# Fungicide "Cheat Sheet" for Alternaria Leaf Spot and Head Rot in Broccoli and Other Cole Crops, 2024

| Product and Rate/A | Active Ingredient | FRAC[1] Group | Rating for Risk of Fungicide Resistance | PHI | Restricted Use[2] | Maximum Use | Rotation Restrictions (No. of apps before rotate to another FRAC group) | Cole Crops on Label[3] | Disease Control | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Relative Control of ALS[4] | Activity on DM[5] |
| **Bravo Weather Stik** 1.5 pt (+ many other formulations) | chlorothalonil | M5 | Very low | 7 days | No | 11.7 pts (= 7 apps) | none | ALL | Mediocre | Good |
| **Quadris** 6-15.5 fl oz (+ other formulations)^ | azoxystrobin | 11 | High | 0 days | No | 90 fl oz (= 5-15 apps) | none | ALL | Good | Mediocre |
| **Switch** 10-14 oz, **Alterity**^ 11-14 oz | cyprodinil + fludioxonil | 9 12 | Medium Low-Medium | 7 days | No | 56 oz (= 4-5 apps) | 2 | ALL | Good | None |
| **Priaxor** 6-8.2 fl oz, **Everlon**^ 6-8.2 fl oz | fluxapyroxad + pyraclostrobin | 7 11 | Medium-High High | 3 days | Yes | 24.6 fl oz (= 3 apps) | 2 | ALL | Caution![6] Good | Mediocre |
| **Endura** 6-9 oz | boscalid | 7 | Medium-High | 0 days | No | 18 oz (= 2 apps) | 2 | ALL | **Resistance!**[6] | None |
| **Luna Experience** 6-8.6 fl oz | fluopyram + tebuconazole | 7 3 | Medium-High Medium | 7 days | Yes | 34 fl oz (= 4 apps) | 2 | Brassica leaf greens only | Caution![6] Mediocre-Good^ | None |
| **Luna Sensation** 5-7.6 fl oz | fluopyram + trifloxystrobin | 7 11 | Medium-High High | 0 days | Yes | 15.3 fl oz (= 2 apps) | 2 | ALL | Caution![6] Good | Mediocre |
| **Luna Flex** 10-13.6 fl oz | fluopyram + difenoconazole | 7 3 | Medium-High Medium | 1 day | Yes | 27.2 fl oz (= 2 apps) | 2 | ALL | Caution![6] Mediocre-Good^ | None |
| **Miravis Prime** 11.4 fl oz | pydiflumetofen + fludioxonil | 7 12 | Medium-High Low-Medium | 7 days | Yes | 34.2 fl oz (= 3 apps) | 2 | ALL | Caution![6] Good | None |
| **Inspire Super** 16-20 fl oz, **Vango Esq**^ 14-20 fl oz | cyprodinil + difenoconazole | 9 3 | Medium Medium | 7 days | No | 80 fl oz (= 4 apps) | 2 | ALL | Good-Mediocre | None |
| **Quadris Top** 12-14 fl oz | azoxystrobin + difenoconazole | 11 3 | High Medium | 1 day | No | 56 fl oz (= 4 apps) | 1 | ALL | Excellent | Not Labeled |
| **Viathon** 2 pt | tebuconazole + pot. phosphite | 3 P07 | Medium Low | 7 days | No | 8 pt (= 4 apps) | none | Brassica leaf greens only | Good | Good |
| **Topguard EQ** 5-8 fl oz | flutriafol + azoxystrobin | 3 11 | Medium High | 7 days | No | 32 fl oz (= 4 apps) | rotation recommended | ALL | Good | Not Labeled |
| **Rhyme**^ 5-7 fl oz | flutriafol | 3 | Medium | 7 days | No | 28 fl oz (= 4 apps) | none | ALL | Mediocre-Good | None |
| **Organic OMRI Listed:** | | | | | | | | | | |
| **Oso 5%SC** 6.5-13 fl oz | polyoxin D zinc salt | 19 | Medium | 0 days | No | 78 fl oz (= 6 apps) | none | ALL | Mediocre | None |
| **Kocide 3000-O** 0.5-0.75 lb[7] | copper hydroxide | M1 | Low | 0 days | No | 8.8 lb (=11 apps) | none | ALL | Mediocre - Poor | Labeled** |
| **Cueva** 0.5% v/v[7] | copper octanoate | M1 | Low | 0 days | No | 13.25 qt (=2 apps) | rotation recommended | ALL | Mediocre - Poor | Labeled** |

1 **FRAC**: **F**ungicide **R**esistance **A**ction **C**ommittee group. Fungicides that belong to the same FRAC group are at risk for developing cross-resistance. For best fungicide resistance management practices, fungicides belonging to different FRAC groups should be rotated.

2 **Restricted Use**: NY DEC spray pesticide license required to use.

3 **ALL Cole crops** includes broccoli, cabbage, cauliflower and Brussels sprouts. Often, kale, collards, kohlrabi and mustard greens also on label (see labels for details). **Luna Experience** and **Viathon** are only labeled on Brassica leaf greens such as broccoli raab, Chinese cabbage (Bok Choy), collards, mizuna, etc. NOT broccoli, cauliflower, or cabbage (see label).

4 **ALS: Alternaria leaf spot and head rot**. Relative disease control based on 2018 (1 on-farm), 2021 (2 conventional & 1 organic at Cornell Agri-Tech, 1 on-farm), 2022 and 2023 (conventional & organic at Cornell AgriTech) fungicide trials (Smart *et. al.* 2021, Hoepting 2018, 2021, 2022, 2023).

**^ Generics. Aframe** is a generic version of Quadris. Generics have not been trialed in Cornell trials; relative performance is estimated.

5 **DM: downy mildew**. Best control of DM is provided by Orondis Opti/Ultra, Revus and Presidio. **Labeled for downy mildew but Cornell has not trialed these products on downy mildew.

6 **Caution! Fungicide resistance was confirmed to FRAC 7 boscalid on 5 farms in Western NY in 2023.** Cross-resistance to other FRAC 7 active ingredients is strongly suspected. Ratings are based on 2023 fungicide trial results inoculated with ALS strain with confirmed resistance to boscalid. Some strains of the ALS pathogen may be insensitive (e.g. not controlled by fungicide) to Endura in New York. Prior to development of fungicide resistance, efficacy of FRAC 7 fungicides was EXCELLENT. As fungicide resistance develops, efficacy declines over time as more isolates become resistant.. .

7 It is likely that other copper-based products have activity on Alternaria diseases of Cole Cops, but Kocide 3000-O and Cueva are the only ones that we have data on at this time.

# Fungicide Recommendations for ALS in Broccoli

**Fungicide "Cheat Sheet"** provides a list of fungicides that are labeled in broccoli and other common Cole crops, for which Cornell research has shown to be effective for control of Alternaria leaf spot (ALS) and head rot. The relative control of ALS was based on results from:

1. On-farm trial conducted under severe ALS pressure in Late-Summer, natural infection (Hoepting, 2018).
2. Conventional and organic fungicide trials (1 of each) conducted at Cornell AgriTech research farm under severe ALS pressure in Summer, artificial inoculation with inoculum from 1) (Smart *et al.*, 2021).
3. On-farm trial conducted under low ALS pressure in Late-Summer, natural infection (Hoepting, 2021).
4. Conventional fungicide trial conducted at Cornell Agri-Tech research farm under moderate-severe ALS pressure in Fall, natural infection from adjacent inoculated trial (Hoepting, 2021).
5. Conventional and organic trial conducted at AgriTech research station under low pressure in Fall, artificial inoculation with inoculum from 1) (Hoepting, 2022).
6. Conventional and organic trial conducted at AgriTech research station under high pressure in Summer, artificially inoculated with new source of inoculum (Hoepting, 2023). **--> emphasis placed on this trial for relative performance ratings in cheat sheet.**

- **Spray fungicides preventatively before disease establishes itself**, because lower frame leaves serve as inoculum to infect heads. This is especially important when disease is present in the area/planting and when conditions are favorable for disease (e.g. leaf canopy is wet from rain, irrigation or dew for prolonged periods (20 hours or more), especially when temperatures are 75-82°F).
  - Bravo would be an economical choice at this timing.

- **Begin application of systemic/translaminar fungicides with very good to excellent activity on ALS once canopy fills in/head formation begins through harvest, especially when disease risk is high.** Once the canopy fills in, aeration is reduced and leaf wetness is prolonged, especially during late-August and into the fall.

- **All fungicides listed in the Cheat Sheet except Bravo (FRAC M5) and copper (FRAC M1), are at risk of ALS developing resistance.**
  - See ALS Fungicide Cheat Sheet/labels for rotation restrictions and seasonal maximum use rates.
  - Be mindful of pre-mixes that have more than one FRAC group per fungicide that need to be managed for fungicide resistance. For example, there are a few products with FRAC 3 and 7 that are pre-mixes with FRAC 11, which makes it easy to accidently apply 3-4 consecutive applications of FRAC 11 when trying to rotate FRAC 3 with FRAC 7.

- **In Fall of 2023, fungicide resistance was confirmed to FRAC 7 boscalid (a.i. in Endura)** via fungicide sensitivity testing on 5 farms in Western New York. Endura failed to control ALS and head rot in 2023 fungicide trial, where ALS strain used to inoculate was confirmed to be resistant to boscalid. In this trial, the field performance of FRAC 7 fluopyram (a.i. in Luna products) failed to significantly reduce head rot, although it reduced the severity of head rot and was excellent at reducing foliar ALS.
  - It is suspected that ALS is developing resistance to all FRAC 7 active ingredients and that their efficacy may also be declining.

- **It is suspected that FRAC 3 is slipping/ALS is developing fungicide resistance.** In 2023, FRAC 3 alone failed to control head rot in fungicide trial, but significantly reduced severity of head rot and had excellent efficacy on foliar ALS.

- For best fungicide resistance management practices:
  - Do not apply more than 1-2 applications before alternating to another FRAC group.
  - Do not use more than 2 applications per FRAC group per crop.
  - Bravo and copper bactericides are the exceptions to this, because their multi-site mode of actions reduce their risk for fungicide resistance and may be used several times.

- **Use the highest labeled rates, especially for Quadris** and when conditions are favorable for disease.

- **Use a 7-day spray interval when disease pressure is high**, and especially for **organic products**.

- **Use an adjuvant with fungicides that have translaminar or systemic activity** (FRAC 3, 7, 9, 11, 12) for improved efficacy. Read labels for details.
  - Be careful about using adjuvants with copper bactericide or sanitizers, as excessive leaf burn injury may occur, especially with oil adjuvants when temperatures are >90°F, or during prolonged cool periods such as in late-Fall.

- **Save products with 0 days** (Endura, Quadris, Luna Sensation, organic products), **1 day** (Quadris Top), **or 3 days** (Priaxor) **pre-harvest interval (PHI) for close to and during harvest.**

- **ALS products with no activity on downy mildew (DM)** include Luna Experience/Flex, Endura, Miravis Prime, Inspire Super/Vango ESQ, Switch/Alterity, Rhyme and Oso 5%SC have no activity on DM.
  - ALS fungicides **with good DM activity** include Bravo, those with FRAC 11 active ingredients (Quadris, Quadris Top, Priaxor/Everlon, Luna Sensation, Topguard EQ), and FRAC P07 (Viathon).
  - **Best control of DM** is provided by Orondis Opti/Ultra, Revus and Presidio. Note that none of these fungicides have any activity on ALS.

- **Do your fungicide spray program "puzzle" ahead of time.** Although there are several fungicide options, it can be tricky to not exceed 2 apps per FRAC per crop, especially when most products contain premixes of two FRAC groups (e.g. Luna Sensation contains FRAC 7 and 11).
  - It is a good idea to design a 4-6 week program to use from full canopy fill/early head formation through harvest. Prior to this, Bravo should suffice unless ALS pressure is high.
  - Start with the products that you want to use during harvest with 0 PHI and work backwards to avoid no more than 2 apps per FRAC.

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