

Project Title: Efficacy and Crop Safety of Herbicides on Garden Beet, Spinach and Chard

Ed Peachey, Oregon State University
Dept. of Horticulture
4017 Ag. & Life Sci. Bldg.
Corvallis, OR. 97331

Objective

Determine the efficacy and crop safety of herbicides on garden beet, spinach, and chard for the control of weeds.

Methods

The experiment was located on an experimental farm near Corvallis, OR on a silt loam soil (pH 6.0, OM 4.77%, CEC 29.7 meq/100g soil). Table beets (var. Red Ace), Swiss chard, and spinach (female line) were planted 3 rows per plot with 26 in between rows and in plots 25 ft long. There were 4 replications of each herbicide treatment in each crop, and crops were planted in a strip-plot arrangement. Herbicides were applied with a CO₂ powered back-pack sprayer with a 4 nozzles on an 18 spacing. One of the untreated check plots was hand hoed. Spinach and chard were harvested from 10 ft of row and biomass weighed on June 27. Table beets were pulled from 10 ft of the middle row in each plot and weighed and graded on August 8.

Results

- S-metolachlor caused the least injury to the beets with reasonable but insufficient weed control by seasons end, even though the plots were cultivated (Table 4).
- Amicarbazone at the low rate improved hairy nightshade control slightly (Table 6) but also injured beets more than s-metolachlor. Yield was not improved by the combination of amicarbazone plus s-metolachlor.
- Clomazone caused severe whitening early in the season but also provided weed control that brought yields up to the level of the weeded check plots.
- Pendimethalin caused excessive injury even when applied at the 2-leaf stage.
- Pyroxasulfone (1x) improved weed control compared to s-metolachlor (1x) but caused more injury to beets than s-metolachlor.
- The combination of s-metolachlor (0.48 lb ai/A) plus ethofumesate (0.5 lb ai/A) gave the best yield, even though weed control was poor. Increasing the rate of s-metolachlor to (0.63 lb ai/A) in combination with ethofumesate improved weed control but not yield.
- Triflurosulfuron (Upbeet) EPOST following s-metolachlor had the greatest yield, and weed control averaged 90% at harvest. Swiss chard also was tolerant of triflurosulfuron (Table 5). Future research should develop use-patterns for tank mixes of Upbeet and Spinaid and evaluate application timing to maximize control of pigweed and hairy nightshade.

Table 1. Journal of activities

| | |
|----------------|---|
| May 15, 2012 | Fertilizer broadcast 450 lbs 12/29/10 and field worked a final time |
| May 18, 2012 | Planting, Spinach 6/ft Beets 12/ft Chard 6/ft, Gaspardo vacuum seeder |
| May 19, 2012 | Applied PRE |
| May 25, 2012 | Applied delayed-PRE herbicides |
| June 4, 2012 | Measured emergence Crop injury rating |
| June 11, 2012 | Crop injury rating Weed control rating Cultivated |
| June 12, 2012 | Hoed check plots |
| June 26, 2012 | Crop injury rating |
| July 13, 2012 | Crop injury rating Weed control rating |
| July 27, 2012 | Swiss chard and spinach harvest |
| August 8, 2012 | Table beet harvest |

Table 2. Rainfall and irrigation record.

| Date | Rainfall (in) | Irrigation (in) |
|-------------|---------------|-----------------|
| May 21 | 0.15 | |
| 22 | 0.37 | |
| 23 | 0.14 | |
| 24 | 1.6 | |
| 25 | 0.40 | |
| June 2 | 0.13 | |
| 4 | 0.19 | |
| 5 | 0.42 | |
| 7 | 0.25 | |
| 8 | 0.06 | |
| 9 | 0.14 | |
| 12 | 0.07 | |
| 19 | 0.15 | |
| 22 | 0.05 | |
| 23 | 0.29 | |
| 24 | 0.07 | |
| 26 | 0.23 | |
| 27 | 0.14 | |
| July 1 | 0.34 | |
| 17 | 0.02 | |
| 18 | | 0.66 |
| 25 | | 0.66 |
| Aug 2 | | 1.0 |
| Totals | 5.21 | 2.32 |
| Total water | | 7.53 |

Table 3. Herbicide application data.

| Date | May 19 | May 25 | June 8 | June 9 |
|---------------------------------|---|---|--|--|
| Crop stage | | Beets: all radicles emerged about ¾ in., ~10% poking through soil | 2 true leaves | 2 true leaves |
| Weeds and growth stage | - | - | | |
| Hairy nightshade | - | - | 2 leaf up to 4 cm | 2 leaf up to 4 cm |
| Lambsquarters | - | - | coty to 2 lf | coty to 2 lf |
| Pigweed | - | - | coty to 2 lf | coty to 2 lf |
| Common purslane | - | - | coty | coty |
| Herbicide/treatments | All PRE treatments | 16, 17, 25 | 13 DM, EPOST | 18,19,20 |
| Application timing | PRE | Delayed PRE | EPOST 2-leaf | EPOST 2-leaf |
| Start/end time | 7-12:05 | 2:30-3 PM | 4-4:15PM | 9:15-9:45 |
| Air temp/soil temp (2")/surface | 73/75/75 | 72/76/82 | 59/- /- | 59/- /- |
| Rel humidity | 43% | 40% | 71% | 78% |
| Wind direction/velocity | 0-1 SE | 2-5 NW | 2-5 W | 0-2 SW |
| Cloud cover (%) | 100 | 50 | 100 | 0 |
| Soil moisture | dry on surface | very wet from 4 days of rain | very wet | very wet from rain overnight |
| Plant moisture | - | - | possibly wet from showers | damp |
| Sprayer/PSI | BP 30 | BP 25 | BP30 | BP30 |
| Mix size | 2100 mls | 2100 mls | 2100 mls | 3 gal |
| Gallons H2O/acre | 20 | 20 | 20 | 20 |
| Nozzle type | 5-XR8003 | 5-XR8003 | 4--XR8003 | 4--XR8003 |
| Nozzle spacing and height | 20/20 | 20/20 | 20/20 | 20/20 |
| Soil inc. method/implement | 1 hr of irrigation starting at 12:10; more rain to follow | Showered at night | Light rain off and on after app; 0.05 in or less fell during night | Waited until June 9 to apply to avoid rainfall |

Table 4. Table beet response to herbicides.

| | Herbicide | Timing | Date | Rate | Crop stand June 4 | Crop injury | | | | Beet harvest | | | | | | | |
|----------|----------------------------------|--------------|------------------|---------------|-------------------------|-------------|------------|------------|------------|----------------|-------|-------|-----|-----|------|------|-----------------|
| | | | | | | June 4 | June 11 | June 26 | July 13 | Roots/ plot | Yield | Grade | | | | | Avg. beet wt |
| | | | | | | | | | | | | 1 | 2 | 3 | Over | %1-2 | |
| | | | | | | | | | | | | | | | | | |
| lbs ai/A | no/3 ft | | | | | | | | | | | | | | | | |
| 1 | Unweeded | - | - | - | 10 | 0 | 15 | 0 | 11 | 18 | 4.8 | 4.8 | 0.1 | 0.3 | 1.1 | 35 | 199 |
| 2 | S-metolachlor | PPS | 19-May | 0.63 | 21 | 0 | 0 | 0 | 4 | 55 | 15.2 | 15.2 | 0.1 | 0.8 | 2.6 | 15 | 412 |
| 3 | S-metolachlor | PPS | 19-May | 1.26 | 25 | 0 | 10 | 10 | 14 | 53 | 16.8 | 16.8 | 0.1 | 0.6 | 2.7 | 12 | 360 |
| 4 | Amicarbazone | PPS | 19-May | 0.056 | 16 | 0 | 18 | 23 | 19 | 28 | 5.8 | 5.8 | 0.1 | 0.4 | 1.1 | 34 | 195 |
| 5 | Amicarbazone | PPS | 19-May | 0.111 | 9 | 0 | 43 | 45 | 49 | 20 | 8.9 | 8.9 | 0.0 | 0.2 | 1.4 | 5 | 541 |
| 6 | Amicarbazone | PPS | 19-May | 0.223 | 5 | 0 | 75 | 73 | 84 | 7 | 5.0 | 5.0 | 0.0 | 0.1 | 0.3 | 4 | 666 |
| 7 | Clomazone | PPS | 19-May | 0.5 | 16 | 2 | 53 | 18 | 40 | 25 | 16.1 | 16.1 | 0.0 | 0.3 | 1.2 | 4 | 978 |
| 8 | Clomazone | PPS | 19-May | 1.0 | 17 | 2 | 63 | 53 | 41 | 29 | 14.3 | 14.3 | 0.1 | 0.3 | 1.6 | 6 | 505 |
| 9 | Pendimethalin | PPS | 19-May | 1.0 | 13 | 0 | 63 | 99 | 99 | 0 | 0.4 | 0.4 | 0.0 | 0.0 | 0.0 | 0 | 378 |
| 10 | Pendimethalin | PPS | 19-May | 2.0 | 11 | 0 | 80 | 100 | 100 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0 |
| 11 | Pyroxasulfone | PPS | 19-May | 0.015 | 18 | 0 | 23 | 18 | 24 | 33 | 10.9 | 10.9 | 0.0 | 0.3 | 2.2 | 7 | 551 |
| 12 | Pyroxasulfone | PPS | 19-May | 0.031 | 19 | 0 | 20 | 15 | 8 | 35 | 15.7 | 15.7 | 0.1 | 0.3 | 2.3 | 6 | 582 |
| 13 | S-metolachlor + S-metolachlor | PPS EPOST | 19-May 8-Jun | 0.63 0.63 | 15 | 0 | 8 | 15 | 9 | 48 | 16.1 | 16.1 | 0.1 | 0.6 | 2.8 | 10 | 403 |
| 14 | Amicarbazone + S-metolachlor | PPS PPS | 19-May 19-May | 0.056 0.63 | 13 | 0 | 18 | 23 | 23 | 31 | 14.5 | 14.5 | 0.1 | 0.2 | 2.0 | 5 | 484 |
| 15 | Clomazone + S-metolachlor | PPS PPS | 19-May 19-May | 0.25 0.63 | 19 | 1 | 55 | 35 | 34 | 31 | 12.6 | 12.6 | 0.1 | 0.3 | 1.8 | 8 | 516 |

continued next page

| Herbicide | Timing | Date | Rate | Crop stand | Crop injury | | | | | Beet harvest | | | | | | | | |
|-----------|--|--------------------|------------------|----------------|-------------|---------|---------|---------|------------|--------------|-----------|----------|-----|-----|-----|--------------|------|------|
| | | | | | June 4 | June 11 | June 26 | July 13 | Roots/plot | Yield | Grade | | | | | Avg. beet wt | | |
| | | | | | | | | | | | Chlorosis | stunting | 1 | 2 | 3 | | Over | %1-2 |
| | | | | | | | | | | | | | | | | | | |
| lbs ai/A | no/3 ft | | | | | | | | | | | | | | | | | |
| 16 | Pendimethalin | Delayed PRE | 25-May | 1.0 | 13 | 0 | 70 | 100 | 100 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0 | |
| 17 | Pendimethalin + Pendimethalin | PPS Delayed PRE | 19-May 25-May | 0.5 0.5 | 17 | 0 | 65 | 100 | 100 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0 | |
| 18 | Triflusalufuron + COC 1% | EPOST | 9-Jun | 0.031 | 20 | 0 | 10 | 10 | 8 | 35 | 9.1 | 9.1 | 0.2 | 0.3 | 2.3 | 11 | 260 | |
| 19 | S-metolachlor Triflusalufuron + COC 1% | PPS EPOST | 19-May 9-Jun | 0.63 0.031 | 17 | 0 | 20 | 23 | 21 | 33 | 16.7 | 16.7 | 0.1 | 0.3 | 2.1 | 5 | 824 | |
| 20 | Pyroxasulfone+ Triflusalufuron + COC 1% | PPS EPOST | 19-May 9-Jun | 0.015 0.031 | 18 | 0 | 18 | 33 | 25 | 30 | 10.2 | 10.2 | 0.1 | 0.4 | 1.9 | 8 | 734 | |
| 21 | Pyroxasulfone + Ethofumesate | PPS PPS | 19-May 19-May | 0.015 0.5 | 16 | 0 | 25 | 15 | 35 | 29 | 14.9 | 14.9 | 0.1 | 0.2 | 1.4 | 4 | 905 | |
| 22 | S-metolachlor + Ethofumesate | PPS PPS | 19-May 19-May | 0.48 0.5 | 12 | 0 | 23 | 23 | 25 | 25 | 16.8 | 16.8 | 0.0 | 0.2 | 1.4 | 3 | 1053 | |
| 23 | S-metolachlor + Ethofumesate | PPS PPS | 19-May 19-May | 0.64 0.5 | 12 | 0 | 30 | 5 | 38 | 35 | 14.8 | 14.8 | 0.1 | 0.4 | 2.2 | 7 | 965 | |
| 24 | S-metolachlor + Ethofumesate | PPS PPS | 19-May 19-May | 0.64 1 | 10 | 0 | 50 | 50 | 50 | 19 | 14.0 | 14.0 | 0.0 | 0.3 | 1.0 | 4 | 809 | |
| 25 | S-metolachlor + Pendimethalin | PPS Delayed PRE | 19-May 25-May | 0.4775 0.5 | 12 | 0 | 55 | 90 | 95 | 2 | 0.7 | 0.7 | 0.0 | 0.1 | 0.2 | 13 | 115 | |
| 26 | Weeded | | | | 19 | 0 | 18 | 13 | 28 | 34 | 12.9 | 12.9 | 0.0 | 0.3 | 2.0 | 6 | 520 | |
| | <i>FPLSD (0.05)</i> | | | | 12 | 0.7 | 25 | 21 | 24 | 21 | 4.9 | 0.1 | 0.4 | 1.3 | 2.0 | 17 | 589 | |

Table 5. Swiss chard and spinach tolerance to select herbicide treatments.

| Herbicide | Timing | Date | Rate | Chard | | | | | | Spinach | | | | | | |
|-----------|---|----------------|--------|-----------------------|---------------------------|-----------------------|------------------|---------------------|----------------------------|-----------------------|---------------------------|-----------------------|------------------|---------------------|----------------------------|-----------|
| | | | | Emergence (June 4) | Phytotoxicity (June 4) | Stunting (June 11) | Plants harvested | Biomass | Weed control at harvest | Emergence (June 4) | Phytotoxicity (June 4) | Stunting (June 11) | Plants harvested | Biomass | Weed control at harvest | |
| | | | | <i>lbs ai/A</i> | <i>no/3 ft</i> | <i>0-10</i> | <i>%</i> | <i>no/10 ft</i> | <i>t/A</i> | <i>%</i> | <i>no/3 ft</i> | <i>0-10</i> | <i>%</i> | <i>no/10 ft</i> | <i>t/A</i> | <i>%</i> |
| 1 | Unweeded | | | | 37 | 0 | 0 | 74 | 11.8 | 0 | 16 | 0 | 0 | 38 | 5.3 | 0 |
| 2 | S-metolachlor (1X) | PPS | 19-May | 0.63 | 33 | 0 | 13 | 74 | 20.6 | 83 | 17 | 0 | 8 | 35 | 11.7 | 73 |
| 4 | Amicarbazone 75 WG | PPS | 19-May | 0.056 | 38 | 0 | 18 | 70 | 15.1 | 40 | 17 | 0 | 5 | 32 | 10.2 | 18 |
| 7 | Clomazone (1X) | PPS | 19-May | 0.5 | 32 | 2.8 | 80 | 31 | 14.6 | 90 | 16 | 3.0 | 15 | 31 | 11.5 | 96 |
| 9 | Pendimethalin (1X) | PPS | 19-May | 1.0 | 31 | 0 | 48 | 0 | 0.0 | 86 | 18 | 0 | 63 | 0 | 0.0 | 81 |
| 11 | Pyroxasulfone (1X) | PPS | 19-May | 0.015 | 39 | 0 | 8 | 85 | 17.0 | 83 | 19 | 0 | 10 | 33 | 9.0 | 60 |
| 14 | Amicarbazone + S-metolachlor | PPS | 19-May | 0.056 | 35 | 0 | 18 | 61 | 21.2 | 92 | 16 | 0 | 13 | 33 | 10.7 | 90 |
| | | PPS | 19-May | 0.63 | | | | | | | | | | | | |
| 15 | Clomazone + S-metolachlor | PPS | 19-May | 0.25 | 28 | 1.3 | 78 | 44 | 17.4 | 95 | 18 | 1.0 | 23 | 35 | 9.8 | 97 |
| | | PPS | 19-May | 0.63 | | | | | | | | | | | | |
| 16 | Pendimethalin | Delayed PRE | 25-May | 1.0 | 41 | 0 | 55 | 0 | 0.0 | 89 | 18 | 0.3 | 65 | 0 | 0.0 | 79 |
| 18 | Triflurosulfuron + COC 1% | EPOST | 9-Jun | 0.031 | 40 | 0 | 5 | 70 | 16.0 | 60 | 18 | 0 | 20 | 5 | 0.7 | 23 |
| 19 | S-metolachlor | PPS | 19-May | 0.63 | 31 | 0 | 23 | 70 | 20.0 | 93 | 19 | 0 | 30 | 14 | 9.6 | 81 |
| 20 | Pyroxasulfone+ Triflurosulfuron + COC 1% | PPS | 19-May | 0.015 | 30 | 0 | 20 | 48 | 17.0 | 91 | 20 | 0 | 18 | 11 | 4.6 | 63 |
| | | EPOST | 9-Jun | 0.031 | | | | | | | | | | | | |
| 22 | S-metolachlor + Ethofumesate | PPS | 19-May | 0.48 | 37 | 0 | 13 | 74 | 18.7 | 91 | 18 | 0 | 15 | 37 | 9.9 | 85 |
| | | PPS | 19-May | 0.5 | | | | | | | | | | | | |
| | <i>FPLSD (0.05)</i> | | | | <i>ns</i> | <i>0.3</i> | <i>13</i> | <i>25</i> | <i>5.7</i> | <i>14</i> | <i>ns</i> | <i>0.4</i> | <i>11</i> | <i>11</i> | <i>6.7</i> | <i>13</i> |

Table 6. Weed control with herbicides applied to table beets.

| Plot | Herbicide | Timing | Date | Rate | Weed control 11-June-2012 | | | Weed control 7-July-2012 | | | | | At harvest |
|------|----------------------------------|----------------|------------------|-----------------|------------------------------|---------------------|---------------------|-----------------------------|---------------------|--------------------|---------------|---------------------|---------------------|
| | | | | | Pigweed | Hairy nightshade | Composite rating | Pigweed | Hairy nightshade | Lambs- quarters | Purs- lane | Composite rating | Composite rating |
| | | | | <i>lbs ai/A</i> | ----- % ----- | | | | | | | | |
| 2 | S-metolachlor (1X) | PPS | 19-May | 0.63 | 94 | 73 | 91 | 88 | 75 | 100 | 68 | 69 | 83 |
| 3 | S-metolachlor (2X) | PPS | 19-May | 1.26 | 81 | 75 | 81 | 98 | 93 | 95 | 100 | 95 | 92 |
| 4 | Amicarbazone 75 WG | PPS | 19-May | 0.056 | 60 | 25 | 55 | 8 | 33 | 80 | 50 | 11 | 30 |
| 5 | Amicarbazone 75 WG | PPS | 19-May | 0.111 | 96 | 24 | 91 | 24 | 88 | 100 | 65 | 68 | 33 |
| 6 | Amicarbazone 75 WG | PPS | 19-May | 0.223 | 82 | 78 | 82 | 58 | 100 | 100 | 80 | 82 | 53 |
| 7 | Clomazone (1X) | PPS | 19-May | 0.5 | 98 | 78 | 98 | 93 | 100 | 100 | 100 | 97 | 83 |
| 8 | Clomazone (2X) | PPS | 19-May | 1.0 | 100 | 100 | 100 | 95 | 100 | 100 | 100 | 100 | 91 |
| 9 | Pendimethalin (1X) | PPS | 19-May | 1.0 | 83 | 88 | 82 | 88 | 90 | 100 | 95 | 92 | 75 |
| 10 | Pendimethalin (2X) | PPS | 19-May | 2.0 | 77 | 75 | 72 | 98 | 100 | 100 | 100 | 99 | 85 |
| 11 | Pyroxasulfone (1X) | PPS | 19-May | 0.015 | 80 | 75 | 80 | 65 | 55 | 93 | 65 | 61 | 54 |
| 12 | Pyroxasulfone (2X) | PPS | 19-May | 0.032 | 78 | 100 | 80 | 98 | 75 | 100 | 75 | 74 | 78 |
| 13 | S-metolachlor + S-metolachlor | PPS EPOST | 19-May 8-Jun | 0.63 0.63 | 89 | 100 | 89 | 85 | 50 | 90 | 90 | 71 | 78 |
| 14 | Amicarbazone + S-metolachlor | PPS PPS | 19-May 19-May | 0.056 0.63 | 97 | 96 | 96 | 90 | 75 | 100 | 78 | 76 | 84 |
| 15 | Clomazone + S-metolachlor | PPS PPS | 19-May 19-May | 0.25 0.63 | 100 | 100 | 99 | 98 | 95 | 100 | 100 | 98 | 91 |
| 16 | Pendimethalin | Delayed PRE | 25-May | 1.0 | 91 | 81 | 88 | 84 | 95 | 100 | 98 | 95 | 68 |

continued next page

| Plot | Herbicide | Timing | Date | Rate | Weed control 11-June-2012 | | | Weed control 7-July-2012 | | | | | At harvest |
|------|--|-----------------------|------------------|-----------------|------------------------------|---------------------|---------------------|-----------------------------|---------------------|--------------------|---------------|---------------------|---------------------|
| | | | | | Pigweed | Hairy nightshade | Composite rating | Pigweed | Hairy nightshade | Lambs- quarters | Purs- lane | Composite rating | Composite rating |
| | | | | <i>lbs ai/A</i> | ----- % ----- | | | | | | | | |
| 17 | Pendimethalin + Pendimethalin | PPS Delayed PRE | 19-May 25-May | 0.5 0.5 | 93 | 88 | 89 | 95 | 98 | 100 | 93 | 98 | 81 |
| 18 | Triflurosulfuron + COC 1% | EPOST | 9-Jun | 0.031 | 17 | 7 | 17 | 20 | 57 | 100 | 63 | 15 | 43 |
| 19 | S-metolachlor Triflurosulfuron + COC 1% | PPS EPOST | 19-May 9-Jun | 0.63 0.031 | 85 | 100 | 85 | 90 | 73 | 100 | 80 | 83 | 90 |
| 20 | Pyroxasulfone+ Triflurosulfuron + COC 1% | PPS EPOST | 19-May 9-Jun | 0.015 0.031 | 83 | 66 | 80 | 80 | 80 | 100 | 63 | 80 | 80 |
| 21 | Pyroxasulfone + Ethofumesate | PPS PPS | 19-May 19-May | 0.015 0.5 | 86 | 74 | 88 | 88 | 65 | 100 | 98 | 78 | 79 |
| 22 | S-metolachlor + Ethofumesate | PPS PPS | 19-May 19-May | 0.48 0.5 | 90 | 100 | 90 | 93 | 73 | 100 | 98 | 66 | 73 |
| 23 | S-metolachlor + Ethofumesate | PPS PPS | 19-May 19-May | 0.64 0.5 | 97 | 100 | 97 | 98 | 93 | 100 | 98 | 94 | 88 |
| 24 | S-metolachlor + Ethofumesate | PPS PPS | 19-May 19-May | 0.64 1 | 98 | 100 | 98 | 93 | 98 | 100 | 98 | 98 | 68 |
| 25 | S-metolachlor + Pendimethalin | PPS Delayed PRE | 19-May 25-May | 0.4775 0.5 | 98 | 78 | 98 | 95 | 85 | 100 | 95 | 94 | 75 |
| 26 | Weeded <i>FPLSD (0.05)</i> | | | | 0 25 | 0 44 | 0 26 | 75 22 | 58 30 | 88 14 | 55 32 | 74 26 | 69 23 |



Tr 2 (s-metolachlor)



19 (s-met + triflusulfuron)



20 (pyrox + triflusulfuron)