NORTHWEST CROPS & SOILS PROGRAM

2024 No-Tillage and Dry Bean Variety Performance Trial

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THE UNIVERSITY OF VERMONT EXTENSION

2024 NO-TILLAGE AND DRY BEAN VARIETY PERFORMANCE TRIAL

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Dry beans (*Phaseolus vulgaris*), a high-protein pulse crop, have been grown in the Northeast since the 1800's. As the local food movement continues to diversify and expand, consumers are asking stores to carry more locally-produced foods, and dry beans are no exception. Currently, the demand for locally sourced dry beans has far exceeded the supply. Farmers are also looking for high-value crops to diversify their rotations. Modern breeding efforts have expanded the market classes that can be direct harvested, lowering the barrier to entry by reducing the need for specialized equipment. These alternative market classes are valued by consumers for their culinary characteristics and visual appeal. Current management practices for organic dry beans can deplete the soil because of the reliance on tillage and cultivation for weed management and harvesting. Direct-harvested dry beans, specifically black beans, have shown promise in organic no-till systems and could reduce the negative impacts on soil health while still suppressing weeds. However, there has been little research on how other market classes perform in a no-till production system. To support and expand organic dry bean production throughout the northeast, the University of Vermont Extension Northwest Crops and Soils Program conducted a research trial in 2023-2024 to evaluate the performance of four dry bean market classes (black, navy, pinto, and small red) in an organic tilled system compared to an organic no-till system.

MATERIALS AND METHODS

The trial was conducted at Borderview Research Farm in Alburgh, VT during the 2023-2024 season. The experimental design was a randomized complete block with split plots and four replications. The main plots were two tillage treatments: traditional tillage and no-tillage, and the sub-plot were four dry bean market classes (Table 1).

Table 1. Varietal information for the four dry bean varieties planted in Alburgh, VT, 2024.

Variety	Seed source	Market class
Alpena	Central Bean Company Inc.	Navy
Lariat	Treasure Valley Seed Co.	Pinto
Rojo Chiquito	Central Bean Company Inc.	Small Red
Zorro	Central Bean Company Inc.	Black

Trial management details can be found in Table 2. The entire area was planted with winter rye (var *ND Gardner*) on 9-Sep 2023 at a rate of 3 million pure live seeds ac^{-1} using a Sunflower™ no-till grain drill. For the Till treatment, spring cover crop biomass was measured prior to termination on 7-May 2024 by collecting four representative samples using a 0.5m2 quadrat. All above ground plant material was collected using hand clippers, weighed, dried, and reweighed to calculate dry matter and yield. The rye was terminated using a moldboard plow and then the seedbed was prepared using a Pottinger TerraDisc®. For the No-till treatment, rye biomass was collected prior to termination on 28-May 2024, following the same procedure as the Tilled treatment. On 31-May 2024 the rye was rolled & crimped using an I&J Crop Roller Crimper (Camp Douglas, WI). Dry beans were planted on 5-Jun 2024 with a John Deere no-till planter. The fertilizer Nature Safe (13-0-0) was applied at planting at a rate of 25lbs N ac^{-1}. The seeding rate varied by market class. Black, navy, and small red beans were planted at 125,000 seeds ac^{-1} and pinto beans were

planted at 95,000 seeds ac^{-1}. Prior to planting, the seed was treated with dry bean bacterial inoculant (*Rhizobium leguminosarum biovar phaseoli*). The plot size was 10ft x 20ft, with 4 rows at 30-inch spacing.

Table 2. Trial management information for the dry bean variety x tillage trial, Alburgh, VT, 2023-2024.

Location	Borderview Research Farm, Alburgh, VT	
Soil type	Benson rocky silt loam, over shaly limestone, 8 to 15 % slopes	
Previous crop	Spring barley	
Plot size	10 x 20 ft	
Row spacing	30 inches	
Replicates	4	
Dry bean seeding rates (pure live seeds ac^{-1})	Black, navy, & small red: 125,000 Pinto: 95,000	
Cover crop variety	*ND Gardner* cereal rye	
Cover crop seeding rate	3 million pure live seeds ac^{-1}	
Cover crop planting date	9-Sep 2023	
Tillage operations	Till	No-till
	Moldboard plow	Rolled & crimped
	Pottinger TerraDisc®	I&J Crop Roller Crimper
	7-May 2024	28-May 2024
Dry bean planting date	5-Jun 2024	
Starter fertilizer	25 lbs N ac^{-1}; Nature Safe (13-0-0)	
Dry bean harvest dates	Tillage: 18-Sep 2024 No-till: 27-Sep 2024	

Plant emergence was measured by counting the number of plants in two 1-m sections in each plot on 17-Jun 2024. On 8-Jul 2024 the Till treatment was mechanically cultivated to control weeds. Wet field conditions during the season prevented additional cultivation, and there was no supplemental weed control in the No-till treatment. Starting in mid-July, plots were monitored for signs of flowering. Days to flower were recorded on the date at which approximately 50% of plants in a plot had at least one opened flower. To assess peak dry bean and weed biomass during the growing season, all above ground plant material was removed from within one 0.5 m^2 quadrat per plot using hand clippers when dry bean plants reached R6/R7 growth stage. This stage is characterized by the oldest pods having developed seeds. Other parts of the plant have full-length pods with seeds almost as large as the first pods and pods will be developed over the whole plant. All plots were assessed for peak biomass on 13-Aug 2024, except for the No-till Alpena (navy bean) treatment, which was sampled three days later on 16-Aug 2024 due to slightly delayed maturation. Samples were then weighed, dried, and reweighed to determine dry matter and yield. Plots were scouted and assessed for white mold (*Sclerotinia sclerotiorum*) on 27-Aug 2024. Within each plot, pods were assessed from a 1-m section and given a rating for incidence (percentage of pods exhibiting symptoms) and severity (percent necrosis of the infected pods) using the Modified Cobb Scale for intensity of infection (Table 3).

Table 3. Modified Cobb scale for intensity of infection.

	Description
0	No visible infection

1	1-5% leaf area infected
2	6-10% leaf area infected
3	11-25% leaf area infected
4	26-40% leaf area infected
5	65-100% leaf area infected
Source: Stavely (1985).	

Starting in late August, plants were scouted as they approached maturity. Days to maturity were recorded for each plot when 50% percent of plants in a plot had at least one dry pod. All plots were hand harvested as they reached maturity, about 5 days after 95% of pods were brown. The Till treatment was harvested on 18-Sep 2024 and the No-till treatment was harvested about a week later 27-Sep 2024. At harvest, lodging was measured by visual assessment for the whole plot on a scale of 1 to 5, where 1 meant all plants were erect and 5 meant all plants were horizontal. Pod height was measured by selecting 5 plants at random from two 1-m sections within the center two rows of each plot and measuring the distance from the soil surface to the bottom of the lowest pod. All plants within the two 1-m sections were counted then hand-pulled and hung to dry in a well-ventilated space. Once dry, the beans were threshed using a portable Almaco thresher with a rasp bar rotor. Beans were then weighed to calculate yields and tested for harvest moisture and test weight using a DICKEY-John Mini-GAC Plus moisture and test weight meter. To assess differences in seed size, three sub-samples of 100 seeds were weighed for each plot.

Data were analyzed using a general linear model procedure of SAS (SAS Institute, 1999). Replications were treated as random effects, and treatments were treated as fixed. Mean comparisons were made using the Least Significant Difference (LSD) procedure where the F-test was considered significant, at $p<0.10$.

Variations in yield and quality can occur because of variations in genetics, soil, weather, and other growing conditions. Statistical analysis makes it possible to determine whether a difference among treatments is real or whether it might have occurred due to other variations in the field. At the bottom of each table an LSD value is presented for each variable (i.e. yield). Least Significant Differences (LSDs) at the 0.10 level of significance are shown. Where the difference between two treatments within a column is equal to or greater than the LSD value at the bottom of the column, you can be sure that for 9 out of 10 times, there is a real difference between the two treatments. In this example, treatment C is significantly different from treatment A but not from treatment B. The difference between C and B is equal to 1.5, which is less than the LSD value of 2.0. This means that these treatments did not differ in yield. The difference between C and A is equal to 3.0, which is greater than the LSD value of 2.0. This means that the yields of these treatments were significantly different from one another.

Treatment	Yield
A	6.0^{b}
B	7.5^{ab}
C	**9.0^{a}**
LSD	2.0

RESULTS

Weather data were recorded with a Davis Instruments Vantage Pro2 weather station, equipped with a WeatherLink data logger at Borderview Research Farm in Alburgh, VT (Table 4). Above average rainfall from June through August resulted in a season total of 21.7 inches of precipitation, 6.18 inches more than normal. There was a total of 2319 accumulated Growing Degree Days (GDDs), which is typical for the region.

Table 4. Weather data for Alburgh, VT, 2024.

	2024			
Alburgh, VT	June	July	Aug	Sep
Average temperature (°F)	68.5	73.7	69.2	64.7
Departure from normal	0.95	1.33	-1.45	2.02
Precipitation (inches)	6.65	6.67	5.78	2.61
Departure from normal	2.39	2.61	2.24	-1.06
Growing Degree Days (50-86°F)	548	732	595	444
Departure from normal	25.0	37.0	-47.0	56.0

Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger.
Historical averages are for 30 years of NOAA data (1991-2020) from Burlington, VT.

Interactions

Table 5 below summarizes the significance of main effects (variety and tillage treatment) and main effect interactions (variety x tillage treatment). The only significant interaction between variety and tillage treatment was for 100-seed weight (Figure 1). Overall, the 100-seed weight was higher in the No-till treatment. The three smaller seed varieties, Alpena (navy), Rojo Chiquito (small red), and Zorro (black), all had similar 100-seed weights in the Till and No-till treatments. The average weight of 100 seeds for Lariat (pinto) was 39.5g in the Till treatment and 44.4g in the No-till treatment, making the 100-seed weight 4.9g higher in the No-till treatment. This data suggests that different market classes of beans responded similarly to the tillage systems.

Table 5. Significance of main effects and main effect interactions.

	Variety	Tillage Treatment	Variety x Tillage Treatment
Emergence population	N/A†	**‡	NS§
Flowering date	**	****	NS
Whole plant biomass	NS	***	NS
Weed biomass	NS	**	NS
White mold incidence	NS	*	NS
White mold severity	NS	*	NS
Maturity date	*	**	NS
Pod height	*	***	NS
Lodging	NS	***	NS
Harvest population	N/A	NS	NS
Harvest moisture	NS	****	NS
Test weight	***	NS	NS
Seed yield	NS	NS	NS
100-seed weight	****	**	*

†N/A-Not applicable.
‡****p<.0001; ***.0001<p<.001; **.001<p<.01; *.01<p<0.1
§NS-No significant difference between treatments.

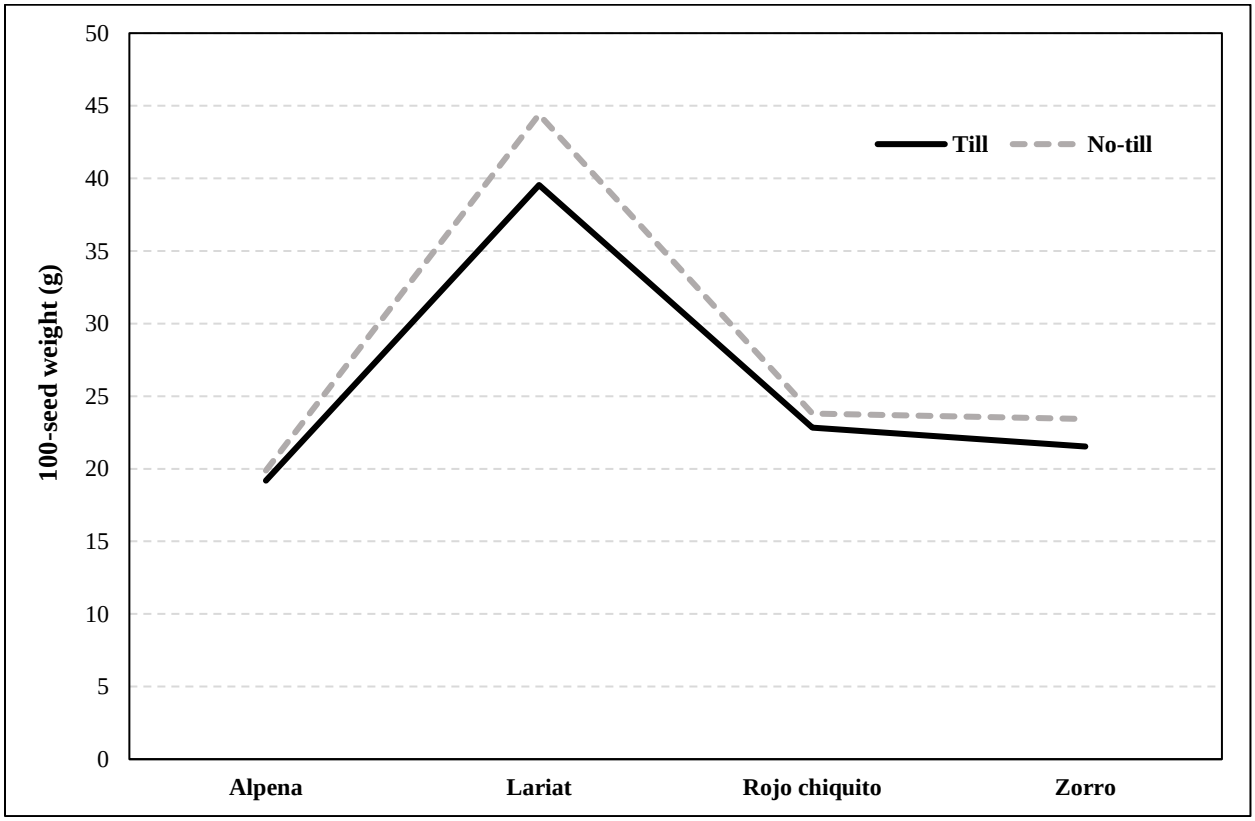

Figure 1. 100-seed weight by variety in tilled treatment compared to no-till treatment, Alburgh, VT, 2024.

Impact of dry bean variety

Since different classes of dry beans were evaluated, it is expected that they would differ in various performance characteristics. However, it is still of value to present the results so farmers can understand differences in performance amongst the market classes. The dry bean varieties had significant differences in flowering and maturity dates (Table 6). Lariat flowered 2 to 4 days earlier than the other three varieties. The other three varieties did not have statistically different flower dates. Lariat also had an earlier maturity date than Alpena and Zorro, but was not significantly different from Rojo Chiquito. Lariat reached maturity 6 days earlier than Alpena and 4 days earlier than Zorro. There were no statistical differences in whole plant bean biomass or weed biomass, nor were there significant differences in white mold incidence or severity between varieties. In this year's trial, weeds accounted for 22% of the total plant biomass. White mold incidence and severity were low across the trial. The average white mold incidence rating was 0.22, so less than 5% of pods were infected with white mold. The average incidence rating was 0.28, so there was less than 5% necrosis on the affected pods.

Table 6. Dry bean characteristics by variety, Alburgh, VT, 2024.

Variety	Market class	Flowering date	Dry beans / Weeds Dry matter biomass		White mold incidence	White mold severity	Maturity date
		Days after planting	lbs ac^{-1}		% of infected pods	% necrosis of affected pods	Days after planting
					Modified Cobb scale (0-5)†		
Alpena	Navy	46^{b}‡	3297	758	0.13	0.13	98^{b}
Lariat	Pinto	**43^{a}**	3103	722	0.38	0.50	**92^{a}**
Rojo Chiquito	Small red	47^{b}	2791	1052	0.00	0.00	95^{ab}
Zorro	Black	45^{b}	3026	826	0.38	0.50	96^{b}
LSD (p = 0.10)§	N/A¥	1.8	NS€	NS	NS	NS	3.8
Trial Mean		45	3054	840	0.22	0.28	95

†Modified Cobb scale for intensity of infection is described in Table 3.

‡Within a column, treatments marked with the same letter were statistically similar (p=0.10).

§LSD-Least significant difference at the p=0.10.

¥N/A-Not applicable

€NS-No significant difference between treatments.

Harvest characteristics are summarized by variety in Table 7. There was no significant difference in lodging, and the trial average was 2.22. Lariat had the greatest pod height, 10.7cm from the soil to the bottom of the lowest pod, and that was not statistically different from Rojo Chiquito (9.11 cm) or Zorro (9.26 cm). Alpena had a significantly lower pod height (5.80 cm) than the other three varieties. The average harvest moisture was 20.2%, but there were no significant differences between varieties. Zorro and Alpena had statistically higher test weight than Lariat and Rojo Chiquito. Dry bean seed yields ranged from 2014 lbs ac^{-1} (Rojo Chiquito) to 2519 lbs ac^{-1} (Lariat) but there were no statistical differences in yield. Lariat had the greatest 100-seed weight, 42.0g, and was statistically higher than the other varieties. Rojo Chiquito (23.3g) and Zorro (22.5g) were not statistically different, and Alpena had the lowest 100-seed weight, 19.5g.

Figure 7. Harvest characteristics by dry bean variety, Alburgh, VT, 2024.

Variety	Market class	Lodging	Pod height	Harvest moisture	Test weight	Yield at 14% moisture	100-seed weight
		1-5 rating†	Cm	%	lbs bu^{-1}	lbs ac^{-1}	grams
Alpena	Navy	2.13	5.80[b]‡	20.6	71.7[a]	2329	19.5[c]
Lariat	Pinto	2.50	**10.7[a]**	17.9	64.7[b]	2519	**42.0[a]**
Rojo Chiquito	Small red	2.63	9.11[a]	21.3	65.2[b]	2014	23.3[b]
Zorro	Black	1.63	9.26[a]	20.7	**72.6[a]**	2520	22.5[b]
LSD (p = 0.10)§	N/A¥	NS€	2.50	NS	3.10	NS	1.36
Trial Mean		2.22	8.72	20.2	68.5	2346	26.8

†Lodging scale: 1=all plants erect; 5=all plants horizontal

‡Within a column, treatments marked with the same letter were statistically similar (p=0.10).

§LSD; Least significant difference at p=0.10.

¥N/A; Not applicable.

€NS-No significant difference between treatments.

Impact of tillage treatment

Winter rye biomass significantly increased from 7-May to 28-May 2024 (Table 8). In the three weeks from when the rye was plowed under in the Till treatment to when the rye was rolled and crimped in the No-till treatment, biomass nearly doubled, from 2.54 to 4.72 DM tons ac^{-1}.

Table 8. Winter rye biomass at spring termination, Alburgh, VT, 2024.

Treatment	Date of termination	Rye dry matter @ termination
		tons ac^{-1}
Till	7-May 2024	2.54[b]†
No-Till	28-May 2024	**4.72[a]**
LSD (p = 0.10) ‡	N/A§	0.71
Trial Mean		3.63

†Within a column, treatments marked with the same letter were statistically similar (p=0.10).

‡LSD; Least significant difference at the p=0.10.

§ N/A; Not applicable.

Dry bean populations at emergence were significantly reduced in the No-till treatment (Table 9). Dry bean populations were 25% lower in the No-till compared to the Till treatment. Dry beans in the Till treatment flowered significantly earlier than in the No-till treatment, 4 days earlier. Dry bean whole plant biomass and weed biomass were both significantly greater in the Till treatment. Whole plant biomass was 1619 lbs

or about 42% greater in the Till treatment. Weed biomass was 6.5X greater in the Till treatment. White mold was not observed in the No-till treatment. In the Till treatment, the white mold incidence rating was 0.44 and severity was 0.56. Maturity date was significantly earlier in the Till treatment, 5 days earlier than the No-till treatment.

Table 9. Dry bean characteristics by tillage treatment, Alburgh, VT, 2024.

Treatment	Emergence population	Flowering date	Dry beans	Weeds	White mold incidence	White mold severity	Maturity date
			Dry matter biomass				
	plants ac^{-1}	Days after planting	lbs ac^{-1}		% of infected pods	% necrosis of affected pods	Days after planting
					Modified Cobb scale (0-5)†		
Till	**89311^{a}**‡	**43^{a}**	**3864^{a}**	**1456^{a}**	0.44^{b}	0.56^{b}	**93^{a}**
No-Till	66236^{b}	47^{b}	2245^{b}	224^{b}	**0.00^{a}**	**0.00^{a}**	98^{b}
LSD (p = 0.10)§	10811	1.3	604	613	0.41	0.53	2.7
Trial Mean	77774	45	3054	840	0.22	0.28	95

†Modified Cobb scale for intensity of infection is described in Table 3.

‡Within a column, treatments marked with the same letter were statistically similar (p=0.10).

§LSD; Least significant difference at the p=0.10.

There was no significant difference in harvest population between the Till and No-till treatments (Table 10). Dry beans in the No-till treatment had significantly less lodging compared to the Till treatment, with lodging ratings of 1.63 and 2.81 respectively. Pod height was significantly higher in the Till treatment, 10.7cm, than the No-till treatment, 6.67cm. Dry bean seed harvest moisture was 17.0% in the Till treatment, which was significantly lower than the No-till treatment, by 6.3%. The trial average for test weight was 68.5 lbs bu^{-1} and there was no statistical difference between the treatments. Till treatment did not significantly impact dry bean seed yield; the trial average was 2346 lbs ac^{-1}. The average 100-seed was significantly higher in the No-till treatment.

Table 10. Harvest characteristics by tillage treatment, Alburgh, VT, 2024.

Treatment	Harvest population	Lodging	Pod height	Harvest moisture	Test weight	Yield at 14% moisture	100-seed weight
	plants ac^{-1}	1-5 rating†	Cm	%	lbs bu^{-1}	lbs ac^{-1}	grams
Till	70055	2.81^{b}‡	**10.7^{a}**	**17.0^{a}**	69.3	2466	25.8^{b}
No-Till	79683	**1.63^{a}**	6.76^{b}	23.3^{b}	67.8	2226	**27.9^{a}**
LSD (p = 0.10)§	NS¥	0.52	1.77	2.15	NS	NS	0.96
Trial mean	74869	2.22	8.72	20.2	68.5	2346	26.8

†Lodging scale: 1=all plants erect; 5=all plants horizontal

‡Within a column, treatments marked with the same letter were statistically similar (p=0.10).

§LSD; Least significant difference at p=0.10.

¥NS; No Significant difference between treatments.

DISCUSSION

In 2023-2024, the UVM Extension Northwest Crops & Soils Program conducted the second year of a no-tillage and dry bean variety performance trial at Borderview Research Farm in Alburgh, VT. Dry beans from four market classes (navy, pinto, small red, and black) were grown in an organic system to determine if they were suitable for a no-till rolled-crimped rye mulch cropping system. The varieties Alpena (navy), Rojo Chiquito (small red), and Zorro (black) were included in the 2023 and 2024 research trials. The pinto bean variety, Max, evaluated in 2023 performed poorly, and was replaced with the variety Lariat in the 2024 trial. Winter rye was planted in early September 2023, and temperatures were unseasonably warm in the fall and winter months following planting. Monthly average temperatures were about 4 to 5 degrees warmer than normal from October 2023 to March 2024. November 2023 was the exception with a monthly average temperature 3.5 degrees colder than normal. Temperatures continued to remain warm in May. The early fall planting of winter rye followed by warm winter conditions led to good establishment and high biomass production. Above average rainfall from June through August resulted in a season total of 21.7 inches of precipitation, 6.18 inches more than normal. Temperatures during the dry bean growing season were typical for the region, and there were 2319 accumulated Growing Degree Days.

There was only one significant variety x tillage treatment interaction and that was in 100-seed weight. Lariat had a 100-seed weight that was almost 5 grams higher in the No-till treatment compared to the Till treatment. For the other three varieties, there were only slight differences in the 100-seed weight between tillage treatments. The lack of significant interaction between variety and tillage treatments suggests that the four dry bean varieties/market classes performed similarly in both tilled and no-tillage systems.

Lariat was the earliest to flower and reach maturity, but all four varieties reached maturity between 5 and 11-Sep, which is ideal for the short growing season of the Northeast. The four varieties included in this trial were chosen because they have a short, upright growth habit that makes them suitable for direct harvest. Growth habit and environmental conditions contribute to lodging, but overall lodging was low in this trial, with an average score of 2.22. Most plants were completely erect or only slightly lodged at harvest and there were no statistical differences between varieties. Alpena had an average pod height that was significantly lower than the other three varieties. Higher pod height is associated with increased ease of direct harvesting and may also reduce disease by reducing contact with soil. All four varieties had good seed yields and there were no significant differences between varieties. The trial average was 2,346 lbs ac^{-1}. These yield results were similar to what was observed in the 2023 trial. In 2023 there were no statistical differences in seed yield between Alpena, Rojo Chiquito, and Zorro. The pinto variety, Max, performed poorly in multiple dry bean performance trials at the Alburgh location in 2023, and had significantly lower yields than the other three varieties. For that reason, Max was replaced with Lariat in the 2024 research trial.

Warm winter temperatures in 2023-2024 led to high rye biomass in this trial. Rye biomass was 2.54 DM ton ac^{-1} when the cover crop was plowed for the Till treatment. Three weeks later the rye biomass had increased to 4.72 DM tons ac^{-1} when the cover crop was rolled and crimped for the No-till treatment. Despite the large amount of rye biomass, lodging was not observed prior to termination. The thick rye mulch in the No-till treatment helped control weeds during the season. Inter-row cultivation was only done once, on 8-

Jul, in the Till plots because of wet field conditions due to excessive rain during the season, and no weed control occurred in the No-till plots. In late August, weed biomass was significantly higher in the Till treatment. Weeds made up 27% of the total plant biomass in the Till plots, but only 9% of the total plant biomass in the No-till plots. The whole bean plant biomass was significantly lower in the No-till treatment, which suggests that plants were smaller than in the Till treatment. Dry beans in the No-till treatment did not have any incidence of white mold, likely due to increased airflow from reduced weed pressure and smaller plants. The Till treatment had significantly greater incidence and severity of white mold, but both were quite low. Emergence populations were significantly lower in the No-till treatment, but by harvest, there were no significant differences in population. This may be due to the delayed emergence of plants in the No-till treatment. Dry beans in the Till treatment flowered and reached maturity earlier than in the No-till treatment, but that did not result in a significant difference in dry bean seed yield at harvest. All four varieties performed well in an organic no-tillage system in 2024. Variety selection is important, and additional research should be done to understand how more varieties within these market classes perform under this management strategy. It is important to remember that these data represent only one year of data at one location.

LITERATURE CITED

Stavely, J.R. 1985. The Modified Cobb Scale for estimating bean rust intensity. Ann. Rep. Bean Improv. Coop. 28:31-32.

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