Diversifying Weed Management Strategies for Improving Weed Control in Cole Crops

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Cole crops, such as cabbage and broccoli, are particularly vulnerable to weed competition due to their short stature and shallow root systems, which limit their ability to compete for water, nutrients, and light. This competition can reduce both the number and size of the crops. For instance, Bellinder (2012) found that weeds like hairy galinsoga, common lambsquarters, pigweed species, and large crabgrass in cabbage fields could reduce yields by about 55%. Over a span of 20 years, studies in various regions (Michigan, New Jersey, New York, Wisconsin, and Ontario) revealed that uncontrolled weeds could lead to a 54% yield loss in cabbage, despite best crop production practices (M. VanGessel, personal communication). Weeds can also disrupt harvest operations and, in some cases, physically contaminate crops, such as cabbage heads being contaminated by weed seeds. Weeds in cole crops can also contribute to indirect issues, such as supporting pests and pathogens specific to Brassica species and creating occupational hazards for agricultural workers during harvest. These factors can negatively impact cole crops head quality, leading to reduced yields and an increase in labor to meet industry standards for both fresh and processed markets

Effective weed management is crucial for optimizing cole crop yield and quality, as well as preventing the onset of diseases and pest problems. Integrated Weed Management (IWM) strategies are key to achieving this, and they must be customized based on the specific weed species present in each cole crop field. These strategies may include a combination of cultural practices, mechanical methods, and herbicides all aimed at reducing weed pressure while minimizing environmental impact. Tailoring the approach to the unique weed challenges in each field can enhance the success of weed control and improve overall tomato crop health.

I. **Prevention.** Prevention is the foundational step in any effective weed management program. The goal is to stop the introduction, establishment, and spread of weed species into areas that are not yet infested. Key elements of a prevention program include:

- **Burndown Herbicide Programs**: Applying herbicides before planting to eliminate emerged weeds and reduce competition.
- **Equipment Sanitation**: Thoroughly cleaning agricultural equipment before moving it between infested and non-infested fields to avoid transferring weed seeds.
- **Weed-Free Irrigation Water**: Using irrigation water free from weed seeds to prevent contamination.

- **Field Border and Ditch Maintenance**: Managing weeds along field borders and in ditches to prevent their spread into crop areas.
- **Prevention of Seed Production**: Implementing strategies to control weeds before they can produce seeds, reducing the future weed seed bank.

Together, these preventive measures help reduce the likelihood of weed establishment and minimize the need for more intensive control measures later.

II. **Weed Scouting:** Weeds should be targeted at the seedling stage whenever possible. Control of fully matured weeds can be inconsistent due to their size, which hinders the even distribution and absorption of herbicides, or because of their ability to regrow after mechanical or chemical treatment. Scouting for weed seedlings shortly after emergence is a crucial part of an effective weed management strategy. The aim of weed scouting is to obtain a representative assessment of the diversity, density, and growth stages of weed species across the entire field. A well-organized scouting program should also monitor crop phenology, as certain herbicides cannot be applied beyond specific growth stages of the crop.

III. **Identification:** Proper weed identification is crucial for effective management, as herbicide efficacy and other control strategies—such as mechanical, cultural, and biological methods—can vary by species. Some weed species may appear similar from a distance but may require very different management approaches. Close examination is necessary to determine the appropriate herbicide programs. Resources such as books, weed identification websites, and smartphone applications can be valuable tools for accurately identifying weed species and understanding their biology and ecology.

IV. **Cultural Weed Control**: Growers should ensure clean soil before planting by removing weeds through methods like a burndown herbicide application, a dense, suppressive cover crop mulch, or mechanical weed control techniques such as tillage and cultivation. Preventing weed seed production in the field before planting, through frequent soil cultivation, helps reduce the weed seedbank in the soil. A late summer or fall application of glyphosate combined with dicamba or 2,4-D on healthy weeds can effectively suppress broadleaf perennial weeds, such as bindweed, Canada thistle, or horsenettle.

V. **Chemical Weed Control Before or at Planting (PPI or PRE)**: Several herbicides are labeled for use on soil applications on cole crops before weed emergence and crop planting. It's important to select herbicides that target the specific weeds present in the field (prior knowledge of the field's weed history is crucial). Apply the correct herbicide rate based on the soil texture and organic matter content of the field. Herbicides should be sprayed and incorporated—either mechanically or through irrigation/rainfall—to reduce the risk of crop injury and ensure effective weed control. **See table 1** for details of labeled herbicides.

VI. **Chemical Weed Control after Planting (POST)**: A limited number of herbicides can be applied postemergence for controlling emerged weeds (**see table 2).** Dual Magnum can also be applied over-the-top within 48 h of transplanting or after direct-seeded cabbage has developed 3 to 4 leaves without injury; however, it will not control emerged weeds.

Table 1: Preplant Incorporated (PPI) or preemergence herbicides labeled for use on cole crops.

WSSA Group	PPI or PRE A.I.	Formulated Product (examples)	Notes
WSSA 3 **Microtubule Inhibitor** Inhibit cell division	pendimethalin trifluralin	**Prowl H2O** **Satellite Hydrocap** **Treflan HFP** broccoli, Brussels sprouts, cabbage, cauliflower, collards, and kale	*Trifluralin* is photosensitive (PPI), stunting can occur in cold (< 60F) and wet soils. weak on ragweeds, mustard, knotweeds, lambsquarters *Pendimethalin* is more stable than trifluralin, can cause stem swelling, S-shaped stems, best above 60-70 F. Mainly annual grasses (crabgrass, foxtail, fall panicum) and some small-seeded broadleaves.
WSSA 8 **Lipid Biosynthesis Inhibitor** Inhibit cell metabolism	bensulide	**Prefar 4E** broccoli, Brussels sprouts, cabbage, cauliflower, collards, kale, and kohlrabi	*Bensulide* (PPI) use in early spring (cold, wet soils) may minimize chances for crop stunting. Annual grasses (crabgrass, foxtail, fall panicum).
WSSA 13 **DDXPS Inhibitor** Generate reactive oxygen molecules	clomazone	**Command 3ME** broccoli ONLY	*Clomazone* may cause bleaching, do not apply near greenhouses, nurseries, etc… Annual grasses (crabgrass, foxtail, fall panicum) and velvetleaf.
WSSA 14 **PPO Inhibitor** Generate reactive oxygen molecules	oxyfluorfen sulfentrazone	**GoalTender 4F** broccoli, cabbage, and cauliflower ONLY **Spartan Charge 3.5F** Transplanted cabbage ONLY	*Oxyfluorfen* should not be applied with *S*-metolachlor, transplants less than 5 weeks old/root balls less than 1 inch square may see more injury; leaves that touch treated soil can be injured. Annual broadleaves (lambsquarters, pigweed, purslane, Eastern black nightshade, fair on ragweed).
WSSA 15 **VLCFA Inhibitor** Inhibit cell division	*S*-metolachlor napropamide	**Dual Magnum** Restricted Use, 24(c) transplanted broccoli, Brussels sprout, cabbage, cauliflower, and Chinese cabbage, collards, kale **Devrinol 2XT /DF-XT** broccoli, Brussels sprouts, cabbage, cauliflower, collards, kale	*S-metolachlor* injury may occur under cool temperatures, POST-T applications can cause foliar burn. Annual grasses and some broadleaf weeds (pigweed), weak on ragweed and lambsquarters but can suppress yellow nutsedge. SLN 24(c) for MI expires on 12/31/2026 *Napropamide* has less chance of stunting at temps below 60 F. Annual grasses.

Table 2: Postemergence herbicides (POST) labeled for use on cole crops.

WSSA Group	PPI or PRE A.I.	Formulated Product (examples)	Notes
WSSA 1 **ACCase Inhibitor** Inhibit fatty acid synthesis (cell membrane)	sethoxydim clethodim	**Poast 1.5EC** **Select Max** Restricted Use	*Sethoxydim* and *clethodim,* see label for recommended surfactant type and rate to be used with these herbicides. Use of COC may increase the risk of crop injury when hot or humid conditions prevail. Annual grasses (crabgrass, foxtails, barnyardgrass, goosegrass, fall panicum).

WSSA 4 **Synthetic auxins** Disruption of plant growth	clopyralid	**Stinger**[Restricted Use]	*clopyralid* controls composite (ragweed, galinsoga, cocklebur, groundsel…) and legume (clover, vetch) weeds. Suppresses perennial composites (Canada thistle, goldenrod, mugwort).
WSSA 14 **PPO Inhibitor** Generate reactive oxygen molecules	oxyfluorfen carfentrazone	**GoalTender 4F**[24(c)] broccoli, cabbage, and cauliflower ONLY **Aim**	*Oxyfluorfen*: broadcast after a minimum of 2 weeks after transplanting or a minimum of 4 true leaves. Can cause severe crop injury if application is made under cool (< 50 For when the crop is growing under stress conditions. Annual broadleaves (lambsquarters, purslane, pigweeds, nightshade). SLN 24(c) for MI expires on 12/31/2025 *Carfentrazone*: hooded sprayer btw rows ONLY.

VII. **Mixing Oxyfluorfen and *S*-metolachlor**: Recent trials in New Jersey and New York evaluated weed management efficacy and cole crop responses to different timing combinations of S-metolachlor and oxyfluorfen. These herbicides are key tools for pre-emergence (PRE) and post-emergence (POST) weed control in cole crop production. While S-metolachlor and oxyfluorfen have complementary weed control spectrums, label recommendations discourage their use within the same season due to potential crop injury. A tank mix of oxyfluorfen and S-metolachlor, which could reduce the need for multiple equipment passes, save time and fuel, and limit soil compaction, effectively controlled weeds but caused early-season crop injury. Similar weed control and crop safety outcomes were observed when oxyfluorfen application followed S-metolachlor. The study found that applying oxyfluorfen PRE, followed by S-metolachlor POST, provided effective weed suppression and good crop safety. This sequence is particularly advantageous for growers planting late spring or fall crops, as it effectively manages pigweed species, which can emerge continuously throughout the summer

VIII. **Living Mulch as an IPM Tool for Broccoli Production**. Ongoing research is investigating the use of living mulch planted within broccoli rows to evaluate its impact on pest populations, weed control, and crop yield. Results indicate that insect counts decreased in plots where broccoli was surrounded by living mulch. l. Weed biomass at harvest was significantly lower in living-mulch plots, with an average dry weight of 2 g m^{-2} compared to 16 g m^{-2} in bare-ground plots. However, broccoli yield was reduced in living-mulch plots. Bare-ground plots produced an average total yield of 24 kg m^{-2} per plot, while living-mulch plots yielded 12 kg m^{-2}. While living mulch shows potential for controlling caterpillars and reducing weed biomass, further research is needed to minimize competition with broccoli plants and improve overall crop yield.