Semi-Dwarf Durum Response to Planting Rate in Northeastern North Dakota

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Durum wheat *(Triticum durum desf.)* is a major small grain crop in northeastern North Dakota. The establishment of plant stands that ensure optimum yields are critical to successful durum production.

Several studies evaluating wheat response to planting rate have been conducted in environments where yield levels have been generally 35 bushels per acre or less. Young and Bauer (12) found a seeding rate of 80 pounds per acre yielded 5.6 bushels per acre more than a 40-pound-per-acre planting rate in east central North Dakota. Test weight was higher and days to maturity and weed populations were lower at the higher planting rate. Work done by Pelton (8) in southwestern Saskatchewan over an eight-year period found that when weeds, insects, and diseases were chemically controlled in hard red spring wheat, low seeding rates of 0.33 and 0.67 bushels per acre produced significantly higher yields than seeding rates of 1.0 and 1.5 bushels per acre. This was especially true in years with severe moisture stress and yield levels less than 20 bushels per acre.

Read and Warder (10) reported that planting durum at 0.6 bushels per acre on fallow and 0.9 bushels per acre on stubble ground was required for maximum yields in Saskatchewan. Riveland et. al. (11) studied hard red spring and durum wheat response to planting rates at Minot, Dickinson, and Williston, North Dakota. They found that both hard red spring wheat and durum maximized yields most consistently at a planting rate of one million plants per acre. They also noted that the average percent emergence for the 0.5, 1.0, and 1.5 million seeds per acre planting rates were 84, 81, and 77 percent, respectively.

Studies evaluating wheat response to planting rates in environments where yield levels have been 50 bushels per acre or greater have also been conducted. Baker (1) reported that across nine locations observed in Saskatchewan the optimum hard red spring wheat yield occurred at 40 plants per square foot or approximately 2.1 bushels per acre. Hoag and Thompson (3) reported that over a five-year period Cando durum (a semi-dwarf) produced optimum yields at a 2.0 million seeds per acre planting rate at Minot, North Dakota. Hoag (4) also examined Lloyd (a semi-dwarf) and Renville (a standard height) durum varieties at 0.5, 1.0, 1.5, and 2.0 million seeds per acre planting rates in 1990. Optimum yields for Lloyd and Renville occurred at 2.0 and 1.5 million seeds per acre, respectively. Lodging occurred only in Renville with the 2.0 million seeds per acre planting rate being the most severe. Average percent emergence for the 0.5, 1.0, 1.5, and 2.0 million seeds per acre planting rate were 81, 64, 69, and 66 percent, respectively.

Seeding rate studies conducted on two irrigated durum varieties in Arizona (6) revealed that the optimum yield occurred at seeding rates from 41-48 plants per square foot (3.1 to 4.0 bushels per acre) depending on the variety. Research conducted at an irrigated semi-arid environment in California (9) indicated that yield of tall durum varieties increased with each increment of seeding rate ranging from 5 to 31 plants per square foot.

Drummond (2) conducted planting rate studies in 12-inch spaced rows on Wells durum in 1963 and 1964 across several sites in North Dakota. Yields increased with increases in seeding rates up to 28 seeds per square foot at all locations but Langdon. There was no significant differences in yield, at Langdon or across locations, between 28, 35, or 41 seeds per square foot. Yields at Langdon in 1964 may have been reduced due to severe lodging. Yield levels in the study ranged from 35 to 50 bushels per acre. Percent emergence averaged over seeding rates was 79 percent in 1963 and 80 percent in 1964.

Many of the studies on wheat response to planting rates have focused on hard red spring wheat or standard height durum varieties. Many also fail to take into account the effect of percent emergence on final stand establishment. The objectives of this study were to evaluate planting rate effects on yield and other agronomic traits of semi-dwarf durum and study the relationship between the established plant population and yield to determine the minimum number of plants per square foot needed to obtain maximum yields of semi-dwarf durum in the high yield environment of northeastern North Dakota.

Table 1. 'Cando' durum planting rates for trials conducted in northeastern North Dakota in 1985, 1986 and 1991.

Planting Rate[1]					
Million seeds/a	Live seeds/ft²	1985-1986 lbs/a	1985-1986 bu/a	1991 lbs/a	1991 bu/a
0.5	11	45	0.8	51	0.9
1.0	23	90	1.5	102	1.7
1.5	34	135	2.3	153	2.6
2.0	46	180	3.0	204	3.4

[1]Planting rate adjusted for percent germination and seed size.
Thousand kernel weight = 41 grams for 1985-1986 (11,000 seeds per pound) and 40 grams for 1991 (11,350 seeds per pound).

Table 2. Soil series and their classifications for trial locations in 1985, 1986, and 1991.

Soil Series	Location	Year	Classification
Bearden silt loam	Park River	1985	Fine-silty, mixed frigid Aeric Calciaquolls
	Cavalier	1991	
Embden fine sandy loam	Walhalla	1985	Coarse-loamy, mixed, Pachic Udic Haploborolls
Emrick loam	Lakota	1985	
	Tolna	1986	
Glyndon loam	Cando	1986	Coarse-silty, frigid Aeric Calciaquolls
	Park River	1986	
Heimdal loam	Garske	1985	Coarse-loamy, mixed, Udic Haploborolls
Svea loam	Langdon	1985	Fine-loamy, mixed, Pachic Udic Haploborolls
	Rock Lake	1985	
	Langdon	1986	
	Tolna	1991	
	Langdon	1991	
Gardena silt loam	Park River	1991	Coarse-silty, mixed, Pachic Udic Haploborolls
Overly silt loam	Devils Lake	1991	Fine-silty, mixed Pachic Udic Haploborolls

Methods and Materials

Trials were located across northeastern North Dakota at six locations in 1985 and 1991 and five locations in 1986. Trials were grown near Cavalier, Walhalla, Park River, Lakota, Tolna, Rock Lake, Cando, and at the Langdon Research Center.

Trials were planted with a plot seeder in a randomized complete block design replicated four times. Depth bands on double disk openers regulated seed depth at 1½ to 2 inches. Seven 6-inch spaced rows 16 feet long were harvested for grain yield. Planting rates for the trials are given in Table 1. Stands counts were taken after emergence to determine established plant population and percent emergence at all locations except at Langdon in 1985 and Cando and Tolna in 1986. Two random 1-yard lengths were counted in each plot. Carboxin + Thiram treated foundation grade Cando durum seed was used in all trials. The thousand kernel weight of the durum seed was 40 grams (11,000 seeds per pound) in 1985-1986 and 41 grams (11,350 seeds per pound) in 1991. Cando is considered a small seeded durum cultivar, so the seed used for this study would be considered large.

The average planting date was May 3 for the 1985 and 1991 trials and May 12 for 1986 trials. Fertility was adequate for a yield goal of 60 bushels per acre or greater at all locations. Soil series and their classifications are listed in Table 2. Weeds were controlled by the use of herbicides and hand weeding. The plots were harvested with a small plot combine. Samples were dried, cleaned, and weighed for grain yield and test wight. Results from the three-year study were analyzed by treating individual location and years as separate environments.

Table 3. Climatological data for May through August of 1985, 1986, and 1991 growing seasons at 17 environments across northeastern North Dakota.[1]

Location	1985 Precip. (in.)	1985 Avg. Temp. (F°)	1986 Precip. (in.)	1986 Avg. Temp. (F°)	1991 Precip. (in.)	1991 Avg. Temp (F°)
Langdon	16.20	58.6	12.29	60.9	13.54	63.0
Walhalla	14.03	59.7	—	—	—	—
Cavalier	—	—	10.84	62.6	12.71	65.0
Park River	11.82	63.9	12.14	66.0	17.52	67.3
Lakota	12.41	61.3	—	—	—	—
Tolna	—	—	10.20	64.3	14.62	65.7
Garske	9.07	62.1	—	—	—	—
Cando	—	—	9.12	63.4	13.63	64.6
Rock Lake	13.45	59.6	—	—	—	—
Devils Lake	—	—	—	—	17.39	66.1

[1]Climatological data of North Dakota 1985, 1986, and 1991. National Oceanic and Atmospheric Administration. Precipitation and temperature obtained from the nearest reporting station to each location.

Results and Discussion

Temperature averages and precipitation totals for each location are given in Table 3. The 1985 growing season was cool and wet across northeastern North Dakota, which was excellent for durum development. The cooler than normal temperatures slowed disease development until the later durum growth stages when effects on yield were minimal. Seedbed moisture was limited at planting time in all locations, except at Walhalla and Park River. The lower moisture locations had lower percent emergence.

The 1986 growing season began with high temperatures and little precipitation in late May. This dried out seedbeds and caused spotty emergence, especially at Tolna and Cavalier. Precipitation amounts across northeastern North Dakota were quite variable in June with only Langdon receiving normal amounts. Frequent rains and heavy dews in July created an ideal environment for durum disease development. Tanspot *(Pyrenophora tritici-repentis)* Septoria leaf blotch *(Septoria tritici)*, septoria glume blotch *(Septoria nodorum)*, and scab *(Fusarium graminearum)* were the prevalent diseases which resulted in yield losses in the trials. The average yield across environments in 1986 was 28 bushels per acre lower than in 1985. Most of that difference was attributed to disease.

The 1991 growing season started with excellent seedbed moisture. Above normal precipitation amounts were quite general over northeastern North Dakota in June and July. Frequent rainfall and heavy dews created an ideal environment for disease development. Tanspot and scab were the prevalent diseases and were especially evident at the Devils Lake and Langdon locations.

Agronomic Characteristics

Planting rate effect on plant height and days to head from planting are given in Table 4. There was no difference in plant height response to planting rate averaged across 17 environments. The effect of planting rate on days to head from planting averaged across seven environments was significant. The number of days to head from planting was highest at the lowest planting rate and decreased with increasing planting rates.

A combined analysis of 1985, 1986, and 1991 data revealed a significant environment by planting rate interaction for yield and test weight. This was due to high levels of disease incidence across environments in 1986. Because of this, 1985 and 1991 data are analyzed together and the 1986 data is analyzed separately.

A significant test weight response to planting rate was observed across the 12 environments in 1985 and 1991 (Table 5). The 0.5 million seeds per acre planting rate had a significantly lower test weight compared to the 1.0, 1.5 and 2.0 million seeds per acre planting rates. No significant differences among the three higher planting rates were noted. This same general response of test weight to planting rate was also observed by Hoag (4).

Test weight response to planting rate varied across and within environments in 1986 mainly due to the effects of the head diseases scab and septoria glume blotch. When averaged across the five environments the 0.5 million seeds per acre planting rate had the lowest test weight and the 2.0 million seeds per acre planting rate had the highest test weight.

Planting rate effects on yield were significant across the 12 environments studied in 1985 and 1991 (Table 6). The 2.0 million seeds per acre planting rate had the highest yield but it was not significantly different from the 1.5 million seeds per acre planting rate.

Table 4. Planting rate effect on days to head and plant height of durum across several environments during the 1985, 1986, and 1991 growing seasons in northeastern North Dakota.

Planting Rate	Plant Height (17 location avg.)	Days to head from planting (7 location avg.)
Million seeds/a	inches	
0.5	29.3	64.0
1.0	29.7	63.2
1.5	29.3	62.5
2.0	29.2	62.2
LSD 5%	NS	0.4

Table 5. Planting rate effect on 'Cando' durum test weight during the 1985, 1986, and 1991 growing seasons in northeastern North Dakota.

Planting Rate	1985 and 1991[1]	1986 Langdon	1986 Cavalier	1986 Park River	1986 Tolna	1986 Cando	1986 mean
Million seeds/a	bu/a						
0.5	58.9	55.3	56.3	57.1	51.6	57.4	55.5
1.0	59.4	57.0	54.9	57.4	53.3	58.5	56.2
1.5	59.7	57.0	57.3	56.8	53.3	58.3	56.5
2.0	59.7	57.8	56.6	57.1	54.8	58.3	56.9
LSD 5%	0.4	3.3[2]		2.3[3]			NA[4]

[1]Average of 12 environments
[2]LSD 5% for Langdon only
[3]LSD 5% for environment by planting rate
[4]NA — LSD 5% not valid for mean values

Table 6. Planting rate effect on 'Cando' durum yield during the 1985, 1986, and 1991 growing seasons in northeastern North Dakota.

Planting Rate	1985 and 1991[1]	1986 Langdon	1986 Cavalier	1986 Park River	1986 Tolna	1986 Cando	1986 mean
Million seeds/a	bu/a						
0.5	51.4	45.9	39.1	48.7	29.2	28.7	38.3
1.0	56.9	50.9	36.0	54.9	30.5	33.5	41.2
1.5	59.7	45.9	45.6	56.2	31.8	32.5	42.4
2.0	60.8	45.9	45.6	57.2	30.3	31.3	42.9
LSD 5%	1.8			7.9[2]			NA[3]

[1]Average of 12 environments
[2]LSD 5% for environment by planting rate
[3]NA — LSD 5% not valid for mean values

The 0.5 and 1.0 million seeds per acre planting rate were significantly different from one another and the two higher planting rates.

Yield response to planting rates in 1986 varied across and within environments. The highest yield occurred at the 1.0 million seeds per acre planting rate at Langdon and Cando while the highest yield at the remaining environments occurred either at the 1.5 or 2.0 million seeds per acre planting rate. These variations in yield response to planting rate were, like test weight, attributed to varying disease pressures at each environment. When averaged across the five environments in 1986, the lowest and the highest yield was at the 0.5 and 2.0 million seeds per acre planting rate, respectively, similar to the 1985 and 1991 trials.

The relationship between established plant population and yield were analyzed to determine the number of plants per square foot needed to obtain optimum yields with semi-dwarf durums. Only nine of the 14 environments where stand counts were taken were used in the analysis to remove high disease locations. The average test weight at the nine sites was 58.0 pounds per bushel or greater. The optimum yield, across nine environments, occurred at an established plant population of 39 plants per square foot (1.7 million plants per acre) (Figure 1). There was no statistical difference in yield, however, between 27 and 50 plants per square foot (1.17 and 2.17 million plants per acre). This suggests that the minimum established plant population needed to obtain optimum yields for semi-dwarf durum, in high yield environments, is 27 plants per square foot. No significant yield benefits were obtained with higher established plant populations.

Stand Establishment

The goal of a producer when selecting a planting rate is to establish a desired target plant population. Percent emergence can have a dramatic affect on final plant population. Predicting percent

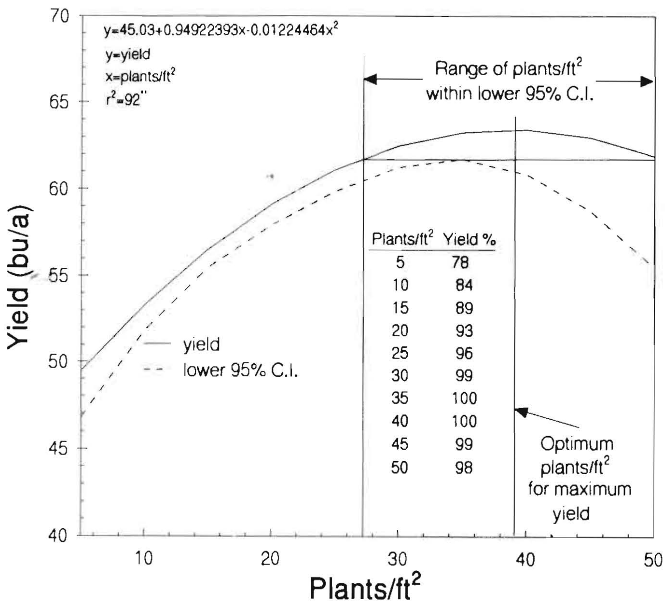

Figure 1. Relationship between plants/ft² and yield of 'Cando' durum averaged across nine environments in northeastern North Dakota in 1985 and 1991, excluding high disease environments.

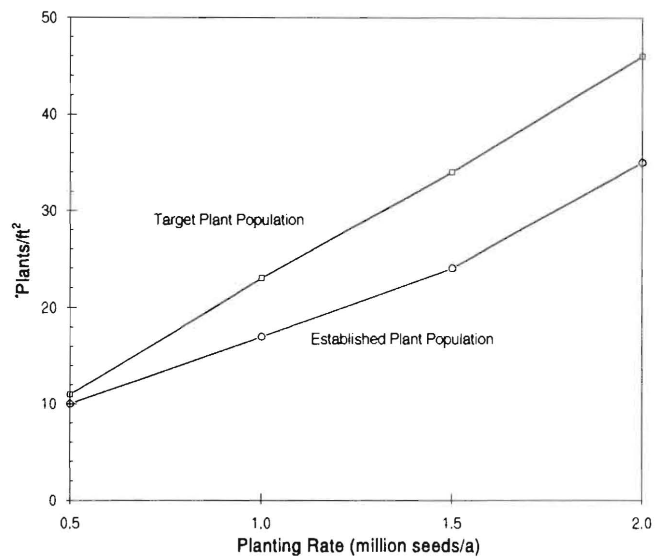

Figure 2. Relationship between target and established plant population of 'Cando' durum averaged across 14 environments in northeastern North Dakota in 1985, 1986, and 1991.

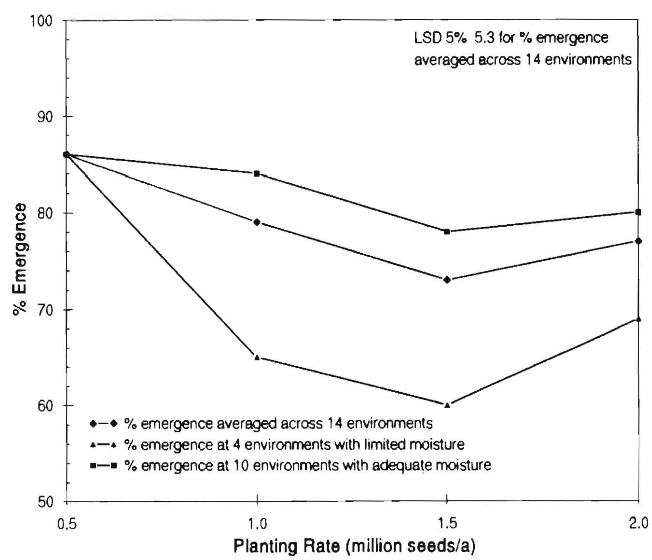

Figure 3. Percentage emergence of 'Cando' durum across 14 environments in northeastern North Dakota in 1985, 1986, and 1991.

emergence is virtually impossible because of the many factors involved such as deep seeding, soil crusting, dry seedbeds, herbicide injury, insect damage, or other reasons.

The relationships between target and established plant population of the 14 environments evaluated in this study are shown in Figure 2. These environments were broken down into categories of environments with adequate seedbed moisture and environments with limited seedbed moisture (based on general observations at planting time). In environments where moisture was adequate at planting (10 environments) the percent emergence averaged across planting rates and environments was 82. In the four environments where moisture was a limiting factor at planting, the percent emergence averaged across planting rates and environments was 70 (Figure 3). The lower emergence in the dryer environments may have been partially due to loose seedbeds at planting which allowed depth bands to penetrate into the soil deeper than 2 inches, resulting in deeper seeding. Subsequent rainfall may have caused a soil crust to form resulting in decreased percent emergence. Lafond and Fowler (5) noted that the median emergence time of winter wheat increased with increasing planting depth. Owen (7) found seeds subjected to longer periods in the soil may exhibit reduced germinating capacity due to an increased susceptibility to disease infection.

Both the limited and adequate seedbed moisture environments had 85 percent emergence at the 0.5 million seeds per acre planting rate. Percent emergence fell more dramatically at the higher planting rates at environments with limited seedbed moisture compared to seedbeds with adequate moisture. The lower percent emergence at the higher planting rates may have been due to increased plant competition for water within the row.

The frequency of various established durum plant populations, for each planting rate, which were within specified plant population ranges are given in Table 7. The 0.5 and 1.0 million seeds per acre planting rate had established plant populations below the minimum required for optimum yields, 27 plants per square foot, in all trials. The 1.5 and 2.0 million seeds per acre planting rate had established plant populations above 27 plants per square foot 40 and 96 percent of the time, respectively.

Table 7. Frequencies of observed durum plant populations for each planting rate at 14 environments in northeastern North Dakota in 1985, 1986, and 1991.[1]

Planting Rate		Established plants/ft²			
		<15	16-26	27-38	38-50
Million seeds/a	Live seeds/ft²	%			
0.5	11	100	0	0	0
1.0	23	19	81	0	0
1.5	34	0	60	40	0
2.0	46 .	0	4	69	27

[1]27-50 plants/ft² was considered optimum.

Recommended Seeding Rates

Large differences in percent emergence that can occur from field to field every year makes the selection of the best planting rate difficult. The goal of a producer in a high yield potential environment is to establish a plant population of at least 27 plants per square foot. A planting rate of 1.43 million seeds per acre (2.1 bushels per acre of the seed source used in this study) which had 82 percent emergence resulted in 27 established plants per square foot in seedbeds with adequate moisture. A planting rate of 1.68 million seeds per acre (2.5 bushels per acre) with an average percent emergence of 70 in seedbeds with limited moisture was needed to establish 27 plants per square foot. Seedbed conditions at planting time, in addition to percent germination and seed size, will dictate the planting rate that a producer chooses. A favorable seedbed at planting may allow producers to reduce planting rates and still obtain target plant populations.

When plant populations are low in high yield environments a replanting decision is required. Figure 1 shows percent of optimum yield based on established plants per square foot. At 20 plants per square foot, a producer who assumes a yield potential of 45 bushels per acre can expect 3.2 bushels per acre (7 percent) less than a stand of 35 plants per square foot. Using $3.25 per bushel this would equal a $10.40 loss per acre. Potential yield loss from late planting (at least a two-week delay), in addition to added seed, tillage and labor costs, may easily raise replanting costs above the loss to the low plant stands. Weed control cost may increase if very low plant stands are left. Producers must carefully consider these factors before replanting.

Summary

1. Planting rate effects on plant height and days to head from planting were insignificant or small in this study and should not affect cultural practices by producers in most years.
2. Test weights were significantly lower, 1 pound per bushel, at the 0.5 million seeds per acre planting rate compared to the 1.0, 1.5, and 2.0 million seeds per acre planting rate in the lower disease years of 1985 and 1991.
3. Established plant populations of 39 plants per square foot produced the optimum yield with no statistical difference in yield occurring between 27 and 50 plants per square foot. This is based on data from nine experiments with very low weed competition and high yield levels averaging 58.5 bushels per acre.
4. Stand establishment is unpredictable due to environmental effects. Percent emergence can vary from field to field resulting in large differences in plant populations from the same seeding rate. The goal of a producer in a high yield potential environment should be to establish a plant population of at least 27 plants per square foot. A seed

lot with 95 percent germination and 11,000 seeds per pound at 100, 90, 80, 70, and 60 percent emergence would require a planting rate of 1.8, 2.0, 2.2, 2.5, and 3.0 bushels per acre, respectively, to obtain 27 plants per square foot. Seedbed conditions at planting, percent germination, and seed size will dictate the planting rate that a producer chooses. When stand establishment is below 27 plants per square foot, careful consideration of potential yield loss from delayed planting, in addition to added seed, tillage and labor costs, must be considered before a replanting decision is made.

5. The recommended seeding rates in this study are for strong-strawed semi-dwarf durums and may not hold true for weaker-strawed standard height durum varieties. These seeding rate recommendations are intended for high yielding environments. Western North Dakota data (11) indicate that when water availability limits yields to less than 30 bushels per acre a lower seeding rate of 1 million plants per acre will maximize yields. Saskatchewan data (8) indicate that when water availability limits yields to less than 20 bushels per acre that durum seeding rates of 20 to 40 pounds per acre will produce maximum yields. This is far different than the 60 bushels per acre yields and 2 bushels per acre seeding rate recommended by the data in this study.

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