Improving mechanical in-row weed control for vegetables and row crops

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Abstract:
In the crop row, it can be challenging to control weeds mechanically without damaging the crop. Based on the encouraging results of previous research using "stacked" combinations of in-row cultivation implements, we attempted to refine the use of these tools by testing several setups and adjustments. In snap beans, several implement combinations controlled over 90% of the weeds with very little crop damage. In 2-leaf beets, crop damage was unacceptably high, even when using standard implements such the spring tine harrow. But in 4-leaf beets, damage was greatly reduced and satisfactory weed control was obtained with a setup of sweeps followed by finger weeders followed by disk hillers. These setups and adjustments may be used as a starting point for growers investing in this equipment.

Background and Justification:
Mechanical weed control is an important part of an integrated weed management approach for vegetable and field crop operations. While between-row cultivation is typically very effective, it is challenging for growers to control in-row weeds without damaging their crop. In this project, we looked to build on previous research that found by "stacking" several different cultivation implements together in a synergistic way, it is possible to dramatically increase the percentage of weeds that are killed (Brown and Gallandt 2018). Specifically, the most effective combination of implements involved first undercutting, then uprooting, and finally burying the weeds. However, crop damage remained a concern from previous trials. Therefore, in this project we aimed to adjust or replace the implements which I believed to be causing the crop damage in previous trials.

Objectives:
Refine the setup and adjustment of "stacked" cultivation so that high efficacy is maintained but with minimal crop damage.

Procedures:
Experimental design. In this project, we conducted several field trials comparing several "stacked" cultivation setups to standard sweeps and harrows. The first trail was conducted in snap beans (*Phaseolus vulgaris* cv Provider) planted on 30" rows with 1.6" in-row spacing on June 14, 2018. The second trial was in beets (*Beta vulgaris* cv Ruby Queen) planted at 10 pounds per acre on 30" rows. Half of the beet plots were cultivated at the 2-leaf stage and the other half where cultivated at the 4-leaf stage. In both trials, planting and cultivation were conducted using GPS guidance and each treatment was replicated four times. Weeds in the 4"

in-row zone were counted several days after cultivation and compared to uncultivated controls to calculate efficacy.

Rationale for implement setup. The implement responsible for undercutting weeds in previous trials of Brown and Gallandt (2018) was a torsion weeder, but super-slow-motion video analysis revealed that this tool was very aggressive on the crop, despite its spring-steel design. Therefore, we replaced this implement with shallow sweeps, which operated farther from the crop but undercut weeds and loosened soil in a similar manner to the torsion weeders (Figure 1). The finger weeder remained as the implement responsible for uprooting weeds but the fingers were widened to allow more space for the crop to pass through. A row harrow was the final implement in the previous trials, but video revealed it was primarily burying weeds, so we sought other ways to achieve burial without having tines contact the crop. Specifically, we removed the five center tines from the row harrow and re-arranged the outer tines to pull soil into the crop row (Figure 2). We also tested a small disk hiller (Figure 3). Several one-, two-, and three-tool setups were tested (Table 1). All tools were obtained from KULT Kress and mounted on their 2-row Argus system with rear steering.

Figure 1. Sweeps were the first implement in the "stacked" sequence.

Figure 2. A row harrow (foreground) and finger weeders (background).

Figure 3. A small disk hiller with guide wheels.

Table 1. Treatments and implement adjustments for each cultivation trial. All treatments were conducted at 2.5 mph, except spring tine harrowing, which was conducted at 7 mph. All implements were adjusted to operate about 0.5" deep.

Trial conditions	Treatment	Adjustment
Snap beans (1st trifoliate, 4" tall). Weeds mostly broadleaf, 1" tall	Sweeps	8.5" in-row space. This adjustment was used for the "stacked" treatments.
	Sweeps (aggressive)	6.9" in-row space.
	Sweeps+Fingers	Finger tips 1" apart when not in use.
	Sweeps+Row Harrow	Drop weight on heaviest setting.
	Sweeps+Disk Hiller	Disks 7.8" apart in front, 4.7" apart in rear.
	Sweeps+Fingers+Row Harrow	Finger tips 1" apart when not in use. Row harrow on heaviest setting.
	Sweeps+Fingers+Row Harrow (light)	Finger tips 2" apart when not in use. Row harrow on lightest setting.
	Sweeps+Fingers+Disk Hiller	Finger tips 1" apart when not in use. Disks 7.8" apart in front, 4.7" apart in rear.
Beets (2-leaf, 1.5" tall). Weeds mostly broadleaf, 0.5" tall.	Spring tine harrow	Tine angle at middle setting.
	Sweeps	7.5" in-row space.
	Sweeps+Fingers	Finger tips nearly touching when not in use.
	Sweeps+Row Harrow	Drop weight on lightest setting.
	Sweeps+Disk Hiller	Disks 7.8" apart in front, 4.7" apart in rear.
	Sweeps+Fingers+Row Harrow	Finger tips 2.4" apart when not in use. Drop weight on lightest setting.
	Sweeps+Fingers+Disk Hiller	Finger tips 2.4" apart when not in use. Disks 7.8" apart in front, 4.7" apart in rear.
Beets (4-leaf, 3" tall). Weeds mostly broadleaf, 1.5" tall	Spring tine harrow	Same as above trial.
	Sweeps	–
	Sweeps+Fingers	–
	Sweeps+Row Harrow	–
	Sweeps+Disk Hiller	–
	Sweeps+Fingers+Row Harrow	–
	Sweeps+Fingers+Disk Hiller	–

Results and Discussion:
In snap beans, weed control efficacy was very high relative to crop damage (Figure 4), reflecting the dry conditions that allowed the crop to emerge with almost no weed pressure until several weeks after planting. While sweeps alone threw some soil into the row to bury 50-70% of the weeds, the "stacked" combinations had the greatest efficacy. In particular, the combinations of three implements all killed over 90% of the weeds. The "light" adjustment of the sweeps+fingers+row harrow appeared to reduce crop damage while retaining high weed control.

In 2-leaf-stage beets, crop mortality from cultivation was unacceptably high (Figure 5A). But damage was greatly reduced when beets were in the 4-leaf stage (Figure 5B). Unexpectedly, weed control efficacy remained high despite larger weeds present when beets were in the 4-leaf stage. This may relate to drier conditions during the latter cultivation. Most of the "stacked" combinations killed a greater percentage of the weeds than the spring tine harrow. The sweeps+finger+disk hiller combination performed very well in this trial.

Overall, the cultivation setups in these trials provide a relatively low-tech solution for farmers to improve their in-row weed control. These extra implements can be "stacked" onto farmers' existing equipment at a reasonable cost.

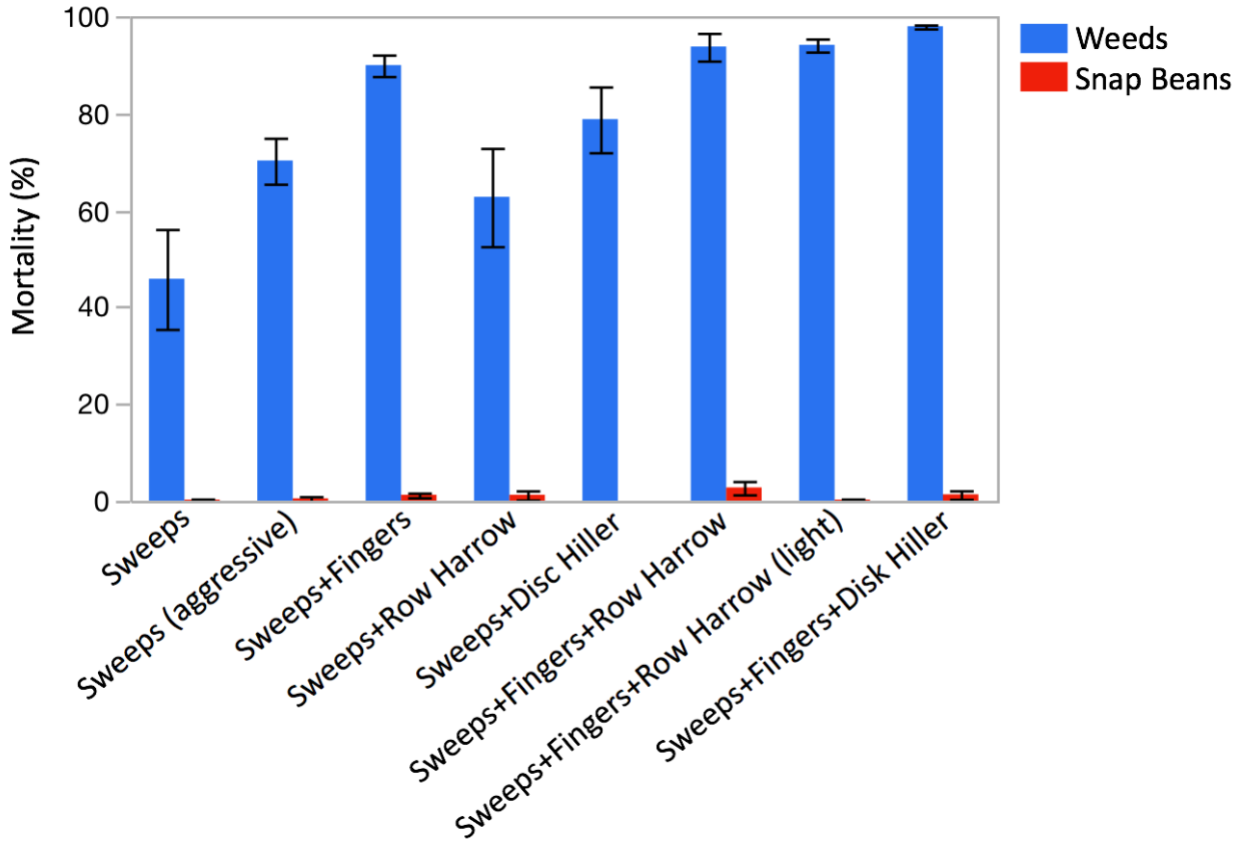

Figure 4. Mortality of weeds and snap beans resulting from different implement combinations and adjustments.

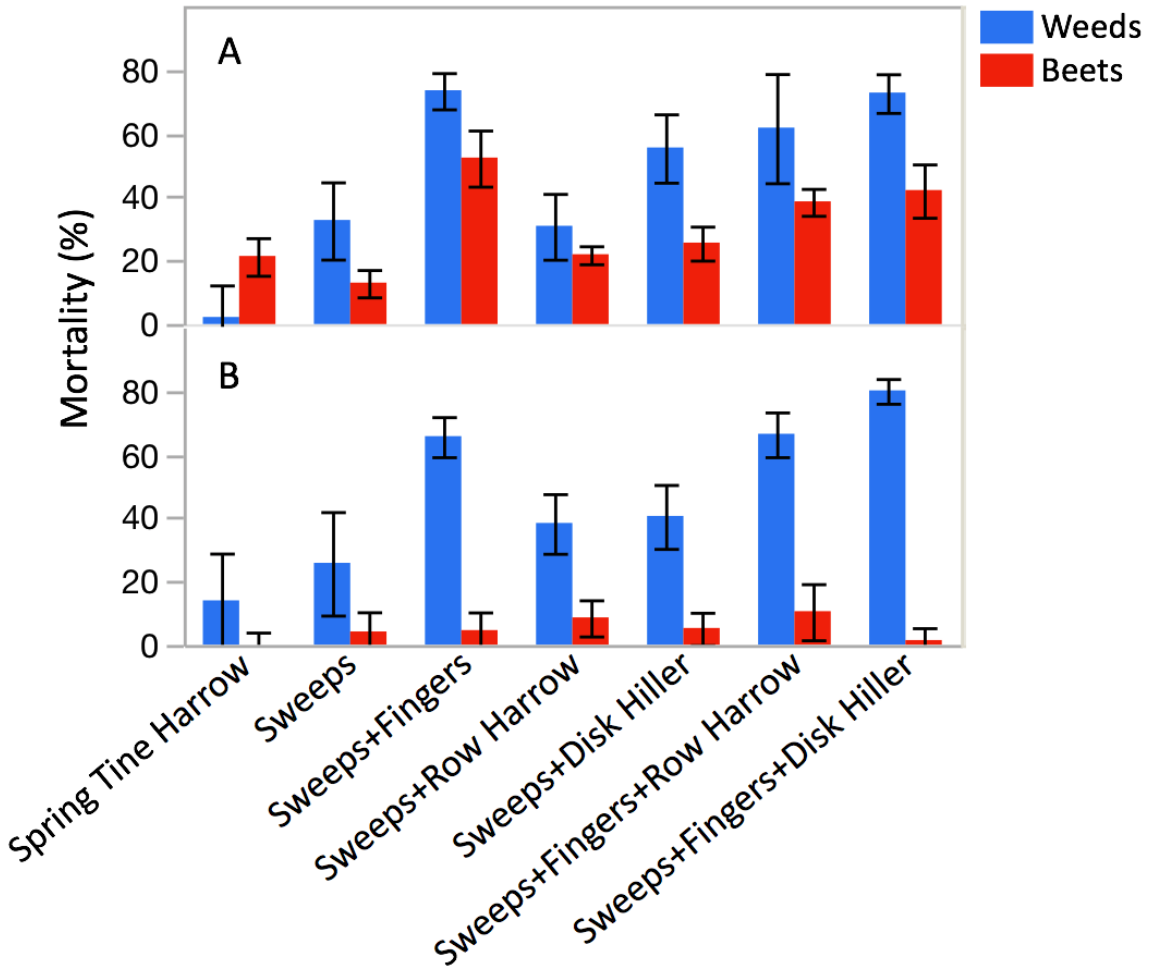

Figure 5. Mortality of weeds and beets resulting from different implement combinations and adjustments. Cultivations occurred in either 2-leaf (A) or 4-leaf (B) beets.

Literature Cited:

Brown B, Gallandt ER (2018). Evidence of synergy with 'stacked' intrarow cultivation tools. Weed Research. doi.org/10.1111/wre.12309.

Project Locations:

Trials and demonstrations were conducted in Ontario County and Essex County, but research results apply statewide.

Resources Developed:

Video:

Brown, B. Stacked cultivation trials, 2018. NYSIPM. Available at https://youtu.be/jdzv6x8QI2A

Presentations:

Brown, B. Reduced Tillage in Organic Systems Field Day, Cornell University, Willsboro, Essex Co, Adjusting in-row cultivation tools, 7/31/18

Brown, B. Greater WNY Vegetable Farming Collaborative Teach-In, NYSIPM and the Cornell Vegetable Program, Geneva, Ontario Co, In-Row Cultivation Demo, 9/30/18

Brown, B. Long Island Agricultural Forum, Cornell Cooperative Extension, Riverhead, Suffolk Co, Improving Your Cultivator to Increase Weed Control, 1/9/19

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