning future research work.

We hope that you will take the time to complete the enclosed survey form by filling in the appropriate spaces and placing checkmarks in brackets where applicable. Please fill out one form per field. Return the survey using the postage-paid envelope provided. The information from the entire survey will be combined and a summary of the results sent to you in the late summer or early fall. None of the individual respondents will be identified in the summary or in the final report so confidentiality is assured.

We hope to get as many replies back as possible to ensure a good overview of the problem. If at all possible could you please return the completed questionnaire some time within the next two weeks so that Mark can begin putting the information together over the summer.

Thanking you in advance.

Yours sincerely,

Ian Morrison
Associate Professor

IM/mf
Encl.

APPENDIX 4

Density and Distributions of
Weeds in the 1983 Survey
by Regions

INTERLAKE REGION

SPECIES	FREQUENCY (%)	FIELD UNIFORMITY (%) ALL	FIELD UNIFORMITY (%) OCCURRENCE	FIELD DENSITY (#/M2) ALL	FIELD DENSITY (#/M2) OCCURRENCE	DENSITY RANGE Low---High	RELATIVE ABUNDANCE
Quack grass	59.4	22.5	37.9	18.4+	30.9	0.8 - 99.0+	61.2+
Poa spp.	37.5	9.1	26.4	7.8+	22.6	0.0 - 79.2+	27.0+
Dandelion	75.0	21.5	43.3	1.3	1.7	0.0 - 12.1	24.9
Canada thistle	71.9	24.2	33.7	1.1	1.5	0.1 - 3.6	20.5
Sow-thistle spp.	62.5	18.0	28.7	1.2	2.0	0.1 - 7.3	17.3
Timothy	28.1	5.6	20.0	3.3+	11.9+	0.0 - 38.0+	13.6+
Wild buckwheat	46.9	12.7	27.0	0.4	0.8	0.0 - 2.5	11.3
American dragonhead	46.9	13.0	27.7	0.3	0.7	0.0 - 1.6	11.3
Narrow-leaved hawk's beard	37.5	12.8	37.3	0.7	1.9	0.2 - 4.0	11.0
Wild oats	31.3	12.2	39,0	0.9	3.0	0.1 - 10.8	10.7
Wild mustard	37.5	9.4	25.0	0.3	0.9	0.0 - 4.3	8.8
Smooth brome	15.6	2.3	15.0	1.8+	11.6+	0.8 - 19.8+	7.2+
American vetch	34.4	6.9	20.0	0.1	0.4	0.1 - 0.9	6.9
Hemp-nettle	21.9	5.9	27.1	0.5	2.1	0.0 - 4.3	6.0
Stinkweed	25.0	5.2	20.6	0.3	1.1	0.0 - 2.8	5.5
Sweet clover (white and yel.)	25.0	3.6	14.4	< 0.1	0.2	0.0 - 0.3	4.3
Smartweed (annual) spp.	21.9	3.9	17.9	< 0.1	0.4	0.0 - 0.6	4.2
Rough cinquefoil	18.8	4.2	22.5	< 0.1	0.4	0.1 - 0.6	4.0
Plantain spp.	12.5	3.4	27.5	0.4	3.0	0.0 - 7.8	3.7
Green foxtail	15.6	2.8	18.0	0.3	1.8	0.0 - 4.6	3.6
Canada goldenrod	15.6	3.7	24.0	0.1	0.8	0.0 - 4.6	3.6
Lamb's-quarters	18.8	2.7	14.1	< 0.1	0.3	0.0 - 0.8	3.3
White clover	18.8	2.0	10.8	< 0.1	0.2	0.0 - 0.4	3.0
Flixweed	15.6	2.3	15.0	< 0.1	0.2	0.0 - 0.4	2.8
Night-flowering catchfly	15.6	1.7	11.0	< 0.1	0.6	0.0 - 1.5	2.6

Continued on the next page

INTERLAKE REGION (continued)

SPECIES	FREQUENCY (%)	FIELD UNIFORMITY (%) ALL	OCCURRENCE	FIELD DENSITY (#/M2) ALL	OCCURRENCE	DENSITY RANGE Low---High	RELATIVE ABUNDANCE
Hare's-ear mustard	9.4	2.7	28.3	0.1	1.2	0.8 - 1.6	2.4
Northern Bedstraw	12.5	1.2	10.0	< 0.1	0.3	0.0 - 0.5	2.0
Cleavers	6.3	1.1	17.5	0.2	3.0	1.0 - 5.0	1.6
Shepherd's-purse	6.3	1.2	20.0	< 0.1	1.1	0.4 - 1.8	1.4
Absinth	9.4	0.8	8.3	< 0.1	< 0.1	0.0 - 0.1	1.4
Yellow evening-primrose	3.1	1.4	45.0	0.1	4.0	4.0 - 4.0	1.2
Redroot pigweed	6.3	1.1	17.5	< 0.1	0.5	0.3 - 0.6	1.2
Wood's rose	6.3	0.8	12.5	< 0.1	0.2	0.1 - 0.3	1.0
Water-parsnip	3.1	1.4	45.0	< 0.1	0.6	0.6 - 0.6	1.0
False cleavers	3.1	0.5	15.0	0.1	4.2	4.3 - 4.3	0.9
Alsike clover	3.1	1.1	35.0	< 0.1	0.5	0.5 - 0.5	0.8
Foxtail barley	6.3	0.3	5.0	< 0.1	< 0.1	0.0 - 0.1	0.8
Yarrow	3.1	0.8	25.0	< 0.1	0.4	0.4 - 0.4	0.7
Stork's-bill	3.1	0.6	20.0	< 0.1	0.4	0.4 - 0.4	0.6
Annual fleabane	3.1	0.3	10.0	< 0.1	1.2	1.3 - 1.3	0.6
Bluebur	3.1	0.5	15.0	< 0.1	0.2	0.2 - 0.2	0.5
Canada anemone	3.1	0.3	10.0	< 0.1	< 0.1	0.1 - 0.1	0.5
Field horsetail	3.1	0.3	10.0	< 0.1	< 0.1	0.1 - 0.1	0.5
Bird'sfoot trefoil	3.1	0.3	10.0	< 0.1	< 0.1	0.1 - 0.1	0.5
Biennial wormwood	3.1	0.3	10.0	< 0.1	< 0.1	0.1 - 0.1	0.5
Purslane	3.1	0.2	5.0	< 0.1	0.1	0.1 - 0.1	0.4
Red Clover	3.1	0.2	5.0	< 0.1	< 0.1	0.0 - 0.0	0.4
Kochia	3.1	0.2	5.0	< 0.1	< 0.1	0.0 - 0.0	0.4
Common pepper-grass	3.1	0.2	5.0	< 0.1	< 0.1	0.0 - 0.0	0.4

PARKLAND REGION

SPECIES	FREQUENCY (%)	FIELD UNIFORMITY (%) ALL	FIELD UNIFORMITY (%) OCCURRENCE	FIELD DENSITY (#/M2) ALL	FIELD DENSITY (#/M2) OCCURRENCE	DENSITY RANGE Low---High	RELATIVE ABUNDANCE
Quack grass	77.8	12.2	15.7	9.4+	12.1+	0.3 - 24.8+	42.9+
Dandelion	77.8	37,2	47.9	2.6	3.4	0.2 - 13.5	32.8
Wild buckwheat	77.8	21.7	27,9	1.9	2.4	0.0 - 10.0	23.1
Smooth brome	44.4	6.1	13.7	3.7+	8.3+	0.0 - 19.0+	18.8+
Wild oats	77.8	8.9	11.4	1.6	2.1	0.0 - 7.0	16.4
American dragonhead	77.8	13.3	17.1	0.7	0.9	0.0 - 3.6	15.4
Poa spp.	11.1	4.4	40.0	2.9+	25.8+	25.8 - 25.8+	12.3+
Flixweed	44.4	10.6	23.7	1.0	2.2	0.1 - 4.9	12.0
Night-flowering catchfly	33.3	8.3	25.0	1.6	4.7	0.0 - 11.8	11.9
Narrow-leaved hawk's beard	33.3	12.8	38.3	0.7	2.2	0.8 - 4.8	11.3
Canada thistle	55.6	10.6	19,0	0.4	0.8	0.1 - 2.1	11.3
Sow-thistle spp.	44.4	7.8	17.5	1.0	2.3	0.0 - 7.9	10.9
Lamb's-quarters	44.4	10.6	23.7	0.5	1.0	0.0 - 3.0	10.4
Stinkweed	44.4	7.2	16.2	0.4	1.0	0.1 - 2.7	8.8
Field horsetail	33.3	3.3	10.0	0.6	1.8	0.1 - 3.3	6.5
Absinth	22.2	8,3	37.5	0.2	0.8	0.0 - 1.6	6.5
American vetch	44.4	4.4	10.0	0.1	0.3	0.0 - 0.8	6.5
Shepherd's-purse	33.3	4.4	13.3	0.2	0.5	0.1 - 0.9	5.6
Hemp-nettle	22.2	4.4	20.0	0.4	1.6	0.6 - 2.6	5.2
Sweet clover (white and yel.)	22.2	1.7	7.5	0.6	2.5	0.1 - 4.9	4.6
Wild mustard	33.3	2.8	8.3	< 0.1	0.2	0.0 - 0.3	4.5
Canadian anemone	22.2	3.3	15.0	< 0.1	0.4	0.0 - 0.8	3.9
Plantain spp.	22.2	2.8	12.5	0.1	0.5	0.0 - 1.0	3.7
Smartweed (annual) spp.	22.2	1.1	5.0	< 0.1	< 0.1	0.0 - 0.0	2.6
Kochia	11.1	1.7	15.0	0.2	1.6	1.6 - 1.6	2.4

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PARKLAND REGION (continued)

SPECIES	FREQUENCY (%)	FIELD UNIFORMITY (%)		FIELD DENSITY (#/M2)		DENSITY RANGE Low---High	RELATIVE ABUNDANCE
		ALL	OCCURRENCE	ALL	OCCURRENCE		
Rough cinquefoil	11.1	2.2	20.0	< 0.1	0.8	0.8 - 0.8	2.3
Annual blue grass	11.1	1.1	10.0	< 0.1	0.8	0.8 - 0.8	1.8
Pygmyflower	11.1	1.1	10.0	< 0.1	< 0.1	0.1 - 0.1	1.6
Northern Bedstraw	11.1	1.1	10.0	< 0.1	< 0.1	0.1 - 0.1	1.6
Red Clover	11.1	0.6	5.0	< 0.1	< 0.1	0.0 - 0.0	1.3
Annual Fleabane	11.1	0.6	5.0	< 0.1	< 0.1	0.0 - 0.0	1.3

SOUTHEAST REGION

SPECIES	FREQUENCY (%)	FIELD UNIFORMITY (%) ALL	FIELD UNIFORMITY (%) OCCURRENCE	FIELD DENSITY (#/M2) ALL	FIELD DENSITY (#/M2) OCCURRENCE	DENSITY RANGE Low---High	RELATIVE ABUNDANCE
Quack grass	75.0	25.2	33.6	14.9+	19.9+	0.1 - 99.0+	66.8+
Canada thistle	83.3	35.6	42.7	2.0	2/4	0.0 - 9.8	32.5
Dandelion	83.3	24.2	29.0	0.6	0.8	0.0 - 3.3	22.8
Wild mustard	66.7	20.0	30.0	1.6	2.4	0.0 - 11.2	21.9
Poa spp.	33.3	6.2	18.7	4.8+	14.5+	0.0 - 99.0+	21.7+
Wild buckwheat	54.2	18.1	33.5	1.0	1.8	0.0 - 8.9	17.8
Sow-thistle spp.	45.8	10.2	22.3	0.8	1.7	0.0 - 9.0	12.4
Wild oats	37.5	7.9	21.1	1.0	2.7	0.0 - 18.6	11.1
Field Horsetail	37.5	7.9	21.1	0.3	0.7	0.0 - 2.3	8.8
Lamb's-quarters	29.2	6.7	22.9	0.5	1.6	0.1 - 6.8	7.9
Plantain spp.	37.5	6.5	17.2	0.1	0.4	0.0 - 0.9	7.7
Kochia	16.7	3.7	22.5	1.2	7.3	0.0 - 15.9	7.4
American vetch	29.2	4.8	16.4	0.2	0.8	0.0 - 4.9	6.3
Sweet clover (white and yel.)	20.8	5.0	24.0	0.1	0.6	0.0 - 0.9	5.1
Narrow-leaved hawk's beard	16.7	4.2	25.0	0.1	0.9	0.0 - 2.0	4.3
White clover	20.8	2.7	13.0	< 0.1	0.3	0.0 - 0.8	3.8
Smartweed (annual) spp.	25.0	1.5	5.8	< 0.1	< 0.1	0.0 - 0.1	3.6
Rye	4.2	0.8	20.0	0.8	19.8	19.8 - 19.8	3.4
Canada goldenrod	16.7	2.5	15.0	0.1	0.7	0.1 - 1.1	3.4
Smooth brome	4.2	0.8	20.0	0.7+	15.8+	15.8 - 15.8+	2.9+
Night-flowering catchfly	12.5	2.1	16.7	0.1	1.1	0.3 - 2.4	2.8
White cockle	16.7	1.7	10.0	< 0.1	0.1	0.0 - 0.3	2.7
American dragonhead	16.7	1.7	10.0	< 0.1	0.1	0.0 - 0.1	2.7
Green foxtail	16.7	0.8	5.0	< 0.1	0.6	0.0 2.0	2.6
Annual Fleabane	12.5	1.9	15.0	< 0.1	0.2	0.0 - 0.4	2.4

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SOUTHEAST REGION (continued)

SPECIES	FREQUENCY (%)	FIELD UNIFORMITY (%) ALL	FIELD UNIFORMITY (%) OCCURRENCE	FIELD DENSITY (#/M2) ALL	FIELD DENSITY (#/M2) OCCURRENCE	DENSITY RANGE Low---High	RELATIVE ABUNDANCE
Stinkweed	8.3	2.1	25.0	0.1	1.5	0.1 - 2.8	2.3
Timothy	4.2	0.4	10.0	0.4	9.9	9.9 - 9.9	1.9
Hemp-nettle	12.5	0.8	6.7	< 0.1	0.2	0.1 - 0.2	1.9
Red clover	12.5	0.8	6.7	< 0.1	< 0.1	0.0 - 0.1	1.8
Foxtail barley	8.3	0.4	5.0	< 0.1	< 0.1	0.0 - 0.0	1.1
Annual blue grass	4.2	0.2	5.0	0.2	4.0	4.0 - 4.0	1.1
Northern Bedstraw	4.2	0.8	20.0	< 0.1	0.4	0.4 - 0.4	0.9
Dock	4.2	0.6	15.0	< 0.1	0.1	0.1 - 0.1	0.8
Wormseed mustard	4.2	0.4	10.0	< 0.1	0.6	0.6 - 0.6	0.7
Canada Anemone	4.2	0.4	10.0	< 0.1	< 0.1	0.1 - 0.1	0.7
Shepherd's-purse	4.2	0.4	10.0	< 0.1	< 0.1	0.1 - 0.1	0.7
Milkweed spp.	4.2	0.2	5.0	< 0.1	0.2	0.3 - 0.3	0.6
Cocklebur	4.2	0.2	5.0	< 0.1	< 0.1	0.0 - 0.0	0.6

SOUTHWEST REGION

SPECIES	FREQUENCY (%)	FIELD UNIFORMITY (%) ALL	FIELD UNIFORMITY (%) OCCURRENCE	FIELD DENSITY (#/M2) ALL	FIELD DENSITY (#/M2) OCCURRENCE	DENSITY RANGE Low---High	RELATIVE ABUNDANCE
Quack grass	50.0	18.3	36.7	11.5	23.1	1.5 - 51.6	63.1
Sow-thistle spp.	75.0	22.5	30.0	2.8	3.8	0.0 - 15.4	34.1
Canada thistle	100.0	26.7	26.7	0.8	0.8	0.1 - 2.7	31.7
Wild mustard	50.0	21.7	52.0	1.4	3.3	1.3 - 8.9	24.5
Smooth brome	25.0	7.5	30.0	3.8	15.1	2.0 - 36.4	22.6
Dandelion	83.3	18.3	22.0	0.3	0.3	0.0 - 0.5	22.4
Narrow-leaved hawk's beard	33.3	9.6	28.7	2.6	7.9	0.0 - 31.3	20.3
Wild buckwheat	33.3	9.2	27.5	0.3	1.0	0.5 - 1.8	10.9
Green foxtail	41.7	3.7	11.2	0.5	1.6	0.1 - 4.1	9.7
Wild oats	33.3	6.2	18.7	0.2	0.5	0.1 - 1.3	8.6
Sweet clover (white and yel.)	41.7	2.5	6.0	< 0.1	< 0.1	0.0 - 0.3	6.9
Lamb's-quarters	33.3	3.3	10.0	< 0.1	0.2	0.1 - 0.4	6.4
Smartweed (annual) spp.	33.3	2.5	7.5	0.1	0.3	0.0 - 1.1	6.1
Stinkweed	25.0	2.5	10.0	0.1	0.5	0.0 - 1.4	5.1
Plantain spp.	16.7	2.9	17.5	< 0.1	0.2	0.2 - 0.3	4.0
Scentless chamomile	8.3	3.7	45.0	< 0.1	0.8	0.8 - 0.8	3.5
Field horsetail	16.7	1.2	7.5	< 0.1	0.2	0.1 - 0.3	3.0
American dragonhead	16.7	1.2	7.5	< 0.1	< 0.1	0.0 - 0.1	2.9
White cockle	16.7	0.8	5.0	< 0.1	< 0.1	0.0 - 0.0	2.6
Night-flowering catchfly	8.3	1.7	20.0	< 0.1	0.2	0.2 - 0.2	2.1
Pineappleweed	8.3	1.2	15.0	< 0.1	0.8	0.8 - 0.8	2.1
Hemp-nettle	8.3	0.4	5.0	0.1	1.5	1.5 - 1.5	1.8
Flixweed	8.3	0.8	10.0	< 0.1	0.1	0.1 - 0.1	1.6
Poa spp.	8.3	0.4	5.0	< 0.1	< 0.1	0.0 - 0.0	1.3
American vetch	8.3	0.4	5.0	< 0.1	< 0.1	0.0 - 0.0	1.3
Absinth	8.3	0.4	5.0	< 0.1	< 0.1	0.0 - 0.0	1.3

APPENDIX 5

Grower's Responses to the 1983 Questionnaire

Appendix Table 1. Response Rate to the Alfalfa Seed Field Questionnaire.

Parameter	No. of Respondents (no.)	Provincial Total (no.)[1]	Response Rate (%)
Growers	75	123	61
Fields	131	200	66
Hectares	1728	2446	71

[1]From the Plant Products and Quarantine Division (Agriculture Canada).

Appendix Table 2. Response Rate to the Alfalfa Seed Field Questionnaire (by region).

Parameter	No. of Respondents (no.)	Provincial Total (no.)[1]	Response Rate (%)
Parklands	20	20	100
Interlake	54	87	62
Southeast	30	56	54
Southcentral	27	46	59

[1]From the Plant Products and Quarantine Division (Agriculture Canada).

Appendix Table 3. Seeding Years of Fields Assessed in the Questionnaire.

Year seeded	Fields (no.)	Fields (%)	Hectares (no.)	Hectares (%)
1983	2	2	16	1
1982	20	15	350	20
1981	39	30	491	28
1980	40	30	587	34
1979	14	11	112	6
Before 1979	12	9	115	8

Appendix Table 4. Status of Stands Assessed in the Questionnaire.

Status	Fields (no.)	Fields (%)	Hectares (no.)	Hectares (%)
Foundation	71	54	942	55
Certified	52	40	689	40
Breeder	4	3	38	3

Appendix Table 5. Varieties of Stands Assessed in the Questionnaire.

Variety	Fields (no.)	Fields (%)	Hectares (no.)	Hectares (%)
Algonquin	65	48	764	44
Beaver	12	10	185	13
Angus	10	8	82	6
Vernal	9	7	140	10
Vista	8	5	137	8
Citation	4	3	70	5
Saranac	2	2	71	5
Rambler	8	6	136	8
Grimm	2	2	32	2
Pickstar	4	3	25	2
Rangelander	2	2	22	1
Anchor	2	2	23	1
Futura	1	<1	22	1
Ladak	1	<1	6	<1
Kane	1	<1	4	<1

Appendix Table 6. Method of Seeding of Fields Assessed in the Questionnaire Survey.

Method of Seeding	Fields (no.)	Fields (%)	Hectares (no.)	Hectares (%)
Broadcast	46	35	598	35
Rows	84	65	1117	65

Appendix Table 7. Method of Inoculation of Fields Included in the Questionnaire Survey.

Inoculation Method	Fields		Hectares	
	(no.)	(%)	(no.)	(%)
Dry powder	83	67	1099	64
Slurry	39	32	484	28
None	4	1	55	3

Appendix Table 8. Bee Sources of Fields Assessed in the Questionnaire Survey.

Source	Fields		Hectares	
	(no.)	(%)	(no.)	(%)
Grower-owned	55	44	947	52
Contractor	39	30	466	28
Natural pollinators	25	29	232	15

Appendix Table 9. Stocking Rate of Bees in Fields Assessed in the Questionnaire Survey.

Stocking Rate ,000 bees/ha	Fields		Hectares	
	(no.)	(%)	(no.)	(%)
Less than 15	10	8	75	4
16-20	27	22	469	27
21-25	12	10	141	8
26-30	3	2	28	2
31-35	24	20	286	16
36-40	11	9	319	18
More than 40	30	2	54	3

Appendix Table 10. Insecticide Usage in Fields Assessed in the Questionnaire Survey (1982).

Insecticide Usage	Fields		Hectares	
	(no.)	(%)	(no.)	(%)
Insecticide applied	75	61	1033	60
No insecticide applied	47	38	646	36

Appendix Table 11. Insecticides Used in Fields Assessed in the Questionnaire Survey (1982)

Insecticide	Fields (no.)	Fields (%)	Hectares (no.)	Hectares (%)
Dimethoate	42	33	705	40
Trichlorfon	35	26	316	19
Carbofuran	2	2	64	4
Malathion	3	3	40	3
Deltamethrin	1	<1	27	2

Appendix Table 12. Insect Problems in Fields Assessed in the Questionnaire Survey (1982)

Insect Problem	Fields (no.)	Fields (%)	Hectares (no.)	Hectares (%)
Lygus bugs	69	53	921	53
Adelphocoris	31	25	369	24
Aphids	5	4	180	8
Grasshoppers	12	10	202	14