WHEAT PRODUCTION IN A MINIMUM TILLAGE SYSTEM USING TWO RESIDUAL SOIL INCORPORATED HERBICIDES

P.D. Gerwing and R.B. McKercher

Saskatchewan Institute of Pedology,
University of Saskatchewan

Introduction

Preemergent soil incorporated herbicides which control weeds shortly after germination and persist for season long weed control offer advantages with respect to moisture conservation and reductions in weed seed production. There is concern regarding the practice of sowing wheat into a trifluralin-treated layer of soil. The literature shows that a protective band of untreated soil is required between the wheat seed and trifluralin treated soil when relatively high levels of trifluralin application are required for weed control. Heath et al. (1985) reported stand thinning, and subsequent yield reduction in one of two years, resulting from seeding wheat into a layer of soil which contained 0.2 ppm trifluralin. Similiarly, Friesen and Bowren (1973) found yields unaffected when wheat was seeded into soil which had received a trifluralin application of 1.1 Kg ha^{-1} the previous year. A growth room study by Olson et al. (1982) revealed that 0.4 ppmw trifluralin resulted in only slight damage to wheat seedlings. Damaged seedlings recovered after a short period of time.

The competitive ability of greenfoxtail in wheat has been reported by several authors (Rahman and Ashford 1972; Blackshaw et al. 1981; Bubar and Morrison, 1984). Relatively early establishment of greenfoxtail is necessary for subsequent wheat yield reductions. As competition from the wheat crop is increased, greenfoxtail has less affect on final wheat yield. Water is generally considered the most limiting growth factor for cereal production on the prairies. Therefore lack of weed control in a cereal crop, through ineffective herbicide usage or low levels of crop competition, should result in a relatively low water use efficiency (WUE) for that crop. Crop response to water is often expressed as Kg ha^{-1} grain produced per cm water transpired. Depending on soil and environmental conditions, WUE of a wheat crop can vary considerably. Grevers et al. (1986) calculated efficiencies as low as 49.7 and highs of 186 Kg ha^{-1} cm^{-1} on Saskatchewan soils.

The objective of this paper is threefold. Soil receiving a preplant-incorporation of applied granular trifluralin during the summerfallow year, preceding the crop year, was seeded to wheat the following spring. One objective was to determine the extent of seedling damage when wheat was sown into a trifluralin treated layer of soil. Secondly, seeding density and herbicide residues in the soil were studied to ascertain their affects on weed control and final grain yield. The final objective of this paper was to define a relationship between seeding density and herbicide treatment with respect to the WUE of spring wheat.

Materials and Methods

Site Charactersitics:

Two Saskatchewan locations were chosen for this particular study. The composition and physical characteristics of the surface soils (0-10 cm) are shown in Table 1. Climatic data for the 1987 growing season is presented in Table 2 and was collected from on site weather monitoring equipment. During the 1986 summerfallow season, approximate weed densities at each field location for non-herbicide treated soil, were as follows. Craik maintained a single weed species, greenfoxt: (Setaria viridis L Beauv.) at an approximate density of 30 plants m^{-2}. At Saskatoon, that same wee at 40 plants m^{-2} plus stinkweed (Thlaspi arvense L.) at 200 plants m^{-2} were the main species presei Only at Saskatoon was greenfoxtail seed spread over the plot area to ensure an adequate infestation. A hand held spreader uniformly delivered 5 Kg ha^{-1} seed in the fall of 1985.

Table 1. Composition and physical characteristics of the surface soil at the two field locations.

Location	composition (%) sand	silt	clay	organic content	pH[a]	Soil Association
Craik	39.0	38.2	22.8	2.6	7.2	Weyburn
Saskatoon	15.3	51.6	33.1	3.8	7.2	Weyburn

[a] Soil/Water ratio, 1:1.

Table 2. Climatic data for 1987 growing season.

Location	Period	Mean Air Temp. (C) max	min	mean	Mean Soil Temp. at 5-cm Depth (C)	Precipitation (mm)
Craik	May 9 to Aug.28	25.9	9.1	16.9	17.2	144.8
Saskatoon	"	25.2	8.0	16.3	17.1	145.0
30 yr norm. (Craik)[a]	May 1 to Aug.31	22.9	8.8	15.9	-	216.1
30 yr norm. (Saskatoon)[b]	"	22.7	8.8	15.8	-	204.9

[ab] Normal climate data for the period 1951-1980 recorded at Aylesbury and Saskatoon, Sask., respectively.

General Procedures:

For the majority of this report, four herbicide treatments and three seeding rates of wheat will be emphasized at each site. On May 19, 1986, trifluralin (5G) [2, 6 - dinitro - N, N - dipropyl - 4 - trifluoromethylaniline] and chlorsulfuron (75DF) {2 - chloro - N - [[(4 - methoxy - 6 - methyl - 1, : 5 - triazin - 2 - yl) amino] carbonyl] benzenesulfonamide} were applied alone and in combination at label recommended rates of 1.10 Kg ha^{-1} a.i. and 0.023 Kg ha^{-1} a.i., respectively. At Craik the herbicides were applied to standing wheat stubble. These same herbicide treatments were studied a Saskatoon. However, with application being delayed until June 27, 1986, the amount of trifluralin applied was reduced to 0.97 Kg ha^{-1} a.i.. Herbicide application was onto preworked wheat stubbl At both sites the plot sizes were indentical, 4.5 m x 15 m. A continuous air flow applicator (Valma with a ground driven delivery system was used to apply the trifluralin granule. A tractor mounted CO_2 spray system regulated to a pressure of 240 kPa, using 8004 flat fan nozzles and delivering 1C L water ha^{-1}, was used to apply the chlorsulfuron. Immediate incorporation of the herbicide was accomplished with a 2.2 m wide vibrashank cultivator set to a cutting depth of 6.5 cm. The cultivator was pulled at 10 Km hr^{-1} and was structured with three rows of shanks, 19 cm sweeps at 15 cm spacings. The herbicides were incorporated twice during the summerfallow year.

Prior to seeding, in the spring of 1987 (May 9), the experimental plots were worked once with a tandem disc to a depth of 5 cm and at a forward speed of 8 Km hr^{-1} followed by one harrow operation at 11 Km hr^{-1}. The plots were always worked in the same longitudinal direction.

Katepawa wheat was seeded on May 13 and 14 at Craik and Saskatoon, respectively. Three rates of seeding, 45, 90, and 135 Kg ha^{-1}, were used. The wheat was sown perpendicular to, and across the 1986 applied herbicide treatments. The seeds were treated with the fungicide Maneb, at a rate of 30 g per 25 Kg seed, and were sown to 5 cm depth into a packed but dry seedbed using a double disc drill with drill runs spaced 18 cm apart. Flexicoil packers were pulled behind the drill. Fertilizer was applied according to Saskatchewan Soil Testing Laboratory (SSTL) recommendations. If nitrogen was required, it was applied as ammonium nitrate (34 - 0 - 0) and drilled to 10 cm prior to seeding. All phosphorus was seed placed as monoammonium phosphate (11 - 55 - 0).

Plant Measurements:

Roots, from seedlings of similiar size, were randomly selected to determine the extent of herbicide damage. Root samples were taken 25 days after seeding. Earlier sampling would have been more desireable however dry seedbed conditions resulted in variable and delayed seedling emergence. The following root measurements were made: number of seminal roots per plant; total length of seminal roots per plant; seminal root dry weight. Prior to measurements, roots were gently rinsed in warm water to remove soil particles.

Early wheat emergence was studied 24 days after seeding. Evaluations were made on 2 samples per plot which were always taken from the same drill rows within the different treatments. Each sample was 3 rows by 1 m length (1/2 m^2). The parameters measured were: number of plants; dry weight. Using a forced air oven, drying was at 60 C until constant weight.

At harvest, plant samples were taken in the same manner as described for early wheat emergence measurements. At both sites, the following parameters were quantified: wheat grain yield; number of greenfoxtail plants; number of greenfoxtail heads; greenfoxtail dry weight. As well, for the Saskatoon site, stinkweed growth characteristics were evaluated: number of plants; seed yield; straw yield. Wheat grain was separated from the straw using a stationary thresher. The seed yield of stinkweed was obtained by hand threshing and seiving. Weed biomass was determined after oven drying at 60 C until constant weight.

Soil Water Measurements:

For the calculation of WUE, a measurement of soil water used by the crop is essential. Water use to a depth of 135 cm was measured at specific intervals within the soil profile using the neutron scatter technique. One access tube was installed within each seeding rate x herbicide treatment combination. The water content of the 0 - 10 cm soil layer was measured gravimetrically. Soil moisture measurements were taken in the spring just prior to seeding and in the fall just after harvest.

Soil Sampling and Gas Chromatographic Analyses of Trifluralin Residues:

In the spring of 1987, four soil cores from each trifluralin containing treatment were randomly collected and placed in paper bags. Each of the four blocks were seperately sampled. Each soil core measured 9.8 cm in depth and 7.0 cm in diameter. Immediately after collection and transport to the laboratory, the four soil cores from each paper bag were poured through a Riffle sampler, five times, to thoroughly mix the soil and evenly distribute the trifluralin residue. Subsequent sample prepara prior to chromatographic analyses parallelled that of Smith (1979). 20 g of soil from each of the replicate samples was weighed into 125-ml glass-stoppered flasks and shaken for 1h on a platform shaker with 50 ml of 90% methanol containing 2.5% of glacial acetic acid. The samples were allowed to sit for 24 h before being shaken a second time for 1 hr. Following centrifugation at 20(rpm for 4 min, 25 ml of the clear supernatant was placed in a 500-ml seperatory funnel and shaken with 5% aqueous sodium carbonate (100 ml) and n-hexane (15 ml). The aqueous phase was discarded and the organic layer dried over sodium chloride and examined by gas chromatography. Trifluralin was quantified using a 3390 A Hewlett-Packard integrator and a 5790 A gas chromatograph equipped with a nitrogen-phosphorus detector (NPD) operated at 350 C. The glas column (1.8 m x 4 mm I.D.) was packed with 5% Dexsil 300 on 80 - 100 mesh Chromosorb W, Carrier gas was helium at a flow rate of 46 ml min^{-1}. With a column temperature of 210 C the retention time for trifluralin was 3.24 min. The hydrogen and air flows to the detector were 3.5 an 80 ml min^{-1}, respectively. The voltage supplied to the NPD element was normally 30% of baselin offset. Five ul sample volumes were injected directly into the column through a heated injection pc (220 C). Trifluralin concentrations in the samples were calculated by comparing sample peak area with those of appropriate standards. A recovery factor was applied to the data since total extractio the herbicide from the soil was impossible. Extraction efficiency from the Saskatoon and Craik so was 84% and 58%, respectively. Interference by soil factors was negligible during analytical quantification.

Statistical Analyses:

Measurements made using 1/2 m^2 samples were converted prior to statistical analyses and are reported on a 1 m^2 base. The experiment was conducted according to a split-block design with randomized complete block arrangement of the whole-plot factor (herbicide treatments). There we four blocks. The sub-plot factor was seeding rate (45, 90, 135 Kg ha^{-1} Katepawa wheat). A protected LSD was used to determine significant differences between factor levels of the main effe and interactions. Certain treatment means were subject to linear regression analysis.

Results and Discussion

Wheat Seedling Development:

At both field locations during the 1986 growing season, average daily atmospheric temperatures were slightly below normal. Growing season precipitation at Saskatoon and Craik w 8% and 22%, respectively, greater than the 30 year normal (1951-1980). Under these relatively normal weather conditions, carry-over of trifluralin into the crop year from greater than recommen rates of application (25% greater than recommended) resulted in minimal root damage at one study site (Table 3). At Saskatoon, seeding wheat into 0.16 Kg ha^{-1} trifluralin resulted in a significant reduction in total seminal root length for a wheat seedling. Although no significant differences we evident at Craik, shorter root lengths were found for seedlings growing in trifluralin treated soil.

Only at the Saskatoon site were seminal root numbers highest for seedlings grown in soil containing trifluralin residues. Olson et al. (1982) also showed that trifluralin may cause a slight stimulation in seminal root production. This increased production may be a compensatory reactior the seedling due to reduced seminal root length. No significant reduction in seminal root dry weig occurred. Olson et al. (1982) also found no dry weight reduction in seminal roots after seeding wl into soil containing a concentration of 0.4 ppmw applied trifluralin.

The affect which herbicides had on above ground early wheat growth can be seen in Table 3. Only at Craik did soil residual trifluralin significantly decrease wheat biomass production below th produced by wheat grown in chlorsulfuron residues. No significant reduction in plant numbers resulted from seedlings grown in soil containing either of the herbicide residues.

Table 3. Seminal root development and emergence of a spring wheat crop as affected by soil residual herbicides.

Location	Herbicide	Soil Residual Trifluralin (Kg ha^{-1})	Seminal Roots: Dry[1] Wt. (mg)	Seminal Roots: Number	Seminal Roots: Total Length (mm)	Wheat Seedlings: Plants[2] (# m^{-2})	Wheat Seedlings: Dry Wt. (g m^{-2})
Craik	Trifluralin[4]	0.14c[3]	38.10	4.91	173.7	9.83	6.23b
	Trifluralin[5]	0.22b	37.13	4.69	163.4	9.74	5.65b
	Trifluralin	0.29a	37.43	5.03	177.1	9.80	5.23b
	Trifluralin + Chlorsulfuron	0.13c	38.13	4.74	179.7	9.92	5.66b
	Chlorsulfuron	-	47.03	4.75	196.2	10.41	8.87a
	Check	-	45.93	4.87	184.5	10.29	7.23ab
LSD (0.05)		0.06	NS	NS	NS	NS	2.59
Saskatoon	Trifluralin[4]	0.16	20.70	4.68ab	121.2c	8.58	8.33
	Trifluralin + Chlorsulfuron	0.09	23.30	4.97a	146.9ab	8.40	9.71
	Chlorsulfuron	-	20.75	4.13c	131.9bc	8.77	12.41
	Check	-	23.65	4.34bc	154.0a	8.96	9.69
LSD (0.05)		NS	NS	0.53	20.0	NS	NS

1. All seminal roots from 8 plants per treatment, averaged over 4 replications.
2. ANOVA performed on square root transformed data and means are presented as such.
3. Means followed by the same letter are not significantly different.
4. Recommended rates of application.
5. Recommended rate of application + 25%.

NS Non-significant.

Wheat Maturity:

Saskatoon

Two weed species, stinkweed and greenfoxtail, were present at this field location. Trifluralin controlled the greenfoxtail population and chlorsulfuron reduced stinkweed numbers. The opposite was not true (Table 4). Although the trend was present, an increase in the seeding rate of wheat did not significantly reduce the number of weeds in either population. Soil residual trifluralin caused a 98% reduction in the number of greenfoxtail plants and heads. On average, soil residual chlorsulfuron gave 86% control of stinkweed.

Figure 1 (a,b,c) shows the relative difference in grain yield between the herbicide treatments as affected by the various weed populations, for each seeding rate. The highest yields were attained when both weed species were being controlled. By observing Figure 1b it becomes apparent that stinkweed is the more competitive of the two weeds. Plots treated with only chlorsulfuron or trifluralin exhibited a high level of greenfoxtail and stinkweed production, respectively. Where stinkweed was controlled, the grain yield was significantly higher.

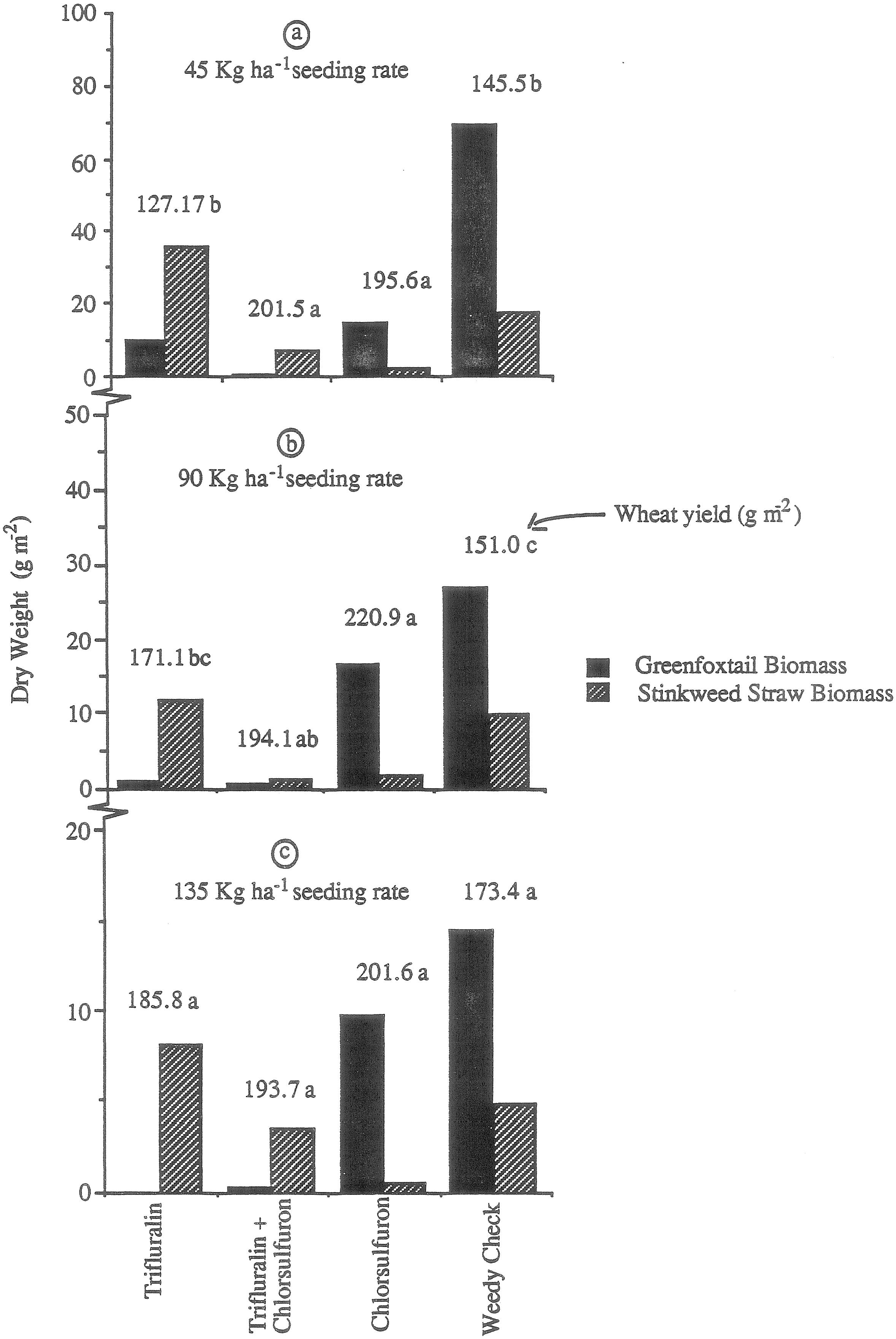

Figure 1. Effect of herbicide treatments on weed control and spring wheat yield, at Saskatoon.

The seeding rate of wheat, and herbicide residue into which the wheat was sown showed an indirect interaction which resulted in grain yield differences. The interaction is evident in Figure 3. Only in those plots where weeds were not being controlled by herbicides did a significant increase in grain yield result from an increased seeding density. The higher grain yields were the result of better weed control due to increased competition from the wheat crop (Figure 2). The significant differences in stinkweed straw and seed yield between the trifluralin and weedy check, at the 45 Kg ha^{-1} seeding rate, is the result of interspecific competition between the two weed species. Note that this only occurs when competition from the wheat stand is at a low level. With good greenfoxtail control in the trifluralin treatment, the greenfoxtail is unable to successfully compete with stinkweed therefore a relatively large stinkweed population results. At the highest seeding rate, no significant differences in greenfoxtail dry weight, stinkweed straw or seed yield was evident between any of the herbicide treatments tested. While not showing significance at the highest seeding rate, the trifluralin x chlorsulfuron herbicide treatment gave the best control of this specific weed combination. At normal to high seeding rates, the chlorsulfuron containing plots showed minimal levels of seed production.

For all the herbicide treatments, greenfoxtail dry weight was lowest in plots seeded at the highest density. No significant differences in greenfoxtail dry weight were present at the 135 Kg ha^{-1} seeding rate (Figure 2c). Regardless of the density at which wheat was sown, differences in greenfoxtail head production between the herbicide treatments did exist (Table 4). Trifluralin containing plots showed a significantly lower number of heads. Visual observations of greenfoxtail growth revealed that 2 cm high plants were capable of head production. Although greenfoxtail biomass was significantly reduced at high seeding densities within non-trifluralin treated experimental plots, high levels of head production did persist. Therefore continued infestations of greenfoxtail, in future crops, would be a problem if only high seeding rates were relied upon for the control of this weed.

Table 4. Inhibition of greenfoxtail and stinkweed growth within a spring wheat stand, as affected by soil residual herbicides and seeding rate, at Saskatoon.

Herbicide	Greenfoxtail Plants (# m^{-2})	Greenfoxtail Heads (# m^{-2})	Stinkweed Plants (# m^{-2})
Trifluralin	1.01b	1.66b	8.57a
Trifluralin + Chlorsulfuron	1.01b	1.14b	2.96b
Chlorsulfuron	5.40a	7.81a	2.31b
Weedy Check	6.70a	10.99a	7.08a
LSD (0.05)	3.78	4.26	4.09
Seeding Rate (Kg ha^{-1})			
45	6.00	8.57	4.77
90	5.08	7.01	4.38
135	3.43	5.41	3.87
LSD (0.05)	NS	NS	NS

For all measured parameters, ANOVA was performed on square root transformed data and means are presented as such.

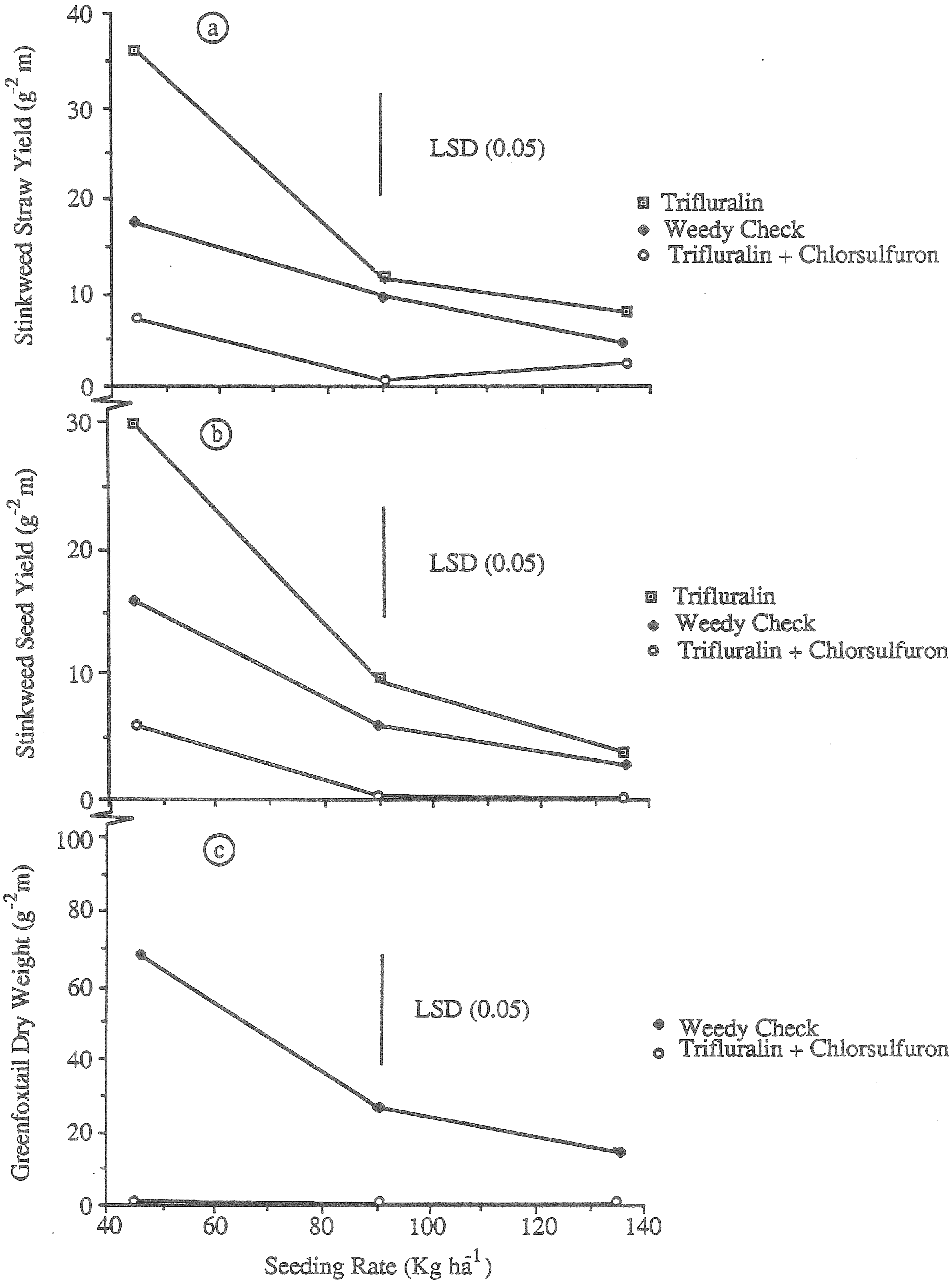

Figure 2. Effect of interspecific competition, provided by increased seeding rates of wheat, on weed growth, at Saskatoon.

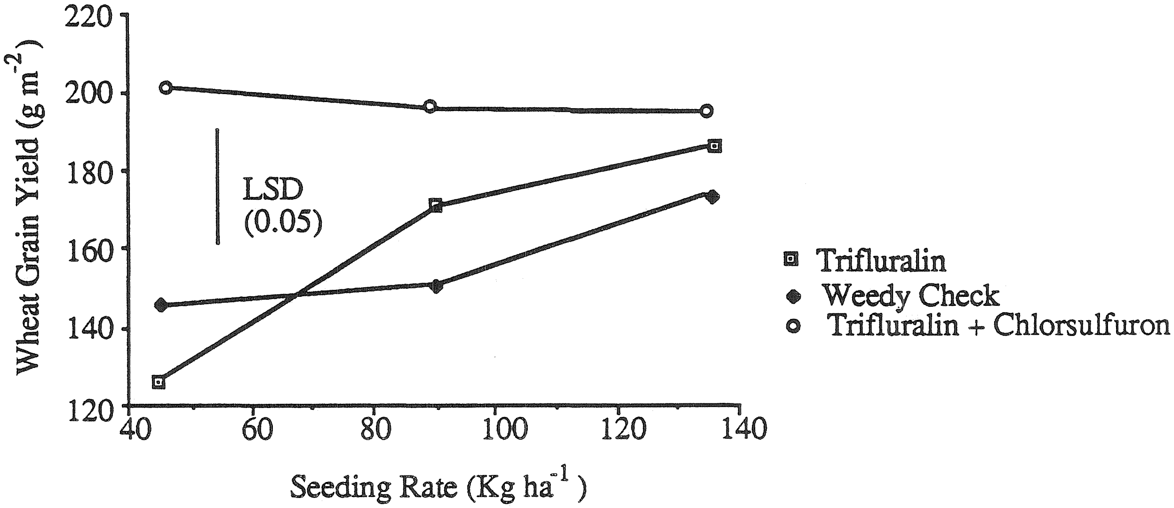

Figure 3. Interaction between the seeding rate of wheat and herbicide treatments on wheat grain production.

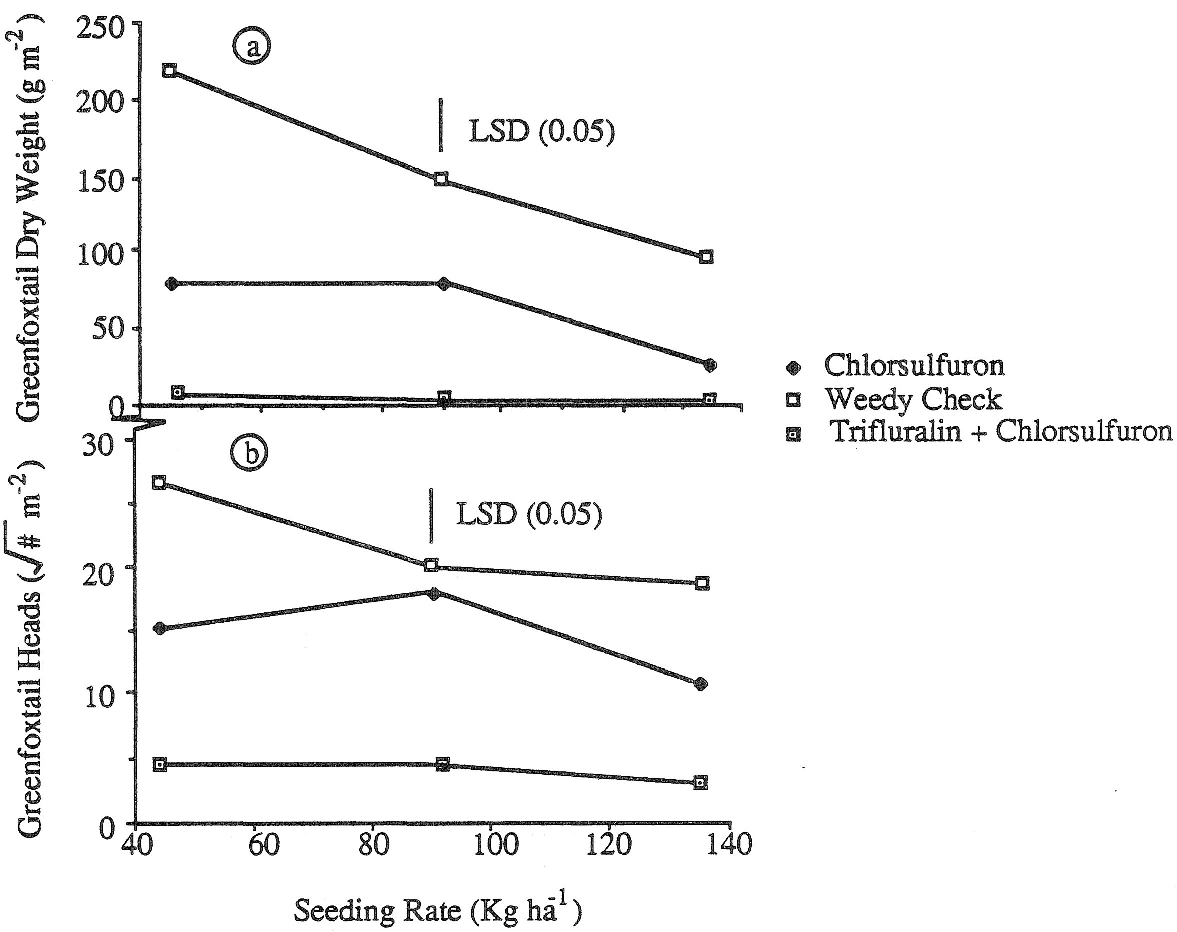

Figure 4. Effect of interspecific competition, provided by increased seeding rates of wheat, on greenfoxtail growth at Craik.

Craik

Both trifluralin and chlorsulfuron provided at least a measure of greenfoxtail control (Table 5). Trifluralin reduced the number of plants by 97% while chlorsulfuron showed only 52% contro compared to the weedy check. In plots where the greenfoxtail was controlled, a relatively high grai yield resulted. As seeding rate was increased, no significant decrease in greenfoxtail numbers was evident but an increase in grain yield did result. Unlike Saskatoon, grain yield was increased regardless of the amount of weed growth which was present. This differential response to weed growth, between the two sites, can be attributed to moisture stress on the Saskatoon crop during th month of July. Desjardins and Ouellet (1977) showed that cereal yields can be seriously reduced when water stress occurs during the growth stages of flowering and heading. At both sites in this study, flowering and heading occurred during the month of July. At Saskatoon, only 30 mm of rainfall was recorded for the month of July. This amount is less than 50% of the 30 year normal fc Saskatoon. At Craik, 75.8 mm of rain was received during the same period, or 45% more than the long term average. At Saskatoon when weeds were being effectively controlled with herbicides, ar increase in grain yield with increased seeding rates was not possible. The extra plants could not produce grain due to a shortage of water. On both July 2 and July 31, soil profile moisture measurements revealed that weed-free plots at Saskatoon only held plant available water below a depth of 105 cm. Total growing season precipitation during 1987 at Craik and Saskatoon was 148 mm and 154.0 mm, respectively.

Table 5. Effect of soil residual herbicides and variable seeding rates of wheat on greenfoxtail growth and Katepawa wheat harvest grain yield, at Craik.

Herbicide	Grain Yield ($g\ m^{-2}$)	Greenfoxtail Plants[1] ($\#\ m^{-2}$)
Trifluralin	345.3a	2.94c
Trifluralin + Chlorsulfuron	334.0a	3.79c
Chlorsulfuron	314.4a	13.81b
Weedy Check	244.9b	19.99a
LSD (0.05)	32.1	3.18
Seeding Rate ($Kg\ ha^{-1}$)		
45	289.4c	12.73
90	309.6b	12.80
135	323.8a	11.95
LSD (0.05)	13.57	NS

1. ANOVA was performed on square root transformed data and means are presented as such.

Similiar to the Saskatoon site, biomass production of greenfoxtail resulting from plots with healthy infestations of this weed was significantly reduced as competition from the wheat crop was increased (Figure 4a). The same was true for greenfoxtail head production (Figure 4b). For both (the above measured greenfoxtail parameters, the excellent control attainable in trifluralin treated soil could not be equalled by the other herbicide treatments.

Water Use Efficiency:

Both study locations showed that the WUE of spring wheat was altered by both the herbicide used and seeding rate (Table 6 and 7). The particular herbicide treatments and seeding rates gave different levels of weed control. Uncontrolled weed growth caused reductions in WUE. Where Y = WUE, and x = weed biomass, the following linear regressions can be interpreted.

Location	Seeding Rate ($Kg\ ha^{-1}$)	Regression Equation	R^2
Craik	45	$Y = 116.66 - 0.11x$	0.61*
	90	$Y = 123.13 - 0.19x$	0.81**
	135	$Y = 144.23 - 0.17x$	0.88***
Saskatoon	45	$Y = 109.79 - 0.43x$	0.72**
	90	$Y = 113.43 - 0.54x$	0.66*
	135	----	0.34 NS

In the regression equations calculated for Saskatoon, x equals total above ground greenfoxtail and stinkweed biomass. At Craik this same variable is contributed to by only greenfoxtail biomass. Note the slope of the regression lines. At both sites, when seeding rates were increased from 45 Kg ha^{-1} to the recommended rate of 90 Kg ha^{-1}, less total weed growth was required to cause a reduction in the WUE of the wheat crop. The more competitive nature of the weed combination at the Saskatoon site as compared to only greenfoxtail at Craik would be the best explanation for the relatively steep slopes calculated for the regression lines at Saskatoon. At Craik, where water stress did not occur during the critical growth period of July and where only greenfoxtail weeds were present, higher R^2 values were calculated for the higher seeding densities.

Using the LSD from Table 6, 19.24 Kg grain ha^{-1} cm^{-1} water, and the linear equations for the Saskatoon site, it can be estimated that approximately 45 g m^{-2} of weed biomass is necessary to cause a significant reduction in WUE within stands of wheat seeded at 45 Kg ha^{-1}. At the 90 Kg ha^{-1} seeding rate, a lower level of weed growth was required, 36 g m^{-2}.

Regardless of weed control obtained by the different herbicide treatments, an increase in seeding rate resulted in increased WUE's for wheat at the Craik location. At Saskatoon this was not the case because of the mid-growing season moisture stress. From the experimental treatments which were studied, it was not possible to detect the amount of water used by the different weed densities or species in relation to wheat. Therefore if the competition provided by weeds within the wheat crop was mainly for water, this could not be determined.

Table 6. Water use efficiency of spring wheat as affected by the interaction between various herbicide treatments and different seeding rates of wheat, at Saskatoon.

Herbicide	Water Use Efficiency (Kg grain ha^{-1} cm^{-1} water) Seeding Rate (Kg ha^{-1}) 45	90	135
Trifluralin	71.32e	102.01abc	113.49a
Trifluralin + Chlorsulfuron	114.72a	111.53a	101.58abc
Chlorsulfuron	102.25abc	111.41a	112.58a
Weedy Check	80.52de	91.43bcd	91.07cd
LSD (0.05)		19.24	

Table 7. Water use efficiency of spring wheat as affected by soil residual herbicides and seeding rate of wheat, at Craik.

Herbicide	Water Use Efficiency (Kg grain ha^{-1} cm^{-1} water)
Trifluralin	127.50a
Trifluralin + Chlorsulfuron	128.20a
Chlorsulfuron	115.32b
Weedy Check	101.12c
LSD (0.05)	8.97
Seeding Rate (Kg ha^{-1})	
45	107.53c
90	113.91b
135	137.95a
LSD (0.05)	3.32

Conclusions

Trifluralin applied to field soils at recommended rates, a year prior to seeding wheat, resulted i minimal seedling damage when wheat was seeded directly into the trifluralin treated layer. Seedlin tolerated the highest absolute soil residual concentration of trifluralin tested, 0.29 Kg ha^{-1}.

Within wheat stands at both study locations, in excess of 97% greenfoxtail control was determined by absolute soil residual trifluralin levels of 0.14 Kg ha^{-1}. Only at Craik did chlorsulfuron show any greenfoxtail control (52%), and at Saskatoon a 86% reduction in stinkweed plant numbers resulted from the use of this herbicide. Both locations revealed the highest grain yields under relatively weed free conditions. Final grain yields at Saskatoon were lower under weed free conditions because of mid-season moisture stress. Increased seeding rates significantly reduced biomass production of both weed species studied, but only when high levels of weeds were initially present. When herbicides were used to control a particular weed, the weed growth escaping control could be reduced with increased seeding rates, however this reduction was not significant. Wheat competition alone was not able to reduce the potential for serious future weed infestations.

WUE of the wheat crops, at both sites, was a function of weed control. In plots where weeds were controlled, a relatively high WUE by wheat was determined.

References

Blackshaw, R.E., E.H. Stobbe, and A.R.W. Sturko. 1981. Effect of seeding dates and densities of green foxtail (Setaria viridis) on the growth and productivity of spring wheat (Triticum aestivum). Weed Sci. 29:212-217.

Bubar, C.J., and I.N. Morrison. 1984. Growth responses of green and yellow foxtail (Setaria viridis and S. lutescens) to shade. Weed Sci. 32:774-780.

Friesen, H.A., and K.E. Bowren. 1973. Factors affecting the control of wild oats in rapeseed with trifluralin. Can. J. Plant Sci. 53:199-205.

Grevers, M.C., J.A. Kirkland, E. de Jong, and D.A. Rennie. 1986. Soil water conservation under zero- and conventional tillage systems on the Canadian prairies. Soil Tillage Res. 8:265-276.

Heath, M.C., R.B. McKercher, and R. Ashford. 1985. Influence of high soil temperature, ammonium ion, and rapeseed residue on trifluralin phytotoxicity to wheat. Can. J. Plant Sci. 65:151-161.

Olson, B.M. 1982. The effect of trifluralin on the root development of wheat and triticale seedlings. M.Sc. Thesis. Soil Science Department, University of Saskatchewan, Saskatoon, Saskatchewan.

Rahman, A., and R. Ashford. 1972. Control of green foxtail in wheat with trifluralin. Weed Sci. 20:23-27.

Smith, A.E. 1979. Soil persistence experiments with [^{14}C] 2,4-D in herbicidal mixtures, and field persistence studies with tri-allate and trifluralin both singly and combined. Weed Res. 19:165-170.