Dry Edible Bean Performance as Influenced by Plant Density

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ABSTRACT

The impact of plant density on dry edible bean (*Phaseolus vulgaris L.*) production is important to growers for varied reasons. Knowledge of impacts from different densities are important to traditional growers looking to optimize yield along with those who may produce dry beans through utilization of non-traditional planting and harvest equipment. Field trials were established near Carrington, ND in 1999 and 2000 to evaluate the influence of different plant densities on indeterminate upright (Type II) cultivars 'Mayflower' navy and 'Shadow' black dry bean. Dry bean were planted in 0.18 and 0.76 m row spacings and at seeding rates of 222,000, 259,000 and 296,000 plants ha^{-1}. Planting dry bean in wide rows generally resulted in a higher percent plant establishment when compared to beans planted in narrow rows. The varied row spacing and plant populations had a limited effect on most agronomic traits. The increased competition among plants caused by wide rows and higher plant population tended to hasten dry bean maturity. Planting beans in narrow rows caused beans to pod higher, while population differences did not impact pod height. Dry bean planted in 0.18 m rows produced higher seed yields than beans in 0.76 m rows in one year of the study. Contrasts among the seeding rates evaluated in the study did not affect seed yield. Indeterminate upright (Type II) dry bean cultivars performed similar to changes in density caused by row spacing and seeding rate differences.

INTRODUCTION

Production of dry edible bean is a major agricultural enterprise in North Dakota and the surrounding region. The fact that the lowest pods are borne close to the ground dictates the need for skilled management to harvest a product that meets the high quality standards of the marketplace. Management practices for dry bean production have changed as equipment options and production regions have evolved and expanded. These changes along with economic challenges, has increased farmer interest in producing dry beans in narrow rows versus traditional wide rows. Producers in the region prefer to maintain one piece of planting equipment to plant a wide array of crops. This planting strategy may improve farm efficiencies by reducing the need for multiple planters and allow use of larger equipment that increases field capacity. Frequently, growers are selecting air seeders that plant in narrow rows and have the capacity to plant large acreages in a reduced period of time (Fig. 1).

Figure 1. Planting with an air seeder in North Dakota.

As dry beans are produced with narrow rows or solid seeding, growers have frequent questions related to crop performance. Some of the questions that occur are the impact of narrow rows on yield, seed quality and pod height. Potential efficiencies of direct harvest of solid seeded bean are a factor in considering this management practice, much like planting with large air seeders (Fig. 2). When direct harvest is adapted the height of the lowest pods becomes an important factor that influences harvest and seed quality losses.

Figure 2. Direct harvest of dry bean.

Earlier research in North Dakota reported that dry bean seed yield was increased significantly as row spacing was reduced from 0.76 to 0.19 m (Grafton et al., 1988). This same research indicated that plant populations of 173,000 plants ha^{-1} for indeterminate vine (Type III) pinto bean and 222,000 plants ha^{-1} for determinate bush (Type I) navy bean allowed for maximum seed yield at all row spacings. Research under irrigation indicated no difference among three pinto bean plant types to plant populations of 178,000 to 247,000 plants ha^{-1} (Mehraj et al., 1996). Density studies with soybean showed that the height of the lowest pods was increased as row spacings were reduced and plant populations increased (Costa et al., 1980). Current recommendations for the region suggest a seeding rate of 222,000 plant ha^{-1} for Type I and II cultivars regardless of row spacing (Berglund, 1997). The selection of dry edible bean cultivars by the producers of the region has shifted toward upright, short-vine types in recent years (Berglund, pers. com.). When available, growers have preferred these cultivars because of favorable yields, possible improved disease tolerance and overall agronomics. Dry bean cultivars of the Type II growth habit have had limited research to investigate the impact of plant density on crop performance.

OBJECTIVE

- Determine the impact of row spacing and seeding rate on the performance of indeterminate upright short-vine dry bean cultivars (Type II).

MATERIALS AND METHODS

A field experiment was conducted at Carrington, ND during the 1999 and 2000 growing seasons. The two Type II indeterminate cultivars evaluated, 'Mayflower' navy and 'Shadow' black, represent contrasting market classes and the type of cultivars that are being considered for solid seeding and direct harvest. The experimental design was a randomized complete block with split plots and four replications. The main plots were cultivars and the subplots were a factorial arrangement of row spacing and seeding rate. Row spacings of 0.18 and 0.76 m were combined with seeding rates of 222,000, 259,000 and 296,000 pure live seeds ha^{-1}. Seeding rates were adjusted upward at planting by an additional 15% in an effort to achieve the desired plant population. The traditional row spacing of 0.76 m was compared to a 0.18 m spacing since that represents a typical spacing that would result from solid seeding dry beans with an air seeder (Fig. 3). Planting dates were 1 June and 19 May in 1999 and 2000, respectively. Each plot was 3.0 m wide with a length of 7.6 m. The soil type at Carrington is a Heimdal loam (coarse-loamy, mixed, frigid, Udic Haploborolls). Preplant incorporation of ethalfluralin at 1.4 kg ha^{-1} was used for weed control and supplemented with hand weeding as required. Soil fertility levels were maintained to obtain a yield goal of 3000 kg ha^{-1} based on current recommendations. Yield determinations were made by harvesting all plants within the 4.6 m of the interior two rows of the 0.76 m spaced plots and eight rows of the 0.18 m row spacing. Plants were subsequently threshed with a stationary thresher and samples were processed further using standard laboratory procedures. Statistical analysis for all variables was conducted with SAS (SAS Institute Inc., V.8, 1999).

Figure 3. Dry bean planted in 0.18 m vs. 0.76 m row spacing.

RESULTS AND DISCUSSION

The 1999 and 2000 growing seasons were favorable for dry bean production. The plentiful precipitation received in July and August of each year was well distributed and coincided with the critical reproductive growth period of dry bean in the region. The rainfall and temperature pattern created an environment where plant stress did not exist for dry bean. The two cultivars selected had a similar response to the row spacing and seeding rates evaluated in this study (data not presented). A similar response between these two cultivars may be expected, given the similar indeterminate growth habit. This finding suggests that impacts of plant density may be similar among the predominant navy and black bean cultivars grown in the region.

Row Spacing

Although the differences were not dramatic, solid seeding dry bean in 0.18 m rows delayed flowering and physiological maturity compared to 0.76 m rows (Table 1). Dry bean in 0.18 m rows averaged two days later in maturity compared to dry bean produced in 0.76 m rows. In 2000, the 0.76 m row spacing resulted in a significantly higher plant population than the 0.18 m row spacing. The greater success of stand establishment in wide versus narrow rows was not unexpected and has been widely observed by agronomists. Dry bean established in a wide row have a closer intra-row spacing that results in more collective force to emerge from the soil. In both years, the height to the lowest pod was significantly greater at the narrow rows compared to wide rows. This could be an important management tool for producers considering direct harvest.

Table 1. Influence of row spacing on seed yield and selected agronomic traits of dry edible bean.

Row Spacing		Days to Bloom	Days to Maturity	Established Stand	Plant Height	Lowest Pod Height	Seed Weight	Seed Yield
m		DAP-1	DAP-1	plants ha^{-1}	m	mm	g 1000^{-1}	kg ha^{-1}
					2000			
0.18		57.4	104	208,000	0.49	51	219	2676
0.76		56.5	102	252,000	0.49	41	216	2700
	LSD.05	0.4	0.9	19,000	NS	7	NS	NS
	LSD.01	0.6	1.2	26,000	NS	9	NS	NS
					1999			
0.18		50.6	nd	245,000	54.0	60	198	2663
0.76		49.3	nd	239,000	54.2	54	200	2392
	LSD.05	0.5	--	NS	NS	5	NS	193
	LSD.01	0.7	--	NS	NS	NS	NS	259

1 Days after planting nd = not determined

Row spacing affected dry bean seed yield differently in the two years of this experiment. In 1999, planting in 0.18 m rows compared to the 0.76 m spacing significantly increased yield. Yields at the two row spacings were similar in 2000. Results from earlier research by Grafton et al. (1988) indicate a general increase in yield as row spacing was reduced from 0.76 to 0.19 m. The impact of row spacing on yield of Type II dry bean cultivars remains unclear based on this trial.

Seeding Rate

The impacts of seeding rate on the factors recorded in this trial were minimal. No significant differences exist among the factors reported from the 1999 trial except stand establishment (Table 2). During the 2000 season, days to maturity, plant height and seed weight were influenced by seeding rate. Lower seeding rates and the resultant lower plant populations caused a delay in plant maturity. This information, along with the response due to row spacing, indicate that increased competition among plants caused by wide rows and higher plant population hastened dry bean maturity. Seeding rates evaluated in this study did not affect pod height. There is an expectation by producers that increased seeding rate will promote increased pod height and thereby improve ease of direct harvest. Seed weight decreased significantly as seeding rates increased from 222,000 to 296,000 plants ha^{-1}. This response was evident in the 2000 study, while seed weights were similar in 1999. Higher seed weights often convey enhanced quality when marketing dry beans.

Seed yield was not influenced by the seeding rate treatments used in this experiment. The magnitude of seeding rate difference (74,000 plants ha^{-1}) evaluated was not great. The tendency by growers and consulting agronomists has been to recommend a moderate increase in the standard seeding rate of 222,000 plants ha^{-1} for dry beans planted in a solid or narrow row spacing. Data from this experiment indicates a seeding rate adjustment is not necessary to optimize seed yield. Dry beans have a high degree of plasticity that allows adjustments among the plants yield components to changes in density. The data indication that a current seeding rate recommendation of 222,000 plants ha^{-1} is sufficient to optimize yield, will allow growers to conserve input costs related to seed expenses.

Table 2. Influence of seeding rate on seed yield and selected agronomic traits of dry edible bean.

Seeding Rate		Days to Bloom	Days to Maturity	Established Stand	Plant Height	Lowest Pod Height	Seed Weight	Seed Yield
PLS ha^{-1}		DAP-1	DAP-1	plants ha^{-1}	m	mm	g 1000^{-1}	kg ha^{-1}
					2000			
222,000		56.8	104	201,000	0.48	43	221	2718
259,000		57.0	103	238,000	0.51	50	218	2780
296,000		56.9	102	251,000	0.48	46	214	2567
	LSD.05	NS	1.1	24,000	0.027	NS	4.2	NS
	LSD.01	NS	NS	32,000	NS	NS	5.6	NS
					1999			
222,000		49.8	nd	220,000	0.53	56	201	2488
259,000		49.8	nd	238,000	0.54	58	199	2407
296,000		50.3	nd	268,000	0.55	56	198	2689
	LSD.05	NS	--	23,000	NS	NS	NS	NS
	LSD.01	NS	--	31,000	NS	NS	NS	NS

1 Days after planting nd = not determined

CONCLUSION

- Differences in plant density had a limited effect on most agronomic traits.
- Row spacing of 0.18 m caused beans to pod higher, while population differences did not.
- Greater seed yield was associated with 0.18 m rows in 1999 but not in 2000.
- Seed yield was not influenced by the seeding rates evaluated.

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