MB-9

Fertilizer by Weed Management Study:

1996
Annual Report

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Forward

The Fertilizer by Weed Management Study was initiated to determine the effect of fertilizer timing and placement in conservation tillage with weed management. The major sponsor of the project is the Canadian Fertilizer Institute with Monsanto Canada Inc. and Ciba Canada Inc. providing additional support.

Note: The data presented within this report are preliminary in nature and should not be taken out of context from other research. Basic agronomic and weed management data are presented in this report. Additional information will become available from further laboratory analysis of 1996 samples. The data from other years and further statistical analysis are required before the data can be generalized. The data should not be used without the permission of the authors.

Executive Summary

1996 saw the successful initiation of the Fertilizer by Weed Management Study, a joint venture among Agriculture and Agri-Food Canada, the Canadian Fertilizer Institute, Ciba, and Monsanto. Management studies were initiated at Brandon, Melfort, and Beaverlodge to address the issue of the effect of the timing and placement of nitrogen fertilizer on weed management and a graduate program was initiated through the University of Manitoba to address the issue of the effect of phosphorus and potassium fertilizer on weed-crop competition.

Results from the management studies indicated that the timing and placement of nitrogen fertilizer had an impact on weed establishment and control and on final crop yield. At Brandon seedling densities were greatest in the sweep treatments. At harvest these differences were not evident. At Beaverlodge weed densities at seeding and at the seedling stage were greater in the two pass seeding systems compared to the one pass systems whether high or low disturbance. At harvest these differences were not evident. At Brandon, there was no difference between full and reduced rates of herbicides in terms of weed control and yield; however, at Beaverlodge the reduced rates of herbicides used in wheat resulted in greater weed densities but did not effect crop yield. Similar results occurred at Melfort where there was no difference in canola or wheat yield in the full versus part rate herbicide treatments. Weed and crop yield differences due to differences in crop row spacing (9 inch versus 12 inch) were not evident in 1996. These initial results support the reason for conducting this trial, in that, although differences in the effect of fertilizer timing and placement on weed management were small in year one, following initial trends over time will be the only way to determine the long-term feasibility of the approaches being tested.

The study of the effects of the different timings, placement, and soil disturbance levels on crop development indicated that crop seeding depth was similar among treatments while crop seedling development in the sweep treatments was ahead of the other treatments. No difference in plant development occurred between narrow and wide row spacings. The implications of differences in plant development will be determined from data from subsequent years. In 1996, higher crop yields were only evident for wheat seeded with sweeps at Melfort.

The field research conducted in 1996 is being supplemented with further laboratory analysis of soil, crop, and weed samples. This information will be presented in next years report along with an initial economic analysis of the treatments.

The graduate student portion of the project was focussed on course work in the winter of 1996. Field and growth room research will begin in 1997 with results will be reported next year.

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INTRODUCTION

Objectives:

1) To determine the impact of fertilizer placement and timing in direct-seeding systems on N fertilizer-use efficiency, herbicide usage, and weed communities. This objective is being met through the establishment of a short-term management study in three agroecological zones of the Black soil zone.

2)To determine the impact of P and K fertilizer on weed-crop competition. This objective is being met through a graduate student MSC. thesis project.

Background:

Direct-seeding systems are the most rapidly evolving agricultural technology in western Canada. Direct economic and soil conservation benefits have been documented at the farm and research level and have become the driving forces behind producer adoption of these conservation-tillage systems. Because the term direct seeding encompasses a broad range of one- and two-pass fertilization and seeding systems, questions have arisen regarding the relative efficiency of these different approaches. The most commonly asked questions relate to the effects of soil disturbance and fertilizer placement on crop yields, weed management, and production economics.

Potential Impact and Benefits:

The project will provide a knowledge base for efficient fuel, fertilizer, and herbicide usage thereby optimizing net-returns at a cropping-systems level for the Black Soil Zone. The data generated from this research will be the largest data base dealing in an integrated manner with the impact of fertilizer placement on weeds in direct-seeding systems and will be of interest to producers and the agro-industry. The principles elucidated will have regional and national application. The commercialization of this knowledge will occur through field days, presentation at grower meetings, and through the publication of results in the farm press, industry and extension publications and scientific journals. As decision support systems are developed, this data will be useful for predicting the response of crops, weed communities, and soils to direct-seeding systems and recommending appropriate management options.

Project Description:

I) Protocol for Management Studies:

a) General description:

The management studies were set up in a split-split plot design with 4 replicates. Plots were 7.3m X 15.0m in size. Crops (wheat and canola) were the main plot, fertilizer placement was the sub-plot, and herbicide rate was the sub-sub plot. For the sake of statistical analysis, all agronomic data was analysed by crop separately. Once several years of data are collected, weed community analysis by multivariate ordination will be done with using all plots in the analysis (wheat and canola plots used together).

In order to reduce site to site variability, seeding was done at all sites using identical seeders. Conservapak zero-tillage air seeders setup to seed on 9 inch and 12 inch row spacings were used (one pair of seeders at each site). For the sweep seeding, sweeps were purchased from a common sourse and used at all locations.

b) Core Treatments at each site:
-each of the following fertilizer treatment will be conducted in wheat and canola at 100% and 66% of in-crop herbicide rates with treatments being continuous (in same plot with crop rotating annually) for 5 years (1 startup year plus 2 cycles of crop rotation).

Treatment	Spacing of fertilizer (in)	Row spacing of seed (in)
fall band	12	9
spring band	12	9
side band at seeding	9	9
side band at seeding	12	12
one pass sweeps	9	9

Note; additional fertilizer treatments have been added at Melfort and Beaverlodge but are not summarized in this years report.

c) Agronomic Information:

I)Fertility: 66% of soil test recommendations for N
-approximately 85lb/ac at Melfort, 70 lb/ac at Beaverlodge, 65 lb/ac at Brandon
-P_2O_5: recommended rate (adjust N)
-S: elemental as required

ii)Crops: Teal wheat-common source from Melfort
Seed at 2 bu/ac (160 kg/ha)
Quest RR canola- common source from Monsanto
Seed at 7 kg/ha plus Furadan or Counter

iii)Herbicides: Pre-seeding, pre-harvest, and post-harvest as required at each site
In-crop use common treatments
Roundup in canola (1.24L/ha (0.5 l/ac) = 1X, 0.82L/ha=66%)
Horizon plus target in wheat
(Horizon rate wild oat rate 230ml/ha(56gai/ha)=1X and reduced

rate of 172.5ml/ha=75%X and 60% of wild oat and green foxtial rate). Reduced rate for Horizon changed based on dose response information from Ciba's data base. Target is to be used as a tank mix (it should control most weeds at all sites). 1X rate = 1.0 L/ha and 66% =0.66L/ha (Note that 1.0l/ha is at the low end of the recommended range, but should still suppress cleavers and other difficult to control weeds).

iv)Fungicides: As needed at each site

d)Data Collection:

I)Crop data: -crop stand prior to tillering (4-1m row counts per plot for wheat & canola using 4-0.25 m2 quadrats per plot for sweeps)
-head count 4 1m row per plot in wheat
-crop height in canola and wheat

ii)Haun Stage (wheat only):
-Haun stage and depth of seeding at 5-6 lf stage (GS 32 start of elongation) in full and reduced rate herbicide plots. Collect 20 plants/plot at 5-6 leaf stage in wheat.

iii)Nutrient dynamics:
-biomass at heading of weeds and crop
-1 of $1m^2$ quadrat per plot (separate weeds and crop) dry weight (also give biomass data to Derksen for weeds) and send ground samples to Grant (need about 25 grams, but for weeds send what there is).

iv)Yield: -per plot
-seed quality (1000k count, protein, green seed in canola, etc?)
-oil content for canola at Beaverlodge ??

e)Soil Sampling:
-soil moisture: 0-6, 6-12, 12-24, 24-36 spring and fall
-archive samples each year
-soil fertility: fall for N and P
0-6 and 6-24

f)Weeds:
-for counts use 20 0.5 X 0.5 m^2 ($0.25m^2$) quadrats per plot (always take the same # crop rows per quadrat). For very dense weed species devide quadrat into 4, count in one quarter of the quadrat, and multiply by 4 for density per quadrat on input sheets.
-count all weeds by species (density/quadrat)
Pre-seeding, pre-spray (in-crop), and residual weed community (July)
-send electronic files to Derksen for analysis (format to be sent out)
-emergence: estimate number of days difference in emergence between each dominate weed and the crop (Derksen will do detailed emergence sampling)
-need a weedy check in each plot (make tarp to cover about $2m^2$ so that a $1m^2$ weedy quadrat remains after spraying. Need a weed count at spraying and in July in this quadrat

that is separate from "20 quadrat" count. Harvest and thrash separately from main plot to obtain an estimate of crop yield loss due to weeds (i.e., sample of crop yield, weed yield)
-crop tolerance 7 DAT on 0-100 ECW scale for wheat and canola

Objective 2:

Master's Thesis Proposal

The Interaction of Phosphorus and Potassium Fertilizer on Weed/Crop Competition

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Literature Review

General Introduction

The use of fertilizer is a key factor in crop production. Of all of the factors that influence production, nutrients are one of the few that producers can control or manage. Effective use of fertilizer input is one of the keys to profitable grain and oilseed farming. In today's farming, fertilizers make up between 18 and 30 percent of oilseed and cereal crop production costs (Anonymous, 1988). On a dollar basis this is a range of \$12-23 ac^{-1} (Anonymous, 1988). Fertilizers have generally been a very good investment for producers in times of 'good' crop prices. However, recently crop prices have been dropping meaning that fertilizer management must be reevaluated. The question is not whether or not to use fertilizer but how to use it most profitably. In Manitoba, the main plant nutrients of concern are nitrogen (N) and phosphorus (P), and to a lesser extent potassium (K) and sulphur (S). The agronomic and economic benefits are well know to the producer, however, proper placement and rate can maximize economic yield response while minimizing overall inputs.

Spring wheat (*Triticum aestivum* L.) and flax (*Linum usitatissimum* L.) have been selected to study weed interference, interactions on refined rate and placement of fertilizer P and K to optimize their competitive advantage. Spring wheat and flax were selected because of their differences in competitive ability and because of their economic value to Manitoban agriculture. Spring wheat production in Manitoba has provided producers with increasing profits over the past two years. It is unlikely that many crops will be able to displace spring wheat because of its suitability to dry areas. In Canada, where the growing season is relatively short, average yields for flax in the provinces of Manitoba, Saskatchewan and Alberta range from 1055-1145 kg ha^{-1} (Flax Council of Canada, 1987). The highest yields are obtained in the wetter province of Alberta, where average fertilizer use per hectare is also higher. Manitoba has the lowest yield reflecting inadequate use of fertilizers and other management associated problems. Recent work has brought flax as a market competitive oilseed crop back into the lime light. It has been indicated that flax seed has the potential to become both a marketable human food grain (Carter, 1993) and an important poultry feed (Schneideler et al., 1994). Flax seed, a rich source of K (Carter, 1993), also accumulates sodium (Na) (Lewis, 1943), an essential element in human nutrition. There has also been renewed interest in flax fibre utilization.

Wild oats (*Avena fatua* L.) has been chosen as the weed species in this study. It is one of the most serious and aggressive weed species that Manitoban producers have had to deal with year after year.

The Need to Study the Interaction of Phosphorus and Potassium Fertility and Weed/Crop Competition

Determination of the proper rate and placement of P and K fertilizers will ultimately promote a more 'competitive', 'healthy', 'higher yielding' crop. Economically, the producer will save money and profit more by becoming more efficient with his/her fertilizer applications. Judicious fertilizer and herbicide use will benefit the environment, and promote political approval.

Throughout the literature, McBeath (1975) has provided the only fertility placement competition study. However, this was only with two fertilizer rates - 0 and an unquantified amount, similar to all other fertility studies looking at competition. Shrefler et al. (1994) has indicated that P fertilizer can influence the outcome of intra specific competition in plants, and may provide a similar influence with interspecific competition. Grimme (1979) has stated that only a small fraction of the K requirement of plants is present in close proximity to roots. Most of it has to move to the roots by means of diffusion and convection or mass flow. Banding and seed placement could increase the contribution of convection to K nourishment of crops (Tisdale et al., 1985). This could become extremely important for increasing flax yield. Bailey and Spratt (1979) reported that at flowering, the K content of the above ground portion of flax plants grown on the prairies averaged 15.5 g kg^{-1}. However, a level of 20 g kg^{-1} of K in the above ground portion of the plants at flowering is required for maximum yield.

There has been little information obtained concerning fertility interactions on weed/crop competition. There is a need to further examine the effects of placements and rates of P and K fertilizer to achieve full utilization of applied fertilizers.

Phosphorus Fertility and Spring Wheat Yield

Phosphorus (P) is an essential and major crop nutrient. Most Manitoban soils are deficient in available phosphorus. Provincially, phosphorus fertilizer would be recommended on most fields (Anonymous, 1988). Crop species vary in their response to phosphorus fertilizers. In Manitoba, wheat shows only a medium level response to phosphorus fertilizer (Anonymous, 1988). Many scientists have tried to select crops or genotypes with a greater ability to absorb P under P limiting conditions. Because soil P is supplied to plants mainly by diffusion (Itoh and Barber, 1983; Otani and Ae, 1996), morphological characteristics such as root length, surface area and fineness are considered to strongly influence P uptake (Barley, 1970; Fohse et al., 1991; Otani and Ae, 1996). However, crops with longer root systems should not always be considered as the most efficient in P uptake, especially when grown in P limiting conditions (Otani and Ae, 1996). For example, because of dry conditions in the prairies spring wheat has an extensive root system, but it only has a medium ability to retrieve available P. Many crops, employ additional mechanisms other than increased root length to increase P uptake.

P availability in the early growth stage (seedling) of all crops is of extreme importance (Vengris et al., 1955). All plants in the young stage of growth are substantially higher in P content than plants approaching maturity. P exported to seed is substantially higher in cereals than in pulse or oilseed crops. Selles et al., in their 1995 experiment found that the amount of P exported to the seed is directly related to P fertilization.

Halvorson and Havlin (1992) found that wheat grain yields increased significantly irrespective of P fertilizer method. However, it is well known that a P band placement provides increases in yield due to the high water solubility of P fertilizer, ie. the P remains in solution for a longer period when banded, and there is greater chance of root interception in early growth stages due to closer proximity to the seed. Dependent on soil P fertility levels, placement of P with the seed of spring wheat would be advantageous. Spring wheat does not typically show crop injury due to P seed placement.

As application of P continues to increase on the Canadian prairies (Campbell and Zenter, 1986) it becomes essential to evaluate placement and rate more rigorously, especially as concerns about the influence of agriculture chemicals on the environment increases.

Phosphorus Fertility and Flax Yield

In field and greenhouse studies, Ukrainetz et al. (1975) and Sadler (1980) found that flax is relatively unresponsive to P fertilizers and generally responds poorly to P placed with the seed, even on soils low in plant available P. With flax, placement of P in relation to the seed appears to be very critical not only to minimize seed injury but also to maximize crop response to the applied P. Racz et al. (1965) found that there was a lack of flax response to 22.4 kg P ha^{-1} as concentrated superphosphate, reasoning that this was partly due to the fact that flax has a low rate of P uptake and low P requirement as compared to rape and wheat. Sadler (1980) and Nyborg (1961) observed reduced germination and a 50% reduction in flax emergence, respectively due to placing P with the seed at varying rates. However, the Flax Council of Canada (1996) states that some provinces recommend a low rate of phosphate - not more that 20 kg ha^{-1} of P_2O_5 to be seed placed. Nyborg and Hennig (1969) recorded yield increases of up to 74% for flax by placing 15 kg P ha^{-1} as mono-ammonium phosphate (MAP) 2.5 cm directly below the seed. Similar yield increases in flax have been recorded by Bailey (1974). Another effective band placement at 2.5 cm to the side and 2.5 cm below the seed has been proven (Flax Council of Canada, 1996). Sadler's (1980) results indicated that flax yields and uptake of P achieved on initially P deficient soils by placement of band applied P in the optimum location relative to the seed may approach or exceed those obtained for flax grown on non - P fertilized soils of initial P status. Sadler (1980), also showed that the further the P was placed away from the seed the later the plant was able to make use of it, resulting in a smaller the growth response. Uptake of P by flax grown on soils that are initially P deficient can be substantially increased by placement of P fertilizer in a band 3 cm to the side and/or 0 - 4.5 cm below the seed (Sadler, 1980). Hennig (1969), Bailey (1974), Sadler (1980) and Grant and Bailey (1993) all agree that restricted root proliferation during the first 3-4 weeks after seeding appeared to be largely responsible for the extreme sensitivity of flax to the location of banded P fertilizer.

Potassium Fertility and Spring Wheat Yield

Potassium is a major crop nutrient, it is required by plants in relatively large amounts. Most agricultural soils contain large quantities of potassium. There is generally more potassium in the soil than any other nutrient, but plants can only draw on a very small proportion of what is available. In Manitoban soils there is generally enough potassium for maximum crop production (Anonymous, 1988). Deficiencies do occur, however, and on these soils the use of potassium fertilizer makes the difference between having a crop and no crop at all. Wheat and other cereal crops require about as much potassium (K) as nitrogen (N), and in some instances the need for K may exceed that of N (Kemmler, 1978). Mengel (1982) noted that K^+ uptake by wheat grown under water limiting conditions may be only 50 kg of K ha^{-1}, however, under optimal growth conditions it may reach 200 kg ha^{-1}. The quantities of K taken up per ton of grain and straw of cereals are 5 and 10-20 kg, respectively, for a wide range of conditions in absence of deficiencies or excesses (Beaton and Sekhon, 1985). Generally, 1 ton of cereal straw will contain about 1 kg of K (Beaton and Sekhon, 1985). Beaton and Sekhon (1985) also showed that K removal by field grown wheat can increase as much as 14 times when high rates of N, P and K are used.

Insufficient use of K with small grains commonly delays anthesis and maturity. This can have serious consequences for areas like Manitoba that have short growing seasons and where adverse weather conditions are likely to delay harvesting operations. Only a small fraction of the K requirement of plants is present in close proximity to roots (Grimme, 1979). Most of the K moves to roots via diffusion, convection or mass flow. Although, diffusion is generally thought to be the most important mechanism for K^+ movement to the roots, Tisdale et al. (1985) suggested that convection could significantly contribute to this process when K^+ concentrations in the soil solution are high. It is therefore thought (Tisdale et al., 1985) that high K^+ concentrations in the vicinity of fertilizer sources, particularly when banded, may increase the contribution of convection to K nourishment of crops. Beaton (1980) found that investment returns of K fertilizer in the USA and Canada for wheat were 200% or higher approximately 60% of the time.

Potassium Fertility and Flax Yield

Very little work has been done to assess the effects of K fertilizer on growth, seed yield, oil content and quality of flax. This is partially due to the fact that the crop is generally grown in fine textured soils that have adequate supplies of available K^+. Flax has a lower potential yield than most other oilseed crops under similar fertility and climatic conditions, and therefore its fertilizer requirement is typically lower. Like most oilseed crops flax requires and utilizes a relatively large amount of K^+ during growth. Bailey (1982) determined that a healthy crop of flax contains approximately 150 kg K ha^{-1} at maximum yield, excluding roots. However, Bailey and Soper (1985) stated that of this large quantity of K^+ taken up during growth, only a small portion (1%) is removed with the seed at harvest. Like most oilseed crops, therefore, flax returns the bulk of K to the soil.

In Western Canada, Bailey (1967) reported an increase in seed yield with a 9.3 kg ha^{-1} rate of K. Placing the K with the seed significantly increased yield over that of the check. Bailey (1967) also showed a synergistic effect of N and K on seed yield. Bailey and Soper (1985) suggest that the probability is very good that flax will respond to applications of K fertilizer when the NH_4OAc - exchangeable K^+ in the soil is <200 ugg^{-1}. But yield response is generally modest, therefore recommended rates of K for flax production in western Canada are relatively low and range form 29-62 kg K ha^{-1}. No effects of K on germination have been found in the literature, however; K may enhance the strength of plants. Banding and seed placement could provide K abundantly to the flax plant which could improve establishment and survival of seedlings.

Wild Oat (*Avena fatua* L.) Competition

Wild oats (*Avena fatua* L.) have long been recognized as one of the most widespread and troublesome weeds of the Northern Great Plains region (Bell and Nalewaja, 1968a). Agronomists estimate that 61 million acres in North Dakota, South Dakota, Montana, Minnesota and the three Prairie provinces of Canada are infested with wild oat (Bell and Nalewaja, 1968a). Of this area, 29 million acres can be rated as having a severe infestation of wild oat, presenting a major weed problem (Bell and Nalewaja, 1968a). Wild oats rate by far as the most serious annual weed of cultivated fields in the prairie provinces of Canada (Sharma and Vanden Born, 1978).

Wild oat persists in most spring planted small grain and flax fields because the seed ripens earlier than the crop and drops to the ground. Some of the wild oat seed may remain dormant in the soil for many years, assuring perpetuation of the species (Bell and Nalewaja, 1968a). High temperatures near the soil surface prevent germination of wild oat (Sexsmith and Pittman, 1963). Seed dormancy and irregular germination throughout the growing season are the most important features contributing to the persistence of wild oats (Sharma and Vanden Born, 1978). The Canadian prairies often experience moisture limitations throughout much of the growing season and under these conditions the competitive effect of wild oats could be expected to occur at earlier growth stages (Kirkland, 1993).

The competitive ability of plant species is affected by their environment (Zimdahl, 1980). Moisture, temperature, and nutrient levels influence germination, growth and competition. Time of weed emergence relative to the crop is important in determining competition (Peterson and Nalewaja, 1992). The agronomic and environmental conditions under which competition experiments are conducted will clearly modify the competitive effects of weeds on the crop (Wall et al., 1991). Pavlychenko and Harrington (1934) studied competition between crops and various weed species. They ranked the crops in order of competitive ability as follows; barley, spring rye, wheat and oats, and finally flax. Among the weeds, wild oats was one of the most competitive, if not the most.

Wild Oat Competition in Wheat

Cudney (1989) suggested that wheat and wild oats are equivalent in competitiveness. Equivalence in competitiveness indicates that wheat could be substituted for wild oats or wild oats for wheat on an equal basis with a similar effect on biomass. Generally, competition between cereals and wild oats occurs below ground (Satorre and Snaydon, 1992). Pavlychenko and Harrington (1934) reported that 5 days after emergence, wild oats had a root system 87 cm in length, and 24 days after emergence the length was 24 m. 80 days after emergence the total length of the root system was 256 m. This root system at 80 days was more extensive than that of any of the cereal crops: barley, wheat, spring rye and oats. However, in terms of root aggressivity Satorre and Snaydon (1992) found that all of the wheat cultivars in their study had higher root competitive abilities. Pavlychenko and Harrington (1934) found that in the case of wheat - the major part of the root mass is found a considerable distance from the surface. This type of root system is better adapted for drought resistance than for competition with weeds. It allows weeds to become established easily due to the scarcity of wheat roots in the upper levels. In drier zones (like the prairies) a longer root system is suitable. Pavlychenko and Harrington (1934) showed that wild oats occupied the soil from the surface to great depths almost completely, the ability of cereals to compete at all with wild oats may be explained first by the slower normal germination of wild oats and secondly by the fact that the wild oat has no more than three primary roots and develops its root system very slowly at early growth stages.

Generally, the longer wild oats were allowed to remain in the plots the lower was their resultant yield (Bowden and Friesen, 1967). Bell and Nalewaja (1968a) found a similar result with wild oat density. They found that wild oat competition reduced the yield of wheat as the density of wild oat seedlings increased. Bell and Nalewaja (1968a) and Kirkland and Hunter (1991) found that yield reduction caused by wild oats probably resulted from a reduction in the number of fertile tillers of wheat. However, the exact density of wild oat seedlings which will cause a yield reduction of economic importance is dependent on the environment, herbicide cost, and price of the crop etc.. For example; Bowden and Friesen (1967) found that only 37 wild oat plants m^{-2} were required to reduce wheat yields significantly. However, Kirkland (1993) had varying result finding that an infestation of 64 wild oat plants m^{-2} maintained up to the 6 leaf (L) stage did not reduce grain yield. However, yields declined 14% when wild oat plants were allowed to remain to the 7L stage and 28% if allowed to compete throughout the growing season. At a density of 118 wild oat plants m^{-2}, Kirkland (1993) found the wheat grain yields where not reduced when this density was maintained up to the 5L stage. When the infestation was allowed to remain to the 6 and 7L stage, grain yield was decreased by 17 and 25% respectively. When the 118 plants m^{-2} wild oat density was allowed to compete throughout the whole season, grain yield was reduced by 39% (Kirkland, 1993).

Wild Oat Competition in Flax

Among cereal and oilseed crops, flax has been shown to be the least competitive with wild oat (Pavlychenko and Harrington, 1934; Sharma and Vanden Born, 1978). If wild oats emerge before the flax crop, yield loss is greater than if the weed emerges later. Serious competition starts before the 2-3L stage of wild oats (Sharma and Vanden Born, 1978; Bell and Nalewaja, 1968a).

Bell and Nalewaja (1968a) reported an average flaxseed yield reduction of 70.2% from only 10 wild oat plants m^{-2} in Manitoba. They also found that flaxseed yield continued to decrease as wild oat densities increased. Components of flaxseed yield, including bolls m^{-2}, seeds $boll^{-1}$, plants m^{-2}, and weight in g 1000 sds^{-1} were measured to determine which components were influenced by wild oat competition (Bell and Nalewaja, 1968a). Wild oat competition reduced all components measured. A density of 37 wild oat plants m^{-2} caused a reduction of 161 bolls m^{-2}, 0.51 seeds $boll^{-1}$, and 8.07 flax plants m^{-2} (Bell and Nalewaja, 1968a).

These results show that wild oat interference was least detrimental to flax yields after the time of flax boll formation. A similar result was reported by Stevenson and Wright (1996). In another study Bell and Nalewaja (1968b) determined that a maximum yield reduction of 76.3% occurred when wild oats were allowed to compete until full head growth stage. They also found that early removal of wild oats yielded more flaxseed and to prevent yield loss the critical time of weed removal was earlier at higher wild oat densities. Comparatively, from Bell and Nalewaja's (1968a and 1968b) studies it was found that even low wild oat densities can cause considerable reductions in flaxseed yield.

Both the 1968a and 1968b studies conducted by Bell and Nalewaja show that the early control of wild oats in flax crops is extremely important. Early control appears even more important at higher wild oat densities (Bell and Nalewaja, 1968b). The ideal time for control would be at germination or shortly thereafter, but wild oats should be controlled before the 5L stage, since a rapid increase in competition was observed at this stage (Bell and Nalewaja, 1968b).

Weed/Fertility Interactions

Changes in competitive interactions between plants as nutrient availability is modified has been documented. Weeds also may vary in response to differences in soil fertility (Shrefler et al., 1994). Some grow well at low levels of available nutrients, while genotypic plasticity allows them to take advantage of high fertility (Glauninger and Holzner, 1982). Generally, weeds require the same nutrients at the same time as the crop but are often more successful at obtaining them. Competition occurs when two or more organisms seek what they need and the supply falls below the combined demand. Fertilization usually stimulates weed growth to the crops detriment. With low fertility, competition is primarily for nutrients, however, with high fertility, competition is primarily for light (Zimdahl, 1993). Vengris et al. (1995) found that even at high rates of fertilization with N, P, and K fertilizers, weeds compete strongly for essential nutrients. In the study by Hoveland et al. (1976), they found that out of the 10 warm season and 7 cool season weed and crop species in their experiment, the weeds were more sensitive to low soil test P and K. Therefore, weeds in general are notably better indicators of nutritional deficiencies than the crops in which they are growing.

Wild Oat/Fertility Interactions

Although added fertilizers enhance the growth of both wild oats and the crop they effectively reduce crop yield losses, especially in crops that are strong competitors (Sharma and Vanden Born, 1978). Sexsmith and Russell (1963) found that N fertilizer increased the number of seed bearing stems, plant height, straw weight and seed yield in spring wheat. P fertilizer had no apparent effect on any aspect of wild oats but increased the wheat yield as did the N fertilizer. However, Haynes et al. (1991) found that wild oats produced more root mass and accumulated P more rapidly than oats (similar competitiveness as wheat). The wild oat plants also produced significantly more dry matter for a given accumulation of P in this study. McBeath et al. (1975) showed that differential placement of P fertilizer had a pronounced effect on the competitive ability of wild oats in barley. When P was available to barley, the enhanced growth helped to prevent wild oat seed production. Conversely, when P was available to wild oats, the weed offered strong competition to barley and reduced the crop yield. A similar study involving flax demonstrated an increase in the proportion of wild oats to flax plants with broadcast N fertilizer (Sexsmith and Russell, 1963). In England, Thurston (1959) reported that nitrogenous fertilizer did not alter the proportion of wild oats to cultivated cereals in an infested field, but increased the yields of both.

Bowden and Friesen (1967) found that once the wild oat density reached 100 plants yd^{-1} no marked differences occurred between fertilized and unfertilized treatments of wheat. The weed populations seemed to have cancelled out any advantage the fertilizer might have provided for the wheat crop. Bell and Nalewaja (1968c) stated that while the addition of fertilizer did not control the wild oats, crop yields could still be increased despite the presence of wild oats. In their study, the fertilized wheat produced larger yields than the corresponding unfertilized plots. However, even though the fertilization of plots infested with wild oat increased crop yields, the actual yield losses from wild oats prevented the crops from fully utilizing the fertilizer.

Objectives

Main Objectives

1. To determine the rate of phosphorus fertilizer (P_2O_5) that will promote an enhanced response of wheat and flax in terms of competitiveness.

2. To determine the rate of potassium fertilizer (KCl) that will promote an enhanced response of wheat and flax in terms of competitiveness.

Supplementary Objective

3. To determine if banding or seed placement of the above fertilizers has a varying effect on the response of wheat and flax.

Overall Objective

To promote efficient fertilizer (P_2O_5 and KCl) usage. To provide the producer with the knowledge of the appropriate P and K fertilizer rates to use in flax and wheat to maximize uptake and utilization, while minimizing the competition from wild oats.

Spring wheat has been and will continue to be a staple crop in the prairies for many years to come. With flax, however, the introduction of effective herbicides, higher flax prices, the need to diversify crop types (Stevenson and Wright, 1996), and expanded markets via an entrance into edible oil markets, point to increased flax acreages in the future. As a result, it is necessary that producers and researchers alike identify the management practices that will maximize flax seed yield in various growing conditions. With all of the concerns associated with herbicide usage, it will be advantageous to identify the appropriate rate and placement of P_2O_5 and KCl that will promote both wheat and flax competitiveness, against wild oat.

Field Experiment

Objective

To determine the optimal rate and placement of P and K in spring wheat and flax during competition for these resources from wild oats.

Materials and Methods

Varieties

Flax - Norlin flax (widely adapted and used, no known specialized P response).
Wheat - Katepwa (standard in variety trials, no differential response known).

Seeding, Row Spacing and Tillage

Katepwa spring wheat and Norlin flax will be seeded at 100 kg ha^{-1} and 40 kg ha^{-1} respectively. They will be seeded in rows 9 inches (22.5 cm) apart. The wheat will seeded 4-5 cm deep and the flax will be seeded 1.5-2.5 cm deep. The tillage type of preference will be direct seeding into standing stubble.

Soil Type and Sites

Two sites will be selected based on their fertility status and location. The soils selected at each site **must** have low P fertility. Soil types will be clay loam, located in the black soil zone close to the Brandon Research Station.

Phosphorus Fertilizer

The phosphorus fertilizer will be mono-ammonium phosphate (MAP), likely 11-51-0. Placement with the seed and side banding will be used in both wheat and flax. A control (with no fertilizer) and 5 rates for each crop will be used.

The rates tested with wheat will be: 0, 10, 20, 40, 80, and 120 P_2O_5 kg ha^{-1}. For both seed placement and banding.

The rates tested with flax will be: 0, 5, 10, 15, 20, and 40 P_2O_5 kg ha^{-1}. For both seed placement and banding.

A Response Curve should result from these rates.

Potassium Fertilizer

The potassium fertilizer will be muriate of potash (KCl). Placement with the seed will be used with wheat only. Usage of a variety other than Katepwa may have to be considered because there is no known varietal response to K.

The rates to be tested will be: 0, 10, 20, 40, 80, and 120 K_2O kg ha^{-1}.

*** any other fertility requirements will be applied according to soil test information.**

Weed Application and Densities

The weed species will be spread in half of each treatment (ie. 2 m). Overseeding will be pertinent, especially with wild oats because of its low germination rate. Densities conducive to yield loss in flax and wheat will be used. A density of 50 wild oat plants/m^2 will be used in wheat and a density of 20-25 wild oat plants/m^2 will be used in flax. All other weed species will be controlled by herbicide application.

Experimental Design

A split plot factorial design will be used. Rate and placement of fertilizer will comprise the main plot effects (10 levels + one control). +/- weeds (2 levels) will comprise the subplots. RCBD will be used with main plots randomized within blocks.

There will be 8 experiments (trials), 4 at each site. They will consist of the following:

1. Wheat +/- wild oats, phosphorus banded and seed placed.
2. Wheat +/- wild oats, potassium banded and seed placed.
3. Flax +/- wild oats, phosphorus banded and seed placed.
4. Flax +/- wild oats, potassium banded and seed placed.

There will be a total of 22 treatments replicated 4 times. Each treatment will be 2 x 8 m. Space will be allowed between each replication for easy machinery turn around.

Data Collection

When the data is collected from each experiment it will be organized according to fertilizer rate, fertilizer placement, presence or absence of weeds.

<u>Measurements to be made:</u>

-agrometerological data collected at each location throughout the season.
-soil test for each location.
-emergence date of crop (on per treatment basis, per m of row).
-emergence date of weed (on per experiment basis, per 1/2 square m quadrat).
-weed and crop biomass and tissue nutrient analysis at 4 weeks after emergence (on per treatment basis).
-weed and crop biomass and tissue nutrient analysis at anthesis/full boll formation (on per treatment basis).
-yield of crops and weed (everything will be harvested, the weed seeds will be separated

per treatment).
-tissue nutrient analysis will also be conducted at harvest per treatment.

Analysis

Analysis will follow an analysis of variance for a split plot as shown in the following table:

Table 1. Anova - split plot design.

Source of Variation	Degrees of Freedom (DF)
Replicates (r)	3
Fertilizer rate and placement (a)	10
R x F (Error a)	30
Main Plot Total	**43**
+/- Weeds (b)	1
F x W	10
Error b	33
Corrected Total	**87**

**** Where: R=replicates**
F=fertilizer rate
W=+/-weeds

For class variables treatment differences will be determined using contrasts and protected LSD. Response curves will be fitted to fertilizer rate data for each placement treatment.

*****this experiment will be conducted for 2 years, during the summers of 1997 and 1998.**

Greenhouse Experiment

Objective

To look more closely at species (spring wheat, flax and wild oats) response to rates of P and K. This information can be used to explain field results.

Materials and Methods

Pots

Pots lined with plastic will be used. They will hold approximately 2 kg of soil.

Soil

Soil with two different texture classifications will be used.

Fertility

Three rates of both P and K will be used for each species (ie. 0, low, and moderate). All other nutrient requirements will be added according to soil tests.

Experimental Design

Treatments will be:

- -species (3)
- -rates (3)
- -replications (3)
- -harvests (5)
- -soil type (2)

Total number of pots/experiment = 270 (1 replication/growth chamber).

Pots will be completely randomized within replications (in each growth chamber).

Data Collection

Measurements To Be Taken:

- -5 biomass harvests, one per week starting two weeks after emergence.
- -harvested material will be kept for tissue nutrient analysis

Analysis

Biomass over time will be plotted for each species/nutrient/rate/soil type combination. Relative growth rate comparisons will also be made.

Conclusion

This research is agronomically practical. The knowledge obtained may help producers to increase their yields and profits through efficient fertilizer use. As well as aiding environmental sustainability. Political approval will result from the decrease in herbicide applications, due to increased crop competitiveness.

There is little information on fertility interactions with weed/crop competition. Therefore, this research will be opening up a new area were improvement in the production system can be achieved, both environmentally and economically.

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1996 RESULTS

Objective A) Field Project

I) Summary of Production Information:

Location	Crop	Seeding Rate kg/ha	Fertilizer Rates kg/ha	Seeding Date	Harvest Date
Brandon	wheat	90	46-0-0: 120 11-51-0: 50	29/05/96	16/08/96
	canola	6	46-0-0: 120 11-51-0: 50	29/05/96	11/08/96
Melfort	wheat	150	46-0-0: 140 11-51-0: 40	29/05/96	18/08/96
	canola	8	46-0-0: 140 11-51-0: 40	29/05/96	20/08/96
Beaverlodge	wheat	100	46-0-0: 145 11-51-0: 56	27/05/96	27/10/96
	canola	4	46-0-0: 145 11-51-0: 56	27/05/96	18/10/96

ii) Herbicide Information:

Location	Crop	Pre-seeding treatment (product L/ha)	Date of application	In-crop treatment (product L/ha)	Date of application
Brandon	wheat	RoundUp 1.24	27/05/96	Horizon+ Target 1X: reduced:	24/06/96
	canola	RoundUp 1.24	27/05/96	RoundUp 1X: reduced:	24/06/96
Melfort	wheat	RoundUp 1.0	30/05/96	Horizon+ Target 1X: reduced:	28/06/96
	canola	RoundUp 1.0	30/05/96	RoundUp 1X: reduced:	28/06/96
Beaverlodge	wheat	1 L /ha 1 L/ha	May 13/96 May 22/96	Horizon+ Target 1X: reduced:	June 25/96
	canola	1 L/ha 1 L/Ha	May 13/96 May 22/96	RoundUp 1X: reduced:	June 25/96

iii) Agrometeorology

Location	Month	Average precipitation (mm)	1996 precipitation (mm)	Average temperature (°C)	1996 monthly average Temperature (°C)
Brandon	May	49	66	10.8	8.5
	June	79.3	53	15.9	17.6
	July	73	59	19	18.3
	August	64.5	25	17.6	18.7
Melfort	May	41.4	68.4	10.6	7.7
	June	61.9	23.2	15.5	17
	July	66.6	146.7	17.6	17.2
	August	53.1	10.2	16.3	17.5
Beaverlodge	May	38.9	70	9.7	6.3
	June	63.6	43.5	13.3	12.3
	July	64.9	93.7	15.4	14.7
	August	55.2	74.2	14.3	14.8

iv) Deviations from protocol in 1996:
-The fall banding treatments were done in the spring at Brandon, due to delays in aquiring new land at BRC for agronomy research.
-The weed counts were conducted at Melfort in a manner which allows for some base line data to be generated, but can not be analyzed with the rest of the data for this report.

v) Information collected but not presented in the 1996 report:
At the time of writing this report some information was collected and was still being analysed, some samples were still being analyzed in the laboratory, and some analyses can not be conducted on the first years data. Therefore, next years report will also include a comparison between weedy a weed free quadrats, weed emergence patterns (at Brandon), nutrient dynamics, and enonomic returns (including crop grade, dockage etc).

Weed Community Analysis

prepared by D. Derksen

Broadleaf and grass weeds species were present within the study. Species perennation included annual, biennial, and perennial. Both native and introduced species were present. The weed communities were reflective of the agroecological zone in which the research was conducted.

The number of individual weeds were counted by species prior to seeding, at the seedling stage, and at maturity. Counts were conducted in twenty quadrats randomly placed quadrats following a "W" pattern across each plot. Total weed densities were calculated as the average density of all individuals of all species per metre squared in each plot. In order to assess spacial as well as density aspects of the weed community, relative abundance values were calculated by species per plot and averaged by experimental factor, such as fertilizer treatment. Relative abundance was calculated as: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Summary of results

Results in 1996 indicate that there were not large differences between treatments, but differences did occur and will be interesting to follow in subsequent years. At Brandon and Beaverlodge differences were minor prior to seeding. When seedling weed communities were assessed, weeds were more dense in the sweep treatments at Brandon while at Beaverlodge densities were greater in the two pass systems (fall and spring band). Differences due to fertilizer treatment were few when mature weed communities (July) were assessed. Differences due to herbicide rates occurred only at Beaverlodge where there were greater weed densities in the low herbicide plots in wheat.

No differences occurred between the narrow and wide row spacing treatments.

Plots were evaluated to determine if crop tolerance to herbicide treatments differed by treatment. No differences occurred in 1996 at Brandon, Melfort, or Beaverlodge (data not presented).

Table 1.0 Average total density (+/- SE) of all weed species at Brandon in 1996.

Crop	Fertilizer application	Herbicide Rate	Pre-seeding Count	Pre-spray Count	July Count
Wheat	Fall Band	100 %	4.7 ± 1.0	21.0 ± 9.3	33.7 ± 19.6
Wheat	Fall Band	66 %	5.6 ± 2.3	17.9 ± 8.8	29.2 ± 13.1
Wheat	Spring Band	100 %	6.2 ± 2.8	21.9 ± 9.4	32.1 ± 12.3
Wheat	Spring Band	66 %	8.4 ± 3.7	34.2 ± 13.1	39.4 ± 21.6
Wheat	Side Band 9"	100 %	4.3 ± 1.4	14.6 ± 8.0	26.6 ± 13.6
Wheat	Side Band 9"	66 %	3.9 ± 2.5	20.6 ± 11.5	38.1 ± 22.5
Wheat	Side Band 12"	100 %	6.0 ± 3.6	15.9 ± 4.3	25.3 ± 12.5
Wheat	Side Band 12"	66 %	2.5 ± 1.3	13.3 ± 4.7	30.8 ± 19.9
Wheat	Sweeps	100 %	8.1 ± 6.5	69.9 ± 40.7	12.4 ± 4.5
Wheat	Sweeps	66 %	6.3 ± 2.6	78.1 ± 36.9	24.4 ± 10.1
Canola	Fall Band	100 %	5.1 ± 1.5	12.1 ± 2.2	10.0 ± 3.5
Canola	Fall Band	66 %	3.7 ± 2.1	16.4 ± 4.3	11.4 ± 3.8
Canola	Spring Band	100 %	7.8 ± 3.3	19.5 ± 5.9	14.3 ± 5.4
Canola	Spring Band	66 %	13.3 ± 9.9	16.4 ± 5.2	12.3 ± 3.7
Canola	Side Band 9"	100 %	4.3 ± 1.5	13.0 ± 1.9	9.4 ± 1.7
Canola	Side Band 9"	66 %	7.5 ± 4.5	13.5 ± 3.9	16.7 ± 6.5
Canola	Side Band 12"	100 %	6.9 ± 4.7	24.9 ± 9.6	24.8 ± 14.4
Canola	Side Band 12"	66 %	5.3 ± 2.7	13.7 ± 7.6	11.4 ± 2.0
Canola	Sweeps	100 %	10.2 ± 4.0	31.4 12.2	17.9 ± 3.0
Canola	Sweeps	66 %	8.9 ± 4.2	21.4 ± 9.9	16.8 ± 4.5

Table 1b. Orthogonal contrasts comparing the average total density of all weeds at Brandon in 1996.

Orthogonal contrasts	**Pre-seed Counts**	**Pre-spray Counts**	**July Counts**
	p value	p value	p value
Wheat (Rec. vs low herbicide)	ns	ns	ns
Canola (Rec. vs low herbicide)	ns	ns	ns
Wheat (rec. herb) Fall vs Spring band	ns	ns	ns
Wheat (rec. herb) Fall + Spring vs Side	ns	ns	ns
Wheat (rec. herb) Side band (9" vs 12")	ns	ns	ns
Wheat (rec. herb) Side band 9" vs Sweep	ns	<0.0024	ns
Wheat (low herb) Fall vs Spring band	ns	ns	ns
Wheat (low herb) Fall + Spring vs Side	ns	ns	ns
Wheat (low herb) Side band (9" vs 12")	ns	ns	ns
Wheat (low herb) Side band 9" vs Sweep	ns	<0.0017	ns
Canola (rec. herb) Fall vs Spring band	ns	ns	ns
Canola (rec. herb) Fall + Spring vs Side	ns	ns	ns
Canola (rec. herb) Side band (9" vs 12")	ns	ns	ns
Canola (rec. herb) Side band 9" vs Sweep	ns	ns	ns
Canola (low herb) Fall vs Spring band	<0.0114	ns	ns
Canola (low herb) Fall + Spring vs Side	ns	ns	ns
Canola (low herb) Side band (9" vs 12")	ns	ns	ns
Canola (low herb) Side band 9" vs Sweep	ns	ns	ns

Table 2.0 Average total density (+/- SE)of all weed species at Beaverlodge in 1996.

Crop	Fertilizer application	Herbicide Rate	Pre-seed Count	Pre-spray Count	July Count
Wheat	Fall Band	100 %	15.1 ± 4.8	251.7 ± 9.5	62.0 ± 8.5
Wheat	Fall Band	66 %	12.9 ± 3.4	271.8 ± 15.0	85.6 ± 16.6
Wheat	Spring Band	100 %	29.7 ± 7.7	218.9 ± 48.9	48.1 ± 10.1
Wheat	Spring Band	66 %	24.3 ± 5.9	271.6 ± 20.0	78.4 ± 17.6
Wheat	Side Band 9"	100 %	47.4 ± 11.4	122.4 ± 32.4	51.9 ± 11.2
Wheat	Side Band 9"	66 %	34.0 ± 8.7	65.8 ± 21.3	49.6 ± 10.1
Wheat	Side Band 12"	100 %	22.2 ± 7.7	122.4 ± 29.7	36.0 ± 9.2
Wheat	Side Band 12"	66 %	50.0 ± 21.2	76.5 ± 10.3	75.0 ± 11.5
Wheat	Sweeps	100 %	30.1 ± 12.4	92.6 ± 17.0	73.4 ± 16.1
Wheat	Sweeps	66 %	57.8 ± 22.1	93.4 ± 20.8	93.8 ± 22.2
Canola	Fall Band	100 %	19.9 ± 6.4	303.8 ± 18.6	45.5 ± 11.4
Canola	Fall Band	66 %	24.9 ± 6.5	332.3 ± 38.2	50.1 ± 9.7
Canola	Spring Band	100 %	32.6 ± 13.9	414.7 ± 47.6	63.8 ± 18.1
Canola	Spring Band	66 %	32.0 ± 5.5	254.2 ± 21.1	76.0 ± 17.8
Canola	Side Band 9"	100 %	48.0 ± 17.7	121.1 ± 25.6	77.2 ± 19.4
Canola	Side Band 9"	66 %	58.4 ± 19.4	142.5 ± 25.7	77.1 ± 29.1
Canola	Side Band 12"	100 %	43.3 ± 12.9	101.0 ± 7.5	62.1 ± 9.9
Canola	Side Band 12"	66 %	34.7 ± 7.4	101.9 ± 17.6	82.8 ± 5.3
Canola	Sweeps	100 %	41.7 ± 13.5	166.4 ± 41.4	79.0 ± 30.1
Canola	Sweeps	66 %	51.8 ± 12.9	120.7 ± 37.4	79.9 ± 9.2

Table 2b. Orthogonal contrasts comparing the average total density of all weeds at Beaverlodge in 1996.

Orthogonal contrasts	Pre-seed Counts	Pre-spray Counts	July Counts
	p value	p value	p value
Wheat (Rec. vs low herbicide)	ns	ns	<0.0146
Canola (Rec. vs low herbicide)	ns	<0.0365	ns
Wheat (rec. herb) Fall vs Spring band	ns	ns	ns
Wheat (rec. herb) Fall + Spring vs Side	ns	<0.0001	ns
Wheat (rec. herb) Side band (9" vs 12")	ns	ns	ns
Wheat (rec. herb) Side band 9" vs Sweep	ns	ns	ns
Wheat (low herb) Fall vs Spring band	ns	ns	ns
Wheat (low herb) Fall + Spring vs Side	<0.0691	<0.0001	ns
Wheat (low herb) Side band (9" vs 12")	ns	ns	ns
Wheat (low herb) Side band 9" vs Sweep	ns	ns	<0.0288
Canola (rec. herb) Fall vs Spring band	ns	<0.0038	ns
Canola (rec. herb) Fall + Spring vs Side	ns	<0.0001	ns
Canola (rec. herb) Side band (9" vs 12")	ns	ns	ns
Canola (rec. herb) Side band 9" vs Sweep	ns	ns	ns
Canola (low herb) Fall vs Spring band	ns	<0.0376	ns
Canola (low herb) Fall + Spring vs Side	ns	<0.0001	ns
Canola (low herb) Side band (9" vs 12")	ns	ns	ns
Canola (low herb) Side band 9" vs Sweep	ns	ns	ns

Table 3.0 Weed relative abundance and density by crop prior to crop seeding at Brandon in 1996.

Weed Species	Wheat RelAb	Wheat #/m^2	Canola RelAb	Canola #/m^2
Mustard species	74.0	6.0	71.0	6.2
Volunteer wheat	10.0	0.3	4.2	0.2
Canada thistle from root	6.0	0.2	9.7	0.2
Wild buckwheat	3.7	0.1	1.9	0.2
Stinkweed	3.4	0.1	4.8	0.4
Narrow leaved hawks beard	1.5	0.1	3.5	1.2
Smooth brome	0.7	<0.1	2.4	0.1
Common lambsquarters	0.4	0.1	---	---
Dandelion	0.2	<0.1	1.3	0.6
AGREE	0.1	<0.1	0.1	<0.1
Perennial sowthistle from root	0.1	<0.1	1.0	0.1
Wild oat	---	---	0.1	<0.1

Relative Abundance values (RelAb) were calculated by plot for each weed species: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Table 4.0 Weed relative abundance and density by crop prior to in-crop spraying at Brandon in 1996.

Weed Species	Wheat RelAb	Wheat #/m^2	Canola RelAb	Canola #/m^2
Canola	52.4	28.3	---	---
Wild mustard	12.2	3.3	17.1	5.4
Canada thistle from root	10.1	1.8	17.9	3.1
Wild buckwheat	9.3	2.5	16.8	4.5
Wild oat	5.1	0.6	19.6	3.5
Perennial sowthistle from root	5.1	1.0	8.3	2.3
Mustard species	2.6	0.3	8.5	0.7
Stinkweed	1.9	0.4	8.5	2.7
Green foxtail	0.7	0.1	1.7	0.3
Common lambsquarters	0.3	0.1	0.2	<0.1
Dandelion	0.2	<0.1	0.1	<0.1
Round-leaved mallow	0.1	<0.1	---	---
Kochia	0.1	<0.1	0.2	0.1
Narrow leaved hawks beard	---	---	0.2	<0.1
Wild tomato	---	---	0.1	<0.1
Volunteer wheat	---	---	0.9	0.1

Relative Abundance values (RelAb) were calculated by plot for each weed species: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Table 5.0 Weed relative abundance and density by crop in July at Brandon in 1996.

Weed Species	Wheat RelAb	Wheat $\#/m^2$	Canola RelAb	Canola $\#/m^2$
Canola	37.2	18.3	1.4	0.3
Canada thistle from root	18.8	4.2	15.1	3.1
Wild buckwheat	16.7	5.8	17.8	5.4
Stinkweed	12.9	4.6	7.8	4.1
Wild oat	5.0	1.3	36.1	7.6
Perennial sowthistle from root	4.5	0.7	7.7	1.9
Wild mustard	1.4	0.4	14.4	3.7
Common lambsquarters	0.5	0.1	0.3	0.1
Green foxtail	0.3	0.1	0.3	0.1
Storks bill	0.2	<0.1	---	---
Round-leaved mallow	0.1	<0.1	0.1	<0.1
Narrow leaved hawks beard	<0.1	<0.1	0.7	0.2
Shepherds purse	---	---	0.1	<0.1
Sweet clover	---	---	<0.1	<0.1
Wild tomato	---	---	<0.1	<0.1
Dandelion	---	---	0.5	0.2
Yellow goats beard	---	---	<0.1	<0.1

Relative Abundance values (RelAb) were calculated by plot for each weed species: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Table 6.0 Weed relative abundance and density by fertilizer treatment in wheat prior to crop seeding at Brandon in 1996.

Weed Species	Fall band		Spring band		Spring band 9"		Spring band 12"		Sweep	
	RelAb	#/m²	RelAb	#/m²	RelAb	#/m²	RelAb	#/m²	RelAb	#/m²
Mustard species	76.8	5.6	73.1	7.8	76.9	4.2	59.1	4.4	83.9	7.8
Canada thistle from root	8.7	0.3	10.2	0.3	7.0	0.3	2.4	0.1	1.9	0.1
Volunteer wheat	8.7	0.3	4.8	0.2	9.2	0.3	19.4	0.4	7.8	0.2
Smooth brome	2.6	0.1	0.9	0.1	---	---	---	---	---	---
Stinkweed	1.5	0.1	4.9	0.3	3.6	0.1	5.8	0.1	1.0	<0.1
Wild buckwheat	1.0	0.1	4.0	0.2	2.1	0.1	8.6	0.2	2.5	0.2
Narrow leaved hawks beard	0.6	<0.1	1.1	0.1	0.6	<0.1	4.7	0.2	0.4	<0.1
Quack grass	---	---	---	---	0.7	<0.1	---	---	---	---
Common lambsquarters	---	---	---	---	---	---	---	---	2.0	0.6
Perennial sowthistle from root	---	---	---	---	---	---	---	---	0.4	<0.1
Dandelion	---	---	0.9	0.1	---	---	---	---	---	---

Relative Abundance values (RelAb) were calculated by plot for each weed species: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Table 7.0 Weed relative abundance and density by fertilizer treatment in canola prior to crop seeding at Brandon in 1996.

Weed Species	Fall band		Spring band		Spring band 9"		Spring band 12"		Sweep	
	RelAb	#/m²	RelAb	#/m²	RelAb	#/m²	RelAb	#/m²	RelAb	#/m²
Mustard species	77.4	4.8	70.6	6.6	64.2	4.8	64.1	5.8	78.6	9.2
Canada thistle from root	7.9	0.2	1.6	0.1	16.3	0.3	16.8	0.3	6.0	0.3
Smooth brome	5.3	0.1	1.4	<0.1	1.3	0.1	4.2	0.2	---	---
Stinkweed	4.2	0.2	5.4	0.5	7.4	0.3	3.6	0.4	3.5	0.3
Volunteer wheat	3.2	0.1	9.8	0.3	4.2	0.2	0.7	<0.1	3.2	0.2
Quack grass	0.7	<0.1	---	---	---	---	---	---	---	---
Narrow leaved hawks beard	0.5	<0.1	6.7	3.2	3.0	0.8	2.0	0.3	5.1	1.7
Wild buckwheat	0.4	<0.1	1.4	<0.1	1.0	0.4	4.5	0.3	2.1	0.1
Perennial sowthistle from root	0.4	<0.1	0.8	<0.1	---	---	2.4	0.2	1.5	0.2
Wild oat	---	---	---	---	0.3	<0.1	---	---	---	---
Dandelion	---	---	2.4	2.3	2.3	0.4	1.6	0.2	---	---

Relative Abundance values (RelAb) were calculated by plot for each weed species: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Table 8.0 Weed relative abundance and density by fertilizer treatment in wheat prior to in-crop spraying at Brandon in 1996.

Weed Species	Fall band		Spring band		Spring band 9"		Spring band 12"		Sweep	
	RelAb	$\#/m^2$	RelAb	$\#/m^2$	RelAb	$\#/m^2$	RelAb	$\#/m^2$	RelAb	$\#/m^2$
Canola	54.2	18.3	49.6	21.5	48.6	14.4	50.0	10.5	59.8	76.6
Canada thistle from root	11.6	1.5	11.2	2.2	12.3	2.1	9.7	1.3	5.5	1.7
Wild mustard	10.0	1.5	16.7	5.5	9.4	1.8	14.3	2.9	10.6	4.8
Wild buckwheat	8.9	1.4	9.0	3.3	11.0	1.7	8.0	1.6	9.5	4.8
Wild oat	7.0	0.5	3.5	0.3	3.8	0.3	8.3	1.0	2.9	0.7
Perennial sowthistle from root	5.0	0.8	5.4	1.3	7.7	0.8	3.1	0.3	4.3	1.8
Green foxtail	1.9	0.1	0.5	0.1	0.3	<0.1	---	---	0.7	0.3
Mustard species	1.0	0.1	2.1	0.3	3.6	0.3	3.0	0.2	3.2	0.8
Common lambsquarters	0.2	<0.1	0.6	0.2	---	---	0.2	<0.1	0.4	0.2
Stinkweed	0.2	<0.1	1.4	0.4	3.3	0.6	2.2	0.3	2.7	0.8
Kochia	---	---	---	---	---	---	---	---	0.3	0.1
Round-leaved mallow	---	---	---	---	---	---	0.4	<0.1	---	---
Dandelion	---	---	---	---	---	---	0.9	0.1	---	---

Relative Abundance values (RelAb) were calculated by plot for each weed species: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Table 9.0 Weed relative abundance and density by fertilizer treatment in canola prior to in-crop spraying at Brandon in 1996.

Weed Species	Fall band		Spring band		Spring band 9"		Spring band 12"		Sweep	
	RelAb	$\#/m^2$	RelAb	$\#/m^2$	RelAb	$\#/m^2$	RelAb	$\#/m^2$	RelAb	$\#/m^2$
Wild buckwheat	20.8	4.8	14.6	4.0	14.7	2.7	12.3	2.3	21.3	9.0
Mustard species	18.2	1.9	8.8	0.3	6.4	0.6	2.1	0.1	7.0	0.8
Wild oat	17.6	2.6	27.9	5.5	14.0	1.6	14.8	2.6	23.6	5.2
Wild mustard	15.4	3.9	20.9	5.3	21.3	4.6	19.7	5.8	8.5	7.2
Canada thistle from root	11.8	2.0	4.9	0.7	29.0	4.6	28.9	3.9	14.8	4.4
Stinkweed	6.3	1.0	10.2	3.4	3.7	0.9	9.9	5.5	12.4	2.4
Perennial sowthistle from root	6.1	1.1	8.7	2.9	6.8	1.1	11.6	3.9	8.2	2.7
Green foxtail	1.4	0.2	1.6	0.3	1.8	0.2	0.5	0.1	3.3	0.9
Volunteer wheat	0.7	0.1	1.9	0.1	1.0	0.1	---	---	0.6	0.2
Common lambsquarters	0.5	0.1	---	---	0.3	<0.1	0.2	<0.1	0.2	<0.1
Kochia	0.5	0.2	---	---	0.3	0.1	---	---	---	---
Wild tomato	0.3	<0.1	---	---	---	---	---	---	---	---
Dandelion	0.3	<0.1	0.2	<0.1	---	---	---	---	---	---
Narrow leaved hawks beard	---	---	0.3	<0.1	0.6	<0.1	---	---	0.2	<0.1

Relative Abundance values (RelAb) were calculated by plot for each weed species: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Table 10.0 Weed relative abundance and density by fertilizer treatment in wheat in July at Brandon in 1996.

Weed Species	Fall band		Spring band		Spring band 9"		Spring band 12"		Sweep	
	RelAb	#/m²	RelAb	#/m²	RelAb	#/m²	RelAb	#/m²	RelAb	#/m²
Canola	46.2	27.0	20.8	11.9	30.7	12.2	44.5	22.2	44.0	17.9
Canada thistle from root	17.6	4.3	19.2	5.3	20.3	2.9	18.5	4.5	18.4	4.0
Wild buckwheat	12.5	3.4	20.0	7.4	21.9	8.5	14.5	5.1	14.6	4.8
Stinkweed	10.7	2.2	11.0	4.1	15.0	6.6	12.9	5.6	14.7	4.4
Wild oat	8.8	3.6	5.2	1.3	5.3	0.9	3.6	0.4	2.1	0.3
Perennial sowthistle from root	2.9	0.5	5.5	1.2	5.6	0.9	4.2	0.8	4.3	0.4
Wild mustard	1.0	0.1	4.7	1.6	0.7	0.2	0.5	<0.1	---	---
Storks bill	0.2	<0.1	---	---	---	---	---	---	0.6	0.1
Common lambsquarters	---	---	0.7	0.1	0.6	0.1	0.5	0.1	0.5	<0.1
Narrow leaved hawks beard	---	---	0.2	<0.1	---	---	---	---	---	---
Round-leaved mallow	---	---	---	---	---	---	0.5	0.1	0.2	<0.1
Green foxtail	---	---	0.2	<0.1	---	---	0.5	0.1	0.7	0.2

Relative Abundance values (RelAb) were calculated by plot for each weed species: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Table 11.0 Weed relative abundance and density by fertilizer treatment in canola in July at Brandon in 1996.

Weed Species	Fall band		Spring band		Spring band 9"		Spring band 12"		Sweep	
	RelAb	#/m²	RelAb	#/m²	RelAb	#/m²	RelAb	#/m²	RelAb	#/m²
Wild oat	36.8	8.2	33.9	7.1	33.7	6.8	35.7	7.6	40.5	8.4
Wild buckwheat	20.8	5.9	16.5	5.0	21.3	8.6	14.8	4.2	15.7	3.3
Wild mustard	17.8	5.1	17.8	4.7	12.6	3.6	8.8	2.2	15.0	3.0
Canada thistle from root	11.1	2.8	11.0	2.9	22.6	4.2	17.2	2.8	13.7	2.6
Stinkweed	7.5	3.4	10.4	9.8	8.2	3.8	7.9	1.9	5.3	1.4
Perennial sowthistle from root	4.9	2.1	7.1	1.8	10.9	2.6	8.5	1.8	6.9	1.2
Common lambsquarters	0.9	0.5	---	---	---	---	0.6	0.1	0.2	<0.1
Green foxtail	0.2	<0.1	---	---	---	---	---	---	1.1	0.3
Canola	---	---	---	---	2.3	0.9	4.7	0.7	---	---
Shepherds purse	---	---	0.3	0.1	0.3	0.1	---	---	---	---
Narrow leaved hawks beard	---	---	1.1	0.3	0.3	<0.1	1.2	0.3	0.9	0.1
Round-leaved mallow	---	---	---	---	---	---	0.4	<0.1	---	---
Sweet clover	---	---	0.2	<0.1	---	---	---	---	---	---
Wild tomato	---	---	0.1	<0.1	---	---	---	---	---	---
Dandelion	---	---	1.7	0.4	0.3	<0.1	0.3	0.1	0.5	0.2
Yellow goats beard	---	---	---	---	---	---	---	---	0.2	<0.1

Relative Abundance values (RelAb) were calculated by plot for each weed species: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Table 12.0 Weed relative abundance and density by herbicide treatment in wheat pre-seeding at Brandon in 1996.

Weed Species	Full rate		Reduced Rate	
	RelAb	#/m^2	RelAb	#/m^2
Mustard species	73.6	6.3	74.3	5.7
Volunteer wheat	11.5	0.3	8.4	0.2
Canada thistle from root	5.4	0.2	6.7	0.2
Stinkweed	3.7	0.2	3.0	0.1
Wild buckwheat	2.5	0.1	4.8	0.2
Narrow leaved hawks beard	2.2	0.1	0.8	0.1
Smooth brome	0.4	<0.1	1.0	<0.1
Dandelion	0.4	<0.1	---	---
Quack grass	0.3	<0.1	---	---
Common lambsquarters	---	---	0.8	0.2
Perennial sowthistle from root	---	---	0.2	<0.1

Relative Abundance values (RelAb) were calculated by plot for each weed species: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Table 13.0 Weed relative abundance and density by herbicide treatment in canola pre-seeding at Brandon in 1996.

Weed Species	Full rate		Reduced Rate	
	RelAb	#/m^2	RelAb	#/m^2
Mustard species	75.2	7.4	66.8	5.0
Canada thistle from root	12.1	0.3	7.3	0.2
Stinkweed	4.8	0.3	4.9	0.4
Volunteer wheat	2.9	0.1	5.6	0.2
Narrow leaved hawks beard	1.8	0.2	5.2	2.2
Wild buckwheat	1.3	0.1	2.5	0.3
Smooth brome	1.0	<0.1	3.9	0.1
Perennial sowthistle from root	0.4	<0.1	1.6	0.2
Dandelion	0.4	<0.1	2.1	1.1
Quackgrass	0.3	<0.1	---	---
Wild oat	---	---	0.1	<0.1

Relative Abundance values (RelAb) were calculated by plot for each weed species: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Table 14.0 Weed relative abundance and density by herbicide treatment in wheat prior to in-crop spraying at Brandon in 1996.

Weed Species	Full rate		Reduced Rate	
	RelAb	#/m^2	RelAb	#/m^2
Canola	54.6	27.0	50.3	29.6
Wild mustard	12.5	3.2	11.9	3.4
Canada thistle from root	10.1	1.6	10.0	1.9
Wild buckwheat	8.0	1.6	10.6	3.5
Wild oat	5.6	0.7	4.6	0.5
Perennial sowthistle from root	5.0	1.1	5.1	0.8
Mustard species	2.2	0.3	3.0	0.4
Stinkweed	1.1	0.2	2.8	0.6
Green foxtail	0.5	<0.1	0.9	0.2
Common lambsquarters	0.2	0.1	0.4	0.1
Dandelion	0.2	<0.1	0.2	<0.1
Kochia	0.1	<0.1	---	---
Round-leaved mallow	---	---	0.2	<0.1

Relative Abundance values (RelAb) were calculated by plot for each weed species: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Table 15.0 Weed relative abundance and density by herbicide treatment in canola prior to in-crop spraying at Brandon in 1996.

Weed Species	Full rate		Reduced Rate	
	RelAb	#/m^2	RelAb	#/m^2
Wild oat	20.3	4.2	18.9	2.8
Wild mustard	19.3	6.2	15.0	4.5
Canada thistle from root	17.8	3.7	18.0	2.6
Wild buckwheat	15.6	4.4	17.9	4.7
Stinkweed	9.8	3.4	7.1	1.9
Perennial sowthistle from root	7.4	2.0	9.1	2.7
Mustard species	7.0	0.9	10.0	0.6
Green foxtail	1.6	0.4	1.8	0.3
Volunteer wheat	0.7	0.1	1.0	0.1
Narrow leaved hawks beard	0.2	<0.1	0.3	<0.1
Common lambsquarters	0.2	<0.1	0.3	0.1
Kochia	0.1	<0.1	0.2	0.1
Wild tomato	---	---	0.1	<0.1
Dandelion	---	---	0.2	<0.1

Relative Abundance values (RelAb) were calculated by plot for each weed species: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Table 16.0 Weed relative abundance and density by herbicide treatment in wheat in July at Brandon in 1996.

Weed Species	Full rate		Reduced Rate	
	RelAb	#/m^2	RelAb	#/m^2
Canola	35.5	18.5	38.9	18.0
Canada thistle from root	21.7	4.3	15.9	4.1
Wild buckwheat	16.1	6.2	17.3	5.4
Stinkweed	12.1	4.6	13.6	4.5
Wild oat	4.9	1.7	5.0	0.9
Perennial sowthistle from root	3.1	0.5	5.9	0.9
Wild mustard	0.8	0.1	2.0	0.7
Green foxtail	0.3	<0.1	0.3	0.1
Round-leaved mallow	0.3	0.1	---	---
Common lambsquarters	0.1	<0.1	0.8	0.1
Narrow leaved hawks beard	0.1	<0.1	---	---
Storks bill	---	---	0.3	<0.1

Relative Abundance values (RelAb) were calculated by plot for each weed species: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Table 17.0 Weed relative abundance and density by herbicide treatment in canola in July at Brandon in 1996.

Weed Species	Full rate		Reduced Rate	
	RelAb	#/m^2	RelAb	#/m^2
Wild oat	33.3	7.5	39.0	7.8
Wild buckwheat	21.1	7.1	14.5	3.8
Wild mustard	13.8	4.0	15.0	3.4
Canada thistle from root	11.9	2.8	18.3	3.4
Stinkweed	8.1	3.4	7.6	4.7
Perennial sowthistle from root	6.8	1.6	8.5	2.2
Canola	2.8	0.7	---	---
Dandelion	0.8	0.2	0.3	0.1
Narrow leaved hawks beard	0.5	0.1	0.9	0.2
Common lambsquarters	0.5	0.2	0.2	<0.1
Round-leaved mallow	0.1	<0.1	---	---
Shepherds purse	0.1	<0.1	0.1	<0.1
Green foxtail	0.1	<0.1	0.4	0.1
Sweet clover	0.1	<0.1	---	---
Wild tomato	---	---	0.1	<0.1
Yellow goats beard	---	---	0.1	<0.1

Relative Abundance values (RelAb) were calculated by plot for each weed species: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Table 18.0 Weed relative abundance and density by crop prior to crop seeding at Beaverlodge in 1996.

Weed Species	Wheat RelAb	Wheat #/m²	Canola RelAb	Canola #/m²
Quack grass	68.7	35.2	67.2	42.0
Dandelion	17.1	2.7	18.2	3.5
Volunteer wheat	8.4	1.3	7.1	1.4
Red clover	5.8	1.1	7.5	1.5

Relative Abundance values (RelAb) were calculated by plot for each weed species: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Table 19.0 Weed relative abundance and density by crop prior to in-crop spraying at Beaverlodge in 1996.

Weed Species	Wheat RelAb	Wheat #/m²	Canola RelAb	Canola #/m²
Wild oat	30.2	87.3	42.2	164.3
Stinkweed	29.4	72.1	17.3	43.2
Wild buckwheat	11.1	14.5	10.6	13.8
Common lambsquarters	8.1	7.5	7.7	6.9
Bluebur	7.2	6.9	7.9	11.8
Common groundsel	4.4	3.5	5.4	6.4
Red clover	4.2	3.6	4.5	4.7
Mustard species	2.3	1.5	<0.1	<0.1
Dandelion	1.2	0.6	1.3	0.5
Quack grass	0.7	0.6	1.8	3.5
Smartweed species	0.3	0.1	0.2	0.1
Perennial sowthistle from root	0.2	<0.1	---	---
Volunteer pea	0.2	<0.1	---	---
Hempnettle	0.2	0.1	0.1	0.1
Vetch species	0.1	0.1	<0.1	<0.1
Cleavers	0.1	<0.1	0.1	0.1
Narrow leaved hawks beard	0.1	<0.1	<0.1	<0.1
Common chickweed	<0.1	<0.1	---	---
Shepherds purse	---	---	<0.1	<0.1
Canada thistle from root	---	---	<0.1	<0.1
Flixweed	---	---	0.1	0.1
Pineapple weed	---	---	0.1	<0.1
Corn spurry	---	---	<0.1	<0.1
Volunteer wheat	---	---	0.8	1.7

Relative Abundance values (RelAb) were calculated by plot for each weed species: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Table 20.0 Weed relative abundance and density by crop prior to in-crop spraying at Beaverlodge in 1996.

Weed Species	Wheat RelAb	Wheat $\#/m^2$	Canola RelAb	Canola $\#/m^2$
Wild oat	29.3	27.0	27.5	36.3
Wild buckwheat	21.6	18.6	25.4	19.1
Stinkweed	10.4	10.6	12.9	11.0
Red clover	9.7	7.0	8.7	7.8
Common groundsel	6.5	5.3	6.3	3.7
Narrow leaved hawks beard	4.4	3.2	2.5	1.1
Bluebur	3.9	2.0	3.5	1.6
Dandelion	2.8	1.5	3.6	1.3
Common lambsquarters	2.8	1.2	3.0	1.2
Ball mustard	2.6	1.4	3.1	2.1
Quack grass	2.0	1.9	1.8	0.8
Purslane	0.9	0.5	0.1	0.1
Shepherds purse	0.4	0.3	0.3	0.1
Prostrate knotweed	0.4	0.2	0.2	0.1
Cleavers	0.4	0.2	0.1	<0.1
Mustard species	0.4	0.1	0.2	0.1
Hempnettle	0.2	0.1	0.1	<0.1
Common vetch	0.2	0.1	0.1	<0.1
Wild tomato	0.2	0.1	<0.1	<0.1
Corn spurry	0.2	0.1	0.1	<0.1
Broadleaved plantain	0.1	0.1	---	---
Bicknells geranium	0.1	0.1	0.1	<0.1
Perennial sowthistle from root	0.1	0.1	0.2	0.1
Pineapple weed	0.1	<0.1	<0.1	<0.1
Common pepergrass	0.1	<0.1	---	---
"wild parsley"	0.1	<0.1	---	---
Volunteer pea	<0.1	<0.1	---	---
Round-leaved mallow	<0.1	<0.1	<0.1	<0.1
Volunteer wheat	<0.1	<0.1	0.1	<0.1
Canada thistle from root	<0.1	<0.1	---	---
Flixweed	<0.1	<0.1	---	---
Foxtail barley	<0.1	<0.1	---	---
Smartweed species	<0.1	<0.1	0.2	0.1

Relative Abundance values (RelAb) were calculated by plot for each weed species: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Table 21.0 Weed relative abundance and density by fertilizer treatment in wheat prior to crop seeding at Beaverlodge in 1996.

Weed Species	Fall band		Spring band		Spring band 9"		Spring band 12"		Sweep	
	RelAb	#/m²	RelAb	#/m²	RelAb	#/m²	RelAb	#/m²	RelAb	#/m²
Quack grass	75.7	15.3	61.9	26.8	62.8	43.9	74.2	41.8	69.1	48.4
Dandelion	11.8	1.0	20.4	4.0	21.2	3.8	14.6	1.7	17.5	3.2
Volunteer wheat	9.8	0.9	10.9	1.7	8.1	1.3	6.0	0.8	7.2	2.1
Red clover	2.7	0.3	6.8	1.3	7.9	1.7	5.2	0.8	6.3	1.3

Relative Abundance values (RelAb) were calculated by plot for each weed species: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Table 22.0 Weed relative abundance and density by fertilizer treatment in canola prior to crop seeding at Beaverlodge in 1996.

Weed Species	Fall band		Spring band		Spring band 9"		Spring band 12"		Sweep	
	RelAb	#/m²	RelAb	#/m²	RelAb	#/m²	RelAb	#/m²	RelAb	#/m²
Quack grass	78.9	25.7	64.8	34.0	65.8	58.3	63.3	41.3	63.1	50.7
Dandelion	12.1	1.4	18.2	3.5	20.6	4.8	20.1	4.2	20.2	3.9
Volunteer wheat	7.0	0.7	8.7	1.2	5.1	1.8	5.8	0.9	8.8	2.3
Red clover	2.0	0.3	8.3	1.7	8.5	1.6	10.9	2.4	7.9	1.5

Relative Abundance values (RelAb) were calculated by plot for each weed species: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Table 23.0 Weed relative abundance and density by fertilizer treatment in wheat prior to in-crop spraying at Beaverlodge in 1996.

Weed Species	Fall band		Spring band		Spring band 9"		Spring band 12"		Sweep	
	RelAb	#/m²	RelAb	#/m²	RelAb	#/m²	RelAb	#/m²	RelAb	#/m²
Wild oat	37.8	179.2	23.4	92.8	36.0	61.7	18.5	41.8	35.3	60.9
Stinkweed	26.9	108.3	32.5	140.3	25.0	32.0	35.4	51.1	27.1	28.7
Wild buckwheat	11.5	14.8	14.1	35.7	9.7	6.5	9.4	6.3	10.7	8.9
Bluebur	7.0	8.8	7.1	8.3	5.0	3.8	8.8	6.2	8.4	7.3
Common lambsquarters	6.3	5.9	9.1	13.7	7.5	5.8	11.0	8.0	6.8	4.2
Common groundsel	4.8	5.2	3.0	3.4	4.6	3.4	4.5	2.9	5.0	2.7
Red clover	2.5	2.3	4.6	7.4	4.1	1.5	7.3	5.6	2.3	1.1
Quack grass	1.0	1.7	0.5	0.4	1.0	0.6	0.3	0.2	0.4	0.4
Mustard species	1.0	0.5	2.9	2.7	2.4	1.4	2.2	1.2	3.2	1.6
Dandelion	0.9	0.4	1.7	0.9	1.4	0.7	1.5	0.6	0.5	0.2
Smartweed species	0.1	0.1	0.2	0.1	1.2	0.1	---	---	0.1	<0.1
Narrow leaved hawks beard	0.1	<0.1	---	---	---	---	0.2	.1	---	---
Hempnettle	---	---	0.3	0.2	---	---	0.5	0.2	0.2	0.1
Cleavers	---	---	0.2	0.1	---	---	0.2	0.1	---	---
Volunteer pea	---	---	---	---	1.0	<0.1	---	---	---	---
Perennial sowthistle from root	---	---	---	---	1.1	0.1	0.1	<0.1	---	---
Common chickweed	---	---	0.1	<0.1	---	---	---	---	---	---

Vetch species	---	---	0.3	0.5	---	---	0.1	<0.1	---	---

Relative Abundance values (RelAb) were calculated by plot for each weed species: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Table 24.0 Weed relative abundance and density by fertilizer treatment in canola prior to in-crop spraying at Beaverlodge in 1996.

Weed Species	Fall band		Spring band		Spring band 9"		Spring band 12"		Sweep	
	RelAb	#/m²	RelAb	#/m²	RelAb	#/m²	RelAb	#/m²	RelAb	#/m²
Wild oat	45.7	279.4	39.8	253.0	35.3	84.7	41.6	71.5	48.4	133.2
Stinkweed	16.9	63.3	21.2	88.0	19.8	27.9	15.1	20.3	13.4	16.7
Wild buckwheat	10.3	16.5	12.6	30.0	6.6	5.0	12.5	9.3	11.1	8.3
Bluebur	9.4	19.9	6.2	13.3	8.1	12.0	8.7	8.7	7.1	5.3
Common lambsquarters	8.5	10.4	6.6	9.7	9.5	6.5	6.8	3.3	7.0	4.8
Common groundsel	3.5	2.7	4.1	5.1	7.5	10.3	5.7	6.8	6.2	6.8
Red clover	2.6	2.9	4.5	9.7	3.8	2.2	6.5	5.3	5.2	3.4
Quack grass	1.4	1.5	0.2	0.3	6.9	15.2	0.3	0.2	0.1	<0.1
Dandelion	1.1	0.5	1.2	0.6	2.4	0.9	1.1	0.4	0.7	0.3
Flixweed	0.5	0.4	---	---	---	---	---	---	---	---
Hempnettle	0.1	0.1	---	---	---	---	0.4	0.3	---	---
Pineapple weed	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.2	0.1	---	---
Shepherds purse	---	---	0.1	<0.1	---	---	---	---	---	---
Canada thistle from root	---	---	---	---	0.1	<0.1	---	---	---	---
Narrow leaved hawks beard	---	---	---	---	---	---	---	---	0.1	0.1
Cleavers	---	---	---	---	---	---	0.4	0.3	---	---
Mustard species	---	---	---	---	0.1	0.1	0.1	<0.1	---	---
Smartweed species	---	---	0.1	0.1	---	---	0.6	0.3	0.1	<0.1
Corn spurry	---	---	---	---	---	---	0.1	<0.1	---	---
Volunteer wheat	---	---	3.3	8.1	---	---	---	---	0.6	0.6
Vetch species	---	---	0.2	0.1	---	---	---	---	---	---

Relative Abundance values (RelAb) were calculated by plot for each weed species: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Table 25.0 Weed relative abundance and density by fertilizer treatment in wheat prior to in July at Beaverlodge in 1996.

Weed Species	Fall band		Spring band		Spring band 9"		Spring band 12"		Sweep	
	RelAb	#/m²	RelAb	#/m²	RelAb	#/m²	RelAb	#/m²	RelAb	#/m²
Wild oat	31.1	37.2	26.1	18.3	35.0	23.0	29.3	23.8	25.1	32.5
Wild buckwheat	24.3	20.7	27.9	24.1	17.2	10.5	17.5	13.4	21.1	24.5
Red clover	10.1	7.8	14.9	11.5	6.3	3.7	9.4	5.5	7.6	6.4
Stinkweed	7.2	5.3	7.6	8.0	11.5	10.0	10.4	8.3	15.4	21.6
Common groundsel	6.1	6.5	5.5	5.5	6.7	4.8	9.9	7.0	4.3	3.0
Quack grass	5.0	5.4	2.2	2.5	---	---	0.8	0.3	1.9	1.3
Narrow leaved hawks beard	4.2	2.7	2.9	3.3	4.5	2.4	4.6	2.9	5.6	4.8
Ball mustard	2.7	2.3	2.2	0.9	2.9	1.6	3.3	1.3	2.0	0.9
Common lambsquarters	2.4	1.5	1.9	0.7	2.8	1.0	2.6	0.9	4.3	1.9
Bluebur	2.3	1.2	4.5	2.4	5.4	2.5	3.8	1.9	3.4	1.8
Dandelion	1.9	0.8	1.5	0.6	3.5	1.7	3.3	1.4	3.8	2.8
Hempnettle	0.8	0.2	0.1	<0.1	0.1	<0.1	---	---	0.2	0.1
Corn spurry	0.3	0.1	0.2	0.1	0.1	<0.1	0.1	0.1	---	---
Cleavers	0.3	0.1	0.2	0.1	0.5	0.1	0.5	0.3	0.4	0.2
Pineapple weed	0.2	0.1	0.1	<0.1	---	---	---	---	0.2	<0.1
Shepherds purse	0.2	0.1	---	---	0.5	0.3	1.1	0.8	0.4	0.1
Volunteer wheat	0.2	0.1	---	---	---	---	---	---	---	---
Purslane	0.2	0.1	0.3	0.2	0.8	0.4	1.2	0.7	1.8	1.4
Common vetch	0.2	0.1	0.7	0.2	---	---	---	---	---	---
Broadleaved plantain	0.1	0.1	0.1	0.1	---	---	---	---	0.5	0.3
Common pepergrass	0.1	<0.1	0.2	0.2	---	---	---	---	---	---
Canada thistle from root	0.1	<0.1	---	---	0.1	<0.1	---	---	---	---
Flixweed	---	---	0.1	0.1	---	---	---	---	---	---
Bicknells geranium	---	---	0.1	0.1	0.2	0.1	0.2	0.1	0.1	0.1
Foxtail barley	---	---	---	---	---	---	0.1	<0.1	---	---
Round-leaved mallow	---	---	---	---	0.2	0.1	---	---	---	---
Mustard species	---	---	0.4	0.1	0.6	0.3	0.7	0.2	0.1	0.1
Volunteer pea	---	---	0.1	<0.1	---	---	0.1	0.1	---	---
Prostrate knotweed	---	---	0.2	0.2	0.5	0.4	0.4	0.2	0.9	0.4
Smartweed species	---	---	---	---	---	---	---	---	0.1	0.1
"wild parsley"	---	---	---	---	---	---	---	---	0.3	0.2
Wild tomato	---	---	---	---	0.4	0.3	0.4	0.2	---	---
Perennial sowthistle from root	---	---	---	---	0.2	0.1	---	---	0.5	0.2

Relative Abundance values (RelAb) were calculated by plot for each weed species: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Table 26.0 Weed relative abundance and density by fertilizer treatment in canola prior to in July at Beaverlodge in 1996.

Weed Species	Fall band		Spring band		Spring band 9"		Spring band 12"		Sweep	
	RelAb	#/m²	RelAb	#/m²	RelAb	#/m²	RelAb	#/m²	RelAb	#/m²
Wild buckwheat	31.8	17.4	34.7	28.3	19.6	15.1	20.8	19.1	20.2	15.5
Wild oat	30.9	26.2	20.0	25.4	32.4	51.9	26.6	30.3	27.6	47.8
Red clover	9.4	5.8	12.2	15.2	6.8	4.0	8.0	7.5	7.2	6.3
Stinkweed	8.0	4.0	10.6	7.4	14.6	11.8	19.1	19.9	12.3	11.9
Dandelion	3.8	1.0	3.7	1.3	3.6	1.1	3.7	1.8	3.3	1.2
Quack grass	3.8	0.8	2.9	2.2	1.2	0.5	---	---	1.2	0.6
Bluebur	3.3	1.4	4.7	2.2	2.0	0.8	3.5	1.8	3.9	1.9
Common groundsel	3.1	0.9	3.7	1.8	9.8	5.9	6.6	4.1	8.2	5.6
Ball mustard	2.4	1.1	2.6	1.4	3.2	3.1	4.2	2.3	3.3	2.5
Common lambsquarters	1.9	0.4	3.3	1.5	2.1	0.7	3.2	1.5	4.2	1.8
Narrow leaved hawks beard	0.7	0.3	1.0	0.3	3.1	1.1	2.0	1.1	5.7	2.8
Hempnettle	0.3	0.1	---	---	0.1	0.1	0.1	<0.1	0.2	0.1
Smartweed species	0.2	<0.1	---	---	0.3	0.1	0.1	<0.1	0.3	0.2
Mustard species	0.1	0.1	---	---	---	---	0.6	0.3	0.3	0.1
Volunteer wheat	0.1	0.1	---	---	0.2	0.1	---	---	---	---
Cleavers	0.1	<0.1	---	---	---	---	---	---	0.1	<0.1
Shepherds purse	---	---	0.1	<0.1	0.2	0.1	0.3	0.1	0.8	0.5
Bicknells geranium	---	---	---	---	0.1	0.1	0.2	0.1	---	---
Round-leaved mallow	---	---	---	---	---	---	---	---	0.1	<0.1
Pineapple weed	---	---	---	---	0.1	<0.1	---	---	0.1	<0.1
Prostrate knotweed	---	---	0.1	<0.1	0.3	0.1	0.4	0.2	---	---
Wild tomato	---	---	---	---	---	---	0.1	0.1	---	---
Perennial sowthistle from root	---	---	---	---	---	---	0.2	0.1	0.6	0.2
Corn spurry	---	---	---	---	0.1	<0.1	---	---	0.4	0.1
Purslane	---	---	0.4	0.2	0.1	<0.1	0.1	<0.1	0.1	<0.1
Common vetch	---	---	---	---	0.1	<0.1	0.1	0.1	---	---

Relative Abundance values (RelAb) were calculated by plot for each weed species: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Table 27.0 Weed relative abundance and density by herbicide treatment in wheat prior to seeding at Beaverlodge in 1996.

Weed Species	Full rate		Reduced Rate	
	RelAb	#/m^2	RelAb	#/m^2
Quack grass	70.4	31.7	67.1	38.8
Dandelion	16.2	2.1	17.9	3.3
Volunteer wheat	7.4	1.0	9.4	1.7
Red clover	6.0	1.2	5.6	0.9

Relative Abundance values (RelAb) were calculated by plot for each weed species: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Table 28.0 Weed relative abundance and density by herbicide treatment in canola prior to seeding at Beaverlodge in 1996.

Weed Species	Full rate		Reduced Rate	
	RelAb	#/m^2	RelAb	#/m^2
Quack grass	68.7	40.9	65.6	43.1
Dandelion	18.5	3.2	17.9	3.9
Volunteer wheat	6.8	1.2	7.4	1.6
Red clover	6.0	1.1	9.0	1.9

Relative Abundance values (RelAb) were calculated by plot for each weed species: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Table 29.0 Weed relative abundance and density by herbicide treatment in wheat prior to in-crop spraying at Beaverlodge in 1996.

Weed Species	Full rate		Reduced Rate	
	RelAb	#/m^2	RelAb	#/m^2
Wild oat	32.1	93.7	28.2	80.8
Stinkweed	29.6	73.7	29.2	70.6
Wild buckwheat	10.9	12.4	11.3	16.5
Common lambsquarters	6.7	6.3	9.5	8.7
Bluebur	6.5	5.7	8.0	8.1
Common groundsel	4.7	3.3	4.1	3.8
Red clover	4.1	3.7	4.2	3.4
Mustard species	3.0	1.9	1.6	1.0
Dandelion	1.1	0.6	1.3	0.6
Quack grass	0.7	0.4	0.6	0.9
Hempnettle	0.2	0.1	0.1	0.1
Vetch species	0.1	0.2	<0.1	<0.1
Smartweed species	0.1	0.1	0.6	0.1
Cleavers	<0.1	<0.1	0.1	0.1
Common chickweed	<0.1	<0.1	---	---
Narrow leaved hawks beard	---	---	0.1	<0.1
Volunteer pea	---	---	0.4	<0.1
Perennial sowthistle from root	---	---	0.5	0.1

Relative Abundance values (RelAb) were calculated by plot for each weed species: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Table 30.0 Weed relative abundance and density by herbicide treatment in canola prior to in-crop spraying at Beaverlodge in 1996.

Weed Species	Full rate		Reduced Rate	
	RelAb	#/m²	RelAb	#/m²
Wild oat	42.6	178.7	41.7	150.0
Stinkweed	16.6	43.3	18.0	43.2
Wild buckwheat	9.5	14.8	11.7	12.9
Bluebur	8.9	15.3	6.9	8.3
Common lambsquarters	7.7	7.7	7.7	6.2
Common groundsel	5.3	5.6	5.5	7.1
Red clover	4.9	6.3	4.1	3.0
Quack grass	1.7	1.9	1.9	5.1
Dandelion	1.4	0.6	1.1	0.5
Volunteer wheat	0.9	2.2	0.7	1.3
Smartweed species	0.2	0.1	0.1	0.1
Flixweed	0.2	0.2	---	---
Pineapple weed	0.1	<0.1	0.1	<0.1
Mustard species	0.1	<0.1	---	---
Narrow leaved hawks beard	0.1	<0.1	---	---
Shepherds purse	<0.1	<0.1	---	---
Canada thistle from root	---	---	<0.1	<0.1
Hempnettle	---	---	0.2	0.1
Cleavers	---	---	0.1	0.1
Corn spurry	---	---	<0.1	<0.1
Vetch species	---	---	0.1	<0.1

Relative Abundance values (RelAb) were calculated by plot for each weed species: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Table 31.0 Weed relative abundance and density by herbicide treatment in wheat in July at Beaverlodge in 1996.

Weed Species	Full rate		Reduced Rate	
	RelAb	#/m^2	RelAb	#/m^2
Wild oat	29.6	25.3	29.1	28.7
Wild buckwheat	21.5	13.6	21.7	23.7
Red clover	10.7	6.4	8.7	7.5
Stinkweed	10.4	7.7	10.4	13.5
Common groundsel	6.7	5.0	6.3	5.7
Narrow leaved hawks beard	4.5	2.9	4.3	3.5
Bluebur	3.8	1.9	3.9	2.0
Dandelion	2.4	1.0	3.2	2.0
Ball mustard	2.2	0.9	3.0	1.9
Common lambsquarters	2.2	0.7	3.4	1.7
Quack grass	2.1	1.0	1.9	2.9
Cleavers	0.7	0.3	<0.1	<0.1
Purslane	0.5	0.2	1.2	0.9
Prostrate knotweed	0.4	0.2	0.4	0.3
Mustard species	0.4	0.1	0.3	0.1
Hempnettle	0.4	0.1	0.1	<0.1
Shepherds purse	0.4	0.2	0.5	0.4
Bicknells geranium	0.2	0.1	<0.1	<0.1
Perennial sowthistle from root	0.2	0.1	0.1	<0.1
Corn spurry	0.2	0.1	0.2	0.1
Common pepergrass	0.1	0.1	---	---
Common vetch	0.1	0.1	0.2	0.1
Wild tomato	0.1	0.1	0.2	0.1
Broadleaved plantain	0.1	<0.1	0.2	0.2
Volunteer pea	0.1	<0.1	<0.1	<0.1
"wild parsley"	<0.1	<0.1	0.1	0.1
Pineapple weed	<0.1	<0.1	0.2	0.1
Canada thistle from root	<0.1	<0.1	<0.1	<0.1
Flixweed	---	---	<0.1	<0.1
Foxtail barley	---	---	<0.1	<0.1
Round-leaved mallow	---	---	0.1	0.1
Smartweed species	---	---	<0.1	<0.1
Volunteer wheat	---	---	0.1	0.1

Relative Abundance values (RelAb) were calculated by plot for each weed species: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Table 32.0 Weed relative abundance and density by herbicide treatment in canola in July at Beaverlodge in 1996.

Weed Species	Full rate		Reduced Rate	
	RelAb	#/m^2	RelAb	#/m^2
Wild oat	25.4	33.7	29.6	39.0
Wild buckwheat	25.2	18.0	25.5	20.1
Stinkweed	13.3	10.6	12.6	11.5
Red clover	9.3	7.7	8.1	7.8
Common groundsel	6.1	2.8	6.5	4.5
Dandelion	3.8	1.2	3.4	1.4
Ball mustard	3.7	2.6	2.6	1.6
Bluebur	3.4	1.3	3.5	2.0
Narrow leaved hawks beard	2.9	1.0	2.1	1.3
Common lambsquarters	2.8	1.2	3.1	1.2
Quack grass	2.3	1.2	1.3	0.5
Shepherds purse	0.3	0.2	0.2	0.1
Perennial sowthistle from root	0.2	0.1	0.1	0.1
Purslane	0.2	0.1	0.1	0.1
Corn spurry	0.2	0.1	---	---
Mustard species	0.2	0.1	0.2	0.1
Prostrate knotweed	0.1	0.1	0.2	0.1
Hempnettle	0.1	<0.1	0.2	0.1
Cleavers	0.1	<0.1	---	---
Smartweed species	0.1	<0.1	0.2	0.1
Common vetch	0.1	<0.1	<0.1	<0.1
Bicknells geranium	0.1	<0.1	0.1	<0.1
Round-leaved mallow	---	---	<0.1	<0.1
Pineapple weed	---	---	0.1	<0.1
Wild tomato	---	---	0.1	<0.1
Volunteer wheat	---	---	0.1	0.1

Relative Abundance values (RelAb) were calculated by plot for each weed species: (relative density + relative frequency)/2. Relative density was calculated as: number of individuals for a given species within the 20 quadrats for each plot divided by the total number of individuals within the plot. Relative frequency was calculated as the proportion of quadrats in which the species was present per plot divided by the total frequency of all species.

Crop Agronomy

prepared by A. Johnston

Wheat

Seedling stands of spring wheat were higher at Melfort than Brandon (Table 1). No seedling stand data was available for this report from Beaverlodge. The sweep treatment resulted in a 20 to 40% increase in seedling numbers over wheat seeded in rows, resulting in a significant increase at Brandon. This response was also observed at Melfort, however, complications in data collection prevented valid statistical analysis. It would appear that spreading seed, versus placement in rows, improved the survival and emergence of the total seed number planted. The seedling stand with 12" rows was similar to 9" rows. Reduced herbicide rates were found to have no effect on crop establishment.

Wheat grain yields at Brandon and Melfort were approximately double that of Beaverlodge, where a cool growing season resulted in considerable frost damage to the crop (Table 1). While no yield differences were recorded to fertilizer placement or herbicide rates at Brandon or Beaverlodge, the sweep treatment produced higher yields than spring banding or side banding on 9" or 12" at Melfort. These increased grain yields with the sweep treatment were reflected in lower grain protein % at Melfort (Table 1). In general, grain protein was approximately 1% higher at Brandon than Melfort while grain yields were very similar.

Canola

Considerable variation was recorded in canola seedling stand between Brandon and Melfort (Table 2). Sweep placement resulted in a doubling of canola seedling numbers at Brandon relative to row seeding (this was due to the increased establishment of volunteer canola). However, at Melfort the poorest canola stand was recorded with sweep placement. The superior canola establishment at Brandon relative to Melfort may reflect the abnormally dry post-seeding conditions recorded at Melfort.

While superior establishment was recorded at Brandon, Canola grain yields were 25% higher at Melfort (Table 2). As mentioned with the wheat, frost on the Beaverlodge crop resulted in very low yields. Neither N placement or herbicide rate showed any effect on canola grain yields at any of the trial locations.

Table 1. Seedling stand, grain yield and grain protein for spring wheat (cv. CDC Teal) in CFI trials at Brandon, Melfort and Beaverlodge, 1996.

Locations		Brandon			Melfort			B.Lodge
Treatments		Seedling Stand	Grain Yield	Grain Protein	Seedling Stand	Grain Yield	Grain Protein	Grain Yield
N Plmt.	Herb.	Plants/m2	kg/ha	%	Plants/m2	kg/ha	%	kg/ha
1. Fall Bd	Full	184	3699	14.2	261	3766	13.1	1620
	2/3	155	3547	14.3	270	3873	13.3	1540
2. Spr Bd	Full	169	3605	14.3	281	3719	12.9	1870
	2/3	167	3627	13.7	251	3620	12.7	2050
3. 9" S.Bd	Full	161	3649	13.9	258	3692	13.8	1820
	2/3	167	3596	13.6	231	3522	12.7	1570
4. 12" S.Bd	Full	160	3682	13.8	260	3711	13.9	1920
	2/3	155	3702	14.1	272	3486	13.4	1980
5. Sweep	Full	223	3605	13.8	317	3934	12.6	2060
	2/3	234	3580	13.4	315	3943	12.5	2060
1. Fall Banded		170 b	3623	14.3	265	3819 ab	13.2 ab	1580
2. Spring Banded		168 b	3616	14.0	266	3669 b	12.8 bc	1960
3. 9" Side Band		164 b	3622	13.8	245	3607 b	13.2 ab	1700
4. 12" Side Band		158 b	3692	13.9	266	3599 b	13.6 a	1950
5. Sweep		228 a	3593	13.6	316	3938 a	12.5 c	2060
Full Herbicide		179	3648	14.0	275	3764	13.2	1860
2/3 Herbicide		176	3610	13.8	268	3689	12.9	1860
Pr>F								
Treatment		0.0001	NS	NS	-	0.0166	0.0038	NS
Herbicide		NS	NS	NS	-	NS	NS	NS
T x H		NS	NS	NS	-	NS	NS	NS
CV		8	10	3	11	6	4	20

Table 2. Seedling stand, grain yield and grain protein for canola (cv. Quest) in CFI trials at Brandon, Melfort and Beaverlodge, 1996.

Locations		Brandon		Melfort		B.Lodge
Treatments		Seedling Stand	Grain Yield	Seedling Stand	Grain Yield	Grain Yield
N Plmt.	Herb.	plants/m2	kg/ha	Plants/m2	kg/ha	kg/ha
1. Fall Bd	Full	135	1822	96	2274	440
	2/3	155	1838	91	2244	570
2. Spr Bd	Full	127	1886	88	2195	650
	2/3	126	1900	91	2248	690
3. 9" S.Bd	Full	128	1855	98	2243	580
	2/3	113	1895	86	2205	410
4. 12" S.Bd	Full	106	1861	131	2470	350
	2/3	89	1927	124	2317	520
5. Sweep	Full	233	1797	66	2337	340
	2/3	259	1807	78	2401	540
1. Fall Banded		145 b	1830	94	2259	500
2. Spring Banded		127 b	1893	90	2221	670
3. 9" Side Band		120 bc	1875	92	2224	490
4. 12" Side Band		97 c	1894	127	2394	430
5. Sweep		246 a	1802	72	2389	440
Full Herbicide		146	1844	96	2304	530
2/3 Herbicide		148	1873	94	2283	440
Pr>F						
Treatment		0.0001	NS	-	NS	NS
Herbicide		NS	NS	-	NS	NS
T x H		NS	NS	-	NS	NS
CV		21	5	11	7	42

Impact of row spacing, fertilizer management and herbicide rate on plant development in spring wheat.

Prepared by Guy Lafond

Objective:
To determine the effects of nitrogen management, row spacing and herbicide rate on seeding depth, main stem Haun stage and plant development in spring wheat at three locations, Brandon, Melfort and Beaverlodge.

Materials and Methods:

Twenty wheat plants per plot were collected from the five core nitrogen management treatments of the CFI project. Each plant was scored for actual depth of seeding, main stem Haun stage and each tiller on each plant was identified and scored for plant development according to the method developed by Klepper et al. (1983). The plants were collected on June 26 in Brandon, on July 1 in Melfort and on July 5 in Beaverlodge.

The analysis of the data for seeding depth and main stem Haun stage was done using an analysis of variance and the N Management x Herbicide Rate x Rep interaction was used as the error term. The main stem Haun stage is a good indicator of rate of emergence as shown by Lafond and Baker (1986).

The analysis of the data for the tillers present was done in three steps. The first step consisted in determining the number of plants from each plot which had a specific tiller and converting this value into a proportion. The second step consisted in doing an arcsin($(x)^{.5}$) transformation of the proportion for each tiller as developed by Snedecor and Cochran (1976). With $n<50$, in this case 20, values of 0% were given a value of 1/4n or 0.0125 and values of 100% values (n-1/4)/n or 0.9875 (Snedecor and Cochran, 1976). The analysis of variance was done on the transformed values and the reported values in the tables are untransformed. The probability values indicated for the contrasts associated with nitrogen management are based on the analysis of the transformed values. The approach for presenting the data is similar to the one used by Wilkins et al. (1988).

Results and Discussion:

Seeding Depth

Nitrogen management had no effect on seeding depth (Table 1). The average depth of seeding for Brandon, Melfort and Beaverlodge was 28, 39 and 27 mm, respectively. Uniform depth of placement was achieved across all treatments.

Table 1. The effects of nitrogen management on seeding depth (mm) of spring wheat at

three locations in 1996.

Nitrogen Management	Brandon	Melfort	Beaverlodge
Fall banding	25	38	30
Spring banding	30	38	26
Side-banding at seeding on 12" spacing	26	40	31
Side-banding at seeding on 9" spacing	27	40	27
Sweep	32	41	23
Mean	28	39	27
s.e.	12	14.1	9.5

Main Stem Haun stage

The results for main stem Haun stage are given in Table 2. At all locations, the sweep treatment gave significantly higher Haun stage values than where the pre-seeding banding was done then seeded on 9" spacing reflecting quicker emergence. The relationship between Haun stage and rate of emergence was previously documented (Lafond and Baker 1986). There was no difference between 9" and 12". At Melfort and Beaverlodge, the sweep treatment was slightly more advanced than the 9 or 12" spacing. It is suggested that what we are looking at here is a differential packing effect between the sweep treatment and the other treatments. We need to consider carefully the implications of packing in the context of this study as a potential confounding effect..

Table 2. The effects of nitrogen management and herbicide rate on main stem Haun stage of spring wheat at three locations in 1996.

Nitrogen Management	Brandon		Melfort		Beaverlodge	
	100%	66%	100%	66%	100%	66%
Fall banding	4.7	4.8	5.2	5.1	5.4	5.3
Spring banding	4.6	4.4	5.2	5.1	5.3	5.6
Side-banding at seeding on 12" spacing	4.5	4.7	5.3	5	5.4	5.2
Side-banding at seeding on 9" spacing	4.8	4.6	5.2	5.2	5.3	5.2
Sweep	4.9	4.8	5.3	5.4	5.7	5.7
Mean	4.7	4.7	5.2	5.2	5.4	5.4
s.e.	0.5		0.3		0.3	
Contrast[1]						
Herbicide 100% vs 66%	ns		ns		ns	
Fall Banding vs Spring Banding	ns		ns		ns	
Sweep vs Pre-Seed banding	*		*		**	
Pre-seed banding vs Side-banding	ns		ns		*	
9" vs 12"	ns		ns		ns	
9" vs Sweep	ns		*		*	
12" vs Sweep	ns		*		*	

[1] Values followed by * and ns are significant at the 5% level or not significant.

Plant Development:

The opportunity was taken to determine the effects of row spacing, fertilizer management and herbicide rate on the extent of plant development between the 5 and 6 leaf stage by quantifying the number of tillers present and which tiller was present relative to the leaf number on the main stem. The results for Brandon, Melfort and Beaverlodge are given in Table 3, 4 and 5, respectively. The Melfort site showed the least number of differences due to treatments while the Beaverlodge showed the greatest number of differences.

Table 3. The effects of nitrogen management and herbicide rate on plant development in spring wheat at Brandon in 1996. The values represents the percentage of plant having a particular tiller.

Nitrogen Management	T0		T1		T2		T3		T01		T11		T21	
	100%	66%	100%	66%	100%	66%	100%	66%	100%	66%	100%	66%	100%	66%
Fall banding	43	34	100	99	93	90	6	13	1	0	26	29	0	1
Spring banding	35	34	95	96	85	93	4	5	1	0	19	10	0	4
Side-banding at seeding on 12" spacing	75	56	100	99	95	98	8	11	1	0	16	33	1	4
Side-banding at seeding on 9" spacing	51	39	98	93	93	84	13	13	4	1	33	25	6	0
Sweep	59	53	99	100	96	99	30	26	8	1	48	33	14	3
Mean	**53**	**43**	**98**	**97**	**92**	**93**	**12**	**14**	**3**	**1**	**28**	**26**	**4**	**2**
Contrast[1]														
Herbicide 100% vs 66%	*		ns		ns		ns		***		ns		ns	
Fall Banding vs Spring Banding	ns		**		ns		ns		ns		ns		ns	
Sweep vs Pre-Seed banding	**		ns		***		***		***		**		*	
Pre-seed banding vs Side-banding	***		ns		ns		ns		ns		ns		ns	
9" vs 12"	**		**		***		ns		*		ns		ns	
9" vs Sweep	ns		**		***		**		ns		ns		ns	
12" vs Sweep	ns		ns		ns		**		***		ns		ns	

[1] Values followed by ***, **, * or ns are significant at the p<1%, p<5%, p<10% or not significant.

Table 4. The effects of nitrogen management and herbicide rate on plant development in spring wheat at Melfort in 1996. The values represents the percentage of plant having a particular tiller.

Nitrogen Management	T0		T1		T2		T3		T01		T11		T21		T31	
	100%	66%	100%	66%	100%	66%	100%	66%	100%	66%	100%	66%	100%	66%	100%	66%
Fall banding	8	10	46	46	13	20	0	8	0	0	0	0	0	0	0	0
Spring banding	14	24	51	74	29	23	1	0	0	0	0	0	0	0	0	0
Side-banding at seeding on 12" spacing	21	15	93	86	91	68	35	36	3	0	16	8	1	0	0	0
Side-banding at seeding on 9" spacing	14	13	85	68	61	50	21	15	0	0	9	0	3	0	1	0
Sweep	26	23	93	98	66	73	14	34	0	1	9	24	0	6	0	0
Mean	**17**	**17**	**74**	**74**	**52**	**47**	**14**	**21**	**1**	**2**	**7**	**8**	**1**	**3**	**0**	**2**
Contrast[1]																
Herbicide 100% vs 66%	ns		ns		ns		ns		ns		ns		ns		ns	
Fall Banding vs Spring Banding	ns		*		ns		ns		ns		ns		ns		ns	
Sweep vs Pre-Seed banding	*		***		***		**		ns		***		**		ns	
Pre-seed banding vs Side-banding	ns		***		***		***		ns		**		ns		ns	
9" vs 12"	ns		*		**		*		ns		*		ns		ns	
9" vs Sweep	*		**		*		ns		ns		**		ns		ns	
12" vs Sweep	ns		ns		ns		ns		ns		ns		ns		ns	

[1] Values followed by ***, ** , * or ns are significant at the p<1%, p<5%, p<10% level or not significant.

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Nutrient Dynamics

An analysis of the dynamics of nitrogen within these studies is being conducted by C. Grant at Brandon. Since laboratory analysis is still underway, a report will be presented next year.

Results from Objective 2:

Part 2 of this project began in the fall of 1996, therefore, no field work has been conducted. Kristen Callow has been completing course work at the University of Manitoba under the supervision of Dr. D. Derksen and Dr. R. Van Acker. Research plans have been completed (see M&M section) with the research to begin in 1997.