A Comparison of Broadcast and Conventional Methods For Seeding Winter Wheat in East Central Saskatchewan

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Introduction

There are optimum seeding dates for successful winter wheat production in the northern Great Plains (Fowler, 1982). In Saskatchewan, fall seeding often overlaps with the end of harvest delaying the seeding operation until after the optimum date. One possible solution to this potential problem is broadcast seeding of winter wheat from an airplane or granular spreader into an established spring crop in July or August. The winter wheat then begins to grow beneath the existing spring crop. Once the spring crop is harvested in the fall the winter wheat seedlings are already established and continue to develop.

Ball (1986) noted that broadcast seeding offers the advantage of being up to four times faster than conventional seeding and is of particular value for sowing large areas of winter cereals. He also observed the valuable time saving with broadcasting, especially during periods of unsettled weather when damp soil can halt conventional seeding methods.

A number of different broadcast methods have been utilized including light airplanes (Isler, 1960), and granular fertilizer applicators (Ball, 1960). Regardless of the method, Barnett and Comeau (1980) found broadcast seeding to be a viable method for early seeding of cereals in Quebec since it relieved the potential problems of a damp spring. Thus, the object of this research was to evaluate the feasibility of broadcast seeding of winter wheat in east central Saskatchewan and compare the results with conventional seeding methods.

Materials and Methods

Broadcast and conventional winter wheat seeding experiments were carried out in field trials at four locations in 1988-89 and 1989-90 in east central Saskatchewan. Five different seeding dates (July 15, August 1, August 15, September 1, and September 15) and five different seeding rates (67, 100, 134, 168, and 202 kg ha^{-1}) were investigated in trials at Clair, Porcupine Plain, and two sites near Canora. This experiment was set up as a split-plot design with dates as the main plots and rates as the sub-plots. Broadcast seeding was simulated by hand spreading the Norstar winter wheat in test plots 1.5 by 5.5 m in size. On August 1 and September 1 a phosphate coated seed (triple super phosphate) treatment was included to determine if there is a practical method of applying phosphate fertilizer with broadcast seeding.

A second experiment (methods) was set up as a randomized complete block design and was a comparison of broadcast and conventional seeding methods. It consisted of five treatments: i)broadcast seeded, ii)broadcast seeded P_2O_5 coated seed, iii)drill seeded, iv)drill seeded P_2O_5 coated seed and, v)drill seeded with seed placed 11-51-0 fertilizer. The conventional drilled-in treatments were sown on the optimum conventional seeding date (September 1) with a small plot hoe drill. The hoe drill was equipped with eight openers on 20 cm centers. Seeding rate was 100 kg ha^{-1} and seeding depth was approximately 2 cm. No P_2O_5

fertilizer was applied except for the P_2O_5 coated seed and seed placed 11-51-0 drilled-in treatments. Both coated and drilled in P_2O_5 rates were 22 kg ha^{-1}.

Plant samples were removed from the field in mid-October and the following measurements were made: Haun scale, number of plants m^{-2}, total number of tillers per plant (sum of primary and secondary tillers), crown depth, plant erectness, and individual plant dry weight.

The next spring and summer the following measurements were made: number of plants m^{-2}, total number of spikes m^{-2}, grain yield, grain test weight, kernel weight, number of kernels $spike^{-1}$, and grain protein.

An inverse polynomial equation (Fowler et al., 1989) was used to describe the relationship between seed rate and grain yield. The inverse polynomial is of the following form:

$$Y = \underline{u}SR(1-SR/\underline{s})/(SR+\underline{u}/\underline{e}) \qquad [1]$$

where Y = predicted grain yield (kg ha^{-1})
SR = seed rate (kg ha^{-1})
$\underline{u}$ = upper limit of yield (kg ha^{-1})
$\underline{e}$ = slope, or maximum response to SR at low SR (kg*kgSR^{-1})
$\underline{s}$ = yield depression, or sensitivity at high SR.

The inverse polynomial was also used to describe the relationship between seed rate and plant and spike densities since their response curves were similar to that of grain yield.

Results and Discussion

The major concern with broadcast seeding is poor seed germination and high plant mortality rates. Barnett and Comeau (1980) found that cereal seed broadcast by an airplane at 4.5 and 9 m altitude did not penetrate the soil or even granular snow. Therefore broadcast seed was exposed to weather fluctuations and to birds. Similar observations were made by Kuizenga and Hartmans (1976) in Europe. They noted that birds caused wheat crop failure by eating the uncovered, aerial sown seed.

Ball (1983) also noted the importance of covering the seed after it was broadcast. He concluded that any implement which cultivates the complete soil surface, covers most of the broadcast seed. However, this operation is unacceptable when the winter wheat is broadcast into an existing spring crop.

In the Canadian Prairies, precipitation and evaporation are the two most important environmental factors that determine if summer broadcast seeds will germinate and continue to develop. Compared to conventional seeding, broadcast seeds are usually directly exposed to sunlight, wind, evaporation and fluctuating air temperatures. However, when broadcast into an established spring crop the crop canopy should produce a microclimate that is more favorable for germination due to an increase in humidity and protection from direct sunlight and wind.

Germination of seeds is dependent upon both temperature and moisture conditions. Lafond and Fowler (1989) found air temperature differences in the 5 to 30°C range had a large influence on rate of kernel water uptake and speed of germination. As temperature increased, rate of water uptake increased and median germination time decreased.

In the present studies, winter wheat was broadcast into canola fields because they have relatively thicker canopies than most spring cereals. It was believed that a thicker canopy would provide a better environment for seed germination and seedling development. At one location, in both years, a flax field was used to compare the effect that the thinner flax canopy may have had on winter wheat germination and growth.

Daily precipitation and pan evaporation values at Clair for July, August, and September 1988 are shown in Fig. 1 to provide an example of the environmental parameters that were recorded at each location. In these studies, the majority of the summer precipitation occurred in the month of August (following the August 1 and 15 seeding dates). A dry September did not favor germination of winter wheat broadcast on the September 1 and 15 seeding dates. There was a reduction in pan evaporation as the summer progressed. This is a common occurrence in this region due to the cooler temperatures that are prevalent later on in the summer.

Fall Measurements

Plants Establishment

Both broadcast seeding date and rate had a significant ($P<0.05$) effect on the number of plants m^{-2}. Equation 1 was used to describe the relationship between broadcast seeding rates and plant densities (Table 1). Since broadcast seeding rates used in this experiment were not high enough to detect a depression in plant densities, the depression term (1-SR/s) was removed. As seeding was delayed from July 15 to August 1 to August 15 there was a significant increase in the number of plants m^{-2} (Fig. 2). This increased number of plants m^{-2} was directly related to the date that precipitation occurred. In the two years of this study, most of the precipitation occurred after the August 15 seeding date. Unlike conventional seeding, broadcast seeds can only make use of post-seeding rainfall for germination. Conventional or 'drilled-in' seeds can absorb moisture from the soil, thus timing of precipitation is not as important as it is with broadcast seeds which remain on the soil surface. In order for broadcast seeds to germinate they must receive rain after they have been broadcast (ie. post-seeding rainfall is imperative for broadcast seeds to germinate).

Plant mortality was another reason why the July 15 and August 1 broadcast seeding dates produced lower number of plants m^{-2} than did August 15 seeding date. Field observations indicated that many seeds which were broadcast on the early dates did germinate, however it was too hot and dry for them to survive and they eventually died.

For the majority of the trials, very few seeds germinated when they were broadcast on September 1 and essentially no seeds germinated when they were broadcast on September 15. Low September precipitation was responsible for these trends. Therefore, further results are only reported for the first three broadcast seeding dates in this study.

As the broadcast seeding rate was increased from 67 to 202 kg ha^{-1}, there was a significant ($P<0.01$) increase in the number of plants m^{-2} (Fig. 2). The August 1 phosphorous coated broadcast seed treatment, produced a similar number of plants m^{-2} as the uncoated broadcast Norstar seeded on the same seeding date.

In the comparison of broadcast and conventionally seeding methods, only three of the five treatments germinated. The two broadcast treatments failed to germinate at essentially all sites. This once again was due to a lack of significant rainfall events in September of both years of the experiment. These two broadcast treatments were eliminated from further analysis. There

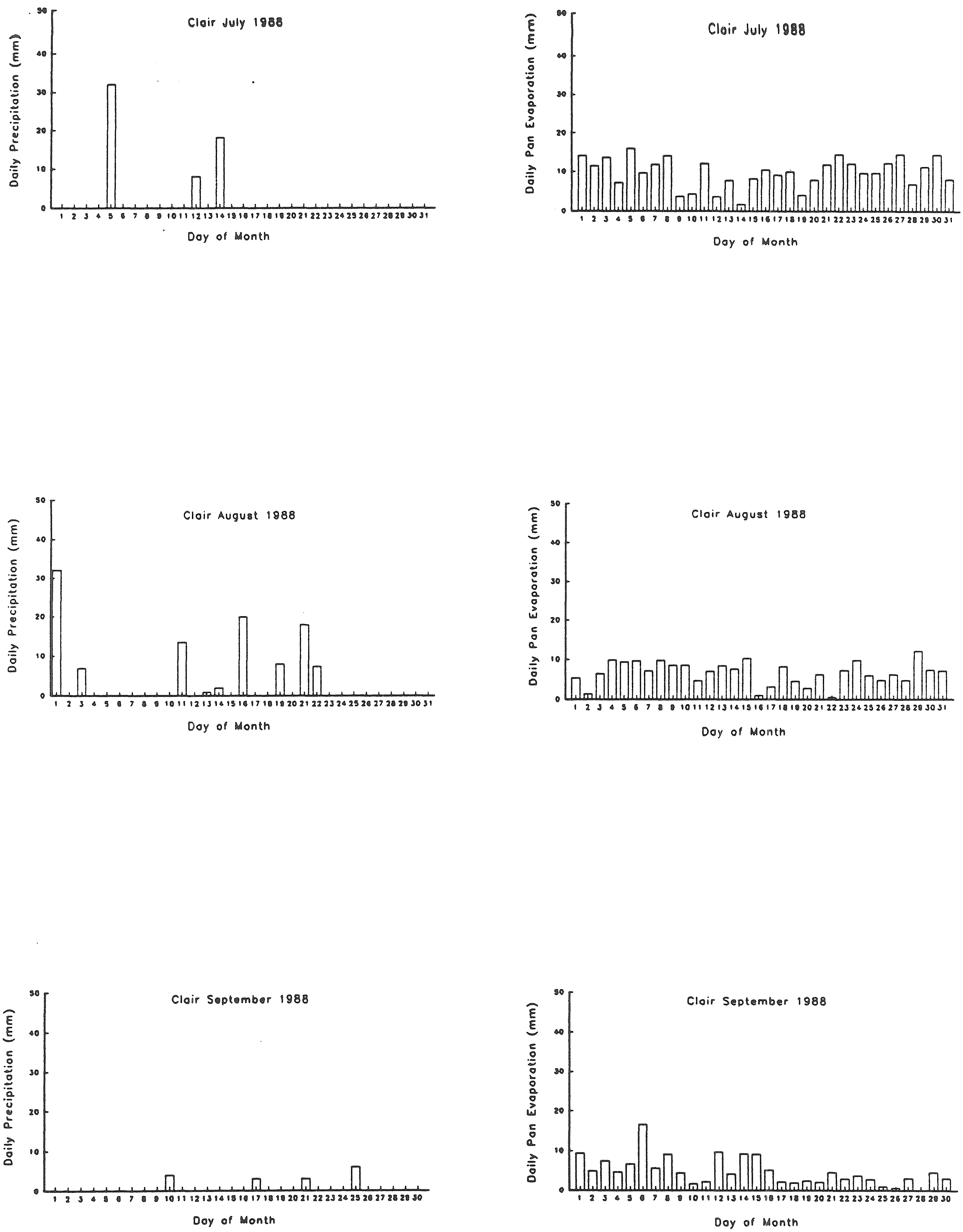

Figure 1. Daily precipitation and pan evaporation values for July, August, and September 1988 at Clair.

was a significant difference ($P<0.01$) in number of plants m^{-2} for the drill treatments (Fig. 2). Conventionally seeded P_2O_5 coated seed produced significantly fewer plants m^{-2}. The P_2O_5 coated seed had a low germination rate, and low plant densities, especially in the conventionally seeded treatments. Barnett and Comeau (1980) have also reported that broadcast seeding methods produced much lower plants m^{-2} than conventional seeding methods. They found oats and wheat had much higher plant counts when seeded by drill than by airplane.

Fall Plant Development

Haun scale is a measurement of plant leaf development. It assigns a numerical value to the leaf stage of a seedling (Haun, 1973). There was no significant ($P>0.05$) effect of either broadcast seeding date (Table 2) or seeding rate on plant development as measured by haun scale. However, there was a significant ($P<0.05$) year difference in Haun scale between years of this study. The trials seeded in 1989 were further developed than those in 1988. There were no differences between conventional seeding method treatments in plant development as measured by Haun scale. However, plants from the broadcast seeded treatments were further advanced than the conventional seeded treatments. This difference was probably because the conventional seeding date was at least two weeks later than the broadcast seeding date.

Broadcast seeding date had a significant ($P<0.05$) effect on the number of tillers per plant in the fall. The earlier the seeding date the greater the tiller number (Table 2). Number of tillers per plant for the P_2O_5 coated seed treatment was not significantly ($P>0.05$) different from the uncoated seed treatment for the August 1 seeding date. Seed placement of P_2O_5 significantly ($P<0.01$) increased the number of tillers per plant. The 11-51-0 seed placed treatment produced 1.3 tillers $plant^{-1}$ compared to less than one tiller $plant^{-1}$ for the two drill treatments which did not have the seed placed 11-51-0. Broadcast seeded treatments had a larger number of tillers $plant^{-1}$ than did the conventionally seeded treatments (Table 2). However, this was probably more of a date and stand density effect than a method of seeding effect.

Plant Erectness

Broadcast seeding date or seeding rate did not have a significant ($P>0.05$) effect on plant erectness (Table 2). However, large differences in plant erectness were observed between broadcast and conventional seeding methods. Seeds that were broadcast tended to produce plants with a prostrate growth habit and seeds that were sown with a drill produced plants with a more erect appearance. The plants from conventional seeding methods were approximately 4 cm more erect than plants from broadcast seeding.

Crown Development

Broadcast seeding date and rate were both found to not have a significant ($P>0.05$) effect on the crown depth. The three drill treatments also did not have a significant ($P>0.05$) effect on the crown depth. However, conventional seeding methods produced winter wheat plants with a larger crown than broadcast seeding methods (Table 2).

Plant Dry Weight

Date of broadcast seeding did not have significant ($P > 0.05$) effect on plant dry weight (Table 2). The later seeded (Sept. 1) conventional treatments produced plants with lower dry weights than the earlier seeded broadcast treatments.

Spring Plant Stands

In the spring, plant counts were performed to help quantify the winter survival of plants that had established in the fall. There was a significant ($P < 0.05$) year x date interaction for the plants m^{-2}. This was caused by a large increase in the plant densities for the August 15 seeding date in 1989-90. This was due to a difference in environmental conditions between the two years. Both broadcast seeding date and rate had a significant ($P < 0.01$) effect on the plant densities the following spring (Fig. 3).

The three conventionally seeded treatments had a significant ($P < 0.05$) effect on the plant densities. The drilled uncoated seed with and without seed placed P_2O_5 both had significantly ($P < 0.01$) higher plant densities than the drilled coated P_2O_5 seed treatment (Fig. 3). In all treatments, the plant densities in the spring were much lower than in the fall. In some cases the reduction in plant densities were as high as 50%. This may be partly due to the fact that many of the treatments did not receive any phosphorous fertilizer at seeding time.

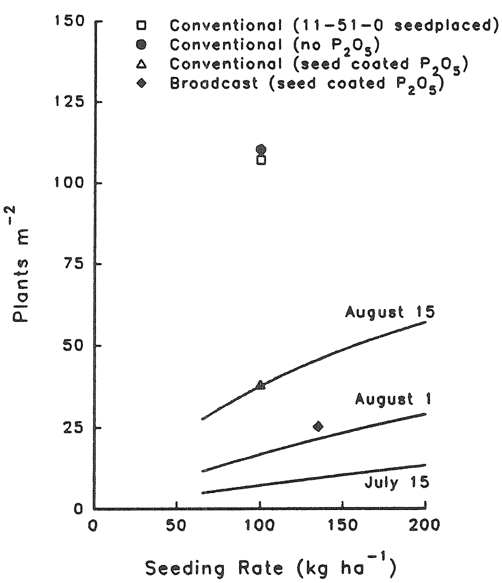

Figure 2. Fall plants m^{-2} versus seeding rate averaged over two years and four locations. (See Table 1 for polynomial coefficients).

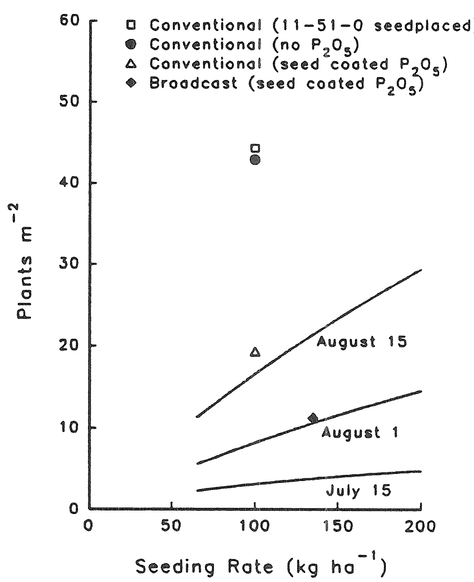

Figure 3. Spring plants m^{-2} versus seeding rate averaged over two years and four locations. (See Table 1 for polynomial coefficients).

Yield and Yield Components

Broadcast seeding rate and date were found to have a significant ($P<0.01$) effect on grain yield. As seeding rate was increased there was an increase in grain yield (Fig. 4). The August 15 seeding date produced the highest yields at all locations in both years. Broadcast seeding date and rate also had a significant ($P<0.01$) effect on the number of spikes m^{-2} (Fig. 5). Forward stepwise regression indicated that 80% of the variation in grain yield due to broadcast seeding rate could be explained by variation in the number of spikes m^{-2}. There was no increase in the predictability of grain yield when kernels $spike^{-1}$ or kernel weight were added to the analyses. Optimum broadcast seeding date (August 15) produced a smaller number of spikes m^{-2} (Fig. 6) and lower grain yields than the conventionally seeded treatments.

As broadcast seeding date was delayed from July 15 to August 15 there was a significant ($P<0.05$) increase in test weight (Fig. 7). The conventional seeded treatments produced test weights that were about 78 kg hl^{-1} compared to test weight of 77 kg hl^{-1} or less for broadcast treatments.

Conclusions

Broadcast seeding winter wheat provides grain producers with a quick, alternate method of performing their seeding operation. Broadcast seeds are more vulnerable to extreme weather conditions than are conventional sown seeds, thus germination and seedling survival are two major concerns with this production system. Broadcast seeding results in plants which exhibit a prostrate growth habit in the fall with winter survival properties as good as conventionally seeded winter wheat. Other conclusions for this study include: 1)Higher seeding rates will be required for broadcast seeding than for conventional seeding. 2)The optimum seeding date for broadcast seeding is approximately August 15 compared to September 1 for conventional seeding in northeastern Saskatchewan. 3)Post-seeding rainfall is essential for adequate stand establishment with broadcast seeding. 4)Grain yields are usually lower with broadcast compared to conventionally seeded winter wheat. 5)Low test weights may be a problem with broadcast seeding.

Acknowledgements

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Table 1. Polynomial coefficients and r^2 values for equation 1.

Parameter		u	e	s	r^2
Grain Yield (broadcast)		5013	33.5	1448	0.99
Grain Yield (conventional)		5161	104	566	0.99
Spikes m^{-2}		269	3.5	1663	0.99
Plants m^{-2} in fall	(July 15 seeding date)	76	0.1	--	0.99
	(August 1 seeding date)	105	0.2	--	0.99
	(August 15 seeding date)	119	0.6	--	0.99
Plants m^{-2} in spring	(July 15 seeding date)	10	0.1	--	0.99
	(August 1 seeding date)	64	0.1	--	0.99
	(August 15 seeding date)	129	0.2	--	0.99

Table 2. Effect of broadcast seeding date and conventional seeding treatment on haun scale, tiller number, plant erectness, crown depth, and plant dry weight.

Treatment	Haun Scale	Tillers Plant^{-1}	Plant Erectness (cm)	Crown Depth (cm)	Plant Dry Weight (g)
Broadcast Seeding					
July 15	3.79	6.35	3.62	0.15	0.250
August 1	3.87	5.31	4.00	0.12	0.211
August 15	3.99	4.38	3.96	0.09	0.139
Level of Significance	NS	*	NS	NS	NS
Conventional Seeding†					
Seedplaced 11-51-0	2.99 a‡	1.29 a	7.74 a	1.94 a	0.08 a
No P_2O_5	2.87 a	0.98 b	7.07 a	2.04 a	0.06 b
Seed coated P_2O_5	2.87 a	0.78 b	7.72 a	2.20 a	0.06 b
LSD	1.52	0.29	4.35	0.27	0.01

* Significant at 0.05 probability level.

† September 1 seeding date.

‡ Means followed by the same letter are not significantly different at p=0.05.

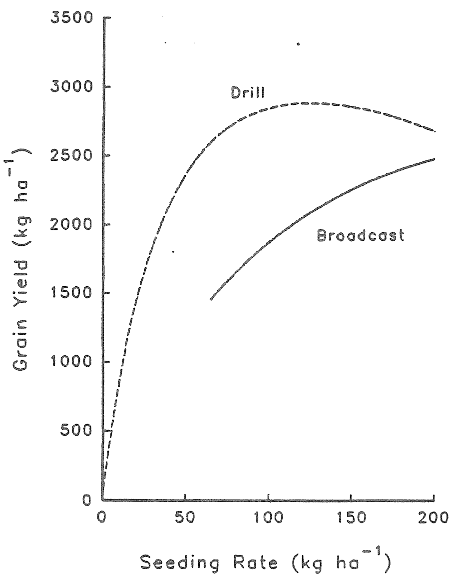

Figure 4. Grain yield versus seeding rate averaged over two years and four locations. (See Table 1 for polynomial coefficients).

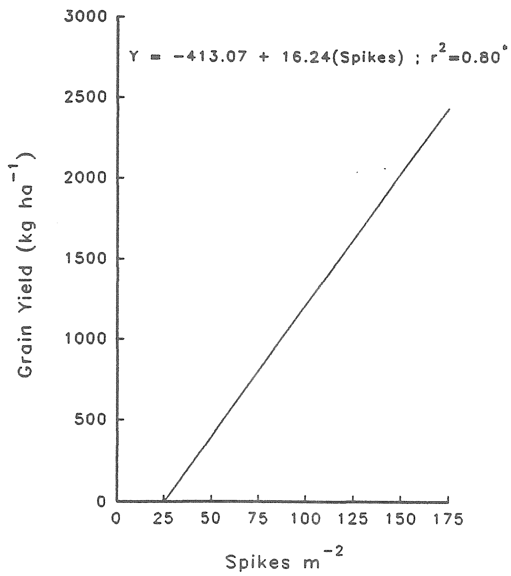

Figure 5. Grain yield versus spikes m^{-2} for broadcast seeded winter wheat on August 15.

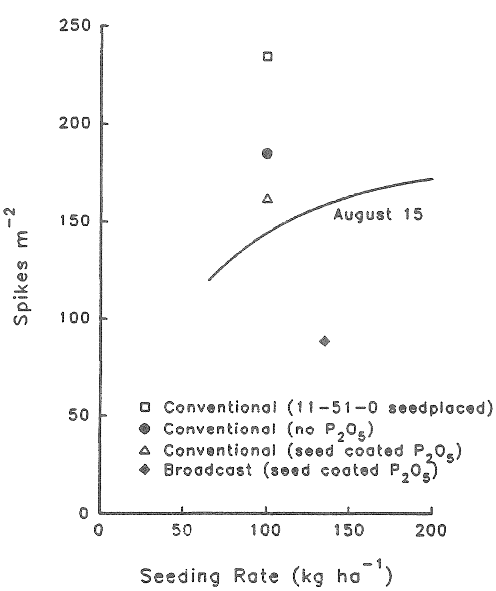

Figure 6. Spikes m^{-2} versus seeding rate for optimum seeding dates of conventional and broadcast seeding methods.

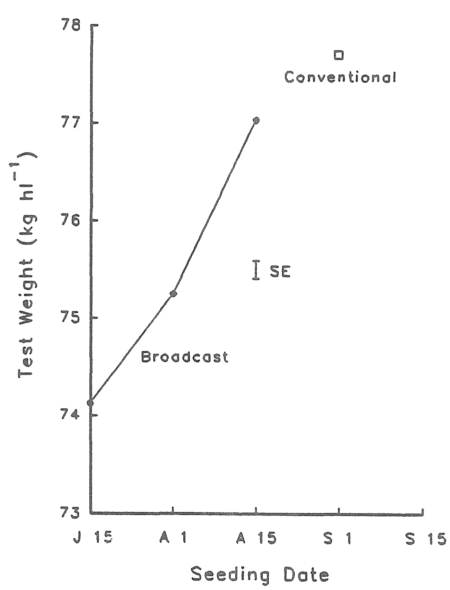

Figure 7. Grain test weight versus seeding date for broadcast and conventional seeding methods.

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