TOLERANCE OF WINTER WHEAT TO FALL-APPLIED HERBICIDES AND DINITROANILINE HERBICIDE RESIDUES

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ABSTRACT

Wright, Eldon Brent. M.Sc., The University of Manitoba, April, 1984. Tolerance of Winter Wheat to Fall-Applied Herbicides and Dinitroaniline Herbicide Residues. Major Professor: E.H. Stobbe.

In seven field experiments conducted over two years and at two sites in Manitoba, the survival, regrowth and yield of winter wheat sown under zero tillage conditions was not affected by fall applications of 2,4-D amine, dicamba + 2,4-D, and chlorsulfuron. Picloram/2,4-D (0.04/0.55 kg/ha) tended to reduce plant dry matter, and yield compared to the control.

In addition, an artificial freezing test was conducted to determine the effect of the herbicides on the cold tolerance of Norstar winter wheat. Based on a rating scale and the length of new leaf growth, dicamba + 2,4-D (0.33 + 0.94 kg/ha) was the only treatment that raised the LT_{50} (-14°C) of the winter wheat compared to the control (-16°C). The results indicate that the fall application of 2,4-D amine, dicamba + 2,4-D, and chlorsulfuron at the suggested field rates of 0.55, 0.15 + 0.42, and 0.02 kg/ha, respectively, will not significantly affect the yield of Norstar winter wheat.

Field studies were also undertaken to determine the effect of soil residues of trifluralin, ethalfluralin, EL5261, and dinitramine on the winter survival and yield of winter wheat sown into rapeseed stubble. In 1980, trifluralin and EL5261 at 2.2 kg/ha reduced the emergence of winter wheat compared to the control at two locations. Spring dry matter production was reduced by trifluralin, ethalfluralin, and EL5261 applied at 2.2 kg/ha, and by dinitramine at 1.7 kg/ha. Dinitramine at 1.7 kg/ha also reduced the yield of Norstar winter wheat by 19% compared to the untreated control. From the field trials, it can be concluded that winter wheat yields will not be affected by residues of trifluralin (1.1 kg/ha), ethalfluralin (1.1 kg/ha), EL5261 (1.1 kg/ha), and dinitramine (0.8 kg/ha) applied at suggested rates to control weeds in rapeseed prior to seeding in the fall.

INTRODUCTION

Winter wheat (*Triticum aestivum* L.) has recently been gaining the attention of Manitoba farmers. Two advantages of winter wheat over spring wheat are the potentially higher yields (40 to 60% higher than spring wheat), and a lower requirement for herbicides because of the crop's superior ability to compete with annual weeds (Rourke 1982). As well, the winter annual growth habit of the crop allows it to make good use of abundant spring moisture, and to escape mid-summer drought. Because the crop matures comparatively early, it can be harvested by mid-August. Not only does this spread the fall work load more evenly, but it allows the crop to be taken off before the damp, cool weather that typically occurs later in the season.

Zero tillage cropping methods have reduced the frequency of winterkill in winter wheat fields by helping to maintain snowcover on the fields throughout the winter. The snowcover and stubble mulch modify the soil temperature and the microclimate surrounding the seedling and help the plants survive periods of low air temperature which ordinarily would kill the plant (Aase and Siddoway 1980). Research at the University of Manitoba has shown other cultural practices, including the application of phosphate fertilizer at seeding, can help to increase the survival of winter wheat (Grant 1982, Rourke *et al*. 1982).

Winter annual weeds such as stinkweed (*Thlaspi arvense* L.) and flixweed (*Descurainia sophia* L.) can compete with the crop. Control of these weeds is possible with fall herbicide applications but current recommendations caution against fall treatments (Manitoba Agriculture 1984), on the basis that they may reduce winter survival of the crop (Freyman and Hamman 1979). Residual herbicides might also interfere with winter wheat production in a crop rotation. Approximately 303,600 hectares of rapeseed are grown in Manitoba each year (Manitoba Agriculture 1982, Statistics Canada 1982), the majority of which is treated with pre-plant incorporated trifluralin (Agriculture Canada 1982). Reports that trifluralin can injure spring wheat crops the year after application (Pritchard 1976) raise the possibility that winter wheat might also be injured by trifluralin residues. Because of the limited area of winter wheat grown in western Canada, the problems of crop tolerance to herbicides and their residues have not been adequately addressed.

In this study, field experiments were initiated to determine the effect of fall-applied herbicides on the winter survival and subsequent yield of winter wheat. Additional experiments were conducted to examine the tolerance of winter wheat to dinitroaniline residues in soil previously sown to rapeseed.

CHAPTER I

LITERATURE REVIEW

The ability of winter wheat to survive the winter is determined by the winter hardiness of the particular cultivar, the severity of the winter, and the cultural practices used to produce the crop. Fall-applied broadleaf weed herbicides, including 2,4-D, have been reported to have detrimental effects on winter wheat (Robison and Fenster 1973, Freyman and Hamman 1979). Recommended rates of dinitroaniline herbicides have been documented to persist beyond the year of application (Smith 1982), and could pose a problem to winter wheat being grown on treated land.

Factors Influencing Hardiness and Winter Survival of Winter Wheat

The ability of winter wheat to cold harden and survive the winter is dependent on the particular cultivar and numerous factors that influence the plant environment. Some of these factors include light, temperature, soil moisture, soil fertility and cultural practices. This section of the Literature Review will dicuss some of the effects of these factors on the hardiness and winter survival of winter wheat.

Cultivars

The degree of cold hardiness found within the existing winter wheat cultivars varies (Fowler and Gusta 1979). In western Canada, the hardiest cultivar currently recommended is Norstar. This hard red winter wheat was developed at the Agriculture Canada Research Station in Lethbridge, Alberta and was licensed in 1977. Norstar averaged a winter survival of 62% when grown on summerfallow plots in 22 tests over a period of five years at various locations in western Canada (Agriculture Canada 1978).

Winalta is a previously recommended variety that was licensed in 1961. Like Norstar, Winalta is also a hard red winter wheat developed at the Lethbridge station (Andrews and Grant 1962). The winter survival of this cultivar was 41% in the tests mentioned above.

Light

Light is a major factor involved in the cold hardening process (Levitt 1972). Suneson and Peltier (1938) reported that high radiation and shortening daylengths were two of the environmental factors necessary to initiate hardening. Light is essential in the initial phase of hardening because it affects assimilate production (Paulsen 1968, Single 1971). Dexter (1933) found no induction of cold hardiness in winter annuals in the absence of light. However, Andrews *et al*. (1974a) were able to induce cold hardening in young seedlings of winter wheat grown in soil in the dark.

McGuire and Flint (1962, cited by Levitt 1972) reported that a threshold illumination of 1,000 foot-candles was necessary for the induction of hardening in cereals. One report (Paulsen 1968) indicated that the low light intensity found in growth chambers (3400 Ft-c) may limit hardening, but that this would not occur under field conditions. Kohn and Levitt (1965) proposed that light may no longer be an important factor in the induction of cold hardiness once the temperature drops below 0°C.

The effect of photoperiod on cold hardening is not as well resolved as that of light. Howell and Dennis (1981) concluded that shortening daylengths promote hardening. Their findings agreed with the above-mentioned observations of Suneson and Peltier (1938). However, Paulsen (1968) found that photoperiod did not determine whether plants hardened, but did modify the degree of hardiness under different temperature treatments. He reported that hardiness was greater under a constant 18-hour photoperiod than under a photoperiod that decreased 15 minutes daily. By decreasing the photoperiod and holding the temperature constant (15.5°C), Paulsen (1968) actually found decreased cold tolerance in winter wheat. He concluded that photoperiod affected photosynthate production which, in turn, influenced the hardening process.

Temperature

Low temperature is believed to be the main stimulus for the hardening response (Paulsen 1968, Single 1971). Suneson and Peltier (1938) reported that in the initial stages of hardening, high daytime temperatures and low night-time temperatures prompted the accumulation of organic reserves to help the plant overwinter. After this, a second stage of sustained low temperatures was required. Paulsen (1968) found that a decrease in temperature of 5/9°C (daily) was sufficient to promote hardening in winter wheat. He believed that the decrease in temperature influenced hardening by altering the plant's metabolic rate which led to cessation of growth and the accumulation of sugars within the plant.

Harvey (1922) suggested that a threshold temperature exists (approximately 5 to 10°C), above which hardening could not be induced. The precise temperature would vary among different species and varieties.

Olien (1964) found that established vegetative plants underwent hardening during periods of temperatures near 2°C. Noticeable changes in response to freezing tests occurred after only a few days at this temperature, but maximum hardiness occurred after a period of about 3 weeks. This is similar to the optimum length of time that Suneson and Peltier (1938) reported to be required in the second stage of hardening. If the temperature remains at 2°C for a longer period of time, a gradual reduction in hardiness can occur, even under optimal conditions of light and fertility (Olien 1967, Gusta and Fowler 1976). Once maximum hardiness attainable in the 0 to 5°C temperature range is achieved, a second increase is possible at temperatures slightly below 0°C (Dantuma and Andrews 1960). At temperatures below freezing, plants retain their hardiness for extended periods of time (Olien 1967, Gusta and Fowler 1976).

Fluctuations in the level of hardiness have been reported to occur in plants under field conditions throughout the winter. Worzella and Cutler (1941) discovered that thawing periods during the winter greatly decreased the hardiness of winter wheat even when the periods were short and the temperature did not rise above 0°C. Their data indicated that the air temperature which prevailed several days before artificial freezing tests greatly affected the cold resistance of the winter wheat. Periods of low atmospheric temperatures were followed by corresponding peaks of high percent survival. The opposite was also true. Periods of high temperatures were followed by a decrease in survival. Other investigators also found that hardened plants can be dehardened and then hardened again as temperatures increase and decrease throughout the winter (Pomeroy et al. 1975, Gusta and Fowler 1976).

Low temperatures and desiccation of plants during the winter have been identified as the major causes of winterkill of winter wheat on the Canadian Prairies (Fowler et al. 1976). Injury of overwintering plants increases as both the duration and the intensity of the cold increases. Alessi and Power (1971) developed a degree-day concept to quantify the intensity and duration of cold during the winter. Degree-days were calculated from the following equation for each day of the period.

$$\text{Degree-day} = \frac{\text{Max.} + \text{Min.}}{2} - (-17.8°\text{C})$$

A base temperature of -17.8°C was used because at this temperature most soil water would be in a frozen state and water uptake by plant roots would no longer be possible. Alessi and Power reported good correlations between their model and winter wheat survival.

Low temperature injury can occur even to the hardiest plants by an untimely frost early in the fall or late in the spring, by a sudden reversal of temperature after a mid-winter thaw, or by extremely low temperatures (Levitt 1972).

Soil Moisture

A number of authors have reported that soil moisture has an influence on winter wheat survival. Klages (1926) found that plants grown on low moisture soils had a higher dry weight/fresh weight ratio and were more resistant to the cold compared to plants grown under moist conditions. These observations agreed with the results reported by Levitt (1941) and Suneson and Peltier (1938). Other authors have also found percent crown moisture content of winter wheat to be closely related to its resistance to low temperatures (Metcalf et al. 1970, Gusta and Fowler 1976, Fowler and Carles 1979, Freyman and Klady 1979). However Klages (1926) noted that once killing started on dry soils, it progressed very rapidly. In contrast, high moisture soils seemed to have a protective influence on the plants later in the season. It was suggested that this protective influence was due to the high-moisture soils cooling more slowly.

Fowler et al. (1976) also found that soil had a large buffering capacity against temperature change. Alessi and Power (1971) reported that the average survival of winter wheat plants was greater when moisture was plentiful in the fall. They also found mid-winter thaws to be beneficial to winter wheat survival and concluded that the water from the snow melt supplemented the crown moisture supply, and prevented desiccation of the plants that otherwise might occur at very low temperatures. Contrary to these findings, Gusta and Fowler (1976) reported that warm temperatures during the winter were detrimental to winter wheat, partly because the plants were unable to prevent uptake of water. Metcalf et al. (1970) found that a slight change in moisture content of winter cereal crowns had a significant effect upon the lowest temperature plants could survive.

Single (1971) concluded that soil water could indirectly cause winterkill through an action known as soil "heaving." During the spring thaw, redistribution of water in the soil causes soil movement which can result in root or crown breakage and death of the plant. He also suggested that excess soil water could cause formation of an ice crust at the soil surface which could cause death by preventing gas exchange in the soil.

Soil Fertility

The influence of soil fertility on the winter survival of winter wheat has been well documented. Excessive amounts of nitrogen generally decrease the hardiness of winter wheat. Freyman and Klady (1979) reported that additions of 90, 100, and 180 kg N/ha to plots low in nitrogen and phosphorous (10.7 ppm N and 7.3 ppm P) resulted in decreased cold hardiness compared to unfertilized control plots. Grant (1982) also reported that the addition of 120 kg N/ha decreased the winter survival of winter wheat when P_2O_5 was added separately at 25 and 50 kg/ha. However, when phosphorous was added with the nitrogen, winter hardiness was unaffected, even when high rates of nitrogen were applied (Freyman and Klady 1979, Grant 1982).

In a review of the existing literature, Single (1971) reported that the effects of phosphorous and potassium on winter hardiness were variable. Freyman and Klady (1979) concluded that in the absence of nitrogen, phosphorous had little effect on hardiness, whereas Grant (1982) found that the addition of 20 kg/ha of phosphorous to soil with 15 ppm of available phosphorous resulted in an increase in winter survival of winter wheat.

Cultural Practices

Cultural practices are important in determining the level of survival of winter wheat under field conditions. Planting winter wheat into standing stubble of a previous crop modifies the microclimate surrounding the seedling (Aase and Siddoway 1980). During the winter, the standing stubble traps snowfall which insulates the soil surface and prevents temperature extremes (Aase and Siddoway 1979).

Research in western Canada has shown that the crop should be planted 7 to 9 weeks before freeze-up to give the crop time to reach maximum cold tolerance. For most of the Prairies, planting between the last week of August and the second week of September is recommended (Andrew et al. 1960, Roberts and Grant 1968, Andrew et al. 1974b, Freyman 1978). Planting at these dates normally allows the seedling to reach the 4- to 6-leaf stage in the fall, and to reach maximum winter hardiness (Andrew et al. 1960). Planting winter wheat at the optimum time has been shown to give increased grain yields in relation to crops planted at later seeding dates (Musick and Dusek 1980). The crop should be sown shallowly, preferably 5 cm deep or less, into moist soil. Deep seeding can cause delayed emergence and reduced hardiness (Grant et al. 1976, Freyman 1978).

Effect of Fall-Applied Herbicides on the Winter Survival and Yield of Winter Wheat

Stinkweed (*Thlaspi arvense* L.) and night-flowering catchfly (*Silene noctiflora* L.) are two of the ten most common weeds found in cultivated fields in Manitoba (Agriculture Canada 1978). Due to their winter annual growth habits, these weeds compete strongly with winter wheat (Best and McIntryre 1975, McNeill 1980). A number of well-known broadleaf herbicides provide adequate control of these weeds if applied in the fall. However, current recommendations warn against fall application on winter cereals (Grant *et al.* 1974, Manitoba Agriculture 1984). Although considerable research has been done on the effect of herbicide treatments on the yield of winter wheat, relatively little has been reported on the influence of fall-applied herbicides on winter hardiness.

2,4-D ((2,4-dichlorophenoxy) acetic acid)

2,4-D and other phenoxy herbicides act as growth regulators and interfere with the process of cell division and enlargement, and respiration (Cartwright 1976). Freyman and Hamman (1979) suggested that these processes were also involved in cold hardening of plants. Although most grass species are relatively resistant to 2,4-D, cereal crops including wheat can be injured by high rates (1.8 kg/ha)[1] or improper timing of application (Bernard and Willard 1950, Olson *et al.* 1951).

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[1]All herbicide rates are expressed as active ingredient.

The influence of 2,4-D on the yield of winter wheat is well documented (Elder 1949, Klingman 1953, Robison and Fenster 1973). Klingman and Shafer (1949) found a 52% reduction in yield after treating winter wheat at the 3-leaf to 1st tiller stage with 1.12 kg/ha of 2,4-D ester. Elder (1950) obtained a 12 to 15% yield reduction from an application of 0.84 kg/ha of 2,4-D ester in the fall at the tillering stage of winter wheat. Fall application of 2,4-D amine at 0.56 kg/ha caused a 14% yield reduction while the same rate of 2,4-D ester caused a 30% reduction (Robinson and Fenster 1973). These observations agree with other reports that ester formulations are more active than amines (Woestemeyer 1950). In contrast to the above, Elder and Gassaway (1951) found no adverse effect on winter wheat resulting from fall applications of 2,4-D ester or amine when plants were in the tillering stage.

Yield reductions caused by 2,4-D treatments, usually result from spike abnormalities including shortened spikes and sterile spikelets (Slife and Fuelleman 1949), or morphological abnormalities including fused or twisted leaf sheaths which hinder or prevent proper heading (Klingman 1953). A few researchers (Slife and Fuelleman 1949, Phillips 1950) have stated that the decreased yields of winter wheat associated with 2,4-D injury were attributed to reduced plant densities. The rates of 2,4-D causing these reductions ranged from 0.4 to 1.5 kg/ha. However, none of the authors commented on whether or not the stand reductions occurred before or after the winter period, or if any differences existed in winter survival between the various treatments.

Freyman and Hamman (1979) designed an experiment to specifically determine the effect of phenoxy herbicides on the cold hardiness of winter wheat in a growth cabinet. They found that treatments of 2,4-D ester and amine at 0.5 kg/ha significantly raised the LT_{50} (lethal temperature at which 50% of the winter wheat plants are killed) to -14.3°C and -13.7°C, respectively, when compared to the control (-16.6°C). The herbicide treatment also reduced plant vigor and the ability of the surviving plants to recover from the freezing test. The authors concluded that in areas where winterkill is likely to occur, spraying with phenoxy herbicides should be delayed until spring.

Dicamba (3,6-dichloro-o-anisic acid)

Dicamba, a benzoic acid compound, is frequently used in mixtures with 2,4-D to control broadleaf weeds in cereals (Manitoba Agriculture 1984). Dicamba has plant growth-regulating properties (Anderson 1977). Spring wheat plants treated beyond the 4-leaf stage with dicamba at 0.28 kg/ha had bent internodes, decreased culm height, delayed heading, and reduced floret fertility and kernel development resulting in decreased yields (Friesen *et al*. 1964, Quimby and Nalewaja 1966). Application of dicamba to winter wheat in the early stages of growth resulted in little or no effect on the crop (Robison and Fenster 1973, Tottman 1977). However, Banks et al. (1979) reported that pre-plant applications of 2.2 kg/ha of dicamba resulted in stunting and malformation of leaves, stems, and inflorescences of the winter wheat crop.

Picloram (4-amino-3,5,6-trichloropicolinic acid)

Picloram is a hormone-type herbicide which exhibits growth regulating properties similar to 2,4-D (Eisinger and Morre 1971, Hamill et al. 1972) but it is more active than 2,4-D at low dosages (Chang and Foy 1971). Because of its persistence, picloram is used at low rates in a mixture with 2,4-D in a commercial formulation (Tordon 202C). Tordon 202C is currently recommended for use on spring wheat at the 4- to 5-leaf stage, but not on winter wheat (Manitoba Agriculture 1984). Nalewaja (1970) reported that spring wheat at the 2- to 4-leaf stage was most tolerant to picloram, but the addition of 2,4-D resulted in a yield reduction. The results support other reports that mixtures of picloram with some chlorophenoxy herbicides are synergistic (Hamill et al. 1972). Kirkland and Keys (1979) observed that spring wheat treated at the 3-leaf stage with picloram was injured. Although injury occurred at all rates tested, tolerance to 0.02 to 0.35 kg/ha of picloram was considered acceptable. Injury to the wheat consisted of minor deformities, including twisting of some stems and a delay in maturity. Keys and Friesen (1968) reported that rates of picloram as low as 0.05 kg/ha could cause a reduction in the height and yield of spring wheat.

Decreased plant height and yield reductions occurred in winter rye when 0.28 kg/ha picloram was applied in the fall (Rahman and Corns 1970). Fall spraying of winter wheat with a picloram/2,4-D mixture (0.03/0.41 kg/ha) caused a significant yield reduction of 7.5% (Robison and Fenster 1973). No reason is given for the reduction. Baur *et al*. (1970) reported that picloram caused an increase in the fresh weight, but not the dry weight, of spring wheat seedlings. Such a shift in water content could reflect a decrease in cold hardiness as indicated by Freyman and Klady (1979). In contrast, Hamill *et al*. (1972) concluded that picloram promoted the loss of moisture and reduced the amount of dry matter accumulation in beans (*Phaseolus vulgaris* L. 'Red Kidney'). However, beans are considered susceptible to picloram.

Chlorsulfuron (2-chloro-N-[(4-methoxy-6-methyl-1,3,5-triazin-2yl) aminocarbonyl]-benzenesulfonamide)

Chorsulfuron is a new herbicide which has not yet received full registration in Canada. The chemical is very active at extremely low rates on a large number of weed species (Levitt *et al*. 1981). Unlike the previously mentioned herbicides, the initial symptom of chlorsulfuron injury is the complete inhibition of growth in susceptible species. Chlorsulfuron has little effect on cell expansion, and no direct effect on photosynthesis or plant respiration (Ray 1982).

Cereal crops, including spring wheat, have been reported to be tolerant to rates of chlorsulfuron up to 200 g/ha (O'Sullivan 1982, Miller and Nalewaja 1983). Suggested rates for weed control in wheat are between 10 and 40 g/ha. Reports of the effects of chlorsulfuron on winter wheat are conflicting. A number of authors have found that winter wheat is tolerant to fall-applied chlorsulfuron at rates ranging from 5 to 200 g/ha (Anderson and Harris 1981, Drew 1981, Blackshaw and Bonsor 1982). However, Stahlman (1980) reported that pre-emergence applications of the herbicide caused visible injury of 5, 13, and 38% for rates of 35, 70, and 140 g/ha, respectively. The nature of the injury was not explained. Moyer and Epp (1980) visually rated winter wheat tolerance to a fall post-emergence application of 50 g/ha of chlorsulfuron at 7 compared to 9 for the unsprayed control, using the ECW visual rating scale (Appendix Table 1). The nature of the injury was not stated. Chlorsulfuron applied to winter wheat in the spring caused yield reductions in experiments conducted in 1983 by Wicks et al.

Persistence and Phytotoxicity of Dinitroaniline Residues to Winter Wheat

Residual soil-applied herbicides used in a crop rotation can potentially pose a problem for the production of winter wheat. Trifluralin (α,α,α-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine), a residual dinitroaniline herbicide, is applied as pre-plant incorporated treatment to approximately 260,000 hectares of rapeseed in Manitoba each year. Prior to 1980, dinitramine (N^4,N^4-diethyl-α,α,α-trifluoro-3,5-dinitrotoluene-2,4-diamine) was also used, but this product is no longer registered in Canada. Ethalfluralin (N-ethyl-N-(2-methyl-2-propenyl)-2,6-dinitro-4-(trifluoro-methyl)benzenamine), a third dinitroaniline herbicide, and EL526 1, an experimental compound containing trifluralin and ethalfluralin (1:1) were also tested as possible alternatives to trifluralin.

Persistence of Dinitroaniline Herbicide in Soil

The potential for dinitroaniline herbicide residues to carry-over in soils has been documented by a number of researchers. Analytical determinations showed that between 9 and 21% of spring-applied trifluralin persisted in the top 5 cm of soil after 15 to 20 weeks (Smith 1972, Hayden and Smith 1980, Pchajek *et al*. 1983). Pritchard and Stobbe (1980) reported that between 17 and 26% of the applied trifluralin remained in the soil after 50 weeks under Manitoba conditions.

In Saskatchewan soils, 12% of the applied dosage remained after 52 weeks (Hayden and Smith 1980).

Rahman and Ashford (1973) concluded that trifluralin applied at 1 to 2 kg/ha in Saskatchewan would take more than one growing season before the residues in the soil decreased to a level that would not be phytotoxic to most susceptible species. The growth of green foxtail (Setaria viridis (L.) Beauv.) on a loamy sand soil was reduced by up to 65%, 4.5 months after an application of 1.0 kg/ha of trifluralin (Jensen and Kimball 1978). Pchajek et al. (1983) reported that residues from spring applications of trifluralin at 0.84 kg/ha were less than from fall applications at 1.12 kg/ha, and were less likely to injure susceptible crops. Based on their results, they stressed the need for extreme care to prevent overlap during field application if a susceptible crop is to be sown the following season.

The rate of ethalfluralin disappearance from soil is about equal to that of trifluralin (Savage 1978, Jensen and Kimball 1978, Hayden and Smith 1980). However, dinitramine dissipates more rapidly (Jansen and Kimball 1978, Pchajek 1982). Savage (1978) determined the half-life of dinitramine to be about one-half and two-thirds that of trifluralin in a clay and sandy loam soil, respectively. Pritchard and Stobbe (1980) found dinitramine residues of 8, 17, and 26% of the initial applications in sandy loam, clay loam, and clay soil, respectively, 50 weeks after being applied. Green foxtail growth was reduced by 33 and 50%, when the weed was planted into pots of soil sampled from a field 4.5 months afer a spring application of dinitramine at 0.6 kg/ha and ethalfluralin at 1.0 kg/ha, respectively (Jensen and Kimball 1978). These authors concluded that trifluralin, ethalfluralin and dinitramine may persist at phytotoxic levels beyond the four-month growing season in Nova Scotia, and could damage winter cereals. In Manitoba, Pchajek (1982) concluded that dinitramine residues would not likely pose a problem for subsequent crop selections in Manitoba. However, he may not have considered the possibility of selecting a winter cereal when reaching his conclusion.

Phytotoxicity of Dinitroaniline Residues to Wheat

Rahman and Ashford (1970) determined that the major phytotoxic effect of trifluralin on wheat was the inhibition of coleoptile elongation. Inhibition of coleoptile development was noted when concentrations of 0.8 ppmw were present in the soil or 5 g was applied directly to the caryopsis. They reported that the coleoptiles of wheat seedlings were considerably more sensitive to trifluralin than the roots. The sensitive plant parts were found to be most susceptible at very early stages of development, and became less sensitive over time. The authors reported that the shoots of wheat planted at a depth of 2.5 cm or less in trifluralin-treated soil developed normally, but that shoot dry weights were reduced when the seeds were planted deeper. They concluded that the dry weight reductions resulted from normal elongation of the coleoptile being inhibited in the presence of trifluralin to the extent that the coleoptile tip of the wheat seedling remained 1 to 2 cm beneath the soil surface. This, in turn, resulted in injury to the first foliage leaves as they forced their way through the soil surface. Trifluralin also inhibits lateral root development within the treated zone (Lignowski and Scott 1971), a symptom which Parka and Soper (1977) claim to be most characteristic of the herbicide.

Pritchard and Stobbe (1980) reported injury to spring wheat grown on soils one year after applications of trifluralin and dinitramine. Crops grown on a sandy loam soil (4.3% organic matter) were deemed to be more susceptible to injury from herbicide residues than those grown on clay soil (6.8% organic matter). The authors found that the phytotoxicity of the chemicals decreased with an increase in organic matter. This is in agreement with Moyer's results (1979), which indicated that trifluralin activity was highly dependent on soil organic matter.

Injury to winter wheat in the fall has been reported on silt loam soils previously seeded to soybeans treated with pre-plant incorporated trifluralin at rates of 1.12 and 2.24 kg/ha (Fink 1972). Banks et al. (1979) found that layering trifluralin (2.2 kg/ha) and dinitramine (1.1 to 2.2 kg/ha) beneath the soil surface resulted in injury to winter wheat if the crop was planted 10 weeks after treatment but not if the crop was planted 60 weeks after treatment. In spite of the injury, no yield reductions were noted. Abernathy and Keeling (1979) found no injury to wheat plants seeded in the fall on a sandy clay loam soil after trifluralin and dinitramine had been applied to a previous crop of cotton at rates of 0.67 and 0.56 kg/ha, respectively.

Effect of Soil Temperature on Phytotoxicity of Dinitroaniline Herbicides

Soil temperatures are generally much higher in the fall than in the spring. Studies on the effect of temperature on the phytotoxicity of trifluralin are inconclusive. Rahman (1973) reported that trifluralin was phytotoxic to wheat at high temperatures when the wheat was planted at a depth of 6.3 cm but no effect was noted at 2.5 cm. Darwent (1980) determined that trifluralin was most effective in reducing wild oat emergence in early May, a time when soil temperatures were at their lowest level during a mid-April to late June study period. Darwent (1980) reported a slight decrease in trifluralin efficacy as the temperature was decreased from 20 to 7.5°C in growth cabinet studies, but noted a major improvement in performance at 4°C. He concluded that the reduced rate of growth at low temperatures increased the length of exposure time to the herbicide resulting in effects equal to or greater than at higher temperatures. Other researchers have concluded that trifluralin toxicity to barley and wild oats is unaffected by temperature (Mulder and Nalewaja 1978, Moyer 1979).

CHAPTER II

TOLERANCE OF WINTER WHEAT TO FALL-APPLIED HERBICIDES

Introduction

Winter wheat (*Triticum aestivum* L.) is very competitive with spring-germinating weeds because of its winter annual nature and rapid spring regrowth. However, winter annual weeds including stinkweed (*Thlaspi arvense* L.) and flixweed (*Descurania sophia* L.) can compete with the crop. Although it is possible to control these weeds with fall herbicide applications, current recommendations caution against this practice (Manitoba Agriculture 1984).

Freyman and Hamman (1979) reported that the application of phenoxy herbicides to winter wheat that is not cold-hardened, significantly reduced the LT_{50} (lethal temperature at which 50% of the winter wheat plants are killed). The herbicide treatments also reduced plant vigor and the ability of the surviving plants to resume growth after freezing.

Based on Freyman and Hamman's results and the need for fall weed control recommendations in winter wheat, field experiments were initiated to study the effect of fall-herbicides on the winter survival and the subsequent yield of Norstar winter wheat. An artificial freezing test was also undertaken to study the effect of the herbicides on the cold tolerance of Norstar winter wheat.

Materials and Methods

Field Experiments

In the fall of 1980 and 1981, field trials were established at the University of Manitoba field stations at Minto (Ryerson clay loam), and Portage la Prairie (Fortier silty clay). The physical characteristics of the soils are given in Table 1.

The trials were arranged in a randomized complete block design with each treatment replicated four times. The plot sizes were 2 by 7.5 m for all trials.

The site had previously been sown to barley. The barley was harvested, the straw chopped, spread, and harrowed prior to seeding of the winter wheat. The winter wheat was seeded directly into the standing barley stubble at all of the sites. An additional trial was established at Portage in 1981 using conventional tillage. The conventional tillage site was cultivated twice with a heavy duty cultivator, once with a light duty field cultivator and then harrowed prior to seeding. The conventional tillage trial was added to try to amplify any herbicide injury on the winter wheat by exposing the crop to greater temperature extremes during the winter.

TABLE 1. Physical characteristics of soils at each experimental site.

Location	Soil Series	% Organic Matter	Inorganic Separates (%) Sand	Silt	Clay	pH
Minto	Ryerson clay loam	5.1	30	42	28	7.5
Portage	Dugas silty clay	6.3	5	49	46	7.9

Winter wheat was seeded at a rate of 70 kg/ha at a depth of 2.5 cm. The cultivars of winter wheat, the seeding date, and the types of drills used in the experiments are listed in Table 2. Ammonium phosphate fertilizer was applied with the seed at a rate of 40 kg/ha P_2O_5. In the 1980 trials, nitrogen in the form of urea was broadcast in mid-November shortly after the first snowfall. In the 1981 trials, nitrogen in the form of ammonium nitrate, was broadcast at the end of April. In both years, nitrogen was applied at a rate of 100 kg/ha.

The herbicide treatments, including the rates and dates of application, are listed in Tables 3 and 4. The herbicides were applied in a volume of 110 L/ha water using a bicycle sprayer equipped with Teejet 65015 flat fan nozzles, and operated at a forward speed of 5.7 km/h and a spray pressure of 276 kPa. An overall treatment of diclofop methyl (Hoegrass) at 0.9 kg/ha was applied to the winter wheat in the two conventional tillage trials on June 10, 1982 to control wild oats and green foxtail. Grassy weed populations in the zero tillage trials were low and did not warrant specific control measures.

In the trials established in 1980, spring plant counts were taken only at the Minto site. Dry matter samples were also taken at this time. The plant counts and dry matter samples were taken using a 0.5 by 0.5 m quadrat placed randomly at four locations within the plot. In the trials

TABLE 2. Tillage systems, cultivars of winter wheat, dates of seeding, and types of drills used in field trials.

Location	Year	Tillage System	Cultivar of Winter Wheat	Date of Seeding	Type of Seed Drill
Minto	1980-81	zero tillage	Norstar	11/09/80	Wilrich air seeder with ZT openers
	1981-82	zero tillage	Norstar	14/09/81	Wilrich air seeder with ZT openers
Portage	1980-81	zero tillage	Norstar	18/09/80	International 620 press drill with cutting coulters
	1981-82	zero tillage	Norstar) Winalta)	10/09/81	Noble 2000 hoe drill with ZT openers
		conventional tillage	Norstar) Winalta)	10/09/81	Noble 2000 hoe drill with ZT openers

TABLE 3. Herbicides, rates, and dates of application for 1980-81 field trials.

Treatment	Rate (kg/ha)	Stage of Winter Wheat	Date of Application Minto	Date of Application Portage
Control (Glyphosate)	2.25	pre-emergence	18/09/80	22/09/80
Untreated control	-	-	-	-
2,4-D amine	1.10	pre-emergence	18/09/80	22/09/80
2,4-D amine	0.55	3- to 4-leaf	11/10/80	04/11/80
2,4-D amine	0.85	early spring	02/05/81	14/05/81
Dicamba + 2,4-D amine	0.22+0.62	pre-emergence	18/09/80	22/09/80
Dicamba + 2,4-D amine	0.15+0.42	3- to 4-leaf	11/10/80	04/11/80
Picloram/2,4-D	0.04/0.55	3- to 4-leaf	11/10/80	04/11/80

TABLE 4. Herbicides, rates, and dates of application for 1981-82 field trials.

Treatment	Rate (kg/ha)	Stage of Winter Wheat	Date of Application Minto	Date of Application Portage
Control (Glyphosate)	2.25	pre-emergence	16/09/81	-
Untreated control	-	-	-	-
2,4-D amine	0.55	3- to 4-leaf	10/10/81	06/10/81
2,4-D amine	1.10	3- to 4-leaf	10/10/81	06/10/81
2,4-D amine	0.85	early spring	18/05/82	12/05/82
Dicamba + 2,4-D amine	0.15+0.42	3- to 4-leaf	-	06/10/81
Dicamba + 2,4-D amine	0.33+0.94	3- to 4-leaf	-	06/10/81
Picloram/2,4-D	0.04/0.55	3- to 4-leaf	10/10/81	06/10/81
Chlorsulfuron	0.02	pre-emergence	16/09/81	16/09/81
Chlorsulfuron	0.04	pre-emergence	16/09/81	16/09/81
Chlorsulfuron	0.02	3- to 4-leaf	10/10/81	06/10/81
Chlorsulfuron	0.04	3- to 4-leaf	10/10/81	06/10/81

established in 1981, plant counts were taken in fall prior to freeze-up. The quadrats were marked and counts taken again in the spring after growth had resumed. In these trials, the counts and dry matter samples were taken using a 0.25 by 0.5 m quadrat placed randomly at three locations within the plot. Plant growth stages and the number of tillers per plant were recorded at the time the spring plant counts were taken. Counts and dry matter values for both years were expressed as number of plants/m^2 and g/m^2, respectively. Plant growth stage assessments were based on the Feekes Scale (Large 1954). Tiller counts were also taken.

A Hege small plot combine was used to harvest the trials. The harvest dates are listed in Table 5. An area of 8.5 m^2 was harvested. Following seed cleaning, moisture contents of the samples were determined using a Labtronics moisture meter (Model 919). Plot yields were calculated and expressed in kg/ha at 14% moisture.

Visual weed control assessments based on a 0 to 9 scale adopted by the Expert Committee on Weeds (Western Canada Section), were used to assess broadleaf weed control (Appendix Table 1). Weed control ratings were taken only in the 1981 trials, and were done on June 28 and July 21, 1982 at the Minto and Portage sites, respectively. The dates correspond to 6 and 12 weeks after the spring herbicide treatments were applied at the respective sites.

TABLE 5. Dates of counts, dry matter samples, and harvests for field trials.

Location	Year	Tillage System	Cultivar of Winter Wheat	Fall Plant Counts	Spring Plant Counts - Dry Matter Samples	Harvest
Minto	1980-81	zero tillage	Norstar	-	20/05/81	12/08/81
	1981-82	zero tillage	Norstar	29/10/81	05/06/82	16/08/82
Portage	1980-81	zero tillage	Norstar	-	-	12/08/81
	1981-82	zero tillage	Norstar Winalta	14/10/81 15/10/81	10/06/82 14/06/82	10/08/82 10/08/82
		conven-tional	Norstar Winalta	19/10/81 19/10/81	16/06/82 21/06/82	13/08/82 13/08/82

Precipitation and temperature data for periods over which the experiments were conducted are provided in Appendix Tables 2 and 3. Soil temperatures at the 2.5 cm depth measured on a nearby experiment at Portage are also included in the Appendix (Table 4).

Artificial Freezing Test

To determine the effect of certain broadleaf herbicides on the cold hardiness of Norstar winter wheat, an artificial freezing test was developed. Wheat seedlings were grown in wooden flats (50 x 30 x 10 cm) filled with a 2:3 (v/v) mix of sand and soil. The wheat was planted at a depth of 2.5 to 3.0 cm. The flats were placed in the greenhouse at 18°C for one week by which time the wheat was in the 1- to 2-leaf stage. One week after seeding (September 29, 1982), the flats were transferred outside and placed on cultivated ground. Four weeks after seeding (October 20, 1982) when the wheat was in the 3-leaf stage, the flats were removed from the field and sprayed in a cabinet sprayer with the herbicides listed in Table 6. The chemicals were applied with a single Teejet flat fan 80015 nozzle tip at 276 kPa. Spray output was equivalent to 150 L/ha. The nozzle height was 45 cm above the flat. During the time the flats were sprayed, the plants were subject to 18°C temperatures for approximately 2.5 hours. After spraying, the flats were returned to the

TABLE 6. Herbicides and rates of application for artificial freezing test.

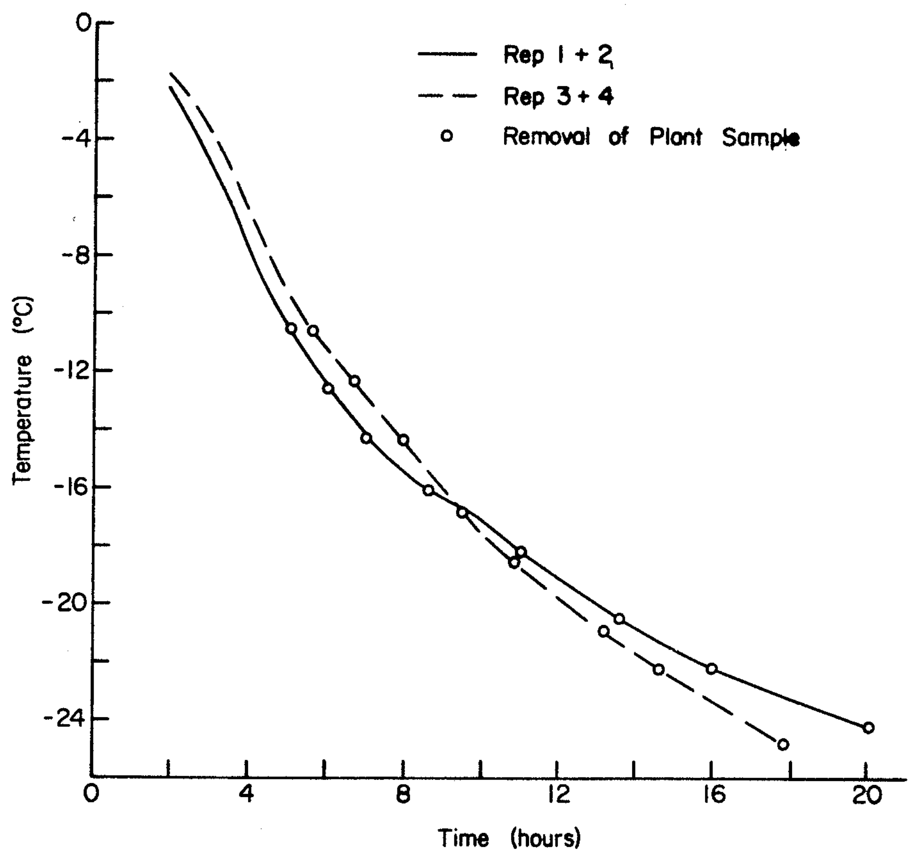
Herbicide	Rate (kg/ha)
Control (water)	-
2,4-D amine	0.55
2,4-D amine	1.10
Dicamba + 2,4-D amine	0.15 + 0.42
Dicamba + 2,4-D amine	0.33 + 0.94
Picloram/2,4-D	0.04/0.55
Chlorsulfuron	0.02
Chlorsulfuron	0.04
Untreated control	-

field. One set of control flats was not sprayed and remained in the field. A second set of flats was sprayed only with water.

In the field, the various treatments (flats) were arranged in a randomized complete block design with four replicates. A row of flats was placed along both ends of the experiment to act as guards. Soil was also piled along the front and back of Replicates 1 and 4, respectively. Since there was little snow cover by the third week in November and the forecast was for extremely low temperatures, the flats were covered with a double layer of burlap to moderate the temperatures to which the plants would be exposed. The burlap remained in place until the flats were retrieved from the field on January 25 and 31, 1983 for Replicates 1 and 2, and Replicates 3 and 4, respectively.

After the flats were removed from the field and allowed to thaw for 24 hours in a refrigerator at 3.5°C, the plants were removed from the soil and rinsed in ice water. Most of the leaf and root tissue was clipped from the plants using a procedure described by Marshall (1965). Ten of the clipped plants from each treatment were placed in small plastic bags. The bags were then heat sealed after most of the air was excluded from the bags. Each of the bags was heat sealed inside a second plastic bag to prevent leakage of the freezing solution into the bags. One bag of plants from each treatment was positioned on one of eight frames. Two additional bags with thermocouples placed inside with the plant samples were also attached to the frame.

The frames with the bags attached were submerged in a plastic barrel containing 115 L of a mixture of 45% ethylene glycol and 65% water at a temperature of 3.0°C. Due to the size of the freezing solution container, only 2 replicates could be put through the freezing cycle at one time. After allowing the samples to equilibrate for two hours, the barrel was moved into a freezer set at -30°C. The mixture in the barrel was circulated with an electric stirrer and a plastic tube located vertically in the centre of the barrel. Temperatures within the sample bags were monitored using thermocouples and a Campbell Scientific CR5 Digital Recorder. The rate of decrease of temperature is plotted in Figure 1. One frame for each replicate was removed from the solution as the mixture cooled to each of the following temperatures: -10, -12, -14, -16, -18, -20, -22, and -24°C. Upon removal, the samples were returned to the 3°C refrigerator to thaw for 24 hours. The bags were then opened and the plants rinsed with water. The bags were closed with twist-ties and placed in the greenhouse at a temperature of 10°C. After 10 days, the vigor of regrowth was rated using the scale in Table 7, and the length of new leaf growth was measured.



Rep 1 + 2
Rep 3 + 4
Removal of Plant Sample
Temperature (°C)
0
-4
-8
-12
-16
-20
-24
0
4
8
12
16
20
Time (hours)

TABLE 7. Scale for rating vigor of regrowth after freezing test*.

Rating	Description
1	- dead - colorless, dried or moldy
2	- appears dead, but green shoot within dead sheaths
3	- living - has produced one leaf
4	- living - has green coloration and with some regrowth evident - has more than 1 leaf per crown
5	- living - has healthy green coloration and considerable regrowth evident - has more than 1 leaf per tiller

*Each plant is rated individually. The ratings for each of the 10 plants per bag are added to give the Total Rating per bag.

(Maximum Total Rating = 50; Minimum Total Rating = 10)

RESULTS AND DISCUSSION

Field Experiments

Fall plant stands did not appear to be affected by the pre-emergence herbicide treatments (Tables 8, 9, 10, 11, and 12). Survival was significantly affected in only one of the five station-years (Table 11). Chlorsulfuron applied as a pre-emergence treatment at 0.02 kg/ha on the conventional tillage site in 1981-82 reduced the percent survival of Norstar winter wheat when compared to the control. However, chlorsulfuron applied as a pre-emgerence treatment at the 0.04 kg/ha rate had no effect on survival, in contrast to the lower rate. Therefore it can not be concluded that the 0.02 kg/ha treatment will affect survival. No other trends or rate effects were visible in the five experiments in which survival was measured (Table 8, 9, 10, 11, and 12). Plant survivals greater than 100% may be accounted for by plants emerging after the counts were taken in the fall and/or before the counts were taken in the spring. Difficulties in distinguishing between plants and tillers may also have led to errors in this measurement. Any apparent anomolies in survival between treatments may be due to the inherent variability in winter stress experienced in field survival trials as discussed by Fowler (1979).

Significant differences in dry matter production were found only in 1981-82 at the Minto location (Table 8). The picloram/2,4-D treatment and the spring application of

TABLE 8. The effect of herbicides on the plant stand, survival, dry matter, and seed yield of Norstar winter wheat grown at Minto, 1981-82 - zero tillage.

Treatments	Rate (kg/ha)	Time of Application	Plant Counts ($no./m^2$) Fall	Spring	Survival %	Dry Matter (g/m^2)	Seed Yield (kg/ha)
Control (Glyphosate)	-	pre-emergence	117	119	101	268.7 ab[1]	4279
Untreated Control	-	-	128	115	95	231.3 bcd	4094
2,4-D amine	1.10	pre-emergence	114	146	129	287.5 a	4297
2,4-D amine	0.55	3-4 lf stage	112	119	109	255.4 abcd	4243
2,4-D amine	0.85	early spring	110	123	113	223.0 cd	4394
Picloram/2,4-D	0.04/0.55	3-4 lf stage	106	111	105	211.5 d	4131
Chlorsulfuron	0.02	pre-emergence	117	136	117	259.1 abc	4250
Chlorsulfuron	0.04	pre-emergence	111	127	116	224.9 bcd	4093
Chlorsulfuron	0.02	3-4 lf stage	98	125	129	238.6 bcd	4135
Chlorsulfuron	0.04	3-4 lf stage	111	136	123	226.7 bcd	4141
			n.s.[2]	n.s.	n.s.		n.s.

[1]Numbers followed by the same letter do not differ significantly at the 10% level using Duncan's multiple range test.

[2]n.s. - Numbers do not differ significantly at the 10% level.

TABLE 9. The effect of herbicides on the plant stand, survival, dry matter, and seed yield of Norstar winter wheat at Portage, 1981-82 - zero tillage.

Treatments	Rate (kg/ha)	Time of Application	Plant Counts (no./m^2) Fall	Plant Counts (no./m^2) Spring	Survival %	Dry Matter (g/m^2)	Seed Yield (kg/ha)
Untreated Control	-	-	149	157	111	437.2	3203
2,4-D amine	0.55	3-4 lf stage	140	160	120	437.6	2791
2,4-D amine	1.10	3-4 lf stage	141	175	129	421.4	2994
2,4-D amine	0.85	early spring	139	166	121	413.3	3519
Dicamba + 2,4-D	0.15+0.42	3-4 lf stage	138	161	131	410.8	3040
Dicamba + 2,4-D	0.33+0.94	3-4 lf stage	139	181	135	468.3	3065
Picloram/2,4-D	0.04/0.55	3-4 lf stage	146	164	119	397.8	2799
Chlorsulfuron	0.02	pre-emergence	140	168	127	385.3	3202
Chlorsulfuron	0.04	pre-emergence	127	153	126	384.3	2478
Chlorsulfuron	0.02	3-4 lf stage	161	171	113	395.8	3093
Chlorsulfuron	0.04	3-4 lf stage	149	175	122	433.0	3565
			n.s.[1]	n.s.	n.s.	n.s.	n.s.

[1]n.s. - Numbers do not differ significantly at the 10% level.

TABLE 10. The effect of herbicides on the fall and spring plant stand, survival, dry matter, and seed yield of Winalta winter wheat at Portage, 1981-82 - zero tillage.

Treatments	Rate (kg/ha)	Time of Application	Plant Counts (no./m^2) Fall	Spring	Survival %	Dry Matter (g/m^2)	Seed Yield (kg/ha)
Untreated Control	-	-	111	110	104	267.2	3043
2,4-D amine	0.55	3-4 lf stage	123	137	128	347.8	2675
2,4-D amine	1.10	3-4 lf stage	111	121	117	245.1	2637
2,4-D amine	0.85	early spring	129	149	122	401.6	2869
Dicamba + 2,4-D	0.15+0.42	3-4 lf stage	115	137	136	360.1	2911
Dicamba + 2,4-D	0.33+0.94	3-4 lf stage	127	115	98	285.5	2685
Picloram/2,4-D	0.04/0.55	3-4 lf stage	125	125	104	330.6	2909
Chlorsulfuron	0.02	pre-emergence	118	132	114	373.4	3159
Chlorsulfuron	0.04	pre-emergence	112	133	134	385.6	2817
Chlorsulfuron	0.02	3-4 lf stage	123	133	112	322.2	2521
Chlorsulfuron	0.04	3-4 lf stage	110	130	132	369.5	2799
			n.s.[1]	n.s.	n.s.	n.s.	n.s.

[1]n.s. - Numbers do not differ significantly at the 10% level.

TABLE 11. The effect of herbicides on the plant stand, survival, dry matter and seed yield of Norstar winter wheat at Portage, 1981-82 - conventional tillage.

Treatments	Rate (kg/ha)	Time of Application	Plant Counts (no./m²) Fall	Spring	Survival %	Dry Matter (g/m²)	Seed Yield (kg/ha)
Untreated Control	-	-	127	171 abc[1]	137 ab	502.0	4273
2,4-D amine	0.55	3-4 lf stage	126	172 ab	143 ab	450.6	3893
2,4-D amine	1.10	3-4 lf stage	122	186 a	155 a	414.0	3878
2,4-D amine	0.85	early spring	127	154 abcd	123 bc	490.1	3716
Dicamba + 2,4-D	0.15+0.42	3-4 lf stage	102	158 abc	155 a	406.2	3877
Dicamba + 2,4-D	0.33+0.94	3-4 lf stage	106	155 abcd	149 ab	389.6	3480
Picloram/2,4-D	0.04/0.55	3-4 lf stage	108	138 cd	135 ab	404.6	3643
Chlorsulfuron	0.02	pre-emergence	120	124 d	105 c	392.2	3639
Chlorsulfuron	0.04	pre-emergence	111	156 abcd	144 ab	384.5	3823
Chlorsulfuron	0.02	3-4 lf stage	112	144 bcd	131 abc	421.3	3843
Chlorsulfuron	0.04	3-4 lf stage	121	173 ab	142 ab	393.5	3835
			n.s.[2]			n.s.	n.s.

[1]Numbers followed by the same letter do not differ significantly at the 10% level using Duncan's multiple range test.

[2]n.s. - Numbers do not differ significantly at the 10% level.

TABLE 12. The effect of herbicides on the plant stand, survival, dry matter and seed yield of Winalta winter wheat at Portage, 1981-82 - conventional tillage.

Treatments	Rate (kg/ha)	Time of Application	Plant Counts (no./m^2) Fall	Spring	Survival %	Dry Matter (g/m^2)	Seed Yield (kg/ha)
Untreated Control	-	-	97	121	127	283.4	2974
2,4-D amine	0.55	3-4 lf stage	104	149	149	372.6	3026
2,4-D amine	1.10	3-4 lf stage	101	101	103	257.0	3086
2,4-D amine	0.85	early spring	99	121	124	340.8	3094
Dicamba + 2,4-D	0.15+0.42	3-4 lf stage	104	125	122	328.0	3254
Dicamba + 2,4-D	0.33+0.94	3-4 lf stage	111	123	120	273.3	2844
Picloram/2,4-D	0.04/0.55	3-4 lf stage	113	109	105	257.2	2862
Chlorsulfuron	0.02	pre-emergence	106	127	125	346.4	3371
Chlorsulfuron	0.04	pre-emergence	105	121	120	293.7	3258
Chlorsulfuron	0.02	3-4 lf stage	100	115	119	260.7	3177
Chlorsulfuron	0.04	3-4 lf stage	96	119	133	312.2	3172
			n.s.[1]	n.s.	n.s	n.s.	n.s.

[1]n.s. - Numbers do not differ significantly at the 10% level.

2,4-D reduced the dry matter production below the control (glyphosate). This is in agreement with Tottman (1977) who reported that spring application of growth-regulating herbicides including 2,4-D could cause crop damage. Although not significantly different, the Winalta winter wheat treated with 1.10 kg/ha of 2,4-D tended to produce 30% less dry matter than that treated with 0.55 kg/ha on both types of tillage (Table 10 and 12). No trends were apparent with the other herbicides. This is in agreement with Robison and Fenster (1973) who reported that an application of dicamba resulted in no effect on winter wheat, and with a number of authors who found that winter wheat is tolerant to fall-applied chlorsulfuron at rates ranging from 5 to 200 g/ha (Anderson and Harris 1981, Drew 1981, Blackshaw and Bonsor 1982).

The Feekes' growth stage and tiller counts did not vary significantly, nor were any trends visible over the two years at either of the two stations. These results are presented in the Appendix (Table 5 and 6).

No significant differences or apparent trends were found between yields in any of the experiments over the two locations and the two years. This is in contradiction with a number of authors who report that fall applications of 2,4-D at rates from 0.56 to 1.12 kg/ha on winter wheat can cause significant yield reductions (Klingman and Schafer 1949, Elder 1950, Robison and Fenster 1973). Robison and Fenster (1973) found that picloram/2,4-D (0.03/0.41 kg/ha) caused significant yield reductions of 7.5% when applied to winter wheat in the fall.

TABLE 13. The effect of herbicides on the plant stand, dry matter and yield of Norstar winter wheat, 1980-81.

Treatments	Rate (kg/ha)	Time of Application	Minto: Spring Plant Counts (no./m^2)	Minto: Dry Matter (g/m^2)	Minto: Seed Yield (kg/ha)	Portage: Seed Yield (kg/ha)
Control (glyphosate)	-	pre-emergence	163 ab[1]	65.4 ab	4473	3660
Untreated control	-	-	168 a	79.8 a	4157	3603
2,4-D amine	1.10	pre-emergence	153 b	57.4 b	3964	3799
2,4-D amine	0.55	3-4 lf stage	160 ab	67.0 ab	3553	4054
2,4-D amine	0.85	spring	168 a	57.5 b	3579	4234
Dicamba + 2,4-D	0.22+0.62	pre-emergence	157 ab	70.6 ab	4026	3539
Dicamba + 2,4-D	0.15+0.42	3-4 lf stage	169 a	77.0 a	3992	3536
Picloram/2,4-D	0.04/0.55	3-4 lf stage	159 ab	55.8 b	3808	3851
					n.s[2]	n.s.

[1]Numbers followed by the same letters do not differ significantly at the 10% level using the Duncan's multiple range test.
[2]n.s. - Numbers do not differ significantly at the 10% level.

Visual weed control assessments for the 1981-82 experiment at Minto are presented in Table 14. The chlorsulfuron treatments, as well as the spring application of 2,4-D amine, provided excellent control of the three weed species present [stinkweed, wild mustard (*Sinapis arvensis* L.), kochia (*Kochia scoparia* (L.) Schrader)]. The picloram/2,4-D treatment resulted in acceptable control of stinkweed and kochia, but had little effect on wild mustard. The other treatments rated less than 7 which would not be commercially acceptable. Weed populations in the other experiments were not uniform enough to assess, nor were they sufficiently dense to compete with the winter wheat.

Artificial Freezing Test

The effects of freezing temperatures on the regrowth of Norstar winter wheat are presented in Table 15. The GR_{50} temperature (temperature at which regrowth rating or length of new growth is reduced by 50%) in the experiment approximates the LT_{50} value of -16°C obtained by Freyman and Hamman (1979) for winter wheat. The regrowth rating and the length of new growth obtained for plants subjected to -16°C differ significantly from those subjected to -18°C. The treatment means for the effect of herbicides on the regrowth of the plants after being subjected to freezing temperatures are presented in Table 16. The total regrowth rating and the length of new growth for each of the herbicide treatments for the selected temperatures are presented sepa-

TABLE 14. The effect of herbicides on the control of broadleaf weeds in Norstar winter wheat at Minto, 1981-82.

Treatments	Rate (kg/ha)	Time of Application	Visual Weed Control Ratings*		
			Stinkweed	Wild Mustard	Kochia
Control					
(Glyphosate)	-	pre-emergence	6	7	8
Untreated Control	-	-	1	0	3
2,4-D amine	1.10	pre-emergence	5	3	5
2,4-D amine	0.55	3-4 lf stage	6	4	6
2,4-D amine	0.85	early spring	9	9	8
Picloram/2,4-D	0.04/0.55	3-4 lf stage	7	2	7
Chlorsulfuron	0.02	pre-emergence	9	9	9
Chlorsulfuron	0.04	pre-emergence	9	9	9
Chlorsulfuron	0.02	3-4 lf stage	9	9	9
Chlorsulfuron	0.04	3-4 lf stage	9	9	9

*Ratings based on Expert Committee on Weeds (Western Canada) Rating Scale (Appendix Table 1).

TABLE 15. The effects of freezing temperatures on the regrowth of Norstar winter wheat using the combined data for all herbicide treatments.

Temperature (°C)	Total Rating	Length of new growth (cm/10 plants)
+3	46 a[1]	40.7 a
-10	40 b	25.8 b
-12	40 b	25.0 bc
-14	33 c	19.0 bc
-16	32 c	17.9 c
-18	24 d	7.7 d
-20	23 d	5.3 d
-22	24 d	3.0 d
-24	24 d	3.2 d

[1] Numbers followed by the same number do not differ significantly at the 10% level using Duncan's multiple range test.

TABLE 16. The effect of herbicides on the regrowth of Norstar winter wheat after being subjected to freezing temperatures using the combined data for all freezing temperatures.

Treatment	Rate (kg/ha)	Total Regrowth Rating	Length of New Growth (cm/10 plants)
Water	-	31.1 b[1]	15.6 b
Control	-	32.1 b	16.7 b
2,4-D amine	0.55	32.0 b	15.6 b
2,4-D amine	1.10	31.4 b	15.0 b
Dicamba + 2,4-D	0.15+0.42	34.3 a	19.3 a
Dicamba + 2,4-D	0.33+0.94	28.8 c	12.5 c
Picloram/2,4-D	0.04/0.55	33.1 ab	20.0 a
Chlorsulfuron	0.02	32.3 b	16.7 b
Chlorsulfuron	0.04	31.6 b	15.1 b

[1]Numbers followed by the same letter do not differ significantly at the 10% level using Duncan's multiple range test.

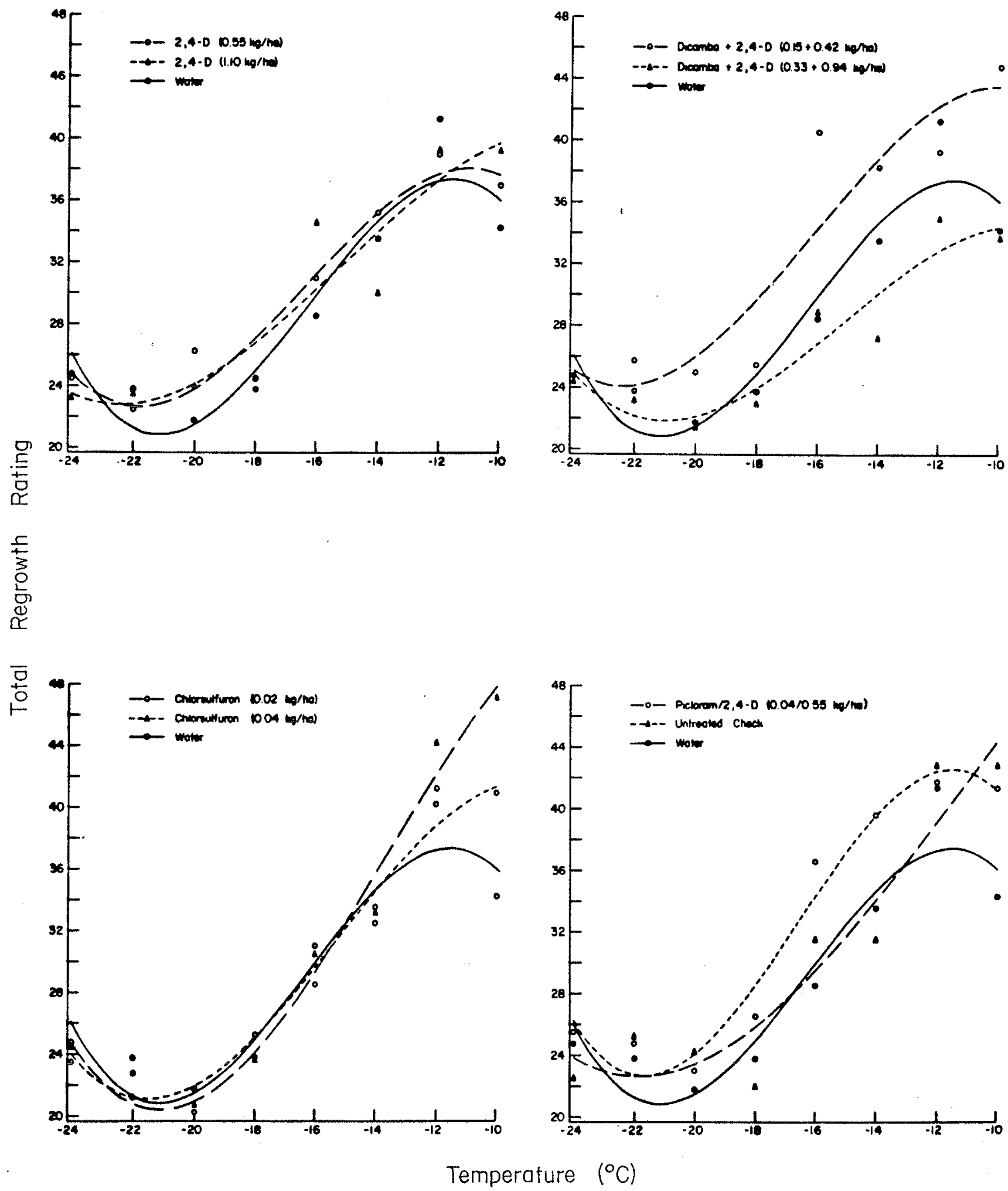
rately in graphical form in Figures 2 and 3, respectively. GR_{50} temperature values were estimated from the graphs (Table 17).

The high rate of dicamba + 2,4-D amine (0.33 + 0.94 kg/ha) was the only treatment which significantly reduced the amount and vigor of regrowth by the winter wheat compared to the water treatment. Both of the estimated GR_{50} temperature values for this herbicide treatment were considerably higher than those for the other treatments.

The low rate of dicamba + 2,4-D (0.15 + 0.42 kg/ha) significantly increased the length of new growth and the total regrowth rating compared to the water treatment. The picloram/2,4-D treatment also significantly increased the length of new growth, and tended to increase the total regrowth rating although not significantly compared to the water treatment (Table 16). Dicamba, 2,4-D, and picloram have growth-regulating activity (Eisinger and Morre 1971, Cartwright 1976, Anderson 1977), and may be responsible for inducing leaf and shoot elongation after the short freezing period. This could account for the decrease in GR_{50} temperatures estimated from the graphs for these two herbicide mixtures (Table 17).

Conclusion

The field data showed no consistent significant effects of the herbicides on survival or seed yield under either of the tillage systems or with either of the two cultivars tested. Any trends that were noted, usually occurred


2,4-D (0.55 kg/ha)
2,4-D (1.10 kg/ha)
Water
Dicamba + 2,4-D (0.15 + 0.42 kg/ha)
Dicamba + 2,4-D (0.33 + 0.94 kg/ha)
Water
Chlorsulfuron (0.02 kg/ha)
Chlorsulfuron (0.04 kg/ha)
Water
Picloram/2,4-D (0.04/0.55 kg/ha)
Untreated Check
Water
Total Regrowth Rating
Temperature (°C)

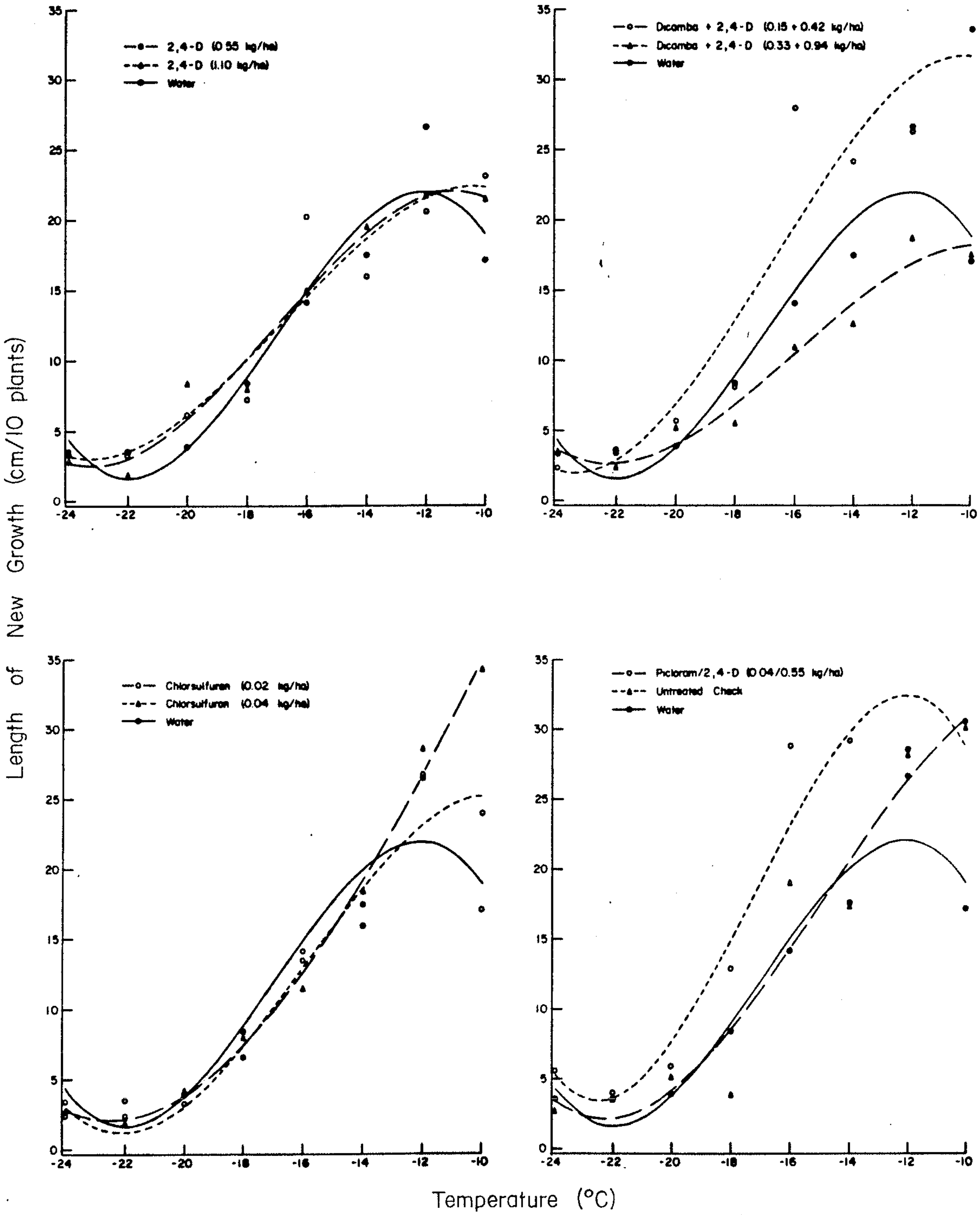

2,4-D (0.55 kg/ha)
2,4-D (1.10 kg/ha)
Water
Dicamba + 2,4-D (0.15 + 0.42 kg/ha)
Dicamba + 2,4-D (0.33 + 0.94 kg/ha)
Water
Chlorsulfuron (0.02 kg/ha)
Chlorsulfuron (0.04 kg/ha)
Water
Picloram/2,4-D (0.04/0.55 kg/ha)
Untreated Check
Water
Length of New Growth (cm/10 plants)
Temperature (°C)

TABLE 17. The effect of herbicides on the GR_{50} temperature of Norstar winter wheat as estimated from the graphs of regrowth ratings and length of new growth.

Treatment	Rate (kg/ha)	GR_{50} temperatures estimated from graphs of:	
		Regrowth Ratings	Length of New Growth
Water	-	-16.0	-16.0
Control	-	-15.7	-15.8
2,4-D amine	0.55	-16.6	-16.0
2,4-D amine	1.10	-16.2	-15.8
Dicamba + 2,4-D	0.15+0.42	-17.9	-17.3
Dicamba + 2,4-D	0.33+0.94	-14.0	-13.5
Picloram/2,4-D	0.04/0.55	-17.5	-18.0
Chlorsulfuron	0.02	-15.7	-15.2
Chlorsulfuron	0.04	-15.8	-15.2

under the more stressful conditions of conventional tillage or with the less hardy cultivar, Winalta. The effects of fall-applied herbicides on the winter survival of winter wheat may not have been fully realized in these two years since soil temperatures at the 2.5 cm depth did not approach the critical temperature (-16°C).

In the artificial freezing test, dicamba + 2,4-D amine at 0.33 + 0.94 kg/ha was the only treatment which had a negative effect on the regrowth of Norstar winter wheat. This rate, which was also tested in the field, is more than twice the recommended rate (0.15 + 0.42 kg/ha) for spring application on spring or winter wheat (Manitoba Agriculture 1984). The results obtained with the other herbicides are in contradiction with those obtained by Freyman and Hamman (1979). However, unlike their experiment, the herbicides were applied to hardened plants in these trials. Hardened plants may be less affected by the herbicides.

Based on these experiments, it does not appear that the application of fall-applied herbicides at the recommended rates will harm Norstar winter wheat in a zero tillage field situation. Under conditions of stress (e.g., minimal snow cover, extended periods of low temperatures, immature plants), picloram in mixture with 2,4-D may provide an additional adverse effect. However, the chances of the winter wheat dying from the other negative factors is of much greater concern.

CHAPTER III

TOLERANCE OF WINTER WHEAT TO DINITROANILINE RESIDUE

Introduction

The number of hectares of land being sown to winter wheat in western Canada is rapidly increasing. Farmers attempting to seed winter wheat into standing stubble for the first time may desire to use land previously seeded to rapeseed. This crop produces a minimal amount of crop residue that is easily managed and will present few problems with seeding.

About 80% of the rapeseed grown in western Canada is sown on land treated with pre-plant incorporated trifluralin (Wise 1982). The potential for dinitroaniline herbicide residues to carry-over in soils has been documented by a number of researchers (Smith 1972, Hayden and Smith 1980, Pchajek _et_ _al_. 1983). Reports of trifluralin residues injuring spring wheat in Manitoba the year after treatment (Pritchard 1976) raise the possibility that winter wheat might also be injured by trifluralin residues. Injury to winter wheat in the fall has been documented on silt loam soils previously seeded to soybeans treated with pre-plant incorporated trifluralin (Fink 1972).

Based on these results, field experiments were conducted to examine the tolerance of winter wheat to dinitroaniline herbicide residues associated with a previous rapeseed crop.

Materials and Methods

In the spring of 1980 and 1981, field trials were established at two University of Manitoba field stations: Minto (Ryerson clay loam), and Portage la Prairie (Dugas silty clay). The physical charateristics of these soils are given in Table 1 (page 26).

The trials were arranged in a randomized complete block design with each treatment replicated four times. At Minto, the plot sizes were 3 by 15 m and 3 by 8 m in 1980 and 1981, respectively. At Portage, the plot sizes were 6 x 15 m and 5 x 15 m in 1980 and 1981, respectively.

Prior to establishment of the trials, the sites were cultivated, disced, and harrowed. Trifluralin (α,α,α-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine), EL5261 [trifluralin: ethalfluralin (N-ethyl-N-(2-methyl-2-propenyl)-2,-6-dinitro-4-(trifluoromethyl) benzenamine) (1:1)], and dinitramine (N^4,N^4-diethyl-α,α,α-trifluoro-3,5-dinitrotoluene-2,4-diamine) were applied to plots at the rates and on the dates shown in Table 18. The higher rates were included to simulate areas where overlaps occur during herbicide application. The herbicides were applied in a volume of 110 L/ha using a bicycle sprayer equipped with Teejet 65015 flat

TABLE 18. Herbicide treatments for each station-year.

Treatment	Rate (kg/ha)	Minto 1980-81[1]	Minto 1981-82[2]	Portage 1980-81[3]	Portage 1981-82[4]
Control (untreated)	-	X	X	X	X
Trifluralin	1.1	X	X	X	X
Trifluralin	2.2	X	X	X	X
EL5261	1.1	X	X	X	X
EL5261	2.2	X	X	X	X
Ethalfluralin	1.1		X		X
Ethalfluralin	2.2		X		X
Dinitramine	0.8			X	
Dinitramine	1.7			X	

[1]Herbicide applied on June 24, 1980.
[2]Herbicide applied on May 26, 1981.
[3]Herbicide applied on June 19, 1980.
[4]Herbicide applied on June 2, 1981.

fan nozzles and operated at a forward speed of 5.7 km/h, and a spray pressure of 276 kPa. Immediately following application, the herbicides were incorporated twice with a tandem disc. The second incorporation was parallel to the first but in the opposite direction. The implement was set to cut a depth of 10 cm for all treatments.

After herbicide incorporation, the plots were seeded to rapeseed (Brassica campestris cv. Candle) at a seeding rate of 7 kg/ha on the dates shown in Table 19. The control plots were sprayed with diclofop methyl (0.7 kg/ha) to control grassy weeds. The rapeseed in the experiments was harvested on the dates shown in Table 19. The rapeseed straw was chopped and spread at both sites in both years, and the sites were harrowed to facilitate spreading of the straw and chaff. On the dates shown in Table 19, the areas were sprayed with 2.25 kg/ha of glyphosate to control winter annual and perennial weeds.

Winter wheat was seeded into the standing rapeseed stubble at a rate of 70 kg/ha at a depth of 2.5 cm. The cultivar of winter wheat, the date of seeding, and the drill used for each site are listed in Table 20.

In 1981 at Portage, the randomized complete block design was changed to a split-plot design so that two cultivars, Norstar and Winalta, could be included in the trial. Sub-plot sizes were 2.5 by 10 m, and main plots were 5 by 10 m. Ammonium phosphate fertilizer (11-55-0) at a rate of 40

TABLE 19. Dates of seeding and harvest of rapeseed and dates of glyphosate application for preparation of experimental sites.

Location	Trial Year	Date of Seeding	Date of Harvest	Date of glyphosate application
Minto	1980-81	25/06/80	26/09/80	26/09/80
	1981-82	27/05/81	08/09/81	09/09/81
Portage	1980-81	20/06/80	15/09/80	16/09/80
	1981-82	03/06/81	27/08/81	29/08/81

TABLE 20. Cultivar of winter wheat, date of seeding, and types of drills used for trials.

Location	Trial Year	Cultivar of Winter Wheat	Date of Seeding	Type of Drill Used
Minto	1980-81	Norstar	27/09/80	Melroe 701 triple disc drill
	1981-82	Norstar	11/09/81	Melroe 701 triple disc drill
Portage	1980-81	Norstar	18/09/80	Modified International 620 press drill with cutting coulters
	1981-82	Norstar) Winalta)	09/09/81	Noble 2000 hoe drill with zero tillage openers

kg/ha P_2O_5, was placed with the seed. In 1980, nitrogen in the form of urea, was broadcast in mid-November shortly after the first snowfall. In the 1981 trials, nitrogen in the form of ammonium nitrate, was broadcast at the end of April. In both years, the nitrogen was applied at a rate of 100 kg/ha N. An overall treatment of Brominal M was applied to the winter wheat trials to control broadleaf weeds on May 13, 1982.

Plant counts were taken in the fall prior to freeze-up and again in the spring after growth resumed. Dry matter samples, Feekes' growth stages, and number of tillers per plant were also recorded at the time of spring plant counts. In the 1980-81 trials, counts and dry matter samples were taken using a 0.25 m^2 quadrat placed randomly at four locations within the plot. In the 1981-82 trials, counts and dry matter samples were taken using a 0.17 by 0.5 m quadrat randomly placed at three locations within the plot. In the 1981-82 trials, the quadrats where the fall counts were taken, were marked with wire pegs. Counts were taken in these same quadrats again in the spring. Counts and dry matter values for both years were expressed as plants/m^2, and g/m^2, respectively. The dates of counts and dry matter samplings for the trials are listed in Table 21. Growth stage assessments were based on the Feekes Scale (Large 1954). The average number of tillers per plant for each treatment was recorded at the time of sampling.

TABLE 21. Dates of plant counts, dry matter samples, and harvests for trials.

Location	Trial Year	Cultivar of Wheat	Fall Plant Counts	Spring Plant Counts & Dry Matter Samples	Harvest
Minto	1980-81	Norstar	22/10/80	19/05/81	11/08/81
	1981-82	Norstar	26/10/81	01/07/82	16/08/82
Portage	1980-81	Norstar	04/11/80	27/05/81	18/08/81
	1981-82	Norstar	20/10/81	26/05/82	17/08/82
		Winalta	20/10/81	26/05/82	17/08/82

A Hege small plot combine was used to harvest an area of 12 m^2 in each of the plots. Following seed cleaning and moisture content determination, plot yields were calculated and expressed as kg/ha at 14% moisture. The harvest dates are listed in Table 21.

Visual weed control assessments based on a 0 to 9 scale adopted by the Expert Committee on Weeds (Western Canada) (Appendix Table 1) were used to assess the weed control resulting from the dinitroaniline herbicide residues in the inter-subplot area where weed regrowth had occurred. Weed control ratings were done on June 20, 1982.

Precipitation and temperature data for the periods of time over which the experiments were conducted are listed in the Appendix (Table 3). Soil temperatures at the 2.5 cm depth measured in a nearby experiment at Portage are also listed in the Appendix (Table 4).

Results and Discussion

Significant differences between the cultivars, Norstar and Winalta, in the untreated control plots occurred only in the number of tillers per plant in the 1981-82 trial at Portage (Table 22). Differences in the fall plant counts between cultivars in the control plots may be the result of differences in the percent germination of the seed or the seed size used for each cultivar. The Norstar was 1981 registered seed, whereas the Winalta was 1981 commercial seed. It was observed in May, 1982 that the sub-plots containing Norstar were green sooner than the sub-plots containing Winalta. This may reflect increased tissue kill during the winter and lack of regrowth vigor of Winalta. Norstar winter wheat is reported to be more winter hardy than Winalta (Agriculture Canada 1978).

Significant differences in fall plant counts between treatments occurred at Minto in 1980 (Table 23). At Minto, the high rates of the herbicides (2.2 kg/ha) significantly reduced the emergence of the winter wheat compared to the control or the low rates of the herbicides (1.1 kg/ha). These findings agree with Fink's (1972) observations that winter wheat was injured when sown in the fall on silt loam soils previously seeded to soybeans treated with pre-plant incorporated trifluralin. Significant differences at the Portage site in 1981 occurred with the Norstar cultivar

TABLE 22. Plant counts, survival, dry matter production, number of tillers, and seed yield of Norstar and Winalta winter wheat grown in untreated control plots, 1981-82.

Cultivar	Plant Counts ($no./m^2$) Fall	Spring	Survival %	Dry Matter (g/m^2)	Tillers (no./plant)	Seed Yield (kg/ha)
Norstar	149	202	135	217	6.5 a[2]	4170
Winalta	136	159	120	192	7.5 b	4165
	n.s.[1]	n.s	n.s	n.s		n.s

[1]Numbers do not differ significantly at the 10% level.
[2]Numbers followed by the same letter do not differ significantly at the 10% level using Duncan's multiple range test.

TABLE 23. Effect of dinitroaniline herbicide residues on the plant stand, survival, dry matter, and seed yield of Norstar winter wheat at Minto, 1980-81.

Treatment	Rate (kg/ha)	Plant Counts (no./m²) Fall	Spring	Survival %	Dry Matter (g/m²)	Seed Yield (kg/ha)
Control (untreated)	-	129 a[1]	117	92 b	39.0 a	3762
Trifluralin	1.1	132 a	109	83 b	34.5 ab	3528
Trifluralin	2.2	83 b	90	116 ab	20.8 c	3718
EL5261	1.1	108 a	109	101 b	30.8 b	3499
EL5261	2.2	75 b	104	145 a	29.5 b	3789
			n.s.[2]			n.s.

[1]Numbers followed by the same letter do not differ significantly at the 10% level using Duncan's multiple range test.
[2]Numbers do not differ significantly at the 10% level.

TABLE 24. Effect of dinitroaniline herbicide residues on the plant stand, survival, dry matter, and seed yield of Norstar winter wheat at Portage, 1981-82.

Treatment	Rate (kg/ha)	Plant Counts (no./m^2) Fall	Plant Counts (no./m^2) Spring	Survival %	Dry Matter (g/m^2)	Seed Yield (kg/ha)
Control (untreated)	-	149 bc[1]	202 ab	135	216.8	4170
Trifluralin	1.1	168 ab	211 ab	127	228.3	4031
Trifluralin	2.2	155 abc	204 ab	133	201.4	4125
EL5261	1.1	162 abc	211 ab	135	260.3	4041
EL5261	2.2	145 c	192 ab	133	195.2	3830
Ethalfluralin	1.1	173 a	227 a	139	232.5	4250
Ethalfluralin	2.2	155 abc	187 b	122	206.0	3733
				n.s.[2]	n.s.	n.s.

[1]Numbers followed by the same letter do not differ significantly at the 10% level using Duncan's multiple range test.
[2]Numbers do not differ significantly at the 10% level.

TABLE 25. Effect of dinitroaniline herbicide residues on the plant stand, survival, dry matter, and seed yield of Winalta winter wheat at Portage, 1981-82.

Treatment	Rate (kg/ha)	Plant Counts (no./m²) Fall	Plant Counts (no./m²) Spring	Survival %	Dry Matter (g/m²)	Seed Yield (kg/ha)
Control (untreated)	-	136	159	120	192.4 a[2]	4165
Trifluralin	1.1	130	147	109	147.6 bcd	4182
Trifluralin	2.2	134	162	122	180.8 ab	4174
EL5261	1.1	141	132	96	160.1 abcd	4237
EL5261	2.2	123	146	120	140.0 cd	3924
Ethalfluralin	1.1	134	161	120	176.8 abc	3947
Ethalfluralin	2.2	137	131	97	123.4 d	4052
		n.s.[1]	n.s.	n.s.		n.s.

[1]Numbers do not differ significantly at the 10% level.
[2]Numbers followed by the same letter do not differ significantly at the 10% level using Duncan's multiple range test.

(Table 24), but not the Winalta cultivar (Table 25). Although the trends were similar, none of the herbicides significantly reduced the emergence compared to the control, and none of the higher rates resulted in significantly different stand densities than the corresponding lower rates. The plant counts for the 1980-81 trial at Portage and the 1981-82 trial at Minto are included in Tables 26 and 27, respectively.

Winter survival in the four station-years sometimes exceeded 100%. This probably resulted from a number of plants emerging in the plots after fall counts had been taken. An example of this may have occurred in the 1981-82 trial at Portage. Fall plant counts were taken on October 20, but consistent freezing conditions did not set in until mid-November, which could have allowed more plants to emerge. Significant differences in winter survival were found only at Minto in the 1980-81 trial (Table 23). However, in none of the herbicide treated plots was survival significantly lower than in the controls. In two of the trials (Tables 23 and 25), survival in plots treated with the low rate of trifluralin tended to be less than in plots treated with the higher rate. In these two trials, survival in the plots treated with the high rate of trifluralin exceeded 100%. A possible explanation for this apparent anomaly is that the higher her-

TABLE 26. Effect of dinitroaniline herbicide residues on the plant stand, survival, dry matter, and seed yield of Norstar winter at Portage, 1980-81.

Treatment	Rate (kg/ha)	Plant Counts (no./m²)		Survival %	Dry Matter (g/m²)	Seed Yield (kg/ha)
		Fall	Spring			
Control (untreated)	-	144	113	79	57.5	3730 a[2]
Trifluralin	1.1	148	107	73	55.3	3458 ab
Trifluralin	2.2	134	108	80	40.6	3836 a
EL5261	1.1	149	110	73	46.6	3491 ab
EL5261	2.2	145	111	80	38.6	3740 a
Dinitramine	0.8	145	107	74	58.9	3553 ab
Dinitramine	1.7	140	106	76	41.2	3036 b
		n.s.[1]	n.s.	n.s.	n.s.	

[1]Numbers do not differ significantly at the 10% level.
[2]Numbers followed by the same letter do not differ significantly at the 10% level using Duncan's multiple range test.

TABLE 27. Effect of dinitroaniline herbicide residues on the plant stand, survival, dry matter, and seed yield of Norstar winter at Minto, 1981-82.

Treatment	Rate (kg/ha)	Plant Counts (no./m^2) Fall	Spring	Survival %	Dry Matter (g/m^2)	Seed Yield (kg/ha)
Control (untreated)	-	237	214	90	1024.0	3829
Trifluralin	1.1	240	225	94	1003.8	3518
Trifluralin	2.2	246	219	89	1056.3	3504
EL5261	1.1	233	227	94	1043.7	3715
EL5261	2.2	223	211	91	936.4	3672
Ethalfluralin	1.1	240	231	97	1100.7	3807
Ethalfluralin	2.2	230	244	107	1045.5	3760
		n.s.[1]	n.s.	n.s.	n.s.	n.s.

[1]Numbers do not differ significantly at the 10% level.

bicide residues decreased the rate of emergence of the winter wheat resulting in a greater number of plants emerging after fall counts were taken.

Dry matter accumulation in the spring differed significantly between treatments at Minto in the 1980-81 trial (Table 23), and at Portage in the 1981-82 trials (Table 25). At Minto, both rates of EL5261 and the high rate of trifluralin reduced the amount of dry matter produced compared to the untreated control. At Portage in 1981-82, Winalta was the only cultivar which had significant differences in dry weight. Decreased dry matter production occurred with the low rate of trifluralin, and the high rates of EL5261 and ethalfluralin compared to the untreated control. In 1980-81, the low rate of trifluralin resulted in more dry matter production than the high rate at both locations (Tables 23 and 26). A similar trend was found with EL5261 three out of the four experiments (Tables 24, 25, 26 and 27), and with ethalfluralin at Portage in 1981-82 with the Norstar cultivar (Table 24).

No significant differences or trends in the number of tillers per plant or growth stages were found between any of the herbicide treatments during the two years. These data are presented in Appendix Table 8.

TABLE 28. Effect of dinitroaniline herbicide residues on the control of green foxtail and redroot pigweed at Portage, 1982.

Treatment	Rate (kg/ha)	Visual Ratings[1]	
		Green foxtail	Redroot pigweed
Control (untreated)	-	0	0
Trifluralin	1.1	5	5
Trifluralin	2.2	4	4
EL5261	1.1	6	6
EL5261	2.2	7	7
Ethalfluralin	1.1	3	3
Ethalfluralin	2.2	6	6

[1]Ratings based on Expert Committee on Weeds (Western Canada) Rating Scale (Appendix Table 1).

Significant differences in seed yield only occurred at Portage in 1980-81 (Table 26). The high rate of dinitramine significantly reduced yields compared to the untreated control. None of the other herbicide treatments significantly affected yield. These results are in agreement with Banks et al. (1979) who reported that the yield of winter wheat was not reduced in plots treated with a sub-surface layer of trifluralin (2.2 kg/ha) and dinitramine (1.1 kg/ha), 10 weeks prior to seeding, even though crop injury was noted in the early stages of growth. Based on these results, it would appear to be safe to plant winter wheat in rapeseed stubble previously treated with one of these dinitroaniline herbicides at the suggested field rates.

Differences in weed control were seen in all herbicide treated plots compared to the untreated control (Table 28). The plots treated with the higher rates of EL5261 and ethalfluralin had less weed growth than their respective plots treated with the low rate of herbicide. These results indicate that herbicide residues were present in the plots.

An effect of dinitroaniline herbicide residues may occur with winter wheat grown on soils that have a lower organic matter content. On these soils, it could be desirable to increase the seeding rate slightly, and to make sure the winter wheat is planted during the optimum seeding time. This would counteract any decreased or delayed emergence resulting from herbicide residues in the soil.

The effect of dinitroaniline herbicide residues on winter survival may not have been fully realized in these two years since soil temperatures at the 2.5 cm depth did not approach the critical level (-16°C) as proposed by Freyman and Hamman (1979). However, under zero tillage cropping conditions with adequate snow cover, low temperature injury may not present itself as a problem.

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APPENDIX

Appendix Table 1. Expert Committee on Weeds (Western Canada) Rating Scale.

Weed Control	
*9	complete control
*8	excellent control
*7	good control
6	fair control
5	poor control
4	moderate control
3	definite effect
2	slight effect
1	possible effect
0	no effect

* Commercially acceptable

Appendix - Table 2

Climatic Data for the 1980-82 Growing Season
at Portage la Prairie

	Temperature °C					
	May 1980			June 1980		
Date	Max.	Min.	Precip.	Max.	Min.	Precip.
	----(°C)----		(mm)	----(°C)----		(mm)
1	28.5	5.4		14.7	5.6	
2	30.0	7.6		18.3	1.1	
3	31.1	9.8		24.4	5.6	
4	22.6	7.6		26.7	15.6	
5	20.1	3.6		26.1	13.9	0.8
6	7.8	-1.2		17.2	12.2	
7	10.2	-1.0		17.2	5.6	
8	13.6	-4.5		24.2	8.9	
9	18.2	3.4		25.6	10.0	
10	9.1	0.0		27.2	7.5	
11	10.6	2.1		33.1	15.0	
12	9.2	3.1		24.4	18.6	0.5
13	11.5	-0.8		22.8	10.8	0.5
14	15.2	2.4		16.4	10.3	0.5
15	21.8	-1.0		20.0	4.2	
16	21.9	3.1		27.2	6.7	
17	27.0	10.5		20.6	11.7	
18	24.8	10.5		19.4	8.3	
19	20.5	11.0		23.1	5.8	
20	31.7	9.4		27.5	12.2	-
21	32.5	17.2		28.3	11.7	
22	37.2	22.8		33.9	15.8	
23	34.4	20.6		33.9	16.1	0.1
24	33.3	13.9		30.6	20.0	
25	32.5	16.1		22.7	11.4	
26	31.7	16.9		18.6	9.7	
27	32.2	15.6		16.7	11.1	
28	29.8	18.1		15.5	11.7	
29	25.8	13.9		22.8	10.8	
30	20.0	8.1		26.4	12.5	37.3
31	21.3	4.5				
A	21.1	8.1	---	23.5	10.7	39.7
B	6.5	3.9	0%	1.0	-0.4	48%

A = Monthly
B = Departure from Normal
* = Snowfall

Appendix - Table 2

Climatic Data for the 1980-82 Growing Season
at Portage la Prairie

	Temperature °C					
	July 1980			August 1980		
Date	Max.	Min.	Precip.	Max.	Min.	Precip.
	----(°C)----		(mm)	----(°C)----		(mm)
1	22.2	9.2		25.6	14.7	
2	29.4	13.9		23.3	10.8	
3	27.5	15.0		24.2	9.2	
4	18.6	14.7	4.8	18.9	13.3	37.6
5	25.6	8.9		20.6	13.6	
6	30.0	15.6		18.1	10.8	
7	30.6	9.4	2.3	21.9	11.9	10.7
8	28.3	11.9		19.7	11.9	4.6
9	32.8	14.2		19.7	8.9	
10	30.6	15.6		14.7	11.7	
11	29.7	16.7	1.9	21.1	10.0	0.7
12	30.0	17.3		23.3	13.9	1.5
13	34.6	16.3		20.3	12.5	3.1
14	15.0	14.2	6.7	22.2	11.4	
15	23.6	13.6		25.0	8.1	
16	24.2	14.4	4.3	17.5	11.4	
17	26.4	13.6		17.5	11.4	
18	25.5	14.7		25.3	9.4	26.9
19	21.9	13.3		28.6	14.4	
20	16.9	13.6		20.0	15.8	-
21	31.7	13.3	0.8	20.8	13.9	88.9
22	27.5	10.3		20.8	10.3	
23	30.2	17.5		22.5	12.2	
24	25.8	14.7		28.6	10.3	
25	22.2	7.5		18.1	10.8	
26	26.9	10.6		18.6	7.2	0.4
27	26.4	12.8		21.1	4.2	
28	27.2	12.2		20.3	10.3	
29	32.8	14.2		19.2	11.7	0.6
30	28.9	13.6		20.6	10.3	
31	29.4	15.8		21.1	9.2	
A	26.9	13.2	20.8	21.2	11.1	175.0
B	1.0	-0.4	29%	-3.7	-1.2	236%

A = Monthly
B = Departure from Normal
* = Snowfall

Appendix - Table 2

Climatic Data for the 1980-82 Growing Season
at Portage la Prairie

	Temperature °C											
	September 1980				October 1980				November 1980			
Date	Max.	Min.	Mean	Precip. (mm)	Max.	Min.	Mean	Precip. (mm)	Max.	Min.	Mean	Precip. (mm)
1	21.1	9.1	15.1		17.2	4.8	11.0	2.3	2.5	-5.2	-1.3	
2	22.0	9.2	15.6	T	6.4	1.6	4.0	2.3	14.3	-2.5	5.9	2.5
3	23.7	12.1	17.9	5.6	12.3	2.7	7.5		10.8	-0.8	5.0	T
4	19.7	9.5	14.6	1.3	12.3	-0.4	6.0		6.5	-2.5	2.0	
5	24.3	8.8	16.6		18.9	2.3	10.6		14.8	-1.1	6.9	8.4
6	29.4	7.7	18.6		212.3	2.5	11.9		7.6	-1.7	3.6	
7	35.1	10.1	22.6	9.7	25.3	8.9	17.1		0.0	-3.8	-1.9	12.7
8	27.1	9.9	18.5	2.5	17.8	3.3	10.6		1.8	-3.1	-0.7	3.3
9	19.8	6.3	13.1		17.1	3.2	10.2	1.1	-2.1	-12.6	-7.4	1.5
10	25.9	10.3	18.1		10.6	1.3	6.0	3.3	-1.7	-14.9	-8.3	
11	21.2	8.1	14.7	0.8	4.8	-3.4	2.2		4.7	-3.3	0.7	
12	14.1	9.2	11.7	14.7	5.8	-2.6	1.6		2.1	-0.3	0.9	
13	19.0	8.3	13.7		7.3	-3.7	1.6		1.9	2.6	-0.4	
14	19.7	3.8	11.8		6.3	0.1	3.2		4.0	-5.8	-0.9	
15	16.9	6.2	11.6		6.8	2.4	4.6		4.1	5.9	-0.9	
16	11.6	4.0	7.8	1.0	5.6	0.4	3.0	21.1	1.3	7.7	-3.2	
17	5.2	1.5	3.4	1.8	2.6	0.3	1.5	2.3	2.2	-7.7	-2.8	
18	10.9	-3.4	3.3	4.3	5.8	0.2	3.0		7.0	-4.5	1.3	
19	7.0	2.1	4.6	7.6	5.4	1.7	3.6	0.5	5.2	-0.8	2.2	
20	10.9	4.3	7.6	T	9.8	-1.4	4.2		2.6	-14.4	-0.9	
21	14.0	8.0	11.0	5.6	6.6	-3.5	1.6		6.9	-2.8	2.1	
22	9.9	0.8	5.4		5.4	-4.6	0.4	3.8*	7.1	-3.2	2.0	
23	8.7	0.7	4.7	1.3	3.4	-0.6	1.4	T	-2.3	-12.1	-7.2	
24	8.6	3.8	6.2	0.3	2.7	-1.2	0.8	1.8*	4.7	-10.4	-2.9	
25	8.8	0.2	4.5		3.2	-4.0	-0.4		-2.6	-6.6	-4.6	T
26	14.4	-0.9	6.8		5.3	-6.3	-0.5		3.1	-4.5	-0.8	
27	14.2	-1.9	6.2		2.4	-6.1	-1.9		0.9	-8.1	-3.6	1.8
28	23.3	4.4	13.9	0.3	3.5	-7.6	-2.1		2.5	-3.5	-0.5	0.5*
29	17.6	7.3	12.5		7.6	-3.8	1.9		2.9	-1.9	0.5	
30	25.7	6.9	16.3	1.5	11.1	-3.8	7.5		-0.7	-19.8	10.3	
31					4.3	-5.5	-0.6					
A	17.1	5.5	11.6	58.3	8.9	-0.4	4.3	38.5	3.7	-5.5	-0.9	30.7
B	-0.6	-0.9	-0.8	116%	-3.5	-1.9	-2.7	126%	3.5	2.5	2.9	98%

A = Monthly
B = Departure from Normal
* = Snowfall

Appendix - Table 2

Climatic Data for the 1980-82 Growing Season
at Portage la Prairie

	Temperature °C											
	December 1980				January 1981				February 1981			
Date	Max.	Min.	Mean	Precip. (mm)	Max.	Min.	Mean	Precip. (mm)	Max.	Min.	Mean	Precip. (mm)
1	-19.1	-22.5	-20.8		-9.3	-18.0	-13.7	2.0*	-16.6	-22.6	-19.1	0.4*
2	-15.4	-24.5	-20.0		-17.3	-25.7	-21.5		-15.5	-19.8	-17.7	
3	-7.8	-18.1	-19.0	0.5*	-19.8	-27.9	-23.9	0.2*	-11.9	-18.0	-15.0	
4	-1.9	-8.1	-5.0	0.3*	-15.5	-26.1	-20.3	4.2*	-5.1	-21.3	-13.2	T*
5	-2.6	-13.4	-8.0	0.8*	-2.4	-15.8	-9.1	T*	-3.7	-8.1	-5.9	0.5*
6	-12.7	-19.9	-16.3		-8.2	-21.9	-15.1		-3.9	-9.7	-6.8	4.9*
7	-15.8	-20.4	-18.1		-15.2	-23.4	-19.3	0.7*	-6.2	-22.6	-15.4	0.3*
8	-10.8	-18.5	-14.7	0.8*	-10.7	-21.2	-16.0		-17.8	-24.3	-21.1	0.3*
9	-11.3	-23.7	-17.5	1.0*	-18.4	-24.8	-21.6		-19.7	-27.7	-23.7	
10	-20.9	-27.4	-24.2		-13.8	-25.8	-19.8	T*	-24.3	-33.2	-28.8	
11	-11.0	-22.1	-16.6	0.8*	-3.4	-22.6	-13.0		-21.4	-31.7	-26.6	
12	0.4	-21.7	-10.7		0.4	-10.0	-4.3	2.0*	-15.6	-29.0	-22.3	
13	-4.2	-21.3	-12.8		1.4	-7.2	-2.9	T*	-8.7	-19.5	-14.1	
14	-9.5	-19.1	-14.3	1.5*	-3.5	-15.1	-9.3	1.0*	4.8	-16.8	-6.0	
15	-4.2	-10.0	-7.1		-12.0	-18.2	-15.1		8.0	-3.0	2.5	
16	3.5	-10.2	-3.4	2.0	-4.0	-19.9	-12.0		9.3	0.8	5.1	T
17	5.1	-14.2	-4.6		2.3	-5.9	-1.8		11.2	0.5	5.9	T
18	-12.8	-22.1	-17.5		3.5	-10.7	-3.6	0.4*	4.4	-0.6	1.9	T
19	-21.3	-24.6	-23.0		-4.3	-11.4	-7.9		6.1	-1.4	2.4	T
20	-17.3	-26.1	-21.7		0.9	-13.1	-8.1	T*	3.8	-0.8	1.5	1.0
21	-13.5	-24.5	-19.0	1.8*	4.4	-5.7	-0.7	1.8*	6.3	-0.6	2.9	
22	-14.0	-19.6	-16.8	1.3*	5.8	-8.0	-1.1	1.4*	5.3	-4.2	0.6	
23	-15.4	-27.6	-21.5		6.1	-5.0	0.6		10.0	-4.5	2.8	
24	-21.6	-32.1	-26.9	0.2*	1.7	-5.9	-2.1	2.8*	-0.2	-6.0	-3.1	T*
25	-14.2	-25.9	-20.1	T*	-3.1	-7.7	-5.4	T*	-2.0	-8.7	-5.4	
26	-14.1	-27.2	-20.7		-7.0	-21.7	-14.4		3.8	-8.6	-2.4	
27	9.5	-14.3	-2.4		-9.9	-22.5	-16.2	0.6*	1.3	-6.1	-2.4	
28	-1.3	-4.0	-6.5		-11.7	-24.9	-18.3		2.1	-9.6	-3.7	
29	-4.0	-12.4	-8.2	T*	-11.3	-26.6	-19.0					
30	2.0	-4.8	-1.4	T*	-7.6	-22.6	-15.1					
31	1.9	-9.5	-3.8	0.2	-6.4	-17.5	-12.0					
A	-8.8	-19.3	-14.1	11.3	-6.1	-17.2	-11.7	12.7	-3.5	-12.8	-8.2	7.9
B	-1.1	-2.6	-1.9	56.5%	6.4	4.7	5.5	48.5%	5.4	6.9	6.1	35.6%

A = Monthly
B = Departure from Normal
* = Snowfall

Appendix - Table 2

Climatic Data for the 1980-82 Growing Season
at Portage la Prairie

	Temperature °C											
	March 1981				April 1981				May 1981			
Date	Max.	Min.	Mean	Precip. (mm)	Max.	Min.	Mean	Precip. (mm)	Max.	Min.	Mean	Precip. (mm)
1	0.8	-11.5	-5.4		9.4	-2.5	3.4		15.7	-2.4	6.7	0.3
2	-0.6	-17.6	-9.1	1.0*	14.0	-0.4	6.8		19.2	3.9	14.1	
3	0.0	-8.5	-4.3	0.3*	5.6	-2.2	1.7		11.8	3.6	7.7	
4	-2.3	-9.7	-6.0		2.9	-5.7	-1.4		11.2	0.6	5.9	
5	-3.9	-15.0	-9.4		12.4	-6.6	2.9		13.7	-3.8	5.0	
6	-2.8	-14.8	-8.8		13.8	-2.9	8.4		16.4	-2.2	8.1	
7	2.2	-12.1	-5.0		10.4	2.1	6.3		20.6	3.0	11.8	
8	3.8	-9.2	-2.7		11.4	-2.3	4.6		15.1	-1.2	7.0	
9	3.8	-7.1	-1.7	T*	17.2	-2.2	7.5		8.7	-4.2	2.3	
10	6.1	-5.3	0.4		11.3	-5.5	2.9		12.1	-0.5	5.8	
11	14.3	-1.2	6.6		5.9	-6.4	-0.3		17.2	4.1	10.7	
12	4.6	-5.3	-0.4	T*	13.6	-3.9	4.9	1.0	20.3	0.3	10.3	
13	7.4	-7.5	-0.1		6.1	-8.6	-1.3		21.8	-0.8	10.5	
14	12.9	0.1	6.5		7.2	-11.8	-2.3		22.9	1.8	12.4	
15	2.0	-5.6	-1.8		22.8	0.4	11.5		16.3	5.1	10.7	
16	14.3	-4.3	5.0		24.7	3.6	14.2	T	17.5	2.2	9.9	
17	-2.2	-10.6	-6.4		14.5	-3.2	5.7		22.2	3.5	12.9	
18	0.7	-10.8	-5.1		13.3	-2.9	5.2		24.8	2.6	13.8	
19	3.2	-7.1	-2.0		5.3	-3.9	0.7		26.8	10.8	18.8	
20	8.1	-8.4	-0.2		13.5	-8.0	2.8	T	28.9	9.5	19.2	
21	7.6	-6.4	0.3		12.7	2.5	7.6	2.2	30.3	10.3	20.3	3.0
22	1.1	-8.6	-3.8		4.4	1.4	2.9		22.0	5.8	13.9	4.4
23	7.7	-6.2	0.8		5.4	-1.9	1.8		7.3	5.3	6.3	26.2
24	15.0	-5.4	4.8	4.4	12.3	-2.1	5.1	2.0	8.9	6.8	7.9	
25	7.9	-0.7	3.6	9.0	9.9	1.7	5.8		14.2	8.2	11.2	
26	2.0	-1.8	0.1		20.3	-1.6	9.4		20.7	4.9	12.8	
27	8.7	0.8	4.8	3.4	12.9	4.6	8.8		20.2	7.2	13.7	
28	11.3	1.1	6.2		16.9	-0.4	8.3	0.2	23.3	12.2	17.8	5.8
29	13.2	-0.2	6.5		17.8	5.0	11.4	0.2	17.4	3.2	10.3	2.6
30	11.2	0.0	5.6		10.3	2.4	6.4		18.8	0.8	9.8	
31	8.8	-1.1	3.9	0.3					22.3	6.6	14.5	
A	5.4	-6.5	-0.6	18.4	11.9	-1.9	5.0	5.6	18.4	3.6	11.02	43.3
B	7.7	8.2	6.8	58%	3.6	0.3	1.9	13.6%	1.8	-0.6	-0.5	68%

A = Monthly
B = Departure from Normal
* = Snowfall

Appendix - Table 2

Climatic Data for the 1980-82 Growing Season
at Portage la Prairie

	Temperature °C											
	June 1981				July 1981				August 1981			
Date	Max.	Min.	Mean	Precip. (mm)	Max.	Min.	Mean	Precip. (mm)	Max.	Min.	Mean	Precip. (mm)
1	20.9	10.5	15.7		29.9	17.7	23.8		24.8	11.5	18.2	
2	22.8	4.8	13.8		26.0	16.1	21.1	1.2	26.3	14.5	20.4	
3	27.0	4.3	15.7	2.5	28.6	13.5	21.1		24.4	14.4	19.4	7.9
4	21.7	12.1	16.9	9.0	31.4	16.4	23.9		29.0	13.6	21.3	23.7
5	23.7	12.0	17.9		30.6	18.9	24.8		21.6	16.8	19.2	57.2
6	23.7	9.1	16.4		37.2	15.3	26.3		25.4	16.9	21.2	0.4
7	22.8	12.3	17.6	0.2	35.0	22.6	28.8	0.2	29.0	15.2	22.1	
8	19.3	9.2	14.3	5.2	27.6	14.6	21.1		21.5	11.9	16.7	
9	18.9	7.6	13.3	6.0	30.3	11.8	21.1		23.0	10.6	16.8	1.0
10	19.2	7.3	13.3		29.1	13.4	21.3	5.1	27.1	13.5	20.3	
11	21.3	6.9	14.1		27.5	14.7	21.1	0.8	32.7	16.0	24.4	
12	25.6	7.1	16.4	8.8	29.8	16.2	23.0		26.1	13.3	19.7	
13	20.5	13.9	17.2	8.0	30.4	16.5	23.5		33.3	14.0	23.7	
14	17.2	12.9	15.1	11.6	22.9	16.0	19.5	0.4	23.1	12.0	17.6	
15	13.9	7.5	10.7		23.3	15.9	19.6	37.6	21.9	9.0	15.5	
16	25.2	6.6	15.9	6.2	22.4	13.1	17.8	0.4	24.2	6.3	15.3	
17	19.5	11.5	15.5	2.3	24.8	13.4	19.1		29.2	14.6	21.9	
18	17.7	8.4	13.1		27.1	13.8	20.5		30.3	14.2	22.3	
19	21.2	7.0	14.1		27.8	15.0	21.4		31.2	14.4	22.8	
20	22.8	9.0	15.9	2.0	20.9	11.0	16.0		28.7	13.9	21.3	
21	20.0	9.0	14.5		23.9	8.2	16.1		27.2	16.9	22.1	
22	20.4	11.7	16.1		24.0	9.7	16.9		27.6	14.6	21.1	
23	21.0	9.5	15.3	6.4	29.7	13.5	21.6		27.0	18.4	22.7	11.0
24	23.4	12.0	17.7		19.8	12.9	16.4		27.6	18.4	23.0	
25	22.8	12.0	17.4	1.3	21.1	7.5	14.3		27.2	16.8	22.0	
26	26.9	10.0	18.5		25.0	6.8	15.9		27.8	16.9	22.4	
27	28.5	15.5	22.0	11.4	26.2	10.7	18.5		26.8	12.1	19.5	
28	22.3	12.8	17.6	16.6	26.3	13.3	19.8		27.3	12.4	19.9	
29	24.6	10.9	17.8		26.1	14.6	20.4	T	30.1	12.3	21.2	
30	27.6	13.4	20.5		28.3	15.6	22.0	25.0	31.3	13.6	22.5	6.6
31					24.0	13.2	18.6		23.6	8.9	16.3	50.0
A	22.1	9.9	16.0	97.5	27.0	13.9	20.5	70.7	27.0	13.8	20.4	157.7
B	-0.5	-0.6	-0.6	119%	1.1	0.3	0.7	88%	2.1	1.5	1.8	194%

A = Monthly
B = Departure from Normal
* = Snowfall

Appendix - Table 2

Climatic Data for the 1980-82 Growing Season
at Portage la Prairie

	Temperature °C											
	September 1981				October 1981				November 1981			
Date	Max.	Min.	Mean	Precip. (mm)	Max.	Min.	Mean	Precip. (mm)	Max.	Min.	Mean	Precip. (mm)
1	20.0	5.0	12.5		11.8	3.1	7.5		15.0	2.0	8.5	
2	24.4	9.6	17.0		13.7	4.3	9.0		11.7	-2.9	4.4	T
3	15.0	3.8	9.4		9.8	4.2	7.0	24.0	17.4	1.0	9.2	
4	20.5	2.3	11.4		9.8	7.1	8.5		16.7	2.9	9.8	
5	23.6	12.3	18.0		11.2	2.3	6.8	0.6	8.2	-1.9	3.2	
6	18.4	10.9	14.7	34.9	14.4	-0.4	7.0		16.9	-0.3	8.3	
7	22.7	8.9	15.8		13.7	3.7	8.7		15.6	-1.7	7.0	
8	26.1	8.3	17.2		15.9	6.2	11.1	1.0	1.0	-7.9	-3.5	
9	27.8	12.9	20.4		17.8	5.8	11.8	1.5	10.2	-7.4	1.4	
10	34.0	11.4	22.7		19.2	1.6	10.4		6.7	-3.7	1.5	
11	25.3	11.6	18.5		19.2	7.1	13.2	1.8	11.8	-3.8	4.0	
12	24.2	9.9	17.1		14.1	7.9	11.0	12.0	19.0	-3.6	7.7	
13	21.2	7.9	14.6		10.9	4.8	7.9		16.1	2.8	9.5	
14	17.6	6.5	12.1		8.7	2.3	5.5		11.6	-3.6	4.0	T
15	13.3	6.3	9.8		11.1	3.5	7.3		12.4	1.9	7.2	T
16	13.0	6.1	9.6		19.6	4.5	12.1	1.0	5.8	0.0	2.9	T
17	19.8	3.5	11.7		12.6	2.2	7.4	2.0	1.5	-2.0	-0.3	
18	23.6	7.4	15.5		3.9	-1.3	1.3	T	-1.1	-4.9	-3.0	
19	19.9	5.0	12.5		13.0	2.9	8.0	0.4	-3.1	-5.9	-4.5	T
20	19.8	1.6	10.7	2.0	4.0	-5.4	-0.7	T*	-3.2	-11.9	-7.6	
21	17.1	7.6	12.4		-1.4	-9.6	-5.5	4.0*	-1.6	-8.9	-5.3	
22	15.4	3.1	9.3		-2.3	-6.9	-4.6	T*	1.6	-3.7	-1.1	T
23	20.9	6.5	13.7		-1.9	-10.4	-6.2	2.1*	6.9	-3.3	1.8	T
24	20.9	4.1	12.5		0.6	-6.8	-3.1	T	0.5	-2.3	-0.9	
25	19.4	3.7	11.6	39.8	-2.8	-13.4	-8.1		0.0	-2.4	-1.2	T
26	15.3	3.9	10.1		12.6	-4.7	4.0		-0.8	-4.8	-2.8	
27	9.4	-1.5	4.0	2.8	0.3	-2.8	-1.3	3.4	0.7	-7.9	-3.6	
28	2.9	-1.7	0.6	3.8	11.7	-0.4	5.7	0.8	-2.8	-5.1	-4.0	
29	12.6	0.8	6.7	0.4	14.2	4.0	9.1	0.4	1.0	-7.3	-3.2	
30	7.8	2.8	5.3	7.9	11.3	3.5	7.4	5.4	0.2	-8.5	-4.2	
31					13.8	3.5	8.7					
A	19.1	6.0	12.6	91.6	10.0	0.7	5.4	55.8	6.5	-3.5	1.5	T
B	0.8	-0.4	0.2	184%	-2.4	-0.6	-1.3	183%	6.3	4.3	5.3	-

A = Monthly
B = Departure from Normal
* = Snowfall

Appendix - Table 2

Climatic Data for the 1980-82 Growing Season
at Portage la Prairie

	Temperature °C											
	December 1981				January 1982				February 1982			
Date	Max.	Min.	Mean	Precip. (mm)	Max.	Min.	Mean	Precip. (mm)	Max.	Min.	Mean	Precip. (mm)
1	-0.8	-6.2	-3.5		-20.1	-32.0	-26.1	2.0*	-14.3	-25.2	-19.8	0.8*
2	-1.7	-7.7	-4.7		-18.6	-26.7	-22.7		-20.2	-30.4	-25.3	
3	-0.1	-6.8	-3.5		-23.9	-29.4	-26.7	0.2*	-19.8	-32.3	-26.1	T*
4	0.3	-10.3	-5.0		-18.6	-24.9	-21.8	4.2*	-20.6	-29.7	-25.2	
5	-1.8	-13.7	-7.8		-18.0	-29.4	-23.7	T*	-19.5	-32.3	-25.9	0.5*
6	1.1	-8.7	-3.8		-24.7	-32.1	-28.4		-10.6	-26.4	18.5	1.0*
7	-0.3	-4.6	-2.5		-19.1	-31.0	-25.1	0.7*	-12.4	-23.2	-17.8	T*
8	-4.0	-14.3	-9.2		-23.2	-32.8	-28.0		-19.2	-27.6	-23.4	0.2*
9	-5.4	-14.5	-10.0		-26.9	-34.1	-30.5		-18.7	-30.7	-24.7	
10	-3.9	-10.9	-7.4	1.8*	-17.8	-32.9	-25.4	T*	-11.8	-21.8	-16.8	
11	1.5	-7.1	-2.8		-22.3	-27.3	-24.8		-13.9	-20.5	-17.2	
12	-4.3	-11.4	-7.9		-20.1	-30.4	-25.3	2.0*	-12.4	-26.8	-19.6	
13	-6.9	-12.9	-9.9		-20.5	-38.0	-24.3	T*	-13.6	-22.9	-18.3	T*
14	-11.5	-19.7	-15.6		-11.6	-26.4	-19.0	1.0*	-2.6	-16.8	-9.7	
15	-11.0	-20.0	-15.5	T*	-17.6	-30.5	-24.1		-9.4	-18.8	-14.1	T*
16	-14.2	-20.6	-17.4		-27.2	-34.5	-30.9		0.2	-11.4	-5.6	T*
17	-14.6	-23.0	-18.8		-23.1	-33.5	-28.3		5.8	-1.2	2.3	
18	-11.4	-23.8	-17.6		-19.8	-32.6	-26.2	0.4*	1.9	-4.3	-1.2	T*
19	-9.4	-20.6	-15.0	T	-19.7	-35.7	-27.7		6.7	-6.7	0.0	
20	0.9	-12.9	-6.0	T	-24.9	-36.6	-30.8	T*	3.8	-4.0	-0.1	
21	1.6	-8.7	-3.6	0.8*	-23.6	-31.9	-27.8	1.8*	10.1	-4.7	2.7	
22	-7.4	-14.4	-10.9	2.3*	-20.4	-26.0	-23.2	1.4*	0.5	-15.5	-7.4	T*
23	-12.3	-18.9	-15.6	T*	-22.6	-31.2	-26.9		-8.7	-17.0	-12.9	
24	-7.8	-14.3	-11.1		-26.7	-34.7	-30.7	2.8*	-7.3	-15.9	-11.6	
25	-10.8	-26.0	-18.4		-20.4	-33.3	-26.9	T*	-3.3	-16.1	-9.7	T*
26	-7.5	-21.4	-14.5		-7.0	-28.7	-17.9		-10.4	-18.0	-14.2	3.0
27	-8.2	-25.0	-16.6		2.5	-21.6	-9.6	0.6*	-6.7	-20.1	-13.4	
28	-19.6	-26.2	-22.9		-15.5	-22.6	-19.1		-2.6	-12.4	-7.5	
29	-20.0	-26.2	-23.1		-13.1	-23.0	-18.1					
30	-22.2	-31.0	-26.6		-21.6	-29.6	-25.6					
31	-21.6	-31.8	-26.7		-12.7	-29.1	-20.9					
A	-7.5	-16.6	-12.1	4.9	-19.3	-30.1	-24.7	17.1	-8.2	-19.0	-13.6	5.5
B	0.2	0.1	0.1	25%	-5.8	-7.0	-6.4	60%	1.0	0.9	1.0	25%

A = Monthly
B = Departure from Normal
* = Snowfall

Appendix - Table 2

Climatic Data for the 1980-82 Growing Season
at Portage la Prairie

	Temperature °C											
	March 1982				April 1982				May 1982			
Date	Max.	Min.	Mean	Precip. (mm)	Max.	Min.	Mean	Precip. (mm)	Max.	Min.	Mean	Precip. (mm)
1	-11.3	-17.2	-14.3		-2.2	-10.6	-6.4	0.8*	23.7	0.3	12.0	
2	-15.3	-23.6	-19.5	T*	-2.5	-14.1	-8.3	6.6*	28.3	6.1	17.2	
3	-7.8	-23.8	-15.8	0.2*	-9.9	-15.9	-12.9		28.3	15.7	22.0	
4	-7.3	-19.6	-13.5	T*	-7.6	-19.0	-13.3		21.8	7.8	14.8	
5	-5.1	-17.4	-11.3		-6.5	-16.2	-11.4		17.8	4.1	11.0	
6	-6.6	-22.0	-14.3		-2.0	-15.9	-9.0		10.3	0.3	5.6	1.3
7	-11.4	-22.8	-17.1		2.2	-9.9	-3.9		8.0	0.6	4.3	
8	-11.0	-23.8	-17.4		3.2	-4.1	-0.5		7.6	-0.4	3.6	1.3
9	-7.3	-19.8	-13.6	0.2*	2.9	-5.3	-1.2		13.5	2.4	8.0	
10	-5.8	-15.2	-10.5		0.0	-7.0	-3.5		8.1	5.7	6.9	11.2
11	2.6	-14.9	-6.2		12.1	-5.0	3.6		16.4	5.0	10.7	
12	3.6	-3.7	-0.1	1.0	8.8	0.4	4.6		17.6	1.7	9.7	
13	1.0	-7.2	-3.1		6.6	-5.1	0.8	T	19.9	5.9	12.9	
14	3.6	-10.1	-3.3		20.9	1.6	11.3		21.9	8.3	15.1	
15	3.7	0.4	2.1	T*	15.6	6.2	10.9		13.1	8.8	11.0	10.7
16	3.5	-0.4	1.6	2.5*	8.9	-1.0	4.0		14.0	9.9	12.0	
17	0.7	-9.4	-4.4	1.2*	11.1	-6.3	2.4	1.7	12.5	9.4	11.0	7.6
18	-8.4	-14.7	-11.6		10.1	0.7	5.4		14.9	8.8	11.9	
19	-2.4	-18.3	-10.4		8.1	-2.7	2.7		13.9	7.5	10.7	
20	-0.4	-12.9	-6.7		11.5	-6.1	2.7		19.6	6.0	12.8	
21	4.2	-9.1	-2.5		12.8	-0.7	6.1		22.3	4.2	13.3	
22	4.4	-5.2	-0.4		23.8	4.0	13.9		24.7	6.1	15.4	
23	1.8	-3.3	-0.8	0.6*	26.6	10.5	18.6		25.5	6.3	15.9	
24	-1.4	-9.8	-5.6		28.1	7.0	17.6		21.5	11.5	16.5	
25	-1.8	-13.3	-7.6		8.6	-3.5	2.6		26.3	8.8	17.6	
26	-1.7	-14.6	-8.2		11.9	-3.7	4.1		27.8	13.1	20.5	
27	2.6	-8.6	-3.0		17.9	1.0	9.5		28.1	12.0	20.1	
28	8.6	-3.2	2.7		20.1	3.8	12.0		22.9	11.5	17.2	
29	5.3	0.5	2.9	4.2	13.3	3.6	8.5		19.3	8.2	13.8	2.3
30	4.5	0.1	2.3	6.8	19.5	4.5	12.0		16.2	6.9	11.6	
31	3.4	-7.8	-2.2						11.3	3.4	7.4	0.3
A	-1.7	-12.0	-6.9	16.7	9.1	-3.6	2.8	9.1	18.6	6.7	12.7	34.7
B	0.4	0.7	0.5	67%	0.5	-1.3	-0.4	20%	2.0	2.5	2.2	54%

A = Monthly
B = Departure from Normal
* = Snowfall

Appendix - Table 2

Climatic Data for the 1980-82 Growing Season
at Portage la Prairie

	Temperature °C											
	June 1982				July 1982				August 1982			
Date	Max.	Min.	Mean	Precip. (mm)	Max.	Min.	Mean	Precip. (mm)	Max.	Min.	Mean	Precip. (mm)
1	13.2	4.4	8.8		27.6	8.5	18.1		21.3	11.3	16.3	
2	17.6	-0.2	8.7		24.3	17.1	20.7		22.3	16.0	19.2	
3	24.9	4.4	14.7		30.0	16.8	23.4	10.4	30.4	14.0	22.2	
4	24.1	10.7	17.4		31.6	14.0	22.8		25.5	15.3	20.4	
5	25.7	14.3	20.0	21.6	27.6	17.4	22.5	5.3	27.5	11.9	19.7	
6	16.4	12.1	14.3		24.0	12.4	18.2		28.2	18.1	23.2	
7	14.2	3.2	8.7	3.8	22.9	9.0	16.0		25.8	15.0	20.4	3.8
8	11.2	0.4	5.8		23.8	9.8	16.8	0.3	20.2	11.8	16.0	
9	17.0	6.8	11.9		25.3	14.5	19.9		17.8	9.0	13.4	
10	24.2	4.4	14.3		26.2	14.4	20.3	3.8	21.5	5.6	13.6	
11	17.2	7.9	12.6		27.5	12.5	20.0		25.2	8.4	16.8	
12	24.3	4.1	14.2	0.8	28.2	15.2	21.7	6.1	20.3	14.1	17.2	1.3
13	24.7	9.6	17.2		20.8	14.6	17.7	0.3	27.7	14.1	20.9	
14	21.2	8.7	15.0		24.9	9.4	17.2		31.0	15.1	22.6	23.4
15	20.4	6.3	13.4		29.8	18.2	24.0	20.3	24.4	14.2	19.3	
16	22.9	10.3	16.6		25.3	16.4	20.9		26.0	14.4	18.7	
17	13.7	6.4	10.1		22.1	12.6	17.4		29.9	12.8	20.4	2.0
18	18.9	8.5	13.7		23.7	9.4	16.6	25.7	28.7	16.9	22.8	0.8
19	15.8	10.3	13.1	6.9	26.8	12.5	19.7		26.1	13.6	19.9	
20	19.8	8.9	14.4		25.3	16.0	20.1		25.6	11.9	18.8	
21	20.2	7.5	13.9		22.8	12.8	17.8		23.8	13.7	18.8	17.3
22	19.5	7.8	13.7		23.2	11.7	17.5	4.6	21.8	12.3	17.2	
23	28.7	11.5	20.1		26.8	16.8	21.8		22.1	9.1	15.6	
24	18.0	6.9	12.6		27.7	17.5	22.6		18.3	11.0	14.7	0.3
25	23.2	4.2	13.7		24.6	14.5	19.6		13.0	4.2	8.8	
26	25.2	12.7	19.0	0.5	27.5	12.6	20.1	34.5	16.0	3.2	8.4	
27	23.4	10.8	17.1		25.3	15.7	20.5		14.9	1.4	8.2	
28	21.0	10.5	15.8		26.9	12.8	19.9	43.2	20.7	4.9	12.8	
29	19.6	6.4	13.0		23.2	12.2	17.7		19.7	5.6	12.7	
30	24.0	4.2	14.1		26.3	12.9	19.6		17.1	4.5	10.8	
31					30.0	15.9	23.0		24.5	8.3	16.4	
A	21.0	7.5	13.9	35.2	25.9	13.7	19.8	154.5	23.1	10.9	17.0	48.9
B	-1.6	-3.0	-2.7	43%	0.0	-0.1	0.0	192%	-1.8	-1.4	-1.6	60%

A = Monthly
B = Departure from Normal
* = Snowfall

Appendix - Table 3

Climatic Data for the 1980-82 Growing Seasons at Minto

	Temperature °C							
	May 1980				June 1980			
Date	Max.	Min.	Mean	Precip. (mm)	Max.	Min.	Mean	Precip. (mm)
1	28.0	10.0	19.0		19.0	3.0	11.0	
2	29.5	8.0	18.8		22.0	3.5	12.8	
3	30.0	13.5	21.8		25.0	4.0	14.5	
4	25.5	14.0	19.8		25.0	15.0	20.0	11.6
5	19.0	4.0	11.5		25.0	14.0	19.5	
6	8.0	-2.0	3.0		19.5	8.0	13.8	
7	8.5	0.0	4.3		17.0	4.0	10.5	
8	15.5	-6.0	4.8		23.5	6.0	14.8	
9	19.0	4.5	11.8		28.5	10.5	19.5	
10	11.0	-1.0	5.0		29.0	10.5	19.8	
11	13.0	-1.5	5.8		31.0	18.0	24.4	T
12	10.0	-1.5	4.3		26.0	19.0	22.5	
13	9.0	2.0	5.5		26.5	13.0	19.8	21.0
14	17.5	4.0	10.8		19.5	9.5	14.5	
15	22.0	2.0	12.0		20.5	10.5	15.5	
16	24.0	10.0	17.0		25.5	7.5	16.5	
17	26.0	9.0	17.5		22.5	15.0	18.8	7.0
18	28.0	10.5	19.3		20.0	8.0	14.0	
19	28.5	13.5	21.0		23.0	6.5	14.8	
20	30.5	17.5	24.0		26.5	12.0	19.3	
21	35.0	17.5	26.3		31.5	11.0	21.3	
22	36.0	21.0	28.5		33.0	17.0	25.0	1.0
23	31.0	18.5	24.8		32.5	17.0	24.8	
24	30.5	13.0	21.8		28.0	15.0	21.5	
25	30.5	14.5	22.5	2.0	22.0	15.0	18.5	
26	30.0	15.0	22.5	0.3	17.5	7.0	12.3	3.0
27	31.0	10.0	20.5		16.5	11.0	13.8	16.6
28	27.0	16.0	21.5		17.5	11.0	14.3	9.5
29	23.5	9.5	16.5		22.0	9.0	15.5	
30	21.0	7.5	14.3		22.5	13.0	17.8	
31	20.0	6.5	13.3					
A	23.2		15.8	2.3	23.9	23.9	17.4	69.7
B	6.8		5.5	4%	2.4	2.4	1.7	76%

A = Monthly
B = Departure from Normal
* = Snowfall

Appendix - Table 3

Climatic Data for the 1980-82 Growing Seasons at Minto

	Temperature °C							
	July 1980				August 1980			
Date	Max.	Min.	Mean	Precip. (mm)	Max.	Min.	Mean	Precip. (mm)
1	25.0	8.5	16.8		25.5	12.0	18.8	
2	30.0	10.5	20.3		26.0	10.0	18.0	
3	31.5	14.0	22.8	2.0	23.0	12.5	17.8	65.0
4	18.5	12.0	15.3		18.5	10.0	14.3	2.0
5	26.5	9.5	18.0		20.5	10.0	15.3	
6	28.0	19.0	23.5	1.0	21.5	12.0	16.8	
7	25.0	13.0	19.0		22.0	10.5	16.3	1.2
8	29.5	12.0	20.8		19.0	10.0	14.5	
9	32.5	17.5	25.0	0.6	19.5	8.0	13.8	
10	34.5	17.0	25.8	3.8	21.0	13.0	17.0	12.2
11	27.5	18.0	22.8		23.5	10.0	16.8	2.0
12	32.5	14.0	23.3		22.0	13.0	17.5	
13	34.0	16.0	25.0	27.2	20.0	11.0	15.5	2.2
14	24.5	16.0	20.3	0.9	23.0	8.0	15.5	
15	21.0	13.5	17.3	7.0	22.0	9.0	15.5	
16	24.5	13.0	18.8		13.0	11.0	12.0	28.8
17	23.0	13.5	18.3	3.0	16.0	9.0	12.5	
18	23.0	12.0	17.5		28.0	9.0	18.5	
19	20.0	12.5	16.3		29.0	15.0	22.0	
20	21.0	11.0	16.0	35.0	18.0	16.5	17.3	58.5
21	20.5	11.0	15.8		19.5	12.0	15.8	
22	28.0	12.0	20.0		20.5	9.5	15.0	3.0
23	33.0	15.5	24.3		21.5	11.0	16.3	
24	25.0	17.0	21.0		29.0	14.0	21.5	
25	22.0	7.0	14.5		17.5	13.0	15.3	
26	26.5	11.0	18.8		17.0	5.0	11.0	
27	24.0	12.5	18.3	2.6	20.0	5.5	12.8	T
28	26.0	11.5	18.8		23.5	12.0	17.8	2.0
29	30.0	15.5	22.8		18.5	13.0	15.8	8.0
30	26.5	9.0	17.8		19.5	8.0	13.8	
31	26.0	15.0	20.5		17.5	9.0	13.3	22.8
A	26.4	13.2	19.8	83.7	21.1	10.7	15.9	207.7
B	1.0	0.3	0.6	136%	-3.3	-0.6	-1.9	281%

A = Monthly
B = Departure from Normal
* = Snowfall

Appendix - Table 3

Climatic Data for the 1980-82 Growing Seasons at Minto

	Temperature °C							
	September 1980				October 1980			
Date	Max.	Min.	Mean	Precip. (mm)	Max.	Min.	Mean	Precip. (mm)
1	19.0	10.0	14.5	0.8	17.5	5.5	11.5	T
2	21.0	10.0	15.5	T	7.5	1.5	4.5	
3	19.0	12.5	15.8	4.8	17.0	5.0	11.0	
4	19.0	9.0	14.0		18.0	4.0	11.0	
5	24.5	9.5	17.0		21.0	7.0	14.0	
6	31.0	11.0	21.0		26.0	5.0	15.5	
7	32.5	17.0	24.8	3.0	25.5	10.5	18.0	
8	18.0	12.0	15.0		23.0	6.0	14.5	
9	19.5	4.5	12.0		14.0	7.0	10.5	5.6
10	25.0	9.0	17.0		7.5	3.0	5.3	0.8
11	19.0	7.5	13.3	20.0	6.5	0.0	3.3	
12	15.5	9.0	12.3	5.0	4.0	-1.0	1.5	
13	19.0	4.5	11.8		6.5	-2.0	2.3	5.0
14	19.0	4.5	11.8		6.5	-1.9	2.8	
15	14.0	11.0	12.5		3.0	-9.5	1.3	10.0
16	12.0	2.0	7.0	T	4.5	1.5	3.0	14.0*
17	6.0	3.5	4.8	1.9	3.0	-2.0	0.5	3.0
18	12.0	-1.0	5.5	13.0	4.0	-7.0	-1.5	
19	9.0	4.0	6.5	9.1	8.0	2.0	5.0	
20	16.5	6.0	11.3		10.0	3.0	6.5	
21	12.0	9.5	10.8	2.6	11.0	-2.0	4.5	
22	7.5	2.0	4.8	2.6	3.5	-1.0	1.3	10.0*
23	12.5	3.0	7.8	13.5	2.0	-1.5	0.3	
24	7.0	2.0	4.5	6.8	1.0	-2.0	-0.5	2.0*
25	8.0	1.0	4.5	1.4	1.0	-2.5	-0.8	
26	14.5	1.5	8.0		3.0	-8.5	-2.8	
27	15.5	0.0	7.8		2.0	-7.0	-2.5	T*
28	24.0	6.5	15.3		1.0	-7.0	-3.0	
29	22.0	12.0	17.0		7.5	-4.0	1.8	
30	22.5	12.0	17.3		9.5	0.0	4.8	
31					5.0	-2.5	1.3	
A	17.2	6.8	12.0	84.5	9.0	0.3	4.7	50.4
B	-0.6	1.0	0.2	217%	-3.3	-0.3	-1.7	201%

A = Monthly
B = Departure from Normal
* = Snowfall

Appendix - Table 3

Climatic Data for the 1980-82 Growing Seasons at Minto

	Temperature °C							
	November 1980				December 1980			
Date	Max.	Min.	Mean	Precip. (mm)	Max.	Min.	Mean	Precip. (mm)
1	7.0	-0.5	3.3		-19.0	-23.5	-21.3	
2	15.0	-0.5	7.3	T	-12.5	-24.0	-18.3	
3	11.0	1.5	6.3		-6.5	-27.0	-11.8	
4	10.0	-1.5	4.3		0.0	-12.5	-6.3	
5	14.5	1.0	7.8		-7.0	-11.0	-9.0	6.0*
6	9.5	1.0	5.3	7.0	-16.5	-23.5	-20.0	
7	3.0	-3.5	-0.3	9.0*	-12.0	-22.5	-17.3	
8	6.0	-3.0	1.5		-11.0	-21.5	-16.3	6.0*
9	-3.5	-6.5	-5.0		-21.0	-22.0	-21.5	
10	0.0	-9.0	-4.5		-17.0	-27.6	-22.3	
11	5.0	-3.0	1.0		2.0	-25.0	-11.5	
12	1.0	-1.0	0.0		-0.5	-17.0	-8.8	
13	2.0	-2.0	0.0		-1.0	-21.0	-11.0	
14	3.0	-7.5	-2.3		-3.0	-15.0	-9.0	
15	3.0	-5.0	-1.0		-2.0	-10.0	-6.0	
16	2.0	-4.0	-1.0		4.0	-4.5	-0.3	
17	2.5	-8.0	-2.8		0.5	-7.5	-3.5	
18	7.0	-3.0	2.0		-20.0	-22.0	-21.0	
19	5.0	-3.0	1.0	2.5*	-20.5	-24.5	-22.5	
20	1.0	-8.0	-3.5		-14.5	-25.5	-20.0	
21	8.0	-7.0	0.5		-12.5	-18.0	-15.3	6.0*
22	2.5	2.0	2.3		-14.0	-16.0	-15.0	
23	1.0	-9.0	-4.0		-17.0	-22.0	-19.5	
24	2.0	-9.0	-3.5		-11.5	-33.5	-22.5	1.0*
25	2.0	-11.0	-4.5		-11.5	-26.0	-18.8	
26	4.0	-6.0	-1.0		5.0	-24.0	-9.5	
27	2.0	-8.5	-3.3	T*	10.5	-12.0	-0.8	
28	5.0	-3.5	0.8		1.0	-1.0	0.0	
29	3.0	-6.0	-1.5	T*	1.0	-9.0	-4.0	
30	-5.0	-10.5	-7.8		4.5	-3.0	-10.8	
31					0.5	-2.0	-0.8	3.0*
A	4.3	-4.5	-0.1	18.5	-7.1	-17.5	12.3	22.0
B	4.7	4.7	4.7	96%	1.1	0.4	0.8	115%

A = Monthly
B = Departure from Normal
* = Snowfall

Appendix - Table 3

Climatic Data for the 1980-82 Growing Seasons at Minto

	Temperature °C							
	January 1981				February 1981			
Date	Max.	Min.	Mean	Precip. (mm)	Max.	Min.	Mean	Precip. (mm)
1	-5.5	-9.5	-7.5	T*	-18.0	-24.5	-21.3	
2	-14.0	-21.0	-17.5	T*	-17.0	-27.0	-22.0	
3	-15.0	-25.5	-20.3		-13.5	-24.0	-18.8	
4	-6.0	-22.0	-14.0		-5.0	-22.0	-13.5	
5	-2.0	-10.5	-6.3	3.0*	-6.5	-12.5	-9.5	
6	-17.0	-20.0	-18.5	2.0*	-3.5	-12.0	-7.8	3.0*
7	-15.0	-25.0	-20.0		-20.0	-21.0	-20.5	4.0*
8	-12.0	-21.0	-16.5		-20.5	-27.0	-23.8	
9	-21.5	-29.0	-25.3		-23.5	-29.0	-26.3	
10	-18.5	-26.5	-22.5		-25.0	-34.0	-29.5	
11	-2.0	-22.0	-12.0		-22.5	-32.0	-27.3	
12	-2.5	-7.0	-4.8		-9.5	-29.0	-19.3	
13	-3.0	-7.0	-5.0		0.0	-20.5	-10.3	
14	-3.0	-9.0	-6.0		6.5	-8.0	-0.8	
15	-12.0	-14.5	-13.3	1.0*	5.0	-0.5	2.3	
16	-6.5	-20.0	-13.3		7.0	0.5	3.8	
17	0.0	-7.0	-3.5		7.0	2.5	4.8	
18	1.5	-8.0	-3.3		4.5	0.0	2.3	
19	-7.0	-14.0	-10.5		3.5	-2.0	0.8	
20	-2.0	-15.0	-8.5		6.5	-1.0	2.8	
21	-1.0	-8.0	-4.5		6.0	0.0	3.0	
22	2.0	-8.0	-3.0		5.0	-2.5	1.3	
23	6.0	-7.5	-0.8		8.0	-3.0	2.5	
24	5.0	-4.5	0.3	3.0*	-4.5	-4.5	-4.5	
25	-1.5	-5.0	-3.3	8.0*	-0.5	-8.5	-4.5	
26	-11.0	-17.5	-14.3		5.0	-5.5	-0.3	
27	-12.5	-24.0	-18.3		0.0	-3.0	-1.5	
28	-14.5	-22.0	-18.3		0.0	-5.5	-2.8	
29	-10.5	-24.5	-17.5					
30	-6.5	-22.5	-14.5					
31	-9.5	-10.5	-10.0					
A	-7.0	-15.7	-11.4	17.0	-4.5	-12.7	-8.6	7.0
B	5.0	7.2	6.0	69%	3.9	7.5	5.7	38%

A = Monthly
B = Departure from Normal
* = Snowfall

Appendix - Table 3

Climatic Data for the 1980-82 Growing Seasons at Minto

	Temperature °C							
	March 1981				April 1981			
Date	Max.	Min.	Mean	Precip. (mm)	Max.	Min.	Mean	Precip. (mm)
1	-0.5	-6.0	-3.3		15.0	-6.5	4.3	
2	-1.0	-13.0	-7.0		13.0	-0.5	6.3	
3	5.0	-6.0	-0.5		5.5	-4.0	0.8	
4	-2.0	-8.0	-5.0		7.0	-7.0	0.0	
5	0.0	-12.0	-6.0		13.0	-6.5	3.3	
6	0.0	-12.5	-6.3		12.0	5.0	8.5	
7	3.0	-11.5	-4.3		9.5	-1.5	4.0	
8	4.5	-4.5	0.0		11.5	-4.0	3.8	
9	4.0	-5.0	-0.5		16.5	-4.0	6.3	
10	5.0	-4.0	0.5		9.5	0.5	5.0	
11	13.0	-1.0	6.0		10.5	-8.0	1.3	1.0
12	8.0	-4.0	2.0		15.0	-6.0	4.5	
13	6.0	-8.0	-1.0		4.0	-4.5	-0.3	
14	8.5	0.0	4.3		11.5	-12.0	-0.3	
15	7.0	-3.0	2.0		24.0	-0.5	11.8	
16	14.0	-2.5	5.8		27.0	7.5	17.3	
17	-1.0	-10.0	-5.5		11.0	1.0	6.0	
18	1.0	-9.5	-4.3		19.5	-3.5	8.0	
19	3.0	-5.0	-1.0		8.5	-7.0	0.8	
20	6.5	-5.0	0.8		13.5	-7.5	3.0	
21	5.0	-1.0	2.0		20.5	3.5	12.0	
22	3.5	-10.5	-3.5		9.5	-0.5	4.5	
23	10.5	-9.0	0.8		15.0	-7.5	3.8	
24	15.0	-3.0	6.0		20.0	0.5	10.3	
25	3.5	0.0	1.8		18.5	3.5	11.0	
26	8.0	-6.5	0.8		23.0	-0.5	11.3	2.0
27	13.0	-2.0	5.5		13.0	5.0	9.0	10.0
28	9.0	1.0	5.0		15.0	5.0	10.0	5.0
29	15.5	0.0	7.8		13.0	5.5	9.3	4.0
30	12.0	2.0	7.0		10.5	1.5	6.0	
31	8.0	2.0	5.0					
A	6.0	-5.1	0.5	0.0	13.8	-1.8	6.0	22.0
B	9.1	8.8	8.9	0%	4.4	0.2	2.3	79%

A = Monthly
B = Departure from Normal
* = Snowfall

Appendix - Table 3

Climatic Data for the 1980-82 Growing Seasons at Minto

	Temperature °C							
	May 1981				June 1981			
Date	Max.	Min.	Mean	Precip. (mm)	Max.	Min.	Mean	Precip. (mm)
1	16.5	-2.0	7.3		18.5	9.0	13.8	
2	24.5	5.0	14.8		24.0	4.5	14.3	
3	16.5	4.0	10.3		26.5	7.0	16.8	6.0
4	14.0	2.0	8.0		23.0	13.0	18.0	4.4
5	16.5	1.5	9.0		28.5	8.0	18.3	
6	18.5	2.0	10.3		25.5	7.0	16.3	
7	17.5	3.0	10.3		27.0	14.0	20.5	
8	14.0	7.0	10.5		18.0	9.5	13.8	
9	9.5	-9.0	0.3		21.5	5.0	13.3	
10	11.5	-1.0	5.3		22.0	5.5	13.8	
11	18.5	4.5	11.5		23.5	6.0	14.8	1.6
12	19.0	6.5	12.8		25.0	6.5	15.8	1.8
13	20.0	4.5	12.3		17.0	13.0	15.0	5.0
14	21.0	2.0	11.5		16.0	11.5	13.8	2.0
15	14.5	4.0	9.3		15.5	8.0	11.8	2.6
16	17.5	1.0	9.3		24.0	7.0	15.5	
17	22.5	3.0	12.8		15.5	11.5	13.5	11.0
18	23.5	6.0	14.8		18.5	6.5	12.5	
19	24.0	8.0	16.0		19.5	4.0	11.8	
20	28.0	12.5	20.3		20.5	7.0	13.8	2.4
21	28.0	12.5	20.3	0.3	14.0	10.5	12.3	11.0
22	23.0	13.5	18.3	8.8	20.5	9.0	14.8	
23	6.0	3.0	4.5	8.4	20.5	12.0	16.3	
24	9.0	2.0	5.5	5.6	23.0	8.5	15.8	
25	10.5	4.5	7.5		26.0	7.0	16.5	
26	19.0	8.0	13.5		27.0	9.5	18.3	1.2
27	19.5	5.5	12.5		30.5	18.0	24.3	5.3
28	27.5	12.0	19.8		22.5	13.0	17.8	6.0
29	20.0	8.5	14.3		24.0	7.0	15.5	
30	18.0	1.0	9.5		30.0	10.5	20.3	
31	28.5	9.0	18.8					
A	18.6	4.6	11.6	23.1	22.2	9.0	15.7	60.3
B	1.5	0.8	1.1	36%	0.2	-0.7	-0.2	69%

A = Monthly
B = Departure from Normal
* = Snowfall

Appendix - Table 3

Climatic Data for the 1980-82 Growing Seasons at Minto

	Temperature °C							
	July 1981				August 1981			
Date	Max.	Min.	Mean	Precip. (mm)	Max.	Min.	Mean	Precip. (mm)
1	30.5	18.5	24.5	3.6	27.0	9.0	18.0	
2	26.0	16.0	21.0		M	13.0	M	
3	28.0	9.5	18.8		29.0	M	M	
4	34.5	17.5	26.0		30.5	14.5	22.5	17.6
5	32.0	16.0	24.0		24.5	16.0	20.3	0.4
6	37.0	18.5	27.8		26.0	14.5	20.3	
7	35.0	20.0	27.5		29.0	11.5	20.3	
8	26.0	13.5	19.8		24.5	12.5	18.5	
9	30.5	10.0	20.3		25.0	7.0	16.0	
10	27.0	12.5	19.8	7.4	29.5	13.0	21.3	
11	28.0	13.5	20.8	29.2	34.0	13.0	23.5	
12	29.5	14.0	21.8		28.0	13.0	20.5	
13	30.5	18.0	24.3	T	34.0	16.5	25.3	
14	20.0	16.0	18.0	2.2	26.0	12.5	19.3	
15	25.5	13.0	19.3		20.0	10.5	15.3	2.0
16	26.5	10.0	18.3		25.0	7.0	16.0	
17	25.0	13.0	19.0		28.5	13.5	21.0	
18	25.0	14.0	19.5		30.0	14.5	22.3	
19	27.5	13.5	20.5		30.0	20.0	25.0	
20	20.5	12.5	16.5		27.0	13.5	20.3	
21	23.0	12.0	17.5		31.0	14.5	22.8	
22	26.5	14.0	20.3	11.6	27.5	17.0	22.3	8.6
23	28.5	14.0	21.3		18.5	16.5	17.5	26.0
24	19.0	13.5	16.3	T	25.0	16.5	20.8	2.4
25	20.0	9.0	14.5		23.5	14.0	18.8	
26	24.0	5.0	14.5		25.5	14.0	19.8	
27	25.0	10.0	17.5		26.0	11.0	18.5	
28	24.5	12.5	18.5		26.0	12.5	19.3	
29	31.5	16.0	23.8		29.5	15.5	22.5	
30	31.5	19.5	25.5	8.4	32.5	19.0	25.8	3.2
31	28.5	13.0	20.8		13.0	12.5	12.8	3.8
A	27.3	13.8	20.6	62.4	26.9	13.6	20.3	64.0
B	1.0	1.3	1.2	104%	1.2	2.7	2.0	95%

A = Monthly
B = Departure from Normal
* = Snowfall

Appendix - Table 3

Climatic Data for the 1980-82 Growing Seasons at Minto

	Temperature °C							
	September 1981				October 1981			
Date	Max.	Min.	Mean	Precip. (mm)	Max.	Min.	Mean	Precip. (mm)
1	20.0	4.0	12.0		10.5	1.5	6.0	
2	26.0	12.5	19.3		15.5	3.0	9.3	
3	16.0	2.0	9.0		9.5	1.0	5.3	9.2
4	21.5	4.5	13.0		9.5	5.5	7.5	
5	26.0	10.5	18.3	5.2	9.5	5.5	7.5	
6	20.0	15.0	17.5	1.6	13.5	-2.0	5.8	
7	23.5	7.0	15.3		16.0	2.0	9.0	
8	30.5	9.0	19.8		16.0	7.0	11.5	
9	31.5	13.0	22.3		17.0	8.5	12.8	
10	33.5	11.5	22.5		20.0	1.5	10.8	
11	26.0	7.0	16.5		18.5	7.0	12.8	3.6
12	27.0	12.5	19.8		15.0	10.5	12.8	2.4
13	23.5	7.0	15.3		7.5	3.5	5.5	
14	20.0	6.0	13.0		9.0	0.0	4.5	
15	16.5	0.5	8.5		14.0	1.0	7.5	
16	16.5	1.0	8.8		19.5	3.5	11.5	3.2
17	21.5	0.5	11.0		8.5	5.0	6.8	0.6
18	30.0	10.0	20.0		7.5	0.5	4.0	
19	23.5	7.5	15.5		14.0	0.0	7.0	10.0*
20	20.0	8.0	14.0	2.0	3.0	-4.0	-0.5	
21	20.0	3.5	11.8		-0.5	-10.0	-5.3	1.0*
22	19.5	7.0	13.3	2.0	-4.5	-13.0	-8.8	
23	21.0	9.5	15.3		-0.5	-15.0	-7.8	1.0*
24	20.5	3.0	11.8		-0.5	-13.0	-6.8	
25	15.5	7.5	11.5	34.0	6.5	-8.5	-1.0	
26	9.5	7.5	8.5	5.0	12.0	-7.5	2.3	
27	11.0	3.0	7.0		5.0	-4.5	0.3	T
28	8.0	4.0	6.0		13.5	-5.0	4.3	
29	11.5	0.0	5.8	2.2	16.0	-3.0	6.5	14.0
30	7.0	1.5	4.3	5.4	5.0	3.0	4.0	16.0
31					15.0	0.5	7.8	
A	20.6	6.5	13.6	57.4	10.3	-0.5	4.9	61.0
B	1.8	1.2	1.5	15.5%	-2.3	-0.3	-1.3	237%

A = Monthly
B = Departure from Normal
* = Snowfall

Appendix - Table 3

Climatic Data for the 1980-82 Growing Seasons at Minto

	Temperature °C							
	November 1981				December 1981			
Date	Max.	Min.	Mean	Precip. (mm)	Max.	Min.	Mean	Precip. (mm)
1	14.0	4.0	9.0		-4.5	-14.0	-9.3	
2	14.5	-1.0	6.8		1.0	-14.5	-6.8	8.0*
3	18.5	4.0	11.3		-1.0	-5.0	-3.0	
4	15.0	8.5	11.8		-6.5	-15.0	-10.8	
5	10.0	-4.0	3.0		4.0	-16.5	-6.3	
6	15.5	-2.0	6.8		4.0	-10.0	-3.0	
7	14.0	-0.5	6.8		-1.5	-6.0	-3.8	
8	2.5	-7.0	-2.3		-5.0	-13.0	-9.0	
9	11.0	-7.5	1.8		-4.5	-8.5	-6.5	
10	10.0	-5.0	2.5		-0.0	-8.5	-4.3	T*
11	17.0	-5.0	6.0		-1.0	-6.5	-3.8	
12	18.0	-1.5	8.3		-9.5	-16.0	-12.8	
13	15.0	2.0	8.5		-10.5	-15.0	-12.8	T*
14	12.5	-2.5	5.0		-15.0	-23.5	-19.3	T*
15	12.0	3.0	7.5		-13.0	-24.5	-18.8	
16	6.0	-2.0	2.0		-13.5	-24.0	-18.8	
17	1.5	0.0	0.8	4.0*	-14.0	-26.0	-20.0	
18	-3.0	-3.5	-3.3	5.0*	-10.0	-25.0	-17.5	
19	-5.5	-8.0	-6.8		0.5	-19.5	-9.5	T
20	-2.5	-16.5	-9.5	2.0*	2.0	-11.5	-4.8	
21	0.0	-14.0	-7.0		-1.0	-4.0	-2.5	3.0*
22	2.5	-2.5	0.0	T	-9.0	-12.5	-10.8	2.0*
23	1.0	-1.0	0.0	T*	-7.5	-17.0	-12.3	T*
24	0.0	-2.5	-1.3	3.0*	-10.5	-16.0	-13.3	
25	-1.5	-2.5	-2.0	2.0*	-8.5	-23.0	-15.8	T*
26	-3.0	-5.0	-4.0		-7.0	-21.5	-14.3	1.0*
27	-5.0	-10.0	-7.5	T*	-10.5	-17.0	-13.8	2.0*
28	-3.5	-9.5	-6.5		-22.0	-25.5	-23.8	
29	-1.0	-8.0	-4.5		-22.0	-28.5	-25.3	
30	-2.0	-11.5	-6.8		-22.5	-30.0	-26.3	
31					-19.5	-28.0	-23.8	
A	6.1	-3.7	1.2	16.0	-7.7	-17.0	-12.4	16.0
B	6.3	5.3	5.8	75%	-.1	0.0	0.0	80%

A = Monthly
B = Departure from Normal
* = Snowfall

Appendix - Table 3

Climatic Data for the 1980-82 Growing Seasons at Minto

	Temperature °C							
	January 1982				February 1982			
Date	Max.	Min.	Mean	Precip. (mm)	Max.	Min.	Mean	Precip. (mm)
1	-21.0	-33.0	-27.0	5.0*	-11.0	-25.5	-18.3	
2	-21.5	-30.0	-25.8		-25.0	-32.5	-28.8	
3	-20.0	-32.5	-26.3		-22.5	-33.5	-28.0	
4	-17.5	-27.5	-22.5	6.0*	-22.5	-33.5	-28.0	
5	-22.5	-25.0	-23.5		-18.0	-34.0	-26.0	T*
6	-21.0	-35.0	-28.0		-5.5	-32.5	-19.0	2.0*
7	-18.0	-34.0	-26.0	1.0*	-14.0	-19.0	-16.5	
8	-24.5	-31.5	-28.0		-17.0	-28.0	-22.5	
9	-28.0	-31.0	-29.5		-19.0	-33.0	-26.3	
10	-25.0	-34.5	-29.8		-14.5	-28.0	-21.3	
11	-25.5	-33.5	-29.5		-15.5	-24.0	-19.8	
12	-17.5	-31.5	-24.5	T*	-12.0	-25.5	-18.8	2.0*
13	-10.0	-31.5	-20.8		-7.0	-22.0	-14.5	
14	-2.5	-31.0	-16.8		0.5	-21.0	-10.3	T*
15	-28.0	-30.5	-29.3		-5.5	-19.0	-12.3	
16	-20.0	-34.5	-27.3	T*	2.5	-15.0	-6.3	
17	-16.0	-33.0	-24.5	1.0*	2.0	-6.0	-2.0	
18	-14.0	-28.0	-21.0		5.0	-10.5	-2.8	
19	-24.5	-31.5	-28.0	T*	3.5	-8.5	-2.5	
20	-23.0	-34.0	-28.5	3.0*	6.5	-8.0	-0.8	
21	-24.5	-33.5	-29.0	7.0*	6.5	-5.0	0.8	
22	-22.0	-31.0	-26.5	8.0*	-5.0	-8.5	-6.8	2.0*
23	-21.5	-25.0	-23.3		-10.0	-17.0	-13.5	3.0*
24	-21.5	-34.0	-27.8	4.0*	-5.5	-15.0	-10.3	T*
25	-3.0	-32.5	-17.8		-8.5	-18.5	-13.5	
26	3.0	-28.5	-12.8	6.0*	-10.0	-15.0	-12.5	
27	-3.0	-6.0	-4.5		-3.5	-17.0	-10.3	
28	-9.5	-27.0	-18.3	T*	-7.0	-15.0	-11.0	
29	-15.0	-25.0	-20.0	1.0*				
30	-15.0	-34.5	-24.8					
31	-11.5	-31.0	-21.3					
A	-17.5	-30.4	-24.0	42.0	-8.3	-20.4	-14.4	9.0
B	-5.2	-7.5	-6.4	201%	-0.2	-0.9	-0.6	52%

A = Monthly
B = Departure from Normal
* = Snowfall

Appendix - Table 3

Climatic Data for the 1980-82 Growing Seasons at Minto

	Temperature °C							
	March 1982				April 1982			
Date	Max.	Min.	Mean	Precip. (mm)	Max.	Min.	Mean	Precip. (mm)
1	-11.5	-18.0	-14.8	T*	-1.0	-12.0	-6.5	4.0*
2	-12.5	-20.0	-16.3	2.0*	-9.5	-10.0	-9.8	4.0*
3	-11.0	-19.5	-15.3		-8.5	-17.0	-12.8	
4	-9.5	-20.0	-14.8		-7.0	-20.5	-13.8	
5	-9.5	-23.0	-16.3		-6.0	-15.5	-10.8	
6	-13.0	-21.0	-17.0	T*	-1.5	-18.0	-9.8	
7	-11.0	-26.0	-18.5	5.0*	1.0	-8.0	-3.5	
8	-12.5	-23.0	-17.8		1.0	-7.0	-3.0	T*
9	-1.5	-23.0	-12.3		1.5	-2.5	-0.5	
10	-3.5	-12.5	-8.0		4.5	-10.0	-2.8	
11	+4.0	-17.5	-6.8	T*	8.5	-5.5	1.5	
12	4.0	-4.0	0.0		11.0	2.0	6.5	
13	5.5	-11.0	-2.8		11.5	-1.0	5.3	
14	8.0	-8.0	0.0		19.0	2.0	10.5	T
15	2.5	0.0	1.3	T	12.0	2.0	7.0	
16	0.5	-1.0	-0.3	7.5*	10.0	0.5	5.3	
17	-3.0	-3.5	-3.3	1.5*	12.5	-2.5	5.0	
18	-9.0	-12.5	-10.0		10.5	-2.0	4.3	
19	-5.5	-16.0	-10.8		8.0	-1.5	3.3	
20	-0.5	-17.0	-8.8		10.0	-5.0	2.5	T
21	-0.5	-13.5	-7.0		11.5	-4.0	3.8	
22	0.5	-6.0	-2.8		23.0	1.0	12.0	
23	2.5	-4.5	-1.0	T*	27.0	9.5	18.3	
24	0.0	-5.5	-2.8	T*	22.5	10.0	16.3	
25	1.0	-12.0	-5.5		8.0	1.0	4.5	
26	0.0	-14.0	-7.0		14.0	-2.5	5.8	
27	3.0	-8.0	-2.5		16.5	2.5	9.5	
28	4.5	-5.0	-0.3		18.0	5.0	11.5	
29	6.5	0.0	3.3	9.0*	9.5	5.0	7.3	3.4
30	1.5	0.5	1.0	3.0*	18.5	2.5	10.5	
31	-2.0	-8.5	-5.3					
A	-2.3	-12.0	-7.2	28.0	8.5	-3.4	3.6	11.4
B	-1.4	+0.1	-0.7	124%	-0.9	-1.3	-1.1	35%

A = Monthly
B = Departure from Normal
* = Snowfall

Appendix - Table 3

Climatic Data for the 1980-82 Growing Seasons at Minto

	Temperature °C							
	May 1982				June 1982			
Date	Max.	Min.	Mean	Precip. (mm)	Max.	Min.	Mean	Precip. (mm)
1	24.0	5.0	14.5		18.0	3.0	10.5	
2	27.5	8.0	17.8	2.6	18.5	5.5	12.0	
3	28.5	14.5	21.5		23.0	9.0	16.0	
4	18.0	10.0	14.0		24.0	10.5	17.3	
5	15.0	2.0	8.5	T	26.5	15.0	20.8	
6	3.0	0.5	1.8	1.6*	16.5	13.5	15.0	26.4
7	9.5	-1.0	4.3		15.0	7.5	11.3	T
8	7.0	-2.0	2.0	4.4	11.0	5.0	8.0	4.0
9	5.5	0.5	3.0	16.0	20.0	5.0	12.5	
10	6.5	2.5	4.5	2.0	23.0	2.5	12.8	
11	14.0	4.0	9.0		20.5	9.0	14.8	
12	15.5	3.5	9.5	3.2	23.5	5.0	14.3	
13	16.0	9.0	12.5		26.0	13.5	19.8	6.4
14	21.0	9.5	15.3	6.0	22.0	9.5	15.8	
15	10.0	8.5	9.3	4.0	22.5	9.5	16.0	
16	11.0	8.0	9.5	2.4	25.0	13.0	19.0	5.4
17	12.0	8.5	10.3	0.2	13.5	7.0	10.3	
18	14.5	8.0	11.3	1.6	18.0	8.5	13.3	3.8
19	14.5	8.5	11.5		19.0	11.0	15.0	
20	18.0	6.0	12.0		19.5	6.5	13.0	
21	20.0	6.5	13.3		22.0	6.0	14.0	
22	23.5	6.5	15.0		27.0	12.0	19.5	
23	22.0	11.0	16.5	5.0	25.0	12.0	18.5	2.0
24	19.5	9.0	14.3		20.5	9.5	15.0	
25	23.0	7.0	15.0		22.5	8.5	15.5	
26	25.5	10.5	18.0		27.0	13.0	20.0	13.0
27	24.0	13.5	18.8		24.5	10.0	17.3	T
28	25.5	12.0	18.8	10.4	17.0	12.0	14.5	1.8
29	17.0	5.0	11.0		19.5	6.0	12.8	
30	12.5	3.5	8.0		23.0	7.0	15.0	
31	16.5	2.0	9.3					
A	16.8	6.4	11.6	59.4	21.1	8.8	15.0	62.8
B	-0.8	1.9	0.5	106%	-2.1	-1.5	-1.8	73%

A = Monthly
B = Departure from Normal
* = Snowfall

Appendix - Table 3

Climatic Data for the 1980-82 Growing Seasons at Minto

	Temperature °C							
	July 1982				August 1982			
Date	Max.	Min.	Mean	Precip. (mm)	Max.	Min.	Mean	Precip. (mm)
1	26.5	13.5	20.0		31.0	15.5	23.3	
2	30.0	19.0	24.5		29.5	18.0	23.8	
3	30.0	15.5	22.8	2.4	30.5	11.0	20.8	
4	29.5	15.0	22.3	10.0	27.0	12.0	19.5	
5	26.5	15.5	21.0		29.0	15.5	22.3	10.8
6	23.0	11.0	17.0		28.5	17.0	22.8	12.0
7	26.0	6.5	16.3		24.5	15.0	19.8	
8	18.5	10.0	14.3	12.0	21.0	11.5	16.3	
9	20.5	12.5	16.5		19.0	7.5	13.3	
10	25.5	14.0	19.8		20.5	5.0	12.8	
11	28.0	12.5	20.3		25.0	10.5	17.8	
12	29.0	14.5	21.8	T	24.0	15.5	19.8	
13	23.0	11.0	17.0		28.0	9.5	18.8	
14	21.0	13.0	17.0	20.6	31.5	15.5	23.5	13.0
15	27.5	16.0	21.8	24.0	24.0	14.0	19.0	0.2
16	30.0	18.0	24.0	2.2	26.5	12.5	19.5	
17	22.5	11.0	16.8		28.5	14.0	21.3	1.0
18	24.0	8.0	16.0	2.2	30.0	18.0	24.0	
19	27.5	13.0	20.3		27.0	12.5	19.8	
20	26.0	13.0	19.5		28.5	9.5	19.0	
21	24.0	11.5	17.8		26.0	16.0	21.0	
22	23.0	12.5	17.8	4.2	24.0	9.5	16.8	
23	27.5	14.5	21.0		21.5	8.5	15.0	
24	27.0	15.0	21.0		19.0	8.0	13.5	
25	25.0	12.0	18.5		14.5	9.0	11.8	
26	27.5	10.5	19.0	1.4	16.5	2.0	9.3	
27	25.5	14.5	20.0		15.0	-3.0	6.0	1.6
28	27.0	14.0	20.5	4.8	22.5	6.0	14.3	
29	24.0	10.0	17.0		22.5	7.5	15.0	4.0
30	27.0	9.5	18.3		18.0	8.0	13.0	2.6
31	31.5	12.0	21.8		25.0	9.0	17.0	
A	25.9	12.9	19.4	83.8	24.5	11.0	17.8	45.2
B	-0.2	0.2	0.0	124%	-0.6	0.0	-0.3	63%

A = Monthly
B = Departure from Normal
* = Snowfall

Appendix Table 4a

Mean Weekly Soil Temperatures (°C) at the 2.5 cm Depth for the 1980-81 Stubble Height Experiment at Portage la Prairie

	Treatment	
Week Ending	Conv. Tillage	15 cm Stubble
November 29	- 1.3	- 1.3
December 6	- 5.0	- 5.8
December 13	- 7.8	- 8.7
December 20	- 7.8	- 8.6
December 27	- 9.5	- 9.8
January 3	- 6.4	- 6.6
January 10	-11.1	-12.6
January 17	- 8.2	- 8.5
January 24	- 4.4	- 5.2
January 31	- 9.2	-10.1
February 7	- 8.6	-10.0
February 14	-13.2	-16.0
February 21	- 9.6	- 0.6
February 28	- 2.7	- 3.1
March 7	- 7.1	- 7.5
March 14	- 1.7	- 1.8
March 21	- 2.1	- 2.6
March 28	- 0.6	- 0.5

Appendix Table 4b

Mean Weekly Soil Temperatures (°C) at the 2.5 cm Depth for the 1981-82 Stubble Height Experiment at Portage la Prairie

Week Ending	Treatment: Conv. Tillage	Treatment: 15 cm Stubble
October 10	5.3	5.8
October 17	6.5	6.9
October 24	1.2	1.6
October 31	1.8	1.8
November 7	1.9	2.2
November 14	- 0.4	0.1
November 21	- 0.7	- 0.2
November 28	- 1.7	- 1.4
December 5	- 2.4	- 2.1
December 12	- 3.3	- 2.9
December 19	- 6.6	- 6.2
December 26	- 3.9	- 3.7
January 2	-13.2	- 5.5
January 9	- 9.8	- 4.9
January 16	-11.7	- 5.5
January 23	-11.9	- 5.7
January 30	-10.8	- 5.8
February 6	-12.9	- 6.2
February 13	-11.2	- 6.2
February 20	- 5.3	- 3.9
February 27	- 6.3	- 3.8
March 6	- 9.3	- 6.2
March 13	- 9.6	- 6.8
March 20	- 2.9	- 1.9
March 27	- 5.0	- 3.8
April 3	- 2.2	- 1.5
April 10	- 4.4	- 3.4
April 17	0.2	0.2
April 24	2.0	2.2
May 1	3.0	3.3
May 8	7.9	8.9

Appendix - Table 5. The effect of fall-applied broadleaf weed herbicides on Feekes' growth stage and number of tillers of Norstar winter wheat at Minto, 1981-82.

Treatment	Rate (kg/ha)	Time of Application	Feekes' Scale[1]	Number of Tillers
Control (Glyphosate)	2.25	pre-emergence	7	8
Control (untreated)	-	-	7	8
2,4-D amine	1.10	pre-emergence	7	7
2,4-D amine	0.55	3- to 4-leaf	7	7
2,4-D amine	0.85	early spring	7	8
Picloram/2,4-D	0.04/0.55	3- to 4-leaf	7	7
Chlorsulfuron	0.02	pre-emergence	7	7
Chlorsulfuron	0.04	pre-emergence	7	8
Chlorsulfuron	0.02	3- to 4-leaf	7	7
Chlorsulfuron	0.04	3- to 4-leaf	7	8

[1]Large 1954.

Appendix - Table 6. The effect of fall-applied broadleaf weed herbicides on the Feekes' growth stage and number of tillers of winter wheat at Portage, 1981-82.

			Zero Tillage				Conventional Tillage			
			Norstar		Winalta		Norstar		Winalta	
Treatments	Rate (kg/ha)	Time of Application	Feekes' Scale[1]	No. of Tillers	Feekes' Scale	No. of Tillers	Feekes' Scale	No. of Tillers	Feekes' Scale	No. of Tillers
Control (untreated)	-	-	8	4	8	2	9	3	9	3
2,4-D amine	0.55	3-4 lf stage	8	4	9	2	9	2	9	3
2,4-D amine	1.10	3-4 lf stage	8	4	8	2	9	3	9	4
2,4-D amine	0.85	early spring	8	4	9	3	9	3	10	3
Dicamba + 2,4-D	0.15+0.42	3-4 lf stage	8	3	9	2	9	3	10	3
Dicamba + 2,4-D	0.33+0.94	3-4 lf stage	8	4	8	2	9	3	9	3
Picloram/2,4-D	0.04/0.55	3-4 lf stage	8	3	9	3	9	3	10	3
Chlorsulfuron	0.02	pre-emergence	8	4	9	3	9	3	9	3
Chlorsulfuron	0.04	pre-emergence	8	3	9	3	9	3	10	3
Chlorsulfuron	0.02	3-4 lf stage	8	3	9	2	9	3	9	3
Chlorsulfuron	0.04	3-4 lf stage	8	3	9	2	9	2	10	4

[1]Large 1954.

Appendix - Table 7. The effect of soil residues of dinitroaniline herbicides on the Feekes' growth stage and number of tillers of Norstar winter wheat.

Treatment	Rate (kg/ha)	Portage 1980-81 Feekes' Scale[1]	Portage 1980-81 No. of Tillers	Minto 1981-82 Feekes' Scale	Minto 1981-82 No. of Tillers
Control (untreated)	-	5	8	10	2
Trifluralin	1.1	5	7	10	3
Trifluralin	2.2	5	7	10	3
EL5261	1.1	5	7	10	3
EL5261	2.2	5	6	10	3
Ethalfluralin	1.1	-	-	10	2
Ethalfluralin	2.2	-	-	10	3
Dinitramine	0.8	5	9	-	-
Dinitramine	1.7	5	7	-	-

[1] Large 1954

APPENDIX - TABLE 8. The effect of soil residues of dinitroaniline herbicides on the Feekes' growth stage and number of tillers of winter wheat at Portage, 1981-82.

Treatment	Rate (kg/ha)	Norstar Feekes' Scale[1]	Norstar No. of Tillers	Winalta Feekes' Scale	Winalta No. of Tillers
Control (untreated)	-	6	6	6	7
Trifluralin	1.1	6	7	6	7
Trifluralin	2.2	6	6	6	7
EL5261	1.1	6	8	6	7
EL5261	2.2	6	6	6	8
Ethalfluralin	1.1	6	7	6	7
Ethalfluralin	2.2	6	6	6	6

[1]Large 1954