NORTHWEST CROPS & SOILS PROGRAM

2023 Inter-row Mowing in Organic No-till Black Beans

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THE UNIVERSITY OF VERMONT EXTENSION

2023 INTER-ROW MOWING IN ORGANIC NO-TILL BLACK BEANS

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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. But the yield and quality of organic dry beans has been affected by the lack of information on variety selection, inadequate management of diseases and weeds, and suboptimal recommendations for no-till production. Due to these production challenges, the exponential increase in consumer demand for organic dry beans has not been realized. 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 for incorporation into rolled-crimped cereal rye mulch cropping systems and could reduce the negative impacts on soil health. While cereal rye mulch can reduce weed pressure, there is still a need for alternative weed management strategies. Inter-row mowers are a new tool that can effectively manage weeds without traditional tillage and could be beneficial for use in an organic no-till production system. The timing of weed control is crucial as not to cause significant damage to the crops but still successfully control weeds. To evaluate the efficacy of inter-row mowing in organic no-till planted dry beans, the University of Vermont Extension Northwest Crops and Soils Program (NWCS) conducted a trial to evaluate the impact of inter-row mowing on weed suppression as well as dry bean yield during the 2022-2023 growing season.

MATERIALS AND METHODS

The trial was conducted at Borderview Research Farm in Alburgh, VT in the 2022-2023 growing season. The experimental design was a randomized complete block with four replicates. Trial management details are provided in Table 1. A detailed description of the inter-row mowing treatments is provided in Table 2.

Table 1. Trial management details, Alburgh, VT, 2022-2023.

Location	Borderview Research Farm, Alburgh, VT
Soil type	Benson rocky silt loam, over shaly limestone, 8 to 15 % slopes
Previous crop	Sorghum Sudangrass
Plot size (feet)	10 x 45
Row spacing (inches)	30
Replicates	4
Cover crop variety	*ND Gardner* cereal rye
Cover crop seeding rate (pure live seeds ac^{-1})	3 million
Cover crop planting date	17-Sep 2022
Cover crop termination	Roll/crimp 5-Jun 2023
Black bean variety	*Zorro*
Black bean seeding rate (pure live seeds ac^{-1})	150,000
Black bean planting date	5-Jun 2023
Black bean harvest date	4-Oct 2023

Table 2. Description of inter-row mowing treatments, 2023.

Treatments	Dates	Description
No weed control	N/A	No inter-row mowing
Early weed control	6-Jul	Inter-row mowing occurred once early during the critical period for weed control after beans reached the V2 growth stage and weeds were at least 8 inches tall.
Late weed control	15-Aug	Inter-row mowing occurred once late during the critical period for weed seed control. Mowing occurred before seed maturation of dominant weed species and before beans were susceptible to damage.
As-needed weed control	6-Jul & 26-Jul	Inter-row mowing occurs as needed.

The cereal rye variety *ND Gardner* was obtained from Albert Lea Seed (Albert Lea, MN) and was planted on 17-Sep 2022 at a rate of 3 million pure live seeds ac^{-1} using a Sunflower no-till grain drill. In the spring prior to termination, rye biomass was measured by collecting four representative samples using a $0.5m^2$ quadrat. All above ground plant material was collected using hand clippers, weighed, dried, and reweighed to calculate dry matter and yield. The rye was rolled down using a 10 foot I&J Crop Roller Crimper (Camp Douglas, WI) on 5-Jun 2023. The variety *Zorro* black bean was obtained from Central Bean Co. (Quincy, WA). Black beans were planted into rolled down rye on 5-Jun 2023 using a John Deere no-till planter at a seeding rate of 150,000 seeds ac^{-1}. Prior to planting, all seeds were treated with dry bean inoculant (*Rhizobium leguminosarum biovar phaseoli*). Plot sizes were 10ft x 45ft, with 4 rows at 30-inch spacing.

Dry bean emergence was measured 3 weeks after planting on 27-Jun 2023. The number of plants in two 1-meter sections was recorded. The mower used in this trial was the IRM-X4 Inter-Row Mower from R-Tech Industries Ltd. (Manitoba, CAN) (Figure 1). On 6-Jul 2023 the inter-row mower was used in the Early weed control and As-Needed weed control plots. On 26-Jul 2023, the inter-row mower was used for a second time in the As-Needed weed control plots. Mowing in the Late weed control plots took place on 15-Aug 2023. To assess peak dry bean and weed biomass during the growing season, all above ground plant material was removed from within one $0.5\text{-}m^2$ quadrat per plot using hand clippers when dry bean plants reached R6/R7 growth stage: 23-Aug 2023. 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 whole plant. Samples were then weighed, dried, and reweighed to determine dry matter and yield. Plants were ready to harvest approximately 5 days after 95% of plants were brown/yellow. Black beans were harvested on 4-Oct 2023. All plants were counted, then hand-pulled from two 1-m row lengths in the center two rows of each plot. Plants were then hung to dry in a well-ventilated

Figure 1. IRM-X4 Inter-Row Mower from R-Tech Industries Ltd. Photo credit: © R-Tech Industries Ltd.

space. Once dry, the beans were threshed using a portable Almaco thresher with a rasp bar rotor. The beans were then weighed for plot yield. To assess differences in seed size, a 100-seed weight assessment was completed by counting out 100 seeds and recording the total seed weight for three samples per 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 throughout the season with a Davis Instrument Vantage Pro2 weather station, equipped with a WeatherLink data logger at Borderview Research Farm in Alburgh, VT (Table 3). Below average temperatures and increased precipitation persisted for most of the dry bean growing season. There was a total of 23.8 inches of rain from June to September. There was a total of 2184 accumulated Growing Degree Days (GDDs), which is slightly below the 30-year average.

Table 3. Weather data for Alburgh, VT, 2023.

	2023			
Alburgh, VT	June	July	August	Sept
Average temperature (°F)	65.7	72.2	67.0	63.7
Departure from normal	-1.76	-0.24	-3.73	1.03
Precipitation (inches)	4.40	10.8	6.24	2.40
Departure from normal	0.14	6.69	2.73	-1.27
Growing Degree Days (50-86°F)	483	712	540	449
Departure from normal	-41.0	17.0	-101	62.0

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.

Results are summarized in Table 4 and 5. There were no significant differences in emergence populations, which is to be expected because mowing treatments had not begun, and all plots were planted at the same

seeding rate. Overall black bean stands were good, with an average emergence population of 163,640 plants ac^{-1} which was above the target seeding rate of 150,000 seeds ac^{-1}. In August at the time of peak biomass, there were no significant differences in whole plant bean biomass or weed biomass between mowing treatments. The trial average weed biomass was low, 179 lbs ac^{-1}. Harvest populations were not statistically different between treatments, and the trial average was 126,469 plants ac^{-1}. Black bean seed yield was highest in the Early weed control treatment, with a seed yield at 14% moisture of 3062 lbs ac^{-1}. This was not statistically different from the No weed control treatment. The Late weed control treatment had the lowest seed yield, 2058 lbs ac^{-1}, but was not statistically significant different from the As-Needed and No weed control treatments. The 100-seed weight was greatest in the No weed control treatment, 23.7g, but was statistically similar to the As-Needed and Early weed control treatments.

Table 4. Plant emergence, whole plant biomass, and weed biomass by treatment, Alburgh, VT, 2023.

Treatment	Emergence population	Dry beans	Weeds
		Dry matter biomass	
	plants ac^{-1}	lbs ac^{-1}	
As-Needed	177913	3681	213
Early	150031	3645	255
Late	164636	3512	31
No weed control	161980	4621	215
LSD (p = 0.10)†	NS‡	NS	NS
Trial Mean	163640	3865	178.6

†LSD; least significant difference at the p=0.10.
‡NS; no significant difference between treatments.

Table 5. Black bean harvest characteristics by treatment, Alburgh, VT, 2023.

Treatment	Harvest population	Seed yield at 14% moisture	100-seed weight
	plants ac^{-1}	lbs ac^{-1}	grams
As-needed	136095	2271[b]†	23.6[a]
Early	125473	**3062[a]**	23.3[ab]
Late	99582	2058[b]	22.4[b]
No weed control	144725	2560[ab]	**23.7[a]**
LSD (p = 0.10)‡	NS§	621	0.88
Trial Mean	126469	2487	23.2

†Within a column, treatments marked with the same letter are statistically similar (p=0.10); top performer is in **bold.**
‡LSD; least significant difference at the p=0.10.
§NS; no significant difference between treatments.

DISCUSSION

For the 2022-2023 growing season, the UVM Northwest Crops & Soils Program conducted the first year of a research trial to determine if inter-row mowing can provide adequate weed management while minimizing damage to the organic no-till dry bean crop. Inter-row mowing early, late, and as-needed were compared to a control where no inter-row mowing occurred to understand how the timing of the weed management impacted black bean yields and weed biomass. The average rye biomass at termination was 9546 lbs or 4.8 tons ac^{-1}, resulting in a thick layer of cereal rye mulch. Black bean emergence was very good, and the average emergence population was 163,640 plants ac^{-1}, slightly above the target seeding rate of 150,000 plants ac^{-1}. Excessive moisture and cool temperatures resulted in smaller plants that never got large enough for complete canopy closure. The plants also did not have any vining earlier in the season. As a result, there was little to no damage to the plants after the Early and As-Needed weed control treatments. By early August, there was significant vining throughout the trial, and this caused a lot of damage to the plants in the Late weed control plots. Whole plant bean and weed biomass was measured about a week after the inter-row mowing occurred in the Late weed control treatment. However, there were no significant differences in whole plant biomass or weed biomass between treatments. The thick rye mulch and supplemental weed management with the inter-row mower kept weed pressure low throughout the trial. Black bean seed yields were significantly impacted by the timing of the inter-row mowing. The Early weed control had the greatest black bean yields, 3062 lbs ac^{-1} at 14% moisture. This was not statistically different from the No weed control indicating no negative impact from early mowing. Despite the damage resulting from the Late weed control treatment, black bean yields were not statistically different from the As-Needed or No weed control treatments. Results from this year's trial suggest that the inter-row mower can be a valuable tool for weed management in an organic no-till system, but the timing of inter-row mowing is very important. There is a risk of inter-row mowing too late in the season once plants have approached canopy closure or if the plants have significant vining as was observed in this year's trial. It is important to note that these data represent only one year of data at one location. The NWCS program is repeating this research trial again in the 2023-2024 season.

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