EFFECT OF SEEDING RATE AND ROW SPACING ON THE AGRONOMIC PERFORMANCE OF WINTER WHEAT

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ABSTRACT

The effect of row spacings and seed rates on the agronomic performance of "stubbled in" winter wheat (Triticum aestivum L.) were studied over a period of two years at locations in Central, Northeast and Southeast Saskatchewan.

In both years of the study there was a highly significant relationship between row spacing and yield with increased yields at narrower row spacings. The yield response to seeding rate indicated different trends in each of the two years of the study. In 1985/86 there was a highly significant relationship between seed rate and yield with increased yields at higher seed rates. In 1986/87 the relationship between seeding rate and yield was not significant. In 1985/86 higher head counts/m^2 at higher seeding rates resulted in the higher yields. In 1986/87 the head counts/m^2 were also higher at higher seeding rates however a reduction in seeds/head and/or 1000k weight counteracted the effects of the higher head populations resulting in non-significant yield differences.

INTRODUCTION

The effect of seed rate and row space on the agronomic performance of "stubbled in" winter wheat has not been extensively studied in Saskatchewan. Row spaces of 15 cm. - 17.5 cm. have been traditionally used for spring cereal production, however the introduction of the air seeder equipped with knife openers has resulted in row spaces as wide as 30 cm. Similarly little is known of the effects of seed rate and current recommendations are based on studies from the U.S.A. which may not apply to Saskatchewan environmental conditions. The objective of these studies was to evaluate the effects of row space and seeding rate on the agronomic performance of winter wheat in central, northeast and southeast Saskatchewan.

MATERIALS AND METHODS

Two separate experiments were conducted during 1985/86 and 1986/87 at Watrous, Carlyle, Clair, Porcupine Plain and Saskatoon. The first experiment consisted of treatments with row spaces of 15, 20, 30, 45 and 60 cm. at seed rates of 45 and 90 kg/ha. The second experiment consisted of treatments with seed rates of 20, 40, 60, 80, 100, and 120 kg/ha at row spaces of 15 and 30 cm. A randomized complete block design using four replicates was used at all locations.

Norstar was seeded at all sites and, in addition, Norwin, a semi-dwarf variety, was included at Clair and Porcupine Plain. Data from the Norwin variety was not included in this paper. The winter wheat was seeded at recommended dates at all sites in the 1986/87 season however, during 1985/86, four of the five sites were seeded beyond recommended dates.

All sites were direct seeded into standing stubble using an Edwards HD812 four rank hoedrill. Shanks were moved on the frame to achieve the proper row spacings and the press wheels moved to accommodate the row spacings. The seed metering system was modified by the addition of an Amazone variable speed drive to improve output accuracy. Unused seed cups were blocked when not required. Versatile knife openers were used for seed placement to minimize stubble knockdown. Phosphate was seed placed at the same rate per foot of seeded row. Overall rate of phosphate application was 29 kg/ha P_2O_5 based on 20 cm. row spacings.

Plots at all sites were sampled, prior to November 1, to determine plant population, seed depth, Haun scale, primary leaf length and oven dry weight (plant weight minus the roots and seed).

Ammonium nitrate fertilizer was broadcast at soil test recommendations, in early spring, to correct nitrogen deficiencies.

Post-emergent herbicides for broadleaf and grassy weed control were applied as required.

Head counts/m^2 were taken prior to harvest and all plots were harvested using a small plot combine.

RESULTS AND DISCUSSION

Complete winterkill occurred at the Saskatoon site in 1985/86 and partial winter injury occurred at Porcupine Plain during 1986/87. Late seeding date was a factor in the winter kill that occurred at Saskatoon however the reason for winter injury at the Porcupine Plain site was unknown. Severe stem rust at Watrous, in 1985/86 further reduced yields at that site. Due to winter injury, data was available from four sites in each of the two years of the study.

With the exception of the Carlyle site in 1985/86, all sites suffered from drought stress in both years, especially during the critical month of June. The dry weather contributed to the low average yields reported in this paper.

Visual observations indicated that weed infestations at most sites did not appear to be effected by row spacing or seeding rates. The exception to this observation occurred at Watrous in 1986/87 where green foxtail was a severe problem.

ROW SPACE

1985/86 Results

Increased row spacings resulted in yield reductions that were highly significant at all four sites in the 1985/86 crop year.

TABLE 1. Row space effects on the yield of Norstar winter wheat at four locations, 1985/86.

	Location				
Row Space (cm-kg/ha)	Watrous (kg/ha)	Carlyle (kg/ha)	Clair (kg/ha)	P.Plain (kg/ha)	Mean (kg/ha)
15-45	838	2926	1931	2089	1946 (100%)
20-45	684	3095	2118	1444	1835 (94%)
30-45	670	2731	1930	1676	1752 (90%)
45-45	407	2140	1925	1010	1371 (70%)
60-45	540	2164	1450	1210	1341 (69%)
15-90	1088	3378	2567	2163	2299 (100%)
20-90	1026	3314	2194	2175	2177 (95%)
30-90	786	3134	2068	1885	1968 (86%)
45-90	879	2800	1789	1704	1793 (78%)
60-90	724	2649	1500	1442	1579 (69%)

At all four sites, row spacing had a highly significant effect on yields with a trend towards increased yields at narrower row spacings. Recent studies in northern Saskatchewan (Brant et al., 1987) with both winter and spring wheat support this finding. This trend was apparent at both the 45 kg/ha and 90 kg/ha seed rates. With the exception of one treatment, at one site, all 90 kg/ha treatments outyielded their corresponding 45 kg/ha treatments.

TABLE 2. Plant populations, yield components and grain yield at five row spaces 1985/86 (means from four locations).

Row Space (cm-kg/ha)	Plants /m²	Heads /m²	Grain no. (1000/m²)	Yield (kg/ha)
15-45	93 (100%)	248 (100%)	6.84(100%)	1946 (100%)
20-45	122 (131%)	247 (100%)	6.37 (93%)	1835 (94%)
30-45	114 (123%)	199 (80%)	6.07 (89%)	1752 (90%)
45-45	104 (112%)	178 (72%)	4.81 (70%)	1371 (70%)
60-45	103 (111%)	155 (62%)	4.67 (68%)	1341 (69%)
15-90	236 (100%)	315 (100%)	7.93(100%)	2299 (100%)
20-90	252 (106%)	298 (95%)	7.66 (97%)	2177 (95%)
30-90	207 (88%)	245 (78%)	6.74 (85%)	1968 (86%)
45-90	217 (92%)	266 (84%)	6.38 (81%)	1793 (78%)
60-90	184 (78%)	225 (71%)	5.53 (70%)	1579 (69%)

Plant counts taken in the fall indicated higher plant populations at the 90 kg/ha seed rate compared to the 45 kg/ha rate with a trend towards lower plant populations at wider row spacings. The trend towards lower plant populations was more pronounced at the 90 kg/ha seed rates due to the greater competition among the plants as compared to the lower seed rate. Wider row spaces result in reduced distances between adjacent plants and this competition resulted in lower plant populations. Similarly there was a trend toward reduced heads/m² as the row space increased. The percent reduction in heads/m² was larger than the reduction in seedling establishment as the tillers were lost at a greater rate than the seedlings due to greater competition among the tillers as compared to the seedlings.

During the 1985/86 growing season the main reason for the yield differences among the row spaces was due to the heads/m2 yield component as the 1000k weights and seeds/spike were relatively constant.

1986/87 Results

Increased row spaces resulted in yield reductions that were highly significant at three of four sites in the 1986/87 crop year.

TABLE 3. Row space effects on the yield of Norstar winter wheat at four locations, 1986/87.

	Location				
Row Space (cm-kg/ha)	Watrous (kg/ha)	Carlyle (kg/ha)	Clair (kg/ha)	Saskatoon (kg/ha)	Mean (kg/ha)
15-45	895	1914	2611	1787	1793 (100%)
20-45	820	1706	2145	1189	1465 (82%)
30-45	1002	1828	2343	1560	1683 (94%)
45-45	1063	1991	2335	1443	1708 (95%)
60-45	776	1369	2060	1079	1319 (74%)
15-90	1324	2363	2541	1648	1974 (100%)
20-90	1125	1947	2472	1471	1754 (89%)
30-90	1192	1902	2108	1219	1605 (81%)
45-90	1107	1756	2003	1765	1658 (84%)
60-90	881	1420	1833	941	1268 (64%)

At three of four sites, row space had a highly significant effect on yield with a trend towards increased yields at narrower row spacings. The only exception to the trend towards reduced yield, as row spaces were increased, was the 20 cm row space at the 45 kg/ha seed rate. The low yield for the 20 cm-45 kg/ha treatment was the result of low yield for this treatment at three of four sites in 1986/87. This unexpected result did not occur at the 90 kg/ha seed rate so it is possible that the results from the 20 cm (45 kg/ha) treatment were atypical.

TABLE 4. Plant population, yield components and grain yield at five row spaces 1986/87 (means from four locations).

Row Space (cm-kg/ha)	Plants /m²	Heads /m²	Grain no. (1000/m²)	Yield (kg/ha)
15-45	124 (100%)	283 (100%)	5.43 (100%)	1793 (100%)
20-45	112 (90%)	215 (76%)	4.51 (83%)	1465 (82%)
30-45	114 (92%)	238 (84%)	5.14 (95%)	1683 (94%)
45-45	110 (89%)	178 (63%)	5.23 (96%)	1709 (95%)
60-45	96 (77%)	159 (56%)	3.99 (73%)	1319 (74%)
15-90	214 (100%)	339 (100%)	6.17 (100%)	1974 (100%)
20-90	191 (89%)	277 (82%)	5.60 (91%)	1754 (89%)
30-90	183 (86%)	246 (73%)	5.14 (83%)	1605 (81%)
45-90	192 (90%)	226 (67%)	5.22 (85%)	1658 (84%)
60-90	160 (75%)	186 (55%)	4.07 (66%)	1268 (64%)

Plant counts taken in the fall indicated higher plant populations at the 90 kg/ha seed rate compared to the 45 kg/ha rate. The difference among seedling plant populations was small among the 20, 30 and 45 cm row spaces with larger differences between the 15 and 20 cm spaces and between the 45 and 60 cm spaces. That trend was similar at both seed rates.

Head counts taken prior to harvest indicated a different trend compared to the seedling plant populations. The heads/m² data indicated a trend toward reduced head populations with wider row spaces. Fewer tillers were able to compete for the available space in the wider rows so competition would account for the reduced head populations at the wider seed rates.

During the 1986/87 growing season the main reason for the yield differences among the row spaces was due to the grain no. yield component. Grain no. is the product of the heads/m² and seeds/head yield components and both of those components were factors in determining grain yield. Within each seed rate the 1000k weights were constant, so that 1000k weight did not contribute to the yield differences.

Combined Results 1985/86 and 1986/87

TABLE 5. Average yield of Norstar using five row spaces at four locations in 1985/86 and 1986/87.

Row Space (cm-kg/ha)	Yield (kg/ha) 1985/86	1986/87	mean
15-45	1946	1793	1870 (100%)
20-45	1835	1465	1650 (88%)
30-45	1752	1683	1718 (92%)
45-45	1371	1709	1540 (82%)
60-45	1341	1319	1435 (77%)
15-90	2299	1974	2137 (100%)
20-90	2177	1754	1967 (92%)
30-90	1968	1605	1787 (84%)
45-90	1793	1658	1726 (81%)
60-90	1579	1268	1424 (67%)

When the row space data from 1985/86 and 1986/87 were combined, the effect of row space on yield was highly significant with lower yields resulting from wider row spaces. The only exception to the trend towards reduced yield, as row spaces were increased, was the 20 cm row space at the 45 kg/ha seed rate. The low yield for this treatment was the result of low yield for this treatment at three of four sites in 1986/87. This unexpected result did not occur at the 90 kg/ha seed rate or in 1985/86 so it is possible that the results from the 20 cm (45 kg/ha) treatment may be atypical.

Narrow row spaces resulted in increased seedling plant populations which in turn resulted in higher heads/m². The higher heads/m² resulted in high seeds/m² as the seeds/head component did not decline in proportion to the increase in heads/m². High seeds/m² resulted in increased yields, as row space narrowed, as the 1000k weights remained constant within each seed rate.

The results from this study indicate that narrower row spaces result in higher yields of "stubbled in" Norstar winter wheat.

SEED RATE

1985/86 Results

In 1985/86, higher seed rates resulted in yield increases that were highly significant in three of four sites.

TABLE 6. Seed rate effects on the yield of Norstar winter wheat at four locations, 1985/86.

	Location				
Seed Rate (kg/ha-cm)	Watrous (kg/ha)	Carlyle (kg/ha)	Clair (kg/ha)	P.Plain (kg/ha)	Mean (kg/ha)
20-15	251	2059	1387	1430	1282 (49%)
40-15	541	2403	1370	2303	1654 (63%)
60-15	668	2723	2353	2343	2022 (78%)
80-15	905	3010	2545	2301	2190 (84%)
100-15	884	3377	2230	2617	2267 (87%)
120-15	886	3775	3052	2727	2610 (100%)
20-30	223	2083	1458	1213	1244 (54%)
40-30	440	2797	2040	1657	1734 (75%)
60-30	501	3064	2320	1725	1902 (83%)
80-30	562	3249	2308	2593	2178 (95%)
100-30	789	3668	2519	2131	2277 (99%)
120-30	825	3613	2387	2396	2305 (100%)

With the exception of Clair, seed rate had a highly significant effect on yields with a trend towards increased yields at higher seed rates. This trend was evident at both row spacings, however average yields were higher for the 15 cm row spaces as compared to the 30 cm treatments at four of the six seed rates.

TABLE 7. Plant population, yield components and grain yield at six seed rates and two row spaces 1985/86 (means from four locations).

Seed Rate (kg/ha-cm)	Plants $/m^2$	Heads $/m^2$	Grain no. $(1000/m^2)$	Yield (kg/ha)
20-15	88 (27%)	192 (51%)	4.57 (50%)	1282 (49%)
40-15	129 (40%)	232 (61%)	5.89 (65%)	1654 (63%)
60-15	189 (59%)	278 (74%)	7.17 (79%)	2022 (77%)
80-15	218 (67%)	298 (79%)	7.96 (87%)	2190 (84%)
100-15	253 (78%)	332 (88%)	7.90 (87%)	2267 (87%)
120-15	323(100%)	376(100%)	9.10(100%)	2610 (100%)
20-30	61 (22%)	149 (44%)	4.34 (54%)	1244 (54%)
40-30	97 (35%)	209 (62%)	6.17 (77%)	1734 (75%)
60-30	140 (50%)	248 (73%)	6.67 (83%)	1902 (83%)
80-30	230 (83%)	283 (83%)	7.64 (96%)	2178 (94%)
100-30	232 (83%)	307 (91%)	7.83 (98%)	2277 (99%)
120-30	278(100%)	339(100%)	8.00(100%)	2305 (100%)

Seedling plant population increased significantly with seeding rate but not in direct proportion to the seed rate. Plant competition in the rows reduced the number of surviving plants, particularly at the higher seeding rates where only a small fraction of the seed became established. Heads/m^2 also increased with the seeding rate, however the percent increase was much smaller than the percent increase in seedlings/m^2. Tillering, particularly at the lower seed rates, partially compensated for the low plant populations however large differences in plant populations still occurred due to differences in seeding rates.

During the 1985/86 growing season the main reason for the yield differences among the seed rates was due to the heads/m^2 yield component as the 1000k and seeds/head remained relatively constant at the different seed rates.

1986/87 Results

In 1986/87 seeding rate resulted in significant yield differences in only one of four locations.

TABLE 8. Seed rate effects on the yield of Norstar winter wheat at four locations, 1986/87.

Seed Rate (kg/ha-cm)	Location: Watrous (kg/ha)	Carlyle (kg/ha)	Clair (kg/ha)	Saskatoon (kg/ha)	Mean (kg/ha)
20-15	474	1725	2509	822	1383 (89%)
40-15	525	2051	2110	1068	1439 (92%)
60-15	465	2270	2283	1271	1572 (101%)
80-15	671	2238	2292	1198	1600 (103%)
100-15	908	1752	2296	1292	1562 (100%)
120-15	523	2145	2024	1531	1556 (100%)
20-30	263	1933	2201	954	1338 (95%)
40-30	664	2082	1944	1143	1458 (103%)
60-30	717	1994	2012	964	1422 (101%)
80-30	707	2037	2161	1202	1527 (108%)
100-30	498	2107	1843	1002	1363 (96%)
120-30	594	2102	1881	1074	1413 (100%)

The effect of seed rate on yield was not significant at three of four locations in 1986/87. With the exception of one treatment, average yields were higher for the 15 cm treatments as compared to their corresponding 30 cm treatments. At Watrous seed rate resulted in a highly significant effect on yield, however winter injury and weed competition may have effected the yields at this site.

TABLE 9. Plant population, yield components and grain yield at six seed rates and two row spaces 1986/87 (means from four locations).

Seed Rate (kg/ha-cm)	Plants /m²	Heads /m²	Grain no. (1000/m²)	Yield (kg/ha)
20-15	99 (37%)	194 (68%)	4.25 (83%)	1383 (89%)
40-15	120 (45%)	208 (73%)	4.53 (88%)	1439 (92%)
60-15	168 (63%)	234 (82%)	4.89 (95%)	1572 (101%)
80-15	209 (78%)	244 (85%)	5.17 (101%)	1600 (103%)
100-15	257 (96%)	265 (92%)	5.11 (99%)	1562 (100%)
120-15	269 (100%)	287 (100%)	5.14 (100%)	1556 (100%)
20-30	61 (25%)	140 (56%)	4.12 (85%)	1338 (95%)
40-30	97 (40%)	180 (72%)	4.52 (94%)	1458 (103%)
60-30	147 (61%)	209 (84%)	4.56 (94%)	1422 (101%)
80-30	176 (73%)	229 (92%)	4.95 (102%)	1527 (108%)
100-30	207 (86%)	245 (98%)	4.35 (94%)	1363 (96%)
120-30	242 (100%)	250 (100%)	4.83 (100%)	1413 (100%)

Seedling plant population increased significantly with seeding rate but not in direct proportion to the seed rate. Plant competition in the rows reduced the number of surviving plants, particularly at the higher seeding rates where only a small fraction of the seed became established. Heads/m² also increased with the seeding rate, however the percent increase was much smaller than the percent increase in seedlings/m². Tillering, particularly at the lower seed rates, partially compensated for the low plant populations however large differences in plant populations still occurred due to differences in seeding rates.

Heads/m² were lower at every seed rate in 1986/87 compared to the corresponding seed rates in 1985/86. The difference in heads/m² contributed to lower yields in 1986/87, especially at higher seed rates. In addition to lower heads/m² in 1986/87, the seeds/head and 1000k weights both declined at higher seed rates. the combination of these components resulted in non-significant yield differences due to changes in seed rate.

Combined Results 1985/86 and 1986/87

TABLE 10. Average yield of Norstar using five seed rates at four locations in 1985/86 and 1986/87.

Seed Rate	Yield (kg/ha)		
(kg/ha-cm)	1985/86	1986/87	mean
20-15	1282	1383	1332 (64%)
40-15	1654	1439	1547 (74%)
60-15	2022	1572	1797 (86%)
80-15	2190	1600	1895 (91%)
100-15	2267	1562	1915 (92%)
120-15	2610	1556	2083 (100%)
20-30	1244	1338	1291 (69%)
40-30	1734	1458	1596 (86%)
60-30	1902	1422	1662 (89%)
80-30	2178	1527	1853 (100%)
100-30	2277	1363	1820 (98%)
120-30	2305	1413	1859 (100%)

Yield differences were highly significant in 1985/86 but were not significant in 1986/87. The difference in yield response in the two years occurred due to differences in the yield components. In 1985/86 the heads/m² increased with increased seeding rate while the seeds/spike and 1000k weights, at the 15 cm row space remained constant. As a result, grain yield increased with heads/m² increases. At the 30 cm row space, heads/m² increased with increasing seed rate while seeds/spike declined and 1000k weights remained constant. The decline in seeds/head was not large enough to compensate for increased heads/m² resulting in increased grain yield. In 1986/87 the heads/m² yield component also increased with increased seeding rate however that yield component was counterbalanced by reductions in seeds/spike and reduced 1000k weights. This resulted in non-significant yield differences due to seeding rate.

Different growing season environmental conditions in 1985/86 compared to 1986/87 were the cause of the different trends with respect to the 1000k weights and heads/m^2. Stress conditions during 1986/87 lasted longer than in 1985/86 and reduced the seeds/head and 1000k weights which resulted in non-significant yield responses to seeding rate.

It is difficult to speculate which year produced the "normal" yield response to seed rate as both years were atypical with respect to weather conditions. In both years the general yield trend was to higher yields at increasing seed rates up to 80 kg/ha and even during 1986/87 yields dropped off very little at higher seed rates. Under low stress conditions higher seed rates resulted in significantly higher yields while high stress resulted in non-significant yield differences. As the yield penalty for higher seed rates is small, even under stress conditions, seed rates above 80 kg/ha appear to be justified.

CONCLUSIONS

The results of this study indicate that decreasing row spaces result in higher grain yields. The main reason for the higher yield was higher heads/m^2 at the narrow row spaces. The average difference in yield between the 15 and 20 cm row spaces was 8% at the 90 kg/ha seed rate and 12% at the 45 kg/ha seed rate. Yield differences of that magnitude may be sufficient to justify purchase of 15 cm row space seeding equipment for the production of "stubbled in" winter wheat.

The seeding rate experiment resulted in different yield trends in each year of the study as the effect of seed rate on yield was highly significant in one year and non-significant in the second year. Environmental stress was longer lasting during 1986/87 compared to 1985/86 and this stress factor was the determining factor in reducing yield differences. During the high stress year, yields did not decline at higher seeding rates, therefore seeding rates above 80 kg/ha may be justified as there are potential yield gains at higher seed rates under low stress conditions.

These studies suggest that narrow row spacings with seed rates of 80 kg/ha or higher should produce maximum yields of Norstar winter wheat.

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