# SUGARBEET TOLERANCE FROM HERBICIDE MIXTURES WITH INSECTICIDES AND FUNGICIDES

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**Summary**

1. Excalia for rhizoctonia damping off control mixed with herbicides and insecticides caused less vegetative sugarbeet injury than Quadris mixed with herbicides and insecticides.
2. Vegetative injury from complex mixtures sometimes but not always caused loss of sugarbeet root yield.
3. Foliar fungicides for control of Cercospora leaf spot mixed with pesticides for control of weeds and insects did not cause vegetative injury or reduce root yield or sucrose content in these experiments.
4. Product selection matters with complex tank-mixtures; differences in active and inert ingredients can influence crop tolerance.

**Introduction**

Sugarbeet is among the most complicated crops to cultivate, requiring a rigorous and precisely timed pest management program to achieve maximum root yield and sucrose content. Efficient time management and strategic pesticide use remain primary concerns for sugarbeet producers, as postemergence weed control frequently overlaps with soilborne and foliar disease and insect control. Growers regularly inquire about herbicide tank-mixtures of three, maybe four active ingredients. These mixtures may also include a soil-borne fungicide for Rhizoctonia root and crown rot control or an insecticide for root maggot or cutworm control. We are also receiving questions about herbicide and insecticide mixtures with foliar applied fungicides for Cercospora leaf spot as the recommendations to initiate spray programs creep into mid-June. Interest in complex tank-mixtures as a method to enhance operational efficiency and reduce application costs continues to grow, making evaluation of sugarbeet tolerance to complex tank-mixtures a primary focus for research.

Although these practices can reduce trips across the field, combining products with different formulation types, preloaded adjuvant systems, and percent active ingredient may increase the risk of physical incompatibility or crop phytotoxicity. Sugarbeet is particularly sensitive to many of its own registered pesticides and may exhibit phytotoxic responses, especially when formulations contain higher concentrations of oil-based adjuvants or surfactant systems that can increase herbicide uptake and crop injury potential (Kniss 2018). This is especially prevalent with cool and cloudy environmental conditions that slow the metabolism of pesticides by sugarbeet.

Evaluation of sugarbeet tolerance to herbicide-insecticide-fungicide tank-mixtures across multiple locations is necessary to inform best management practices and minimize the risk of crop injury under field conditions. The objectives of this research were: a) evaluate sugarbeet tolerance from herbicide mixtures with soilborne fungicides and insecticides; and b) evaluate sugarbeet tolerance from herbicide mixtures with foliar disease fungicides and insecticides.

**Materials and Methods**

Field experiments were conducted at multiple locations in the 2025 growing season to evaluate sugarbeet vegetative tolerance, root yield and sucrose content from herbicide mixtures with soilborne fungicides and insecticides. Greenhouse experiments conducted in 2022, (Peters et al., Sgbt Res. Ext. Rept. 2022:53:55-59, Peters et al., Sgbt Res. Ext. Rept. 2022:53:60-62,) 2023 and 2024 complement these field experiments. Experiments were arranged as a randomized complete block design (RCBD) with six replications. Ethofumesate was broadcast preemergence at 6 pints per acre (pt/A) to provide season-long weed control, ensuring high quality data. All other insect and disease pests were actively managed in experiments. Applications were made using a $CO_2$-pressurized backpack or bicycle

sprayer calibrated to deliver 17 gallons per acre (gpa). Application dates and weather information are listed below (Table 3).

*Soilborne Disease Complex Mixtures.* Pesticide application was timed to the 4- to 6-leaf (lf) stage (Table 1). A 'base' herbicide treatment, Roundup PowerMax3 mixed with ethofumesate and Outlook at 30 + 12 + 18 fl oz/A, respectively, was added to all treatments. Additional pesticides were Excalia, Quadris, Asana XL, and Stinger HL either tank-mixed with 'base' or following 'base' by three days. Treatments containing Excalia or Quadris with Stinger HL and Asana XL included Amsol liquid AMS at 2.5% v/v. Table 3 are weather conditions at application. Experiments were conducted near Prinsburg, Brushvale, and Crookston, MN. Prinsburg and Brushvale were planted in the typical timeframe when sugarbeet are planted in MN. Unfortunately, Crookston was replanted June 11, 2025 due to stand challenges associated with weather.

**Table 1. Pesticide treatment, pesticide rate, and timing of pesticide application.**

| Pesticide treatment[a,b] | Rate | Sugarbeet stage |
|---|---|---|
| | --------fl oz/A)-------- | (lf stage) |
| Roundup PowerMax3 + ethofumesate + Outlook (Base) | 30 + 12 + 18 | 4 to 6 |
| Base + Excalia | 2 | 4 to 6 |
| Base + Excalia + Asana XL | 2 + 9.6 | 4 to 6 |
| Base + Excalia + Stinger HL | 2 + 2.4 | 4 to 6 |
| Base + Excalia + Asana XL + Stinger HL | 2 + 9.6 + 2.4 | 4 to 6 |
| Base + Quadris | 15 | 4 to 6 |
| Base + Quadris + Asana XL | 15 + 9.6 | 4 to 6 |
| Base + Quadris + Stinger HL | 15 + 2.4 | 4 to 6 |
| Base + Quadris + Asana XL + Stinger HL | 15 + 9.6 + 2.4 | 4 to 6 |
| Base / Excalia + Asana XL + Stinger HL (3 DAB) | 2 + 9.6 + 2.4 | 4 to 6 / 3 DAB |
| Base / Quadris + Asana XL + Stinger HL (3 DAB) | 15 + 9.6 + 2.4 | 4 to 6 / 3 DAB |

[a]Roundup PowerMax3 + ethofumesate + Outlook + Stinger HL and Excalia or Quadris with HSMOC at 1 pt/A + AMS at 2.5% v/v. Roundup PowerMax3 + etho + Outlook + Excalia or Quadris and Stinger HL + Asana with AMS at 2.5% v/v.
[b]Excalia or Quadris mixed with Asana XL and Stinger HL 3 days after base (DAB)

*Foliar Disease Complex Mixtures.* Pesticide application was timed to the 8- to 10-leaf stage (Table 2). A base herbicide treatment for waterhemp control consisted of Roundup PowerMax3 mixed with ethofumesate and Warrant at 22 + 6 fl oz/A and 3 pt/A, respectively. Additional pesticides were Mustang Max, Manzate Pro-Stick, Select Max, and Proline either tank-mixed with 'base' or following 'base' by 3 days. All treatments included Prefer 90 non-ionic surfactant, at 0.25% v/v, and Amsol liquid AMS at 2.5% v/v. Table 3 are weather conditions at application. Experiments were conducted near Brushvale, MN and Prosper, ND. Brushvale was planted May 6, 2025. Unfortunately, Prosper was replanted June 11, 2025 due to stand challenges manifested by May 2025 environmental conditions.

*Data Collection.* Sugarbeet stand counts were collected from the middle two rows of each 30-ft plot at the 2- to 4-

**Table 2. Pesticide treatment, pesticide rate, and timing of pesticide application.**

| Pesticide treatment[a,b] | Rate | Sugarbeet stage |
|---|---|---|
| | --(fl oz or lb or pt/A)-- | (lf stage) |
| Roundup PowerMax3 + ethofumesate + Warrant (Base) | 22 + 6 + 3 pt | 8 to 10 |
| Base + Mustang Max | 4 | 8 to 10 |
| Base + Manzate Pro-Stick | 2 lb | 8 to 10 |
| Base + Mustang Max + Manzate Pro-Stick | 4 + 2 lb | 8 to 10 |
| Base + Mustang Max + Manzate Pro-Stick + Select Max | 4 + 2 lb + 16 | 8 to 10 |
| Base + Manzate Pro-Stick + Proline | 2 lb + 5.7 | 8 to 10 |
| Base + Mustang Max + Manzate Pro-Stick + Proline | 4 + 2 lb + 5.7 | 8 to 10 |
| Base / Manzate Pro-Stick (3 DAB) | 2 lb | 8 to 10 |
| Base + Mustang Max / Manzate Pro-Stick (3 DAB) | 4 / 2 lb | 8 to 10 / 3 DAB |
| Base + Mustang Max / Manzate Pro-Stick + Select Max (3 DAB) | 4 / 2 lb + 16 | 8 to 10 / 3 DAB |
| Base / Manzate Pro-Stick + Proline (3 DAB) | 2 lb + 5.7 | 8 to 10 / 3 DAB |
| Base + Mustang Max / Manzate Pro-Stick + Proline (3 DAB) | 4 / 2 lb + 5.7 | 8 to 10 / 3 DAB |

[a]Roundup PowerMax3 + ethofumesate + Warrant mixed with Mustang Max, Manzate Pro-Stick and/or Proline with Prefer 90 nonionic surfactant at 0.25% v/v and Amsol liquid AMS at 2.5% v/v. Manzate Pro-Stick and/or Proline with Prefer 90 nonionic surfactant at 0.25% v/v 3 days after base (DAB).
[b]Excalia or Quadris mixed with Asana XL and Stinger HL 3 days after base (DAB)

**Table 3. Temperature (F) and relative humidity (%) at pesticide application.**

| Soilborne Disease Complex Mixtures | | | | | | | | | Foliar Disease Complex Mixtures | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Crookston, MN | | | Brushvale, MN | | | Prinsburg, MN | | | Prosper, ND | | | Brushvale, MN | | |
| Date | F | % | Date | F | % | Date | F | % | Date | F | % | Date | F | % |
| 7/8 | 68 | 58 | 6/18 | 74 | 57 | 6/5 | 75 | 34 | 7/24 | 87 | 55 | 7/1 | 74 | 79 |
| 7/14 | 70 | 65 | 6/24 | 65 | 59 | 6/10 | 63 | 68 | 7/29 | 82 | 54 | 7/9 | 82 | 59 |

leaf stage and again prior to harvest. Crop response was visually evaluated for malformation, chlorosis, necrosis, and growth reduction using a 0 to 99% scale, where 0 represented no visible injury compared to glyphosate control and 99% represented complete plant or stand loss relative to the glyphosate control. Evaluations were conducted at approximately 3, 7, and 14 days after treatment. At harvest, sugarbeet was defoliated, harvested mechanically from from the center two rows of each plot and weighed. A root sample (about 20 lbs) was collected from each plot and analyzed for sucrose content and sugar loss to molasses by American Crystal Sugar Company (East Grand Forks, MN) or the Quality Lab at Southern Minnesota Beet Sugar Cooperative (Renville, MN). Single location experiments were analyzed using Agricultural Research Manager (ARM.2025.5). Combined data analysis was done using the GLIMMIX procedure in Statistical Analysis Software (SAS 9.4).

## Results

*Soilborne Disease Complex Mixtures.* We observed necrosis, malformation and growth reduction sugarbeet injury from pesticide treatments (Table 4, Figures 1, 2 and 3). However, we did not observe visible chlorosis injury from treatments. Sugarbeet necrosis injury (P=<0.0001) differed among Quadris and Excalia treatments. Visible necrosis is death of sugarbeet tissues characterized by dark brown or black, dry, brittle, and often sunken patches. Growth reduction also separated treatments. Growth reduction was greatest with treatments containing Quadris; Quadris mixed with Stinger HL or Quadris mixed with Stinger HL plus Asana XL and Roundup PowerMax3, ethofumesate and Outlook. Growth reduction from Excalia alone or tank-mixes with Excalia mixed with Roundup PowerMax3, ethofumesate and Outlook was the same as Roundp PowerMax3, ethofumesate and Outlook alone. We observed leaf malformation, auxin mimic injury as many treatments contained Stinger HL. However, injury wasn't completely related to Stinger HL. Necrosis caused distortion of sugarbeet that was noted as malformation injury. Malformation injury was greater or tended to be greater when Quadris was mixed with pesticide treatments as compared to Excalia mixed with treatments.

**Table 4. Visible necrosis, malformation and growth reduction in response to pesticide treatment, averaged across Prinsburg and Crookston, MN, 2025.[a]**

| Pesticide treatment[b,c] | Rate | % Necrosis | % Malform | % Gr Red | % Gr Red |
|---|---|---|---|---|---|
| | ---(fl oz/A)---- | 2 to 8 DAAB | 2 to 8 DAAB | 2 to 8 DAAB | 13 to 22DAAB |
| Roundup PowerMax3 + ethofumesate + Outlook (Base) | 30 + 12 + 18 | 14 b | 12 d | 12 e | 10 cd |
| Base + Excalia | 2 | 16 b | 16 cd | 12 e | 6 c |
| Base + Excalia + Asana XL | 2 + 9.6 | 13 b | 17 bcd | 14 de | 9 cd |
| Base + Excalia + Stinger HL | 2 + 2.4 | 18 b | 24 bcd | 21 cd | 13 cd |
| Base + Excalia + Asana XL + Stinger HL | 2 + 9.6 + 2.4 | 15 b | 27 bcd | 19 cde | 18 bc |
| Base + Quadris | 15 | 38 a | 30 abc | 38 b | 24 ab |
| Base + Quadris + Asana XL | 15 + 9.6 | 35 a | 29 abc | 36 b | 25 ab |
| Base + Quadris + Stinger HL | 15 + 2.4 | 44 a | 45 a | 48 a | 30 a |
| Base + Quadris + Asana XL + Stinger HL | 15 + 9.6 + 2.4 | 43 a | 33 ab | 40 b | 30 a |
| Base / Excalia + Asana XL + Stinger HL (3 DAB) | 2 + 9.6 + 2.4 | 12 b | 33 ab | 23 c | 18 bc |
| Base / Quadris + Asana XL + Stinger HL (3 DAB) | 15 + 9.6 + 2.4 | 22 b | 25 bcd | 21 cd | 16 bcd |
| P-Value | | 0.0001 | 0.0068 | 0.0001 | 0.0001 |

[a]Means followed by the same alphabetical letter within columns are not significantly different at the 0.05 alpha level.

[b]Base treatment added to the treatment comparisons was Roundup PowerMax3 mixed with ethofumesate and Outlook at 30 + 12 + 18 fl oz/A. Roundup PowerMax3 + ethofumesate + Outlook + Stinger HL and Excalia or Quadris with HSMOC at 1 pt/A + AMS at 2.5% v/v. Roundup PowerMax3 + etho + Outlook + Excalia or Quadris and Stinger HL + Asana with AMS at 2.5% v/v.

[c]Excalia or Quadris mixed with Asana XL and Stinger HL 3 days after base (DAB)

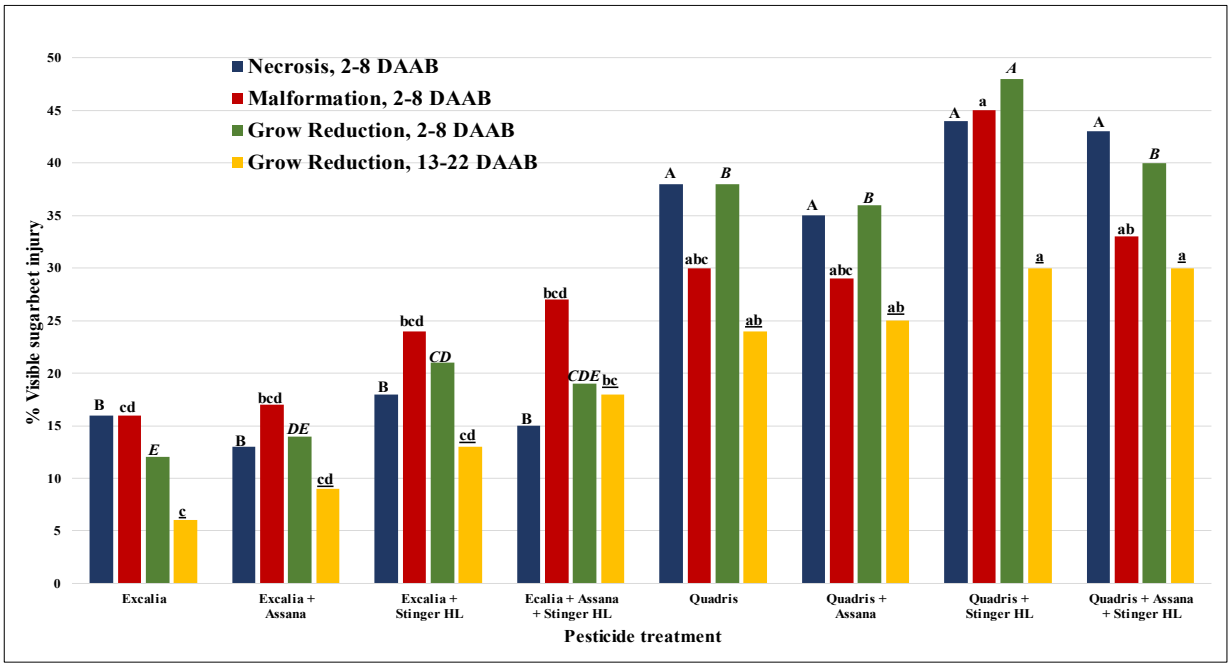


**Figure 1. Visible necrosis, malformation and growth reduction in response to pesticide treatment, averaged across Prinsburg and Crookston, MN, 2025.**

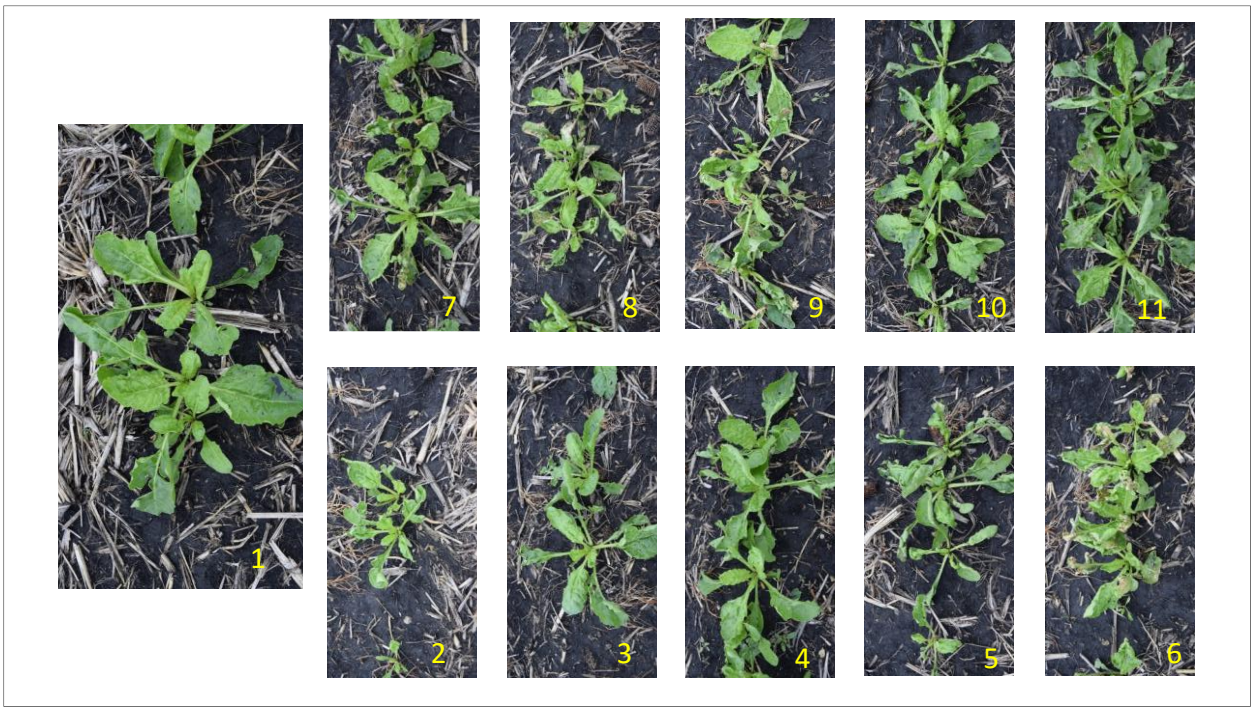


**Figure 2. Sugarbeet injury in response to herbicide treatment, 2 DAAB, Prinsburg, MN, 2025. Image number corresponds to treatment number. Treatment 1 is the base herbicides treatment, Roundup PoweMax3 with ethofumesate and Outlook. Excalia (trt 10) or Quadris (trt 11) mixed with Asana and Stinger HL was applied 3 days after base treatment.**

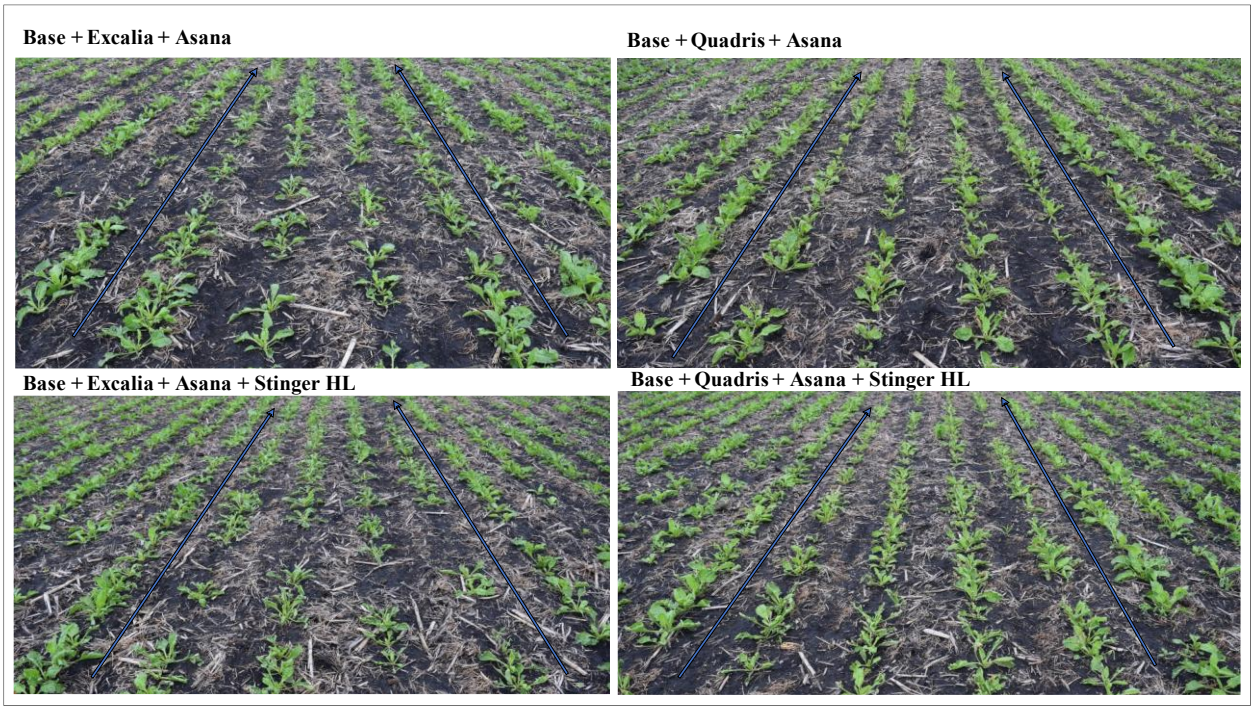


**Figure 3. Growth Reduction injury in response to pesticide treatment, Prinsburg, MN, 2025.**

Root yield differed across treatments and locations (Table 5 and Figure 4) (P=0.0869, Crookston and P=0.0180, Prinsburg). At Crookston, treatments recovered from early season sugarbeet injury. At Prinsburg, treatments with Quadris mixed with Asana XL, Stinger HL and Asana XL and Stinger HL plus Roundup PowerMax3, ethofumesate and Outlook had root yield less or root yield that tended to be less than Excalia mixed with Asana XL, Stinger HL and Asana XL and Stinger HL plus Roundup PowerMax3, ethofumesate and Outlook. We attribute root yield differences to weather conditions in 2025. Prinsburg received greater than 30-inch rainfall after planting as compared to 15 inches at Crookston. Further, Prinsburg received four rainfall events of greater than 3-inch rain. Sugarbeet must metabolize applied pesticides. Pesticide metabolism is much slower when sugarbeet are not actively growing due to cool temperatures, cloudy skies and saturated soils.

**Table 5. Root yield and % sucrose in response to pesticide treatment, Crookston and Prinsburg, MN, 2025.[a]**

| Pesticide treatment[b,c] | Rate | Root yield (TPA) | | % Sucrose | |
|---|---|---|---|---|---|
| | ----(fl oz/A)---- | Crookston | Prinsburg | Crookston | Prinsburg |
| Roundup PowerMax3 + ethofumesate + Outlook (Base) | 30 + 12 + 18 | 30.4 abc | 27.7 a-d | 18.0 | 14.3 |
| Base + Excalia | 2 | 30.3 abc | 29.0 ab | 17.9 | 14.2 |
| Base + Excalia + Asana XL | 2 + 9.6 | 31.0 ab | 29.6 a | 18.2 | 14.2 |
| Base + Excalia + Stinger HL | 2 + 2.4 | 31.3 a | 28.6 ab | 17.7 | 14.4 |
| Base + Excalia + Asana XL + Stinger HL | 2 + 9.6 + 2.4 | 30.7 abc | 27.9 abc | 17.4 | 14.3 |
| Base + Quadris | 15 | 29.7 cd | 27.5 bcd | 17.8 | 14.6 |
| Base + Quadris + Asana XL | 15 + 9.6 | 29.8 bcd | 26.5 cde | 17.7 | 14.5 |
| Base + Quadris + Stinger HL | 15 + 2.4 | 29.0 d | 25.6 de | 17.7 | 14.6 |
| Base + Quadris + Asana XL + Stinger HL | 15 + 9.6 + 2.4 | 30.9 abc | 25.1 e | 18.1 | 14.3 |
| Base / Excalia + Asana XL + Stinger HL (3 DAB) | 2 + 9.6 + 2.4 | 31.1 a | 27.7 a-d | 17.6 | 14.6 |
| Base / Quadris + Asana XL + Stinger HL (3 DAB) | 15 + 9.6 + 2.4 | 30.4 abc | 27.8 a-d | 18.1 | 14.5 |
| P-Value | | 0.0869 | 0.0180 | 0.7298 | 0.1243 |

[a]Means followed by the same alphabetical letter within columns are not significantly different at the 0.1 alpha level.

[b]Base treatment added to the treatment comparisons was Roundup PowerMax3 mixed with ethofumesate and Outlook at 30 + 12 + 18 fl oz/A. Roundup PowerMax3 + ethofumesate + Outlook + Stinger HL and Excalia or Quadris with HSMOC at 1 pt/A + AMS at 2.5% v/v. Roundup PowerMax3 + etho + Outlook + Excalia or Quadris and Stinger HL + Asana with AMS at 2.5% v/v.

[c]Excalia or Quadris mixed with Asana XL and Stinger HL 3 days after base (DAB)

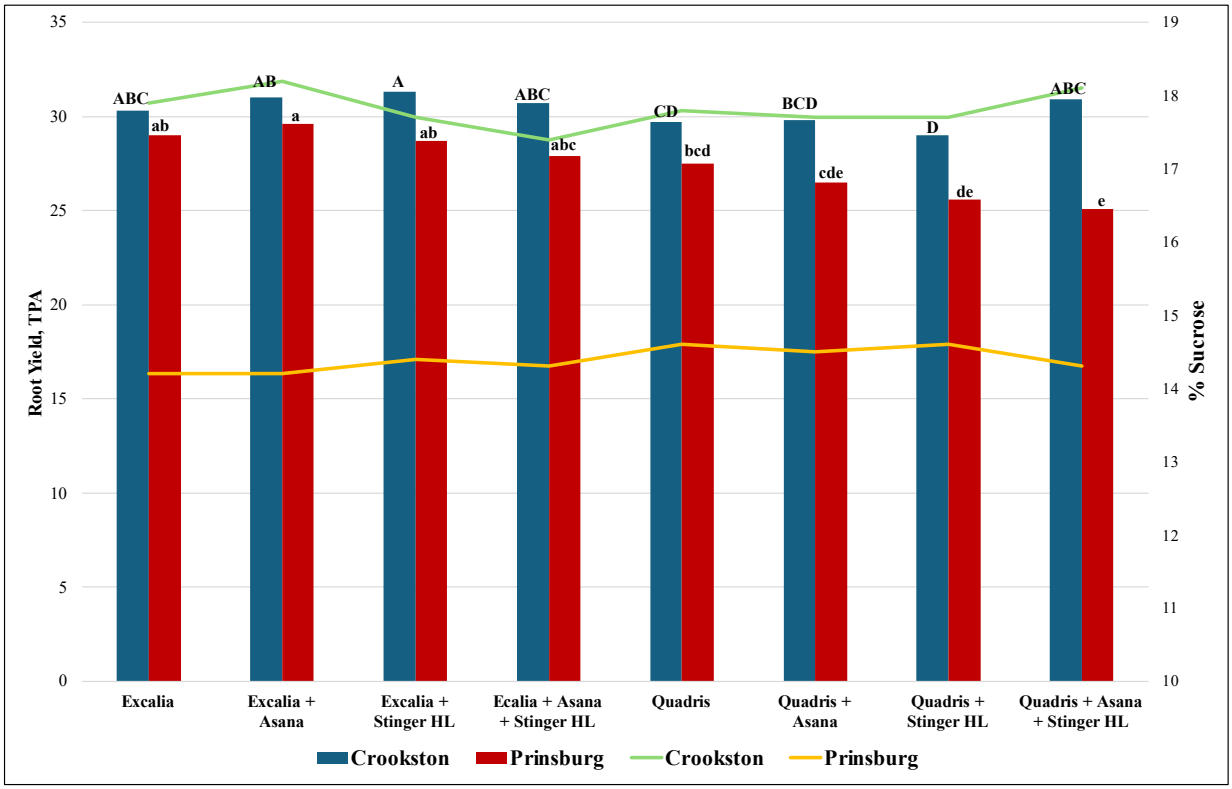


**Figure 4. Root yield (tons per acre) and % sucrose content in response to pesticide treatment at Crookston and Prinsburg, MN. Means followed by the same alphabetical letter within columns are not significantly different at the 0.1 alpha level.**

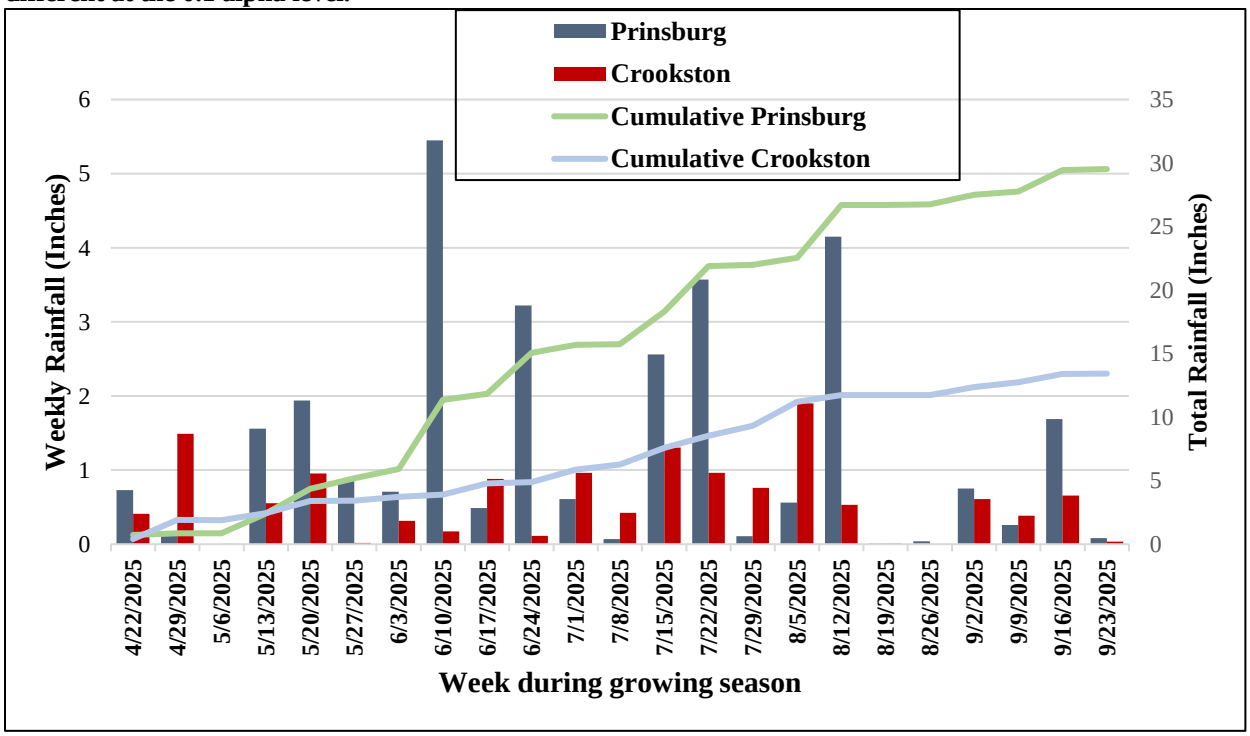


**Figure 5. Rainfall (inch) and cumulative rainfall (inch) at Prinsburg and Crookston, MN, 2025. Data collected from the North Dakota Agricultural Weather Network (Crookston) and from on-site weather instrumentation (Prinsburg).**

We elected not to include the Brushvale location in the combined analysis. Sugarbeet stands and resultant root yields were much more variable at Brushvale as compared to Prinsburg or Crookston. We observed similar sugarbeet necrosis, malformation, and growth reduction with treatments containing Quadris and Stinger HL (Table 6). In general, sugarbeet necrosis and growth reduction injury was greater when Quadris was mixed with Asana XL, Stinger HL or Asana XL and Stinger HL with Roundup PowerMax3, ethofumesate and Outlook as compared to Excalia mixed with Asana XL, Stinger HL or Asana XL and Stinger HL with Roundup PowerMax3, ethofumesate and Outlook. We observed much more malformation injury from treatments containing Stinger HL at Brushvale or distortion caused by necrosis injury from treatments containing Quadris mixed with Asana XL, Stinger HL or Asana XL and Stinger HL with Roundup PowerMax3, ethofumesate and Outlook at Brushvale than Prinsburg or Crookston.

**Table 6. Visible percent necrosis, malformation and growth reduction in response to pesticide treatment, Brushvale, MN, 2025.[a]**

| Pesticide treatment[b,c] | Rate | Necros | Malform | Gr Red | Malform | Gr Red |
|---|---|---|---|---|---|---|
| | ----(fl oz/A)---- | --------(% 6 DAAB)-------- | | | ----(% 13 DAAB)---- | |
| Roundup PowerMax3 + ethofumesate + Outlook (Base) | 30 + 12 + 18 | 2 d | 7 c | 3 e | 3 e | 3 c |
| Base + Excalia | 2 | 3 d | 7 c | 8 e | 5 de | 8 bc |
| Base + Excalia + Asana XL | 2 + 9.6 | 5 d | 8 c | 3 e | 0 e | 3 c |
| Base + Excalia + Stinger HL | 2 + 2.4 | 0 d | 28 b | 12 de | 11 cd | 5 c |
| Base + Excalia + Asana XL + Stinger HL | 2 + 9.6 + 2.4 | 0 d | 31 b | 9 de | 8 de | 8 bc |
| Base + Quadris | 15 | 33 a | 25 b | 33 a | 23 ab | 23 a |
| Base + Quadris + Asana XL | 15 + 9.6 | 29 ab | 31 b | 26 abc | 18 bc | 15 ab |
| Base + Quadris + Stinger HL | 15 + 2.4 | 28 ab | 45 a | 33 a | 26 a | 22 a |
| Base + Quadris + Asana XL + Stinger HL | 15 + 9.6 + 2.4 | 28 b | 39 a | 31 ab | 11 cd | 15 ab |
| Base / Excalia + Asana XL + Stinger HL (3 DAB) | 2 + 9.6 + 2.4 | 0 d | 26 b | 18 cd | 3 e | 8 bc |
| Base / Quadris + Asana XL + Stinger HL (3 DAB) | 15 + 9.6 + 2.4 | 14 c | 41 a | 23 bc | 3 de | 8 bc |
| P-Value | | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0035 |

[a]Means followed by the same alphabetical letter within columns are not significantly different at the 0.1 alpha level.
[b]Base treatment added to the treatment comparisons was Roundup PowerMax3 mixed with ethofumesate and Outlook at 30 + 12 + 18 fl oz/A. Roundup PowerMax3 + ethofumesate + Outlook + Stinger HL and Excalia or Quadris with HSMOC at 1 pt/A + AMS at 2.5% v/v. Roundup PowerMax3 + etho + Outlook + Excalia or Quadris and Stinger HL + Asana with AMS at 2.5% v/v.
[c]Excalia or Quadris mixed with Asana XL and Stinger HL 3 days after base (DAB)

**Table 7. Sugarbeet stand, root yield, % sucrose and recoverable sucrose per acre in response to pesticide treatment, Brushvale, MN, 2025.[a]**

| Pesticide treatment[b,c] | Rate | Stand | Root yield | % Sucrose | Rec Sucrose |
|---|---|---|---|---|---|
| | ----(fl oz/A)---- | Num per 20 ft row | Tons per acre | % | lb/acre |
| Roundup PowerMax3 + ethofumesate + Outlook (Base) | 30 + 12 + 18 | 31 | 27.7 | 16.1 a | 5,996 |
| Base + Excalia | 2 | 28 | 26.5 | 15.9 ab | 5,322 |
| Base + Excalia + Asana XL | 2 + 9.6 | 29 | 30.01 | 15.9 ab | 6,529 |
| Base + Excalia + Stinger HL | 2 + 2.4 | 28 | 29.6 | 16.1 a | 6,423 |
| Base + Excalia + Asana XL + Stinger HL | 2 + 9.6 + 2.4 | 28 | 29.2 | 16.1 a | 6,203 |
| Base + Quadris | 15 | 26 | 27.0 | 16.0 a | 5,466 |
| Base + Quadris + Asana XL | 15 + 9.6 | 30 | 26.8 | 15.7 ab | 4,998 |
| Base + Quadris + Stinger HL | 15 + 2.4 | 30 | 27.5 | 15.6 bc | 5,230 |
| Base + Quadris + Asana XL + Stinger HL | 15 + 9.6 + 2.4 | 28 | 26.9 | 15.2 c | 5,075 |
| Base / Excalia + Asana XL + Stinger HL (3 DAB) | 2 + 9.6 + 2.4 | 26 | 27.4 | 15.6 bc | 5,414 |
| Base / Quadris + Asana XL + Stinger HL (3 DAB) | 15 + 9.6 + 2.4 | 28 | 30.3 | 16.0 ab | 6,101 |
| P-Value | | 0.8362 | 0.3704 | 0.0308 | 0.1172 |

[a]Means followed by the same alphabetical letter within columns are not significantly different at the 0.1 alpha level.
[b]Base treatment added to the treatment comparisons was Roundup PowerMax3 mixed with ethofumesate and Outlook at 30 + 12 + 18 fl oz/A. Roundup PowerMax3 + ethofumesate + Outlook + Stinger HL and Excalia or Quadris with HSMOC at 1 pt/A + AMS at 2.5% v/v. Roundup PowerMax3 + etho + Outlook + Excalia or Quadris and Stinger HL + Asana with AMS at 2.5% v/v.
[c]Excalia or Quadris mixed with Asana XL and Stinger HL 3 days after base (DAB)

*Foliar Disease Complex Mixtures.* Sugarbeet vegetative injury was visible necrosis and growth reduction injury that was negligible at both Brushvale and Prosper (Table 8). Likewise, root yield, % sucrose content and recoverable sucrose reduction where not treatment related or consistent across locations (Table 9).

**Table 8. Sugarbeet stand, and percent visible sugarbeet injury in response to pesticide treatment, Bruvale MN and Prosper ND, 2025.[a]**

| Pesticide treatment[b,c] | Rate | Sugarbeet stand | | Grow Red 3-5 DAA | | Grow Red 5-10 DAB | |
|---|---|---|---|---|---|---|---|
| | ---(fl oz or lb or pt/A)--- | Brushvale (Nu/20 ft) | Prosper (Nu/20 ft) | Brushvale (%) | Prosper (%) | Brushvale (%) | Prosper (%) |
| Roundup PowerMax3 + ethofumesate + Warrant (Base) | 22 + 6 + 3 pt | 25 | 57 | 8 ab | 3 | 5 | 2 b |
| Base + Mustang Max | 4 | 22 | 56 | 12 a | 0 | 3 | 0 b |
| Base + Manzate Pro-Stick | 2 lb | 21 | 57 | 2 cd | 3 | 3 | 2 b |
| Base + Mustang Max + Manzate Pro-Stick | 4 + 2 lb | 24 | 56 | 5 bc | 3 | 0 | 4 b |
| Base + Mustang Max + Manzate Pro-Stick + Select Max | 4 + 2 lb + 16 | 25 | 58 | 3 cd | 6 | 8 | 3 b |
| Base + Manzate Pro-Stick + Proline | 2 lb + 5.7 | 20 | 56 | 2 cd | 0 | 0 | 2 b |
| Base + Mustang Max + Manzate Pro-Stick + Proline | 4 + 2 lb + 5.7 | 24 | 55 | 2 cd | 4 | 0 | 2 b |
| Base / Manzate Pro-Stick (3 DAB) | 2 lb | 24 | 60 | 0 d | 4 | 0 | 0 b |
| Base + Mustang Max / Manzate Pro-Stick (3 DAB) | 4 / 2 lb | 24 | 58 | 2 cd | 9 | 3 | 5 b |
| Base + Mustang Max / Manzate Pro-Stick + Select Max (3 DAB) | 4 / 2 lb + 16 | 23 | 61 | 2 cd | 3 | 2 | 0 b |
| Base / Manzate Pro-Stick + Proline (3 DAB) | 2 lb + 5.7 | 25 | 60 | 0 d | 0 | 3 | 5 b |
| Base + Mustang Max / Manzate Pro-Stick + Proline (3 DAB) | 4 / 2 lb + 5.7 | 24 | 60 | 2 cd | 3 | 0 | 11 a |
| P-Value | | 0.8337 | 0.4343 | 0.0009 | 0.3495 | 0.3310 | 0.0751 |

[a]Means followed by the same alphabetical letter within columns are not significantly different at the 0.1 alpha level.
[b]Roundup PowerMax3 + ethofumesate + Warrant mixed with Mustang Max, Manzate Pro-Stick and/or Proline with Prefer 90 nonionic surfactant at 0.25% v/v and Amsol liquid AMS at 2.5% v/v. Manzate Pro-Stick and/or Proline with Prefer 90 nonionic surfactant at 0.25% v/v.
[c]Abbreviations: Base = Roundup PowerMax3 + ethofumesate + Warrant. DAB = days after base treatment. DAA = days after application A. DAB = days after application B.

## Discussion

Soilborne disease complex mixtures demonstrated that formulation type, active ingredient–preventative or locally systemic, and cumulative adjuvant load influenced sugarbeet tolerance. Although treatments contained the same herbicide base, mixtures with Quadris resulted in greater growth reduction, necrosis, and lower root yield compared to Excalia treatments. These differences likely reflect formulation chemistry and herbicide and fungicide behavior within sugarbeet. Emulsifiable concentrate (EC) formulations and products with preloaded surfactant systems

**Table 9. Root yield, % sucrose and recoverable sucrose in response to pesticide treatment, Brushvale, MN and Prosper, ND, 2025.[a]**

| Pesticide treatment[a,b] | Rate | Root yield | | % Sucrose | | Rec Sucrose | |
|---|---|---|---|---|---|---|---|
| | ---(fl oz or lb or pt/A)--- | Brushvale Tons/A | Prosper Tons/A | Brushvale % | Prosper % | Brushvale lb/A | Prosper lb/A |
| Roundup PowerMax3 + ethofumesate + Warrant (Base) | 22 + 6 + 3 pt | 21.3 cd | 21.7 | 14.9 ef | 15.6 ab | 3,267 | 3,840 |
| Base + Mustang Max | 4 | 20.5 d | 22.3 | 16.0 a | 15.9 a | 3,184 | 3,955 |
| Base + Manzate Pro-Stick | 2 lb | 22.0 bcd | 22.6 | 15.0 def | 14.9 c | 3,313 | 3,634 |
| Base + Mustang Max + Manzate Pro-Stick | 4 + 2 lb | 22.6 a-d | 22.4 | 15.0 def | 15.6 ab | 3,519 | 3,940 |
| Base + Mustang Max + Manzate Pro-Stick + Select Max | 4 + 2 lb + 16 | 23.5 abc | 23.2 | 14.9 f | 15.9 ab | 3,549 | 4,227 |
| Base + Manzate Pro-Stick + Proline | 2 lb + 5.7 | 22.1 bcd | 22.7 | 15.6 abc | 15.7 ab | 3,456 | 4,087 |
| Base + Mustang Max + Manzate Pro-Stick + Proline | 4 + 2 lb + 5.7 | 24.7 a | 22.1 | 15.4 b-e | 15.5 ab | 4,200 | 3,902 |
| Base / Manzate Pro-Stick (3 DAB) | 2 lb | 24.1 ab | 21.9 | 15.3 c-f | 15.8 ab | 4,137 | 3,879 |
| Base + Mustang Max / Manzate Pro-Stick (3 DAB) | 4 / 2 lb | 24.8 a | 20.6 | 15.4 b-e | 15.5 b | 4,353 | 3,208 |
| Base + Mustang Max / Manzate Pro-Stick + Select Max (3 DAB) | 4 / 2 lb + 16 | 22.5 a-d | 22.5 | 15.8 ab | 15.4 bc | 3,891 | 3,841 |
| Base / Manzate Pro-Stick + Proline (3 DAB) | 2 lb + 5.7 | 23.0 abc | 22.7 | 15.5 bcd | 15.7 ab | 3,899 | 4,319 |
| Base + Mustang Max / Manzate Pro-Stick + Proline (3 DAB) | 4 / 2 lb + 5.7 | 20.6 d | 21.4 | 15.4 b-e | 15.1 b | 3,048 | 3,567 |
| P-Value | | 0.0509 | 0.3978 | 0.0037 | 0.0738 | 0.1918 | 0.2008 |

[a]Means followed by the same alphabetical letter within columns are not significantly different at the 0.1 alpha level.
[b]Roundup PowerMax3 + ethofumesate + Outlook + Stinger HL and Excalia or Quadris with HSMOC at 1 pt/A + AMS at 2.5% v/v. Roundup PowerMax3 + etho + Outlook + Excalia or Quadris and Stinger HL + Asana with AMS at 2.5% v/v.
[c]Excalia or Quadris mixed with Asana XL and Stinger HL 3 days after base (DAB).

enhance cuticle penetration; when multiple oil-containing products are combined, the cumulative solvent and adjuvant load can unintentionally "stack" cuticle penetrants in the spray solution. Sugarbeet has a narrow margin of crop safety to postemergence herbicides (Kniss 2018), and excessive penetration may accelerate active ingredient uptake beyond the metabolic capacity of sugarbeet, increasing cellular injury. The necrosis observed in Quadris treatments, a translaminar QoI fungicide, suggests that increased tissue penetration under high oil spray solutions may increase phytotoxicity. In contrast, Excalia-containing mixtures caused minimal vegetative injury and maintained higher root yield, indicating more favorable compatibility with the herbicide and adjuvant system.

Results reinforce that complex tank-mixtures should be constructed based on both economic pest pressure and formulation compatibility. Each additional active ingredient contributes not only another mode of action but also additional solvents, surfactants, or oil-based components that may increase phytotoxic risk. Avoiding unnecessary stacking of EC formulations or oil-containing products is critical, particularly under conditions that favor rapid uptake. Product inclusion should be justified by expected economic return. For example, in fields with a history of Rhizoctonia and early-season weeds such as common lambsquarters, a mixture of glyphosate + ethofumesate + Excalia may be warranted. However, if insect pressure such as sugarbeet root maggot is low, adding an insecticide may increase cumulative oil load and induce sugarbeet phytotoxicity. Strategic product selection remains essential to preserving crop safety while maintaining operational efficiency in soilborne disease complex programs.

Foliar fungicides for control of Cercospora leaf spot mixed with pesticides for control of weeds and insects did not cause vegetative injury or reduce root yield or sucrose content in these experiments. Minor, transient growth reduction was observed in a few treatments, but injury dissipated and considered negligible. Applications occurred at the 8- to 10-leaf stage, when sugarbeet plants have greater leaf area, ticker cuticles, and metabolic capacity, which likely enhanced tolerance and recovery compared with earlier growth stages in soilborne disease complex mixture treatments.

Despite sugarbeet safety, careful product selection is essential. Certain fungicides used for Cercospora leaf spot can influence sugarbeet tolerance, especially when mixed with other actives or oil-based formulations, including pyraclostrobin (Headline® fungicide) and tin-based products such as triphenyltin hydroxide and organotin compounds (Hernandez et al. 2024). However, it is unlikely these products would be used for late June control of Cercospora leaf spot and thus, would not be candidates for mixture with glyphosate, ethofumesate or chloroacetamide herbicides.

Cercospora leaf spot fungicides may contain translaminar or systemic formulations that penetrate leaf tissue. The cumulative effect can unintentionally "stack" cuticle penetrants when fungicides are combined with other penetrative herbicides and insecticides or oil-based emulsifiable concentrates and adjuvants. This enhances herbicide uptake, increasing the risk of phytotoxicity in sugarbeet.

**Literature Cited**

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