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Title: Evaluating the Efficacy and Safety of Pyridate in Snap Bean

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Introduction: Postemergence (POST)-applied herbicides are valuable tools for preventing yield loss in snap bean production. However, relatively few products are labeled, and each comes with constraints regarding use. For example, Basagran can be effective against lambsquarters, but only if the plants are small and resistance has not evolved; other important species, like pigweeds, are not controlled. Fomesafen, a cornerstone of snap bean weed control has limitations with respect to the number of applications that can be made over multiple years. Other products have significant rotation restrictions that can affect cropping decisions. The addition of novel active ingredients would be valuable for suppressing unwanted vegetation. Formulations of pyridate, a WSSA Group 6 herbicide (PSII-inhibitor) are registered for use in chickpeas/garbanzo beans (Boydston et al. 2018. Weed Technol. 32:190-194; Belchim USA - Belchim Crop Protection USA) and have been/are being evaluated in lentils (Ahmadi et al. 2016. Weed Technol. 30:448-455) and peanuts (Edenfield et al. 2001. Weed Technol.15:419-423), and peas, suggesting that other members of the Fabaceae (bean family) may possess a level of tolerance to the chemical. Pyridate (as Tough EC) was found to be effective for controlling lambsquarters, including bentazon resistant biotypes that have evolved in New York and other states, and thus could be a valuable tool.

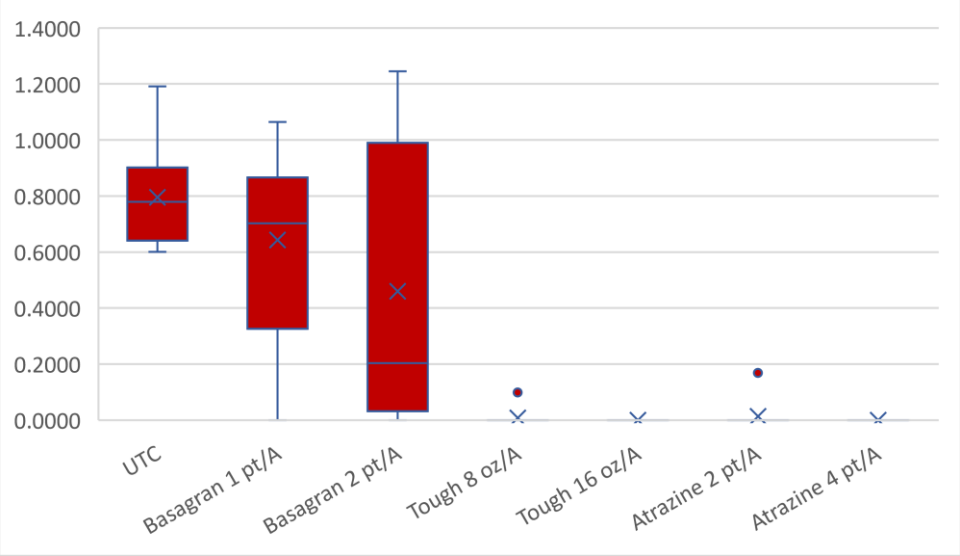


Figure 1. Response of a bentazon-resistant lambsquarters population (NY) to PSII-inhibiting herbicides. The Y-axis represents mean plant biomass, in grams, of untreated check plants (UTC), and plants treated with bentazon (Basagran), pyridate (Tough EC), and atrazine.

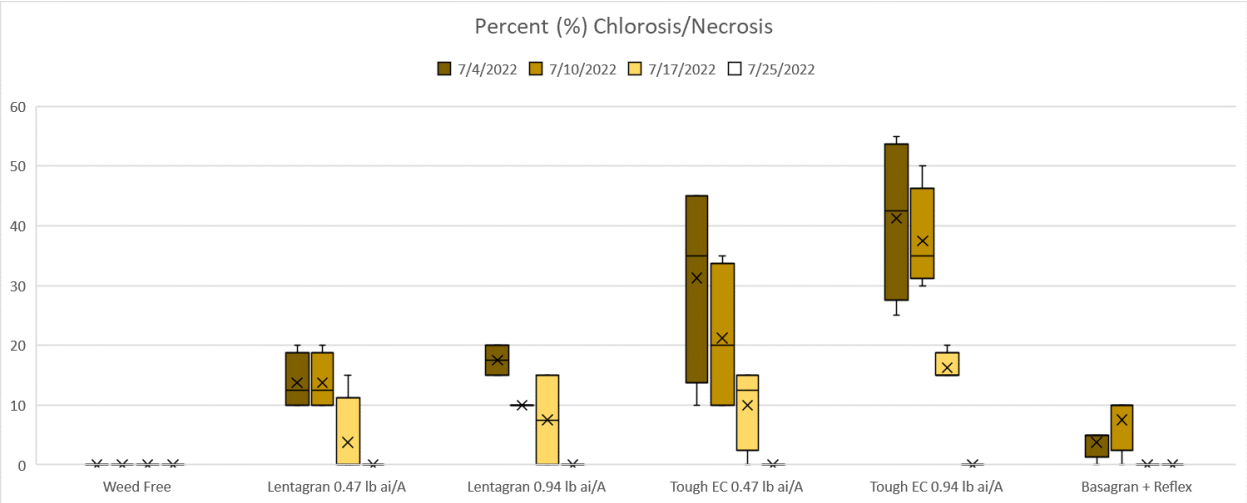
Materials and Methods: Research was conducted at the Cornell AgriTech Experiment Station in Geneva (NY), the Penn State Horticultural Research Farm in Rock Springs (PA), and University of Delaware's Carvel Research and Education Center in Georgetown (DE) to evaluate the safety of two pyridate formulations, Lentagran and Tough EC in snap beans. Lentagran is a

wettable powder (WP) that is registered in several crops in the European Union (EU); Tough EC is an emulsifiable concentrate primarily used in corn in the US. Herbicide treatments included: a weed-free untreated check (UTC), Lentagran at 0.47 lb a.i./A, Lentagran at 0.94 lb a.i./A, Tough EC at 0.47 lb a.i./A, Tough EC at 0.94 lb a.i./A, and Basagran at 1 lb a.i./A) + Reflex at 0.125 lb ai/A. Applications were made at the first trifoliate leaf using a CO2-pressurized backpack sprayers calibrated to deliver 20 GPA. Injury (chlorosis/necrosis and stunting) was rated on a scale of 0% (no injury) to 100% (complete plant death); evaluations were made weekly for 4 weeks beginning at one week after treatment (WAT). The numbers and weights of marketable beans (USDA 1) were recorded at harvest.

Results: Wettable powders are suspensions when mixed with water prior to spraying; WPs can be difficult to mix in spray tanks and can clog filters and nozzles if not fully dissolved. Both Penn State and University of Delaware researchers had mixing issues that resulted in Lentagran contamination in other treatments, which confounded results. Consequently, only Cornell data was statistically analyzed.

Percent (%) chlorosis/necrosis in snap beans at 1 (4 July), 2 (10 July), and 3 (17 July) WAT was significantly ($P < 0.05$) affected by herbicide treatment (Figure 2, Figure 4). The least amount of observable injury occurred in the Basagran + Reflex treatment; less than 10% chlorosis/necrosis was reported at all evaluation dates. Chlorosis/necrosis in the Lentagran treatments did not exceed 20%, with the greatest amount of injury observed 1 WAT. Tough EC applications caused the greatest amount of observed injury at 1 and 2 WAT; maximum chlorosis/necrosis ratings were 45% and 50% for the 0.47 and 0.94 lb a.i./A rates, respectively. Injury decreased with time; no observable chlorosis/necrosis was detected at 4 WAT.

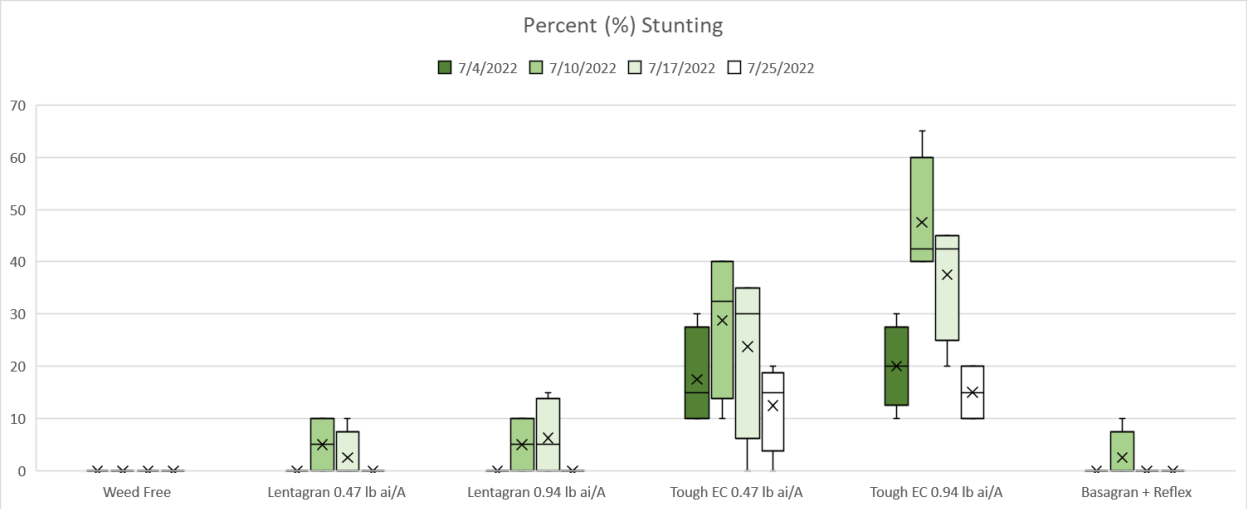
Figure 2. Percent (%) chlorosis in 'Huntington' snap beans in NY in response to pyridate treatments (Lentagran and Tough EC) as compared to a weed free, untreated check and a grower standard of Basagran plus Reflex. All herbicide applications were made at the first trifoliate leaf stage (June 25th)



Percent (%) stunting in snap beans at 1 (4 July), 2 (10 July), and 3 (17 July) WAT was significantly ($P < 0.05$) affected by herbicide treatment (Figure 3, Figure 4.). Stunting responses mimicked the chlorosis/necrosis responses. The least amount of observable injury occurred in the

Basagran + Reflex treatment; less than 10% stunting was reported at all evaluation dates. Stunting in the Lentagran treatments did not exceed 15%, with the greatest amount of injury observed at 2 and 3 WAT. Tough EC applications caused the greatest amount of stunting across all observation dates; maximum stunting ratings were 40% and 65% for the 0.47 and 0.94 lb a.i./A rates, respectively. No stunting was observed in the Lentagran and Basagran + Reflex treatments at 4 WAT while up to 20% stunting was observed in the Tough EC treatment.

Figure 3. Percent (%) stunting in 'Huntington' snap beans in NY in response to pyridate treatments (Lentagran and Tough EC) as compared to a weed free, untreated check and a grower standard of Basagran plus Reflex. All herbicide applications were made at the first trifoliate leaf stage (June 25th)



Marketable snap bean numbers and weights, expressed as a percent (%) of the weed free untreated check, were also affected by herbicide treatment, with the lowest yields occurring in the Tough EC treatments (Figure 6).

S**ummary and Outreach:** Post-emergence herbicides are critical tools for managing weeds in snap bean production. The evolution of bentazon resistance in lambsquarters in NY and other states highlights the needs for additional chemistries. Pyridate is a PS II-inhibitor that has been investigated for use in other leguminous crops. A WP formulation of pyridate (Lentagran) produced less chlorosis and stunting in snap beans than an emulsifiable concentrate formulation (Tough EC). Similar injury responses were observed in Cornell's cabbage research trials; cabbage injury was greater in Tough EC as compared to Lentagran treatments. Lentagran injury was, at times, greater than the Basagran + Reflex standard. The Lentagran treatments did not differ from the Basagran + Reflex treatment with respect to yield. Lentagran is an effective tool for controlling lambsquarters and may have a role in Northeast production.

Results from this study were presented at the 2023 Mid-Atlantic Fruit and Vegetable convention on 31 January ("*IPM Topics: Snap Bean Weed Management Update").* Data is being shared with the registrant for review.

Figure 4. Image showing injury to snap beans following herbicide applications at the first trifoliate leaf stage. Top from left to right: weed free untreated check, Basagran + Reflex, Lentagran at 0.47 lb a.i./A. Bottom from left to right: Lentagran at 0.94 lb a.i./A, Tough EC at 0.47 lb a.i./A, Tough EC at 0.94 lb a.i./A.

Figure 5. Number and biomass (g) of marketable 'Huntington' snap beans in NY in response to pyridate treatments (Lentagran and Tough EC) as compared to a weed free, untreated check and a grower standard of Basagran plus Reflex. All herbicide applications were made at the first trifoliate leaf stage (June 25th)