

SUGARBEET TOLERANCE TO COMPLEX MIXTURES, REVISITED IN 2023

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Summary

1. Sugarbeet injury from formulation changes including Roundup PowerMAX3 and Stinger HL previously have not been evaluated in complex mixtures.
2. We observed more sugarbeet injury from PowerMAX3 and ethofumesate mixed with Outlook than in previous experiments.
3. Stinger HL mixed with PowerMAX3, ethofumesate, and Outlook increased sugarbeet injury with or without high surfactant methylated oil concentrate (HSMOC).
4. Mustang Maxx can be mixed with PowerMAX3, ethofumesate, and Outlook, but should not be mixed with PowerMAX3, ethofumesate, Outlook, and Stinger HL.
5. We continue to recommend reducing the HSMOC rate or eliminating HSMOC from the mixture when Stinger HL and/or Mustang Maxx is mixed with PowerMAX3, ethofumesate, and Outlook.

Introduction

Dr. Dexter wrote: “Sugarbeet herbicides may be tank mixed legally if all herbicides in the mixture are registered for use on sugarbeet, and if no prohibitions against tank mixes appear on a label.”

Questions about tank-mixing herbicides are one of the most common telephone calls I receive from agriculturists and producers, and rightfully so. Combinations of postemergence herbicides can improve overall weed control and spectrum of control as compared with individual treatments. Mixtures also improve time efficiency as compared with making individual applications. However, the risk of sugarbeet injury also increases with combinations, especially under adverse environmental conditions. There are few herbicides truly safe to sugarbeet, meaning sugarbeet must detoxify sugarbeet sprays after application and before normal sugarbeet growth and development can resume. Detoxification is much more challenging with combinations or as “complex mixtures” as I like to call them, especially in cold and wet environments.

Key messages about complex mixtures are as follows. However, most of these messages were developed when Lorsban was available for control of insect pests and Stinger and Roundup PowerMAX formulations were used for weed control.

- Stinger can be mixed with Roundup PowerMAX, ethofumesate, and a chloroacetamide herbicide.
- Malformation injury resembling damage from Stinger when Betamix or Lorsban is mixed with Roundup PowerMAX, ethofumesate, a chloroacetamide herbicide, and Stinger is borderline not acceptable.
- HSMOC rate should be reduced when Lorsban is mixed with PowerMAX, ethofumesate and a chloroacetamide. HSMOC should be eliminated from the mixture when/if Stinger and Lorsban are mixed with PowerMAX3, ethofumesate and, a chloroacetamide herbicide.

The objective of this greenhouse research was a) to investigate sugarbeet injury from Stinger HL and Mustang Maxx mixed with Roundup PowerMAX3, ethofumesate and a chloroacetamide herbicide and b) to investigate if HSMOC contributes to injury when applied in complex mixtures.

Materials and Methods

Greenhouse experiments were conducted in 2023 to evaluate sugarbeet injury from complex mixtures POST with or without HSMOC. Greenhouse experiments were a randomized complete block design with a factorial treatment arrangement and four replications. Treatment factors were a) with or without HSMOC adjuvant and b) herbicide treatment. Herbicide treatment lists are found in Tables 1 and 2.

Soil was a 1:1 mixture of Wheatville silt loam from the Northwest Research and Outreach Center, Crookston and PROMIX general purpose greenhouse media (Premier Horticulture, Inc., Quakertown, PA). Herbicides were applied all sugarbeet were at a strong 2-lf stage. Plants were grown at approximately 73 to 81°C for a 16 h photoperiod under natural light supplemented with artificial lighting. Plants were watered and fertilized as necessary. Herbicide

Table 1. Herbicide treatment with or without HSMOC adjuvant, greenhouse Run 1, 2023.

| Num | Factor A Adjuvant ^a | Factor B Postemergence Herbicide | Rate (fl oz / A) | Sugarbeet stage (lvs) |
|-----|-----------------------------------|--------------------------------------------------------|--------------------------|--------------------------|
| 1 | No | PowerMAX3 + ethofumesate | 30 + 12 | 2-4 lvs |
| 2 | No | PowerMAX3 + etho + Outlook | 30 + 12 + 21 | 2-4 lvs |
| 3 | No | PowerMAX3 + etho + Outlook + Stinger HL | 30 + 12 + 21 + 3.6 | 2-4 lvs |
| 4 | No | PowerMAX3 + etho + Outlook + Stinger HL + Mustang Maxx | 30 + 12 + 21 + 3.6 + 4.0 | 2-4 lvs |
| 5 | HSMOC | PowerMAX3 + ethofumesate | 30 + 12 | 2-4 lvs |
| 6 | HSMOC | PowerMAX3 + etho + Outlook | 30 + 12 + 21 | 2-4 lvs |
| 7 | HSMOC | PowerMAX3 + etho + Outlook + Stinger HL | 30 + 12 + 21 + 3.6 | 2-4 lvs |
| 8 | HSMOC | PowerMAX3 + etho + Outlook + Stinger HL + Mustang Maxx | 30 + 12 + 21 + 3.6 + 4.0 | 2-4 lvs |
| 9 | | Non-treated Control | - | 2-4 lvs |

^aHSMOC=Destiny HC at 1.5 pt/A.

Table 2. Herbicide treatment with or without HSMOC adjuvant, greenhouse Run 2, 2023.

| Num | Factor A Adjuvant ^a | Factor B Postemergence Herbicide | Rate (fl oz / A) | Sugarbeet stage (lvs) |
|-----|-----------------------------------|----------------------------------------------------------|--------------------------|--------------------------|
| 1 | No | PowerMAX3 + ethofumesate | 30 + 12 | 2-4 lvs |
| 2 | No | PowerMAX3 + etho + Outlook | 30 + 12 + 21 | 2-4 lvs |
| 3 | No | PowerMAX3 + etho + Outlook + Mustang Maxx | 30 + 12 + 21 + 4.0 | 2-4 lvs |
| 4 | No | PowerMAX3 + etho + Outlook + Mustang Maxx + Stinger HL + | 30 + 12 + 21 + 4.0 + 3.6 | 2-4 lvs |
| 5 | HSMOC | PowerMAX3 + ethofumesate | 30 + 12 | 2-4 lvs |
| 6 | HSMOC | PowerMAX3 + etho + Outlook | 30 + 12 + 21 | 2-4 lvs |
| 7 | HSMOC | PowerMAX3 + etho + Outlook + Mustang Maxx | 30 + 12 + 21 + 4.0 | 2-4 lvs |
| 8 | HSMOC | PowerMAX3 + etho + Outlook + Mustang Maxx + Stinger HL + | 30 + 12 + 21 + 4.0 + 3.6 | 2-4 lvs |
| 9 | | Non-treated Control | - | 2-4 lvs |

^aHSMOC=Destiny HC at 1.5 pt/A.

treatments were applied using a spray booth (Generation III, DeVries Manufacturing, Hollandale, MN) equipped with a TeeJet® 8002 Even banding nozzle (TeeJet Technologies, Glendale Heights, IL) calibrated to deliver 15 gpa spray solution at 25 psi and 3 mph. Visible sugarbeet injury (0% to 100%, 100% indicating complete loss of stand) was evaluated approximately 5, 10, 14, and 21 days after treatment (DAT). Data were analyzed with the ANOVA procedure of ARM, version 2022.5 software package. This report summarizes results from Run 1 and Run 2. In run 1 Stinger HL was incorporated into the mixture before Mustang Max. The order was flipped in Run 2 (see treatment list, Tables 1 and 2).

Results

Run 1

Herbicide treatment interacted with HSMOC, 10 and 14 DAT but not 5 (data not presented) and 21 DAT (Table 3). Likewise, images captured sugarbeet injury differences between herbicide treatments with or without HSMOC (Figure 1).

Table 3. Sugarbeet injury in response to herbicide treatment with and without HSMOC, Run 1, 2023.^a

| | | Growth Reduction 10 DAT ^b | | Growth Reduction 14 DAT | | Growth Reduction 21 DAT | |
|---------------------------------------------|-------------------|-----------------------------------------|-------|----------------------------|-------|----------------------------|-------|
| Herbicide treatment | Rate | No HSMOC | HSMOC | No HSMOC | HSMOC | No HSMOC | HSMOC |
| | | -----%----- | | | | | |
| Base ^c | | 0 e | 10 d | 5 d | 13 d | 5 | 10 |
| Base + Outlook | 21 | 35 c | 31 c | 33 bc | 30 c | 20 | 13 |
| Base + Outlook and Stinger HL | 21 + 3.6 | 50 ab | 48 b | 48 b | 43 bc | 40 | 33 |
| Base + Outlook, Stinger HL and Mustang Maxx | 21 + 16 + 3.6 + 4 | 46 b | 58 a | 40 bc | 68 a | 33 | 50 |
| LSD (0.10) | | 9 | | 16 | | NS | |

^aMeans within a main effect not sharing any letter are significantly different by the LSD at the 10% level of significance.

^bDAT=Days after POST treatment.

^cBase= Roundup PowerMAX3 at 25 fl oz/A + Ethofumesate 4SC at 12 fl oz/A.

Run 1

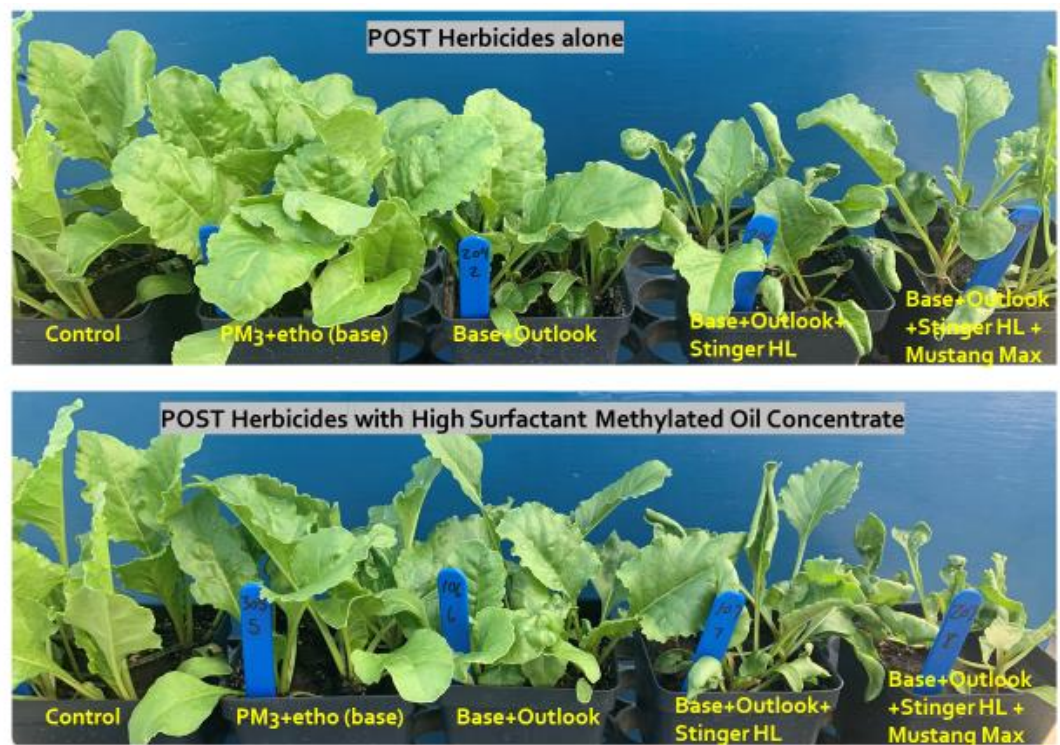


Figure 1. Sugarbeet injury from herbicide treatments with and without HSMOC 14 days after treatment (DAT), greenhouse, 2023.

Roundup PowerMAX3 mixed with ethofumesate caused negligible sugarbeet injury 10, 14 and 21 DAT. However, we observed increased injury from Outlook mixed with Roundup PowerMAX3 than in previous experiments with or without HSMOC. Sugarbeet injury from Stinger HL mixed with Roundup PowerMAX3, ethofumesate, and Outlook was greater or tended to be greater than sugarbeet injury from Roundup PowerMAX3, ethofumesate, and Outlook alone, across evaluation timings. The addition of HSMOC did not increase sugarbeet injury. Sugarbeet injury was or tended to be the greatest when Stinger HL and Mustang Maxx were mixed with Roundup PowerMAX3, ethofumesate, and Outlook. The addition of HSMOC increased or tended to increase injury as compared with no HSMOC.

We wondered if Mustang Maxx would similarly increase sugarbeet injury when mixed with Roundup PowerMAX3, ethofumesate, and Outlook as compared with Roundup PowerMAX3, ethofumesate, Outlook, and Stinger HL. Thus, in our second run, we switched the order; we mixed Mustang Maxx with Outlook, ethofumesate, and Roundup PowerMAX3 before evaluating the 5-way mixture.

Run 2

Herbicide treatment did not interact with oil adjuvant in Run 2 (P-Value > 0.10). Thus, herbicide treatments were averaged across HSMOC adjuvant. We observed less injury from Outlook mixed with Roundup PowerMAX3 and ethofumesate as compared with Run 1; however, we continued to observe more injury than in previous experiments (Table 4, Figure 2).

Table 4. Sugarbeet injury in response to herbicide treatment, averaged across HSMOC, Run 2, 2023.^a

| Herbicide treatment | Rate | 10 DAT ^b | 14 DAT | 17 DAT |
|---------------------------------------------|-------------------|---------------------|--------|--------|
| | ----fl oz/A---- | -----%----- | | |
| Base ^c | | 10 c | 4 c | 3 c |
| Base + Outlook | 21 | 27 b | 12 b | 9 c |
| Base + Outlook and Mustang Maxx | 21 + 4 | 16 c | 15 b | 18 b |
| Base + Outlook, Mustang Maxx and Stinger HL | 21 + 16 + 4 + 3.6 | 37 a | 37 a | 43 a |
| LSD (0.10) | | 10 | 9 | 10 |

^aMeans within a main effect not sharing any letter are significantly different by the LSD at the 10% level of significance

^bDAT=Days after POST treatment.

^cBase= Roundup PowerMAX3 at 25 fl oz/A + Ethofumesate 4SC at 12 fl oz/A.

Run 2

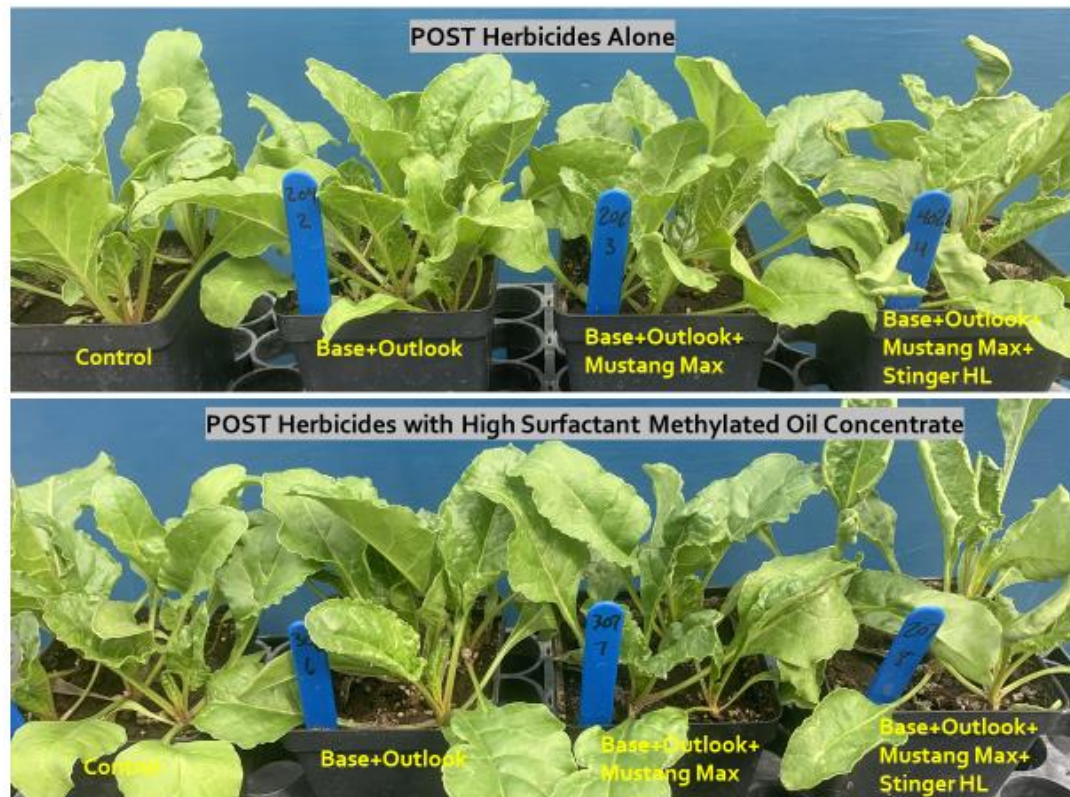


Figure 2. Sugarbeet injury from herbicide treatments with and without HSMOC 17 days after treatment (DAT), greenhouse, 2023.

Outlook in the field is usually split applied at 10 to 14 fl oz/A so perhaps the concern with increased sugarbeet injury with Roundup PowerMAX3 and ethofumesate mixtures with Outlook is unwarranted. Mustang Maxx mixed with Roundup PowerMAX3, ethofumesate, and Outlook was inconsistent; we observed less injury than PowerMAX3, ethofumesate and Outlook, 10 DAT but we observed more injury 17 DAT. Nonetheless, our results indicate it is safe to mix Mustang Maxx with Roundup PowerMAX3, ethofumesate, and a chloroacetamide herbicide.

Once again, sugarbeet injury was greatest with the 5-way mixture or Stinger HL mixed with Roundup PowerMax3, ethofumesate, Outlook, and Mustang Maxx. Observed injury consisted of a combination of growth reduction and malformation. Note, Stinger HL was applied at 3.6 fl oz/A in these experiments.

Conclusion

Pesticides (herbicides, fungicides, and insecticides) approved for use in sugarbeet usually are safe to sugarbeet when applied individually. These same pesticides applied in mixtures, however, occasionally injure sugarbeet since each pesticide must be detoxified by the plant. Environmental stressors such as low air and soil temperatures or saturated soil-water content are conditions that often reduce photosynthesis and may reduce energy needed for the developing sugarbeet to metabolize pesticides (Smith and Schweizer 1983), thus increasing the risk of sugarbeet injury. Sugarbeet is better able to manage biotic or abiotic stressors as it develops; sugarbeet with more leaf area have greater metabolic activity, dissipating the effect of herbicides, and other stressors.

We are using different Roundup PowerMAX3 and clopyralid formulations with potentially different adjuvant systems than formulations previously evaluated. A confusing image from the field (Figure 3) and results from two greenhouse experiments suggest sugarbeet injury from Stinger HL mixed with Roundup PowerMAX3, ethofumesate, and a chloroacetamide herbicide might be different from previous experiments. Likewise, sugarbeet injury is more likely from complex mixtures or combinations of four or five pesticides with or without adjuvants as compared with past observations, both in the field and in the greenhouse, with previous formulations.

These experiments were conducted with individual treatments applied at full rates. I use full rates as an indicator for what might happen in the field under adverse environmental conditions. I will be the first to say that the possibility of Stinger HL injury at 3.6 fl oz/A is much greater than Stinger HL at 1.8 fl oz/A.



Figure 3. Ethofumesate + Dual Magnum (PRE) at 2 + 0.5 pt/A followed by Roundup PowerMAX3 + ethofumesate + S-metolachlor + Stinger HL (2-lf) at 25 + 6 + 16 + 1.5 fl oz/A followed by Roundup PowerMAX3 + ethofumesate + S-metolachlor + Stinger HL (6-lf) at 25 + 6 + 16 + 1.5 fl oz/A, Rothsay, MN, 2022.

Literature Cited

Smith GA, Schweizer EE (1983) Cultivar x herbicide interaction in sugarbeet. Crop Sci 23:325-328