Precision Planting of Dry Edible Bean

Eric Eriksmoen, Research Agronomist, NDSU North Central Research Extension Center, Minot, ND.

Introduction: Seeding equipment utilizing seed singulation technologies is very expensive, but has been proven to enhance corn production by eliminating yield limiting skips and doubles. In other crops like canola, seed singulation technologies have lowered seeding rates by as much as 50%, while maintaining yields. For crops with high seed costs, this savings can be substantial. We now also recognize plant sensory systems as they relate to a plants tolerance to its neighbors and a plants need for its own growing space. Row spacing and plant population are directly related to this interaction. Dry beans are known to have some ability to branch and fill their growing space, and therefore may be an ideal crop for precision planting. A key question to precision seeding technology in dry bean is whether there is a true economic advantage over conventional seeding equipment. This study was initiated during the 2018 growing season and included pinto, navy, black and dark red kidney bean market classes. The 2018 trial sustained severe drought which adversely affected growing conditions and resulted in relatively poor yields. The 2019 trial used the same experimental design but reduced the market classes to just pinto and dark red kidney types.

Approach: The main objective of this replicated small plot research trial was to compare precision seeding vs. conventional seeding equipment. The 2018 trial consisted of “ND Palomino” pinto, “Avalanche” navy, “Eclipse” black and “Montcalm” dark red kidney bean, and the 2019 trial consisted of “ND Palomino” pinto and “Montcalm” dark red kidney beans. Beans were planted into 15 inch and 30 inch row spacing and these row spacing were planted in combination with three seeding rates: 50,000, 70,000 and 90,000 pure live seeds per acre for pinto and kidney beans, and 90,000, 110,000 and 120,000 pure live seeds per acre for navy and black beans, respectively. The trials were planted at the NDSU North Central Research Extension Center at Minot, North Dakota using a split block experimental design with three replications. Precision planted plots were planted with a 4 row SRES Classic Air Flex small plot planter using a Monosem seed singulation metering system and Great Plains double disc openers. The conventional planted plots were planted with a custom-built small plot cone seeder using John Deere MaxEmerge row units. The trials were planted on June 4, 2018 and June 5, 2019 into a minimally tilled Williams loam soil that was spring wheat the previous year. Soil fertility levels were adequate for a 3000 pound crop. All seed was treated with the appropriate strain of Rhizobia inoculant. Weeds were controlled with a preplant application of sulfentrazone & carfentrazone (Spartan Charge) + glyphosate and a post-emergence application of bentazon & imazamox (Varisto) in 2018 and imazamox (Raptor) in 2019. The trials were treated with a pre-harvest application of paraquat + flumioxazin (Valor). Fungicides were not applied. Individual plots were 5 feet wide by 25 feet long and trimmed to 19 feet long for harvest. Plots were direct harvested on September 18, 2018 and September 25, 2019 with a Kincaid small plot combine.

Results and discussion: Detecting positive and negative outcomes, understanding those outcomes and making realistic management decisions is the ultimate goal of this project. The 2018 trial sustained a severe season long drought, with total growing season precipitation of 5.57 inches. This drought obviously affected overall plant growth and seed production and therefore results from each year are shown separately.

Data was tabulated on days to seedling emergence, established plant stand, maturity date, plant height at harvest, lodging, 100 seed weight, test weight and seed yield. Days to seedling emergence was seven days after planting for all plots in 2018 (data not shown) and there was no observed lodging in either year (data not shown). Tables 1 and 2 compare overall means for planter type. Subsequent tables are broken down by market class and year.

The only statistically significant difference between planters in the 2018 trial was for 100 seed weight in which the conventional planted beans producing slightly heavier seed. This was not observed in the 2019 trial. The only statistically significant difference between planters in the 2019 trial was for a one-day difference in seedling emergence and a one-inch difference in plant height. This may be due to slight differences in planting depth, but in general these differences have little overall effect on the practical outcome of the trial.

Table 1. Overall combined mean comparisons between planters, 2018.

Planter	Plant Stand	Maturity Date	Plant Height	100 Seed Weight	Test Weight	Yield
	plants/A	Aug	inches	grams	lbs/bu	lbs/A
Conventional	68,190	24	12	23.7	60.0	540
Precision	72,761	24	12	22.3	59.7	460
LSD 0.05	NS	NS	NS	*	NS	NS

NS = no statistical difference between planters. *Statistically different.

Table 2. Combined mean comparisons between planters, 2019.

Planter	Days to Emerge	Plant Stand	Maturity Date	Plant Height	100 Seed Weight	Test Weight	Yield
	days	plants/A	Sept	inches	grams	lbs/bu	lbs/A
Conventional	13	62,113	18	12	42	58.8	1239
Precision	12	62,597	19	11	42	58.9	1147
LSD 0.05	*	NS	NS	*	NS	NS	NS

NS = no statistical difference between planters. *Statistically different.

Pinto Bean (2018 and 2019)

Statistical differences between planters was observed for maturity and seed weight in the 2018 trial (Table 3), with the conventional planted beans maturing a couple of days later and producing heavier seed than pinto beans planted with the precision planter. Crop maturity and seed weight typically have an inverse relationship with plant stand. When plant populations decrease, maturity and seed weight tend to increase. The 2019 trial (Table 4) did not show any statistical differences between planters except for a one-day difference for seedling emergence.

Table 3. Combined mean comparisons between planters for pinto beans, 2018.

Planter	Plant Stand	Maturity Date	Plant Height	100 Seed Weight	Test Weight	Yield
	plants/A	Aug	inches	grams	lbs/bu	lbs/A
Conventional	50,551	24	13	28.3	58.3	540
Precision	58,295	22	12	26.8	58.3	450
LSD 0.05	NS	*	NS	*	NS	NS

NS = no statistical difference between planters. *Statistically different.

Precision Planting of Dry Edible Bean Continued

Table 4. Combined mean comparisons between planters for pinto beans, 2019.

Planter	Days to Emerge	Plant Stand	Maturity Date	Plant Height	100 Seed Weight	Test Weight	Yield
	days	plants/A	Sept	inches	grams	lbs/bu	lbs/A
Conventional	12	54,853	18	12	36.4	59.6	1394
Precision	11	62,275	18	11	36.8	59.5	1264
LSD 0.05	*	NS	NS	NS	NS	NS	NS

NS = no statistical difference between planters. *Statistically different.

Tables 5 and 6 show combined means for row spacing from the 2018 and 2019 trials, respectively. Results from both trials were similar with narrow rows producing more established plants and lower test weights. These are common observations where wider rows produce more plant-to-plant competition within the row which tends to reduce the overall established plant stand and seed size. Smaller seeds tend to produce a heavier test weight.

Table 5. Combined means for pinto bean row spacing, 2018.

Row Spacing	Plant Stand	Maturity Date	Plant Height	100 Seed Weight	Test Weight	Yield
	plants/A	Aug	inches	grams	lbs/bu	lbs/A
15"	60,446	24	12	27.6	57.9	527
30"	48,400	23	13	27.5	58.7	462
LSD 0.05	*	NS	NS	NS	*	NS

NS = no statistical difference between row spacing. *Statistically different.

Table 6. Combined means for pinto bean row spacing, 2019.

Row Spacing	Days to Emerge	Plant Stand	Maturity Date	Plant Height	100 Seed Weight	Test Weight	Yield
	days	plants/A	Sept	inches	grams	lbs/bu	lbs/A
15"	17	61,307	16	12	36.9	59.2	1369
30"	17	55,821	15	11	36.3	59.9	1288
LSD 0.05	NS	NS	NS	NS	NS	*	NS

NS = no statistical difference between row spacing. *Statistically different.

Tables 7 and 8 show combined means for seeding rates from the 2018 and 2019 trials, respectively. Results from both trials showed no statistical differences for seeding rates in agronomic, seed quality or seed yields. For every incremental increase in seeding rate, there was an incremental decrease in the number of plants that survived and contributed to yield.

Precision Planting of Dry Edible Bean Continued

Table 7. Combined means for pinto bean seeding rates, 2018.

Seeding Rate	Plant Stand	Maturity Date	Plant Height	100 Seed Weight	Test Weight	Yield
Seeds/A	plants/A	Aug	inches	grams	lbs/bu	lbs/A
50,000	48,400	24	12	28.0	58.3	458
70,000	52,595	23	13	27.2	58.3	482
90,000	62,275	24	13	27.5	58.2	545
LSD 0.05	7,734	NS	NS	NS	NS	NS

NS = no statistical difference between seeding rates.

Table 8. Combined means for pinto bean seeding rates, 2019.

Seeding Rate	Days to Emerge	Plant Stand	Maturity Date	Plant Height	100 Seed Weight	Test Weight	Yield
Seeds/A	days	plants/A	Sept	inches	grams	lbs/bu	lbs/A
50,000	17	49,852	16	12	37.1	59.6	1242
70,000	17	60,500	16	12	36.6	59.7	1341
90,000	17	65,340	15	11	36.0	59.3	1352
LSD 0.05	NS	12,597	NS	NS	NS	NS	NS

NS = no statistical difference between seeding rates.

Dark Red Kidney Bean (2018 and 2019)

Statistical differences between planters were observed for maturity, seed weight and yield with the 2018 trial (Table 9). Although statistical differences between planters were detected for maturity, it appears that row spacing probably had a greater influence on this agronomic characteristic. Differences between planters for seed weight were similar to those for pinto bean. Yield differences were not a result of planter, row spacing or seeding rate interactions, but may be attributed to harvest losses during combining. There were no statistical differences for seed quality or seed yield in the 2019 trial (table 10). There were small but statistically significant differences between planters for seedling emergence and maturity. Differences for seedling emergence may be attributed to slight differences in planting depth between planters. Differences between maturities is typically related to plant populations, with thinner stands having longer maturities.

Table 9. Combined mean comparisons between planters for dark red kidney beans, 2018.

Planter	Plant Stand	Maturity Date	Plant Height	100 Seed Weight	Test Weight	Yield
	plants/A	Aug	inches	grams	lbs/bu	lbs/A
Conventional	51,949	26	12	38.4	55.7	446
Precision	55,606	28	12	35.5	55.5	297
LSD 0.05	NS	*	NS	*	NS	*

NS = no statistical difference between planters. *Statistically different.

Precision Planting of Dry Edible Bean Continued

Table 10. Combined mean comparisons between planters for dark red kidney beans, 2019.

Planter	Days to Emerge	Plant Stand	Maturity Date	Plant Height	100 Seed Weight	Test Weight	Yield
	days	plants/A	Sept	inches	grams	lbs/bu	lbs/A
Conventional	13	69,373	21	12	48	58.0	1084
Precision	12	62,920	22	11	48	58.2	1031
LSD 0.05	*	NS	*	NS	NS	NS	NS

NS = no statistical difference between planters. *Statistically different.

2018 and 2019 trial results of kidney bean row spacing are shown in tables 11 and 12, respectively. Plant maturities were indirectly influenced by row spacing in 2018 but not in the 2019 trial. Plant population tends to influence plant maturity to a higher degree which explains this agronomic difference. Similar to the 2019 pinto beans, 2019 kidney bean test weights were also influenced by row spacing.

Table 11. Combined means for kidney bean row spacing, 2018.

Row Spacing	Plant Stand	Maturity Date	Plant Height	100 Seed Weight	Test Weight	Yield
	plants/A	Aug	inches	grams	lbs/bu	lbs/A
15"	64,103	28	12	37.4	55.3	365
30"	43,352	26	12	36.6	55.9	377
LSD 0.05	*	*	NS	NS	NS	NS

NS = no statistical difference between row spacing. *Statistically different.

Table 12. Combined means for kidney bean row spacing, 2019.

Row Spacing	Days to Emerge	Plant Stand	Maturity Date	Plant Height	100 Seed Weight	Test Weight	Yield
	days	plants/A	Sept	inches	grams	lbs/bu	lbs/A
15"	12	60,661	21	11	47.9	57.8	1071
30"	12	58,080	21	11	48.1	58.5	1044
LSD 0.05	NS	NS	NS	NS	NS	*	NS

NS = no statistical difference between row spacing. *Statistically different.

Table 13 shows the 2018 seeding rate results for kidney beans. Differences were observed for yield with the 70,000 seeding rate yielding statistically more than the 50,000 rate, however, all yields were pathetically low. 2019 seeding rate results are shown in table 14. Even though established plant stands were significantly higher for the 90,000 seeding rate, this did not translate into higher yields. Agronomic, seed quality and seed yields were all statistically similar to each other, regardless of seeding rate.

Precision Planting of Dry Edible Bean Continued

Table 13. Combined means for kidney bean seeding rates, 2018.

Seeding Rate	Plant Stand	Maturity Date	Plant Height	100 Seed Weight	Test Weight	Yield
Seeds/A	plants/A	Aug	inches	grams	lbs/bu	lbs/A
50,000	42,592	28	12	37.3	55.9	321
70,000	59,048	26	12	37.1	55.3	401
90,000	59,693	26	12	36.5	55.5	393
LSD 0.05	6,874	NS	NS	NS	NS	76

NS = no statistical difference between seeding rates.

Table 14. Combined means for kidney bean seeding rates, 2019.

Seeding Rate	Days to Emerge	Plant Stand	Maturity Date	Plant Height	100 Seed Weight	Test Weight	Yield
Seeds/A	days	plants/A	Sept	inches	grams	lbs/bu	lbs/A
50,000	12	52,756	21	11	48.2	58.0	985
70,000	12	54,692	22	11	48.2	58.0	1086
90,000	12	70,664	21	12	47.6	58.3	1101
LSD 0.05	NS	14,880	NS	NS	NS	NS	NS

NS = no statistical difference between seeding rates.

Navy Bean (2018)

Small but statistically significant differences between planters were observed for seed weight and test weight (Table 15) with the conventional planter producing heavier seed and heavier test weight. Statistical analysis indicated that this difference was produced by an interaction between planter and row spacing (data not shown). Interactions between planter, row spacing and seeding rates did not account for the differences between planters for test weight.

Table 15. Combined mean comparisons between planters for navy beans, 2018.

Planter	Plant Stand	Maturity Date	Plant Height	100 Seed Weight	Test Weight	Yield
	plants/A	Aug	inches	grams	lbs/bu	lbs/A
Conventional	79,268	25	12	14.1	63.9	598
Precision	76,580	23	12	13.3	63.3	532
LSD 0.05	NS	NS	NS	*	*	NS

NS = no statistical difference between planters. *Statistically different.

Precision Planting of Dry Edible Bean Continued

Table 16 shows results of row spacing. The magnitude of established plants between row spacing was quite remarkable with 15 inch rows producing 41% more established plants than 30" rows. This difference, however, did not significantly affect agronomic characteristics, seed quality or yield.

Table 16. Combined means for navy bean row spacing, 2018.

Row Spacing	Plant Stand	Maturity Date	Plant Height	100 Seed Weight	Test Weight	Yield
	plants/A	Aug	inches	grams	lbs/bu	lbs/A
15"	91,207	24	12	13.6	63.7	599
30"	64,641	23	12	13.9	63.4	531
LSD 0.05	*	NS	NS	NS	NS	NS

NS = no statistical difference between row spacing. *Statistically different.

Table 17 shows results of seeding rates. Statistically significant differences were detected for yield. The 120,000 seeding rate produced a higher yield than the 110,000 rate, but had a similar yield to the 90,000 rate. This is probably related to adverse growing conditions and/or losses during harvest.

Table 17. Combined means for navy bean seeding rates, 2018.

Seeding Rate	Plant Stand	Maturity Date	Plant Height	100 Seed Weight	Test Weight	Yield
Seeds/A	plants/A	Aug	inches	grams	lbs/bu	lbs/A
90,000	72,116	25	12	13.8	63.5	594
110,000	80,344	23	12	13.5	63.4	479
120,000	81,312	24	12	13.9	63.8	622
LSD 0.05	7,888	NS	NS	NS	NS	106

NS = no statistical difference between seeding rates.

Black Bean (2018)

Similar to pinto and kidney bean, the precision planter produced more established black bean plants than the conventional planter (Table 18), however, more plants did not translate into higher yields in this low yielding environment.

Table 18. Combined mean comparisons between planters for black beans, 2018.

Planter	Plant Stand	Maturity Date	Plant Height	100 Seed Weight	Test Weight	Yield
	plants/A	Aug	inches	grams	lbs/bu	lbs/A
Conventional	90,992	22	10	14.1	62.1	575
Precision	100,564	22	10	13.5	61.7	561
LSD 0.05	*	NS	NS	NS	NS	NS

NS = no statistical difference between planters. *Statistically different.

Precision Planting of Dry Edible Bean Continued

Table 19 shows results of row spacing. Like the other market classes, 15 inch row spacing significantly increased plant establishment, however, as stated above, more plants did not translate into significantly higher yields.

Table 19. Combined means for black bean row spacing, 2018.

Row Spacing	Plant Stand	Maturity Date	Plant Height	100 Seed Weight	Test Weight	Yield
	plants/A	Aug	inches	grams	lbs/bu	lbs/A
15"	114,869	23	10	13.8	62.2	606
30"	76,687	21	10	13.7	61.7	531
LSD 0.05	*	NS	NS	NS	NS	NS

NS = no statistical difference between row spacing. *Statistically different.

As would be expected, there was a trend for increasing plant stands with increasing seeding rates (Table 20). This positive trend, however, did not enhance agronomic characteristics, seed quality or yield.

Table 20. Combined means for black bean seeding rates, 2018.

Seeding Rate	Plant Stand	Maturity Date	Plant Height	100 Seed Weight	Test Weight	Yield
Seeds/A	plants/A	Aug	inches	grams	lbs/bu	lbs/A
90,000	87,443	22	10	13.8	61.8	502
110,000	99,059	22	11	13.8	62.2	626
120,000	100,833	22	10	13.7	61.8	577
LSD 0.05	8,578	NS	NS	NS	NS	NS

[a]DAP=Days after Planting NS = no statistical difference between seeding rates.

Conclusions: As previously stated, concrete management decisions based on results derived from adverse growing conditions should be avoided. General observations from this study indicate: 1. the precision planter typically produced a more uniform and higher established plant stand but this did not translate into higher yields or better seed quality. 2. narrow rows tended to produce more established plants than wider rows, but again, these increased plant populations did not significantly enhance seed production, and 3. higher seeding rates tended to produce higher plant stands, but these increased stands also did not significantly enhance seed production. A benefit of higher seeding rates and narrow rows is enhanced crop competition with weeds. This is especially important in no-till or reduced tillage systems. In conventional tillage systems, wider rows allow for in-season cultivation for weed control and lower seeding rates reduces seed costs. From these trials and observations, it would be difficult to justify the additional cost of precision equipment for the sole purpose of dry bean production. A well maintained and properly calibrated conventional planter should provide the same production performance to precision planting equipment.

Acknowledgements: A huge thank you to Northarvest Bean Growers Association for their direction and financial support of this project.