Improving Nursery Weed Control by Choosing Herbicides Based on Application Timing Flexibility and Formulation

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ABSTRACT

Research trials were conducted in 2018 and 2019 to evaluate five different herbicides including indaziflam, flumioxazin, prodiamine, prodiamine + isoxaben, and dimethenamid-P + pendimethalin for control of spotted spurge (*Euphorbia maculata*) and bittercress (*Cardamine flexuosa*) based on their formulation (granular vs. spray-applied) and seeding date relative to the herbicide treatment. Overall results showed formulation was the most significant factor in control of spurge or bittercress. In most cases, dimethenamid-P + pendimethalin, prodiamine, and prodiamine + isoxaben tended to perform similarly regardless of formulation. However, significantly better control was observed with spray-applied formulations of flumioxazin or indaziflam.

OBJECTIVES AND METHODS

This research is part of a multi-year project focused on developing improved herbicide rotation programs and schedules for Florida container growers. Funds from FNGLA allowed us to conduct a study to investigate both current herbicide efficacy protocols utilized by weed scientists and evaluate different herbicide active ingredients in terms of how efficacy is influenced by formulation (granular or spray-applied) and seeding date.

In recent years, container nursery growers have reported different results with many granular preemergence herbicides compared to results developed from small-plot research trials. This problem has begun to emerge over the past three years. At recent meetings and conferences, different results have been reported with the same herbicides. Upon closer inspection of the data and different procedures, the reason for these differences is possibly due to 1) the use of new carrier technologies that could be influencing herbicide release, and 2) inherit differences in research trials and real-world nurseries relating to seeds present in the container substrate.

While poor herbicide control in nurseries could be a result of application/calibration errors, growers may still report poor control of certain weed species after correcting these issues (and other factors such as resistance are determined to not be a factor). Weed species in which poor control have been observed are often fast germinating species, such as bittercress, which germinates in 3 or 4 days in ideal environments. Herbicides applied on new carriers have been shown to provide effective control of bittercress in research trials, but this could be due to differences in nursery environments and in standard herbicide efficacy protocols. Researchers following general procedures will place weed seeds onto clean and sterile substrates 1 to 3 days after herbicide application to evaluate efficacy. In this scenario, excellent weed control is often observed. However, in nurseries, growers may only have weed-free substrates immediately after potting. During production, weeds will inevitably escape control and go to seed before they can be hand pulled. Consequently, later in production cycles, growers will have substrates containing weed seeds at various stages of germination and development. If an herbicide, specifically those applied with these new carriers, are only effective on seeds that are introduced to the substrate 1 to 3+ days after application, they would not be as effective at certain times and other products should be chosen.

The objective of these experiments was to compare efficacy of common nursery preemergence herbicides based on their formulation and application timing relative to seeding spotted spurge (*Euphorbia maculata*) or bittercress (*Cardamine flexuosa*).

Methods

All trials were conducted at the Mid-Florida Research and Education Center in 2018 and 2019. On November 21, 2018, 1.68 L nursery pots were filled with a pinebark:peat:sand (80:20:10 v:v:v) substrate containing incorporated fertilizer and amendments, and placed inside a greenhouse, and received 0.3 inches of overhead irrigation per day. On November 27, herbicides were applied **(Table 1)**. Granular herbicides were applied using a hand-shaker while spray-applied herbicides were applied using a CO_2 backpack sprayer calibrated to deliver 50 gallons per acre. All herbicides were applied at manufacturer label rates and the amount of active ingredient applied with granular and spray-applied herbicides was the same. A non-treated control group was also included for comparison.

Table 1. Herbicides evaluated for control of bitterness and spotted spurge.

Trade name	Active ingredient	Formulation	Rate product	Rate of active ingredient
Marengo G	indaziflam	granular	200 lbs./acre	0.04 lbs./acre
Marengo SC		suspension concentrate	9 fl. oz./acre	
Broadstar	flumioxazin	granular	150 lbs./acre	0.375 lbs./acre
SureGuard		suspension concentrate	12 fl. oz./acre	
Gemini G	prodiamine + isoxaben	granular	200 lbs./acre	0.8 + 0.5 lbs./acre
Gemini SC		suspension concentrate	43 fl. oz./acre	
RegalKade G	prodiamine	granular	300 lbs./acre	1.5 lbs./acre
Barricade		liquid	48 fl. oz./acre	
FreeHand	dimethenamid-P + pendimethalin	granular	200 lbs./acre	1.5 + 2.0 lbs./acre
Tower + Pendulum EC		emulsifiable concentrates	32 + 78 fl. oz./acre	

Bittercress seeds were surface sown onto pots on 5 different dates relative to the herbicide application including 2 days before the application (2DBT), and 0, 2, 4, and 7 days after treatment (DAT). Evaluating herbicide efficacy across different seeding dates allowed us to compare which herbicide active ingredient and/or formulation provided the greatest control across multiple seeding dates and to determine which herbicides are most affected by seeding date and formulation. This trial was repeated for bittercress following the same experimental protocols in 2019 with treatments being applied on February 21. Trials with spotted spurge were also conducted in 2019 with the first experimental run being treated on May 6, and the second experimental run on June 24. All trials contained eight single pot replications per treatment for each weed species and experimental run. After seeding, weed counts were taken in each pot at 4 and 10 weeks after treatment. At 10 weeks, shoots were clipped at the soil line and dried in a forced air oven until reaching a constant weight. All data were converted to percent control relative to the non-treated by using the formula [(non-treated – treated)/non-treated)] × 100. Data were arcsine transformed and then subjected to analysis of variance (ANOVA) using JMP software (SAS Institute). Means and standard errors are reported for significant main effects and interactions. For the sake of brevity, only dry weight data are discussed for each species separately.

RESULTS

Bittercress. Herbicide was the only significant main effect, but interactions for herbicide and formulation, as well as the interaction between herbicide and seeding date **(Table 2)**. Bittercress control differed by formulation for pendimethalin + dimethenamid-P with the granular (FreeHand) providing better control than the spray-applied formulation (Tower + Pendulum), but both formulations provided approximately 90% control **(Figure 1)**.

Table 2. Effects of herbicide, formulation, seeding time, and interactions.

Variable	Bittercress D.W.	Spurge D.W.
	P-value[a]	
Herbicide (H)	**<0.0001**	**<0.0001**
Formulation (F)	0.0791	**<0.0001**
Seeding time (ST)	0.3101	0.0975
H × F	**<0.0001**	**<0.0001**
H × ST	**0.0432**	0.0867
F × ST	0.1001	0.1378
H × F × ST	0.1017	0.6795

[a]Analysis of variance was performed to test fo significant main effects and interactions. Variables were considered significant at <0.05

The spray-applied formulation of flumioxazin (SureGuard) provided better control than the granular (Broadstar), but similar to dimethenamid-P + pendimethalin, both formulations provided over 90% control. Similar results were observed with indaziflam, but only 83% control was observed with the granular formulation (Marengo G) compared with 99% control with the spray-applied formulation (Marengo SC). No difference in formulation was observed for prodiamine + isoxaben (Gemini G and Gemini SC) or prodiamine alone (RegalKade or Barricade), but only the isoxaben + prodiamine combination provided acceptable control.

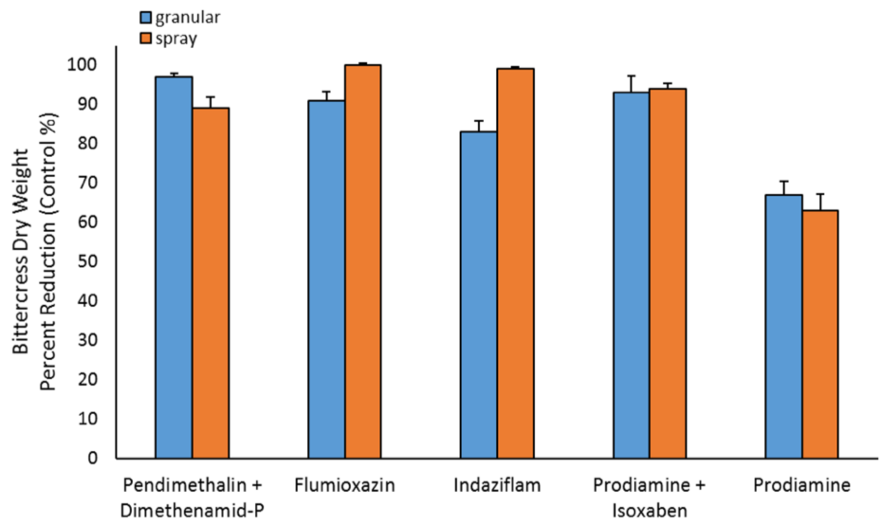

Figure 1. Comparison of five different herbicides by formulation for control of bittercress.

Averaged over both formulations, there was no difference in seeding time for dimethenamid-P + pendimethalin. Flumioxazin and indaziflam both provided better control of bittercress when seeds were sown on the day of (0DAT) or after treatments were applied (2 to 7 DAT) **(Figure 2).** Prodiamine + isoxaben and prodiamine results were variable depending on seeding date, but overall, the combination tended to provide at least 80% control regardless of seeding date while 77% or less control was observed with prodiamine alone.

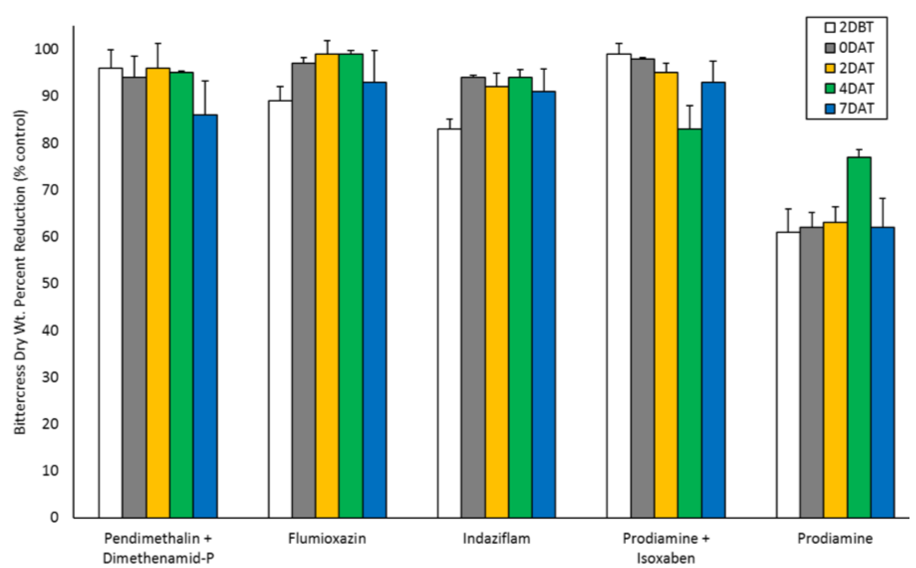

Figure 2. Comparison of five different herbicides by seeding date for control of bittercress.

Spurge. Herbicide, formulation, and the interaction between herbicide and formulation were significant **(Table 2)**. There was no difference in formulation for dimethenamid-P + pendimethaline and both formulations provided over 90% spurge control. For both indaziflam and flumioxazin, better control was observed with the spray applied formulations (100 and 95% control with flumioxazin and indaziflam, respectively) compared with the granular products (79 to 70% control for flumioxazin and indaziflam, respectively). No difference in formulation was observed with prodimaine + isoxaben and prodiamine alone.

CONCLUSIONS

Results from these trials indicate that for the five preemergence herbicides evaluated in these experiments, formulation is more important than seeding date with respect to spotted spurge or bittercress control. Some differences in seeding times were observed with bittercress, notably with flumioxazin and indaziflam, but acceptable (>80% control) was achieved with these herbicides. For both bittercress and spurge, there was no difference in formulation for any herbicide that can be applied over-the-top of ornamental plants including dimethenamid-P + pendimethalin, prodiamine + isoxaben, or prodiamine alone. If proper application procedures are followed, growers should achieve similar control of bittercress or spurge with either granular or spray-applied formulations of these herbicides. Seeding date also had little influence on control with these herbicides, so they should continue to perform well in nursery environments if timely applications are made during regular application schedules.

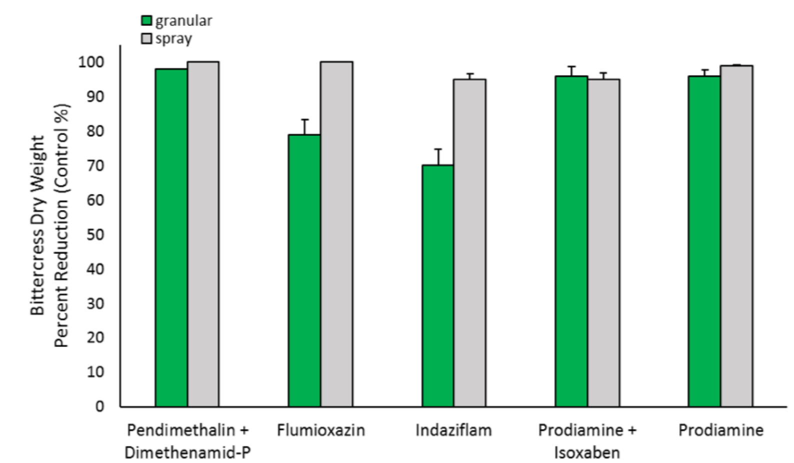

Figure 3. Comparison of five different herbicides by formulation for control of spurge.

Greater spurge and bittercress control was observed with the spray-applied formulations of indaziflam and flumioxazin compared with the granular formulation applied at the same rate. However, neither of these two herbicides can be applied over-the-top of ornamentals due to phytotoxicity concerns. In non-crop areas, growers would likely see better control from a spray-applied formulation compared with a granular formulation applied at a similar rate.

Overall, results suggest that seeding dates ranging from 2 days before application to up to 7 days after application should have little to no influence on control of these herbicides. Growers should expect similar control of bittercress or spurge regardless of formulation for dimethenamid-p + pendimethalin, isoxaben + prodiamine, or prodiamine alone, but greater control would likely be achieved with spray-applied formulations of flumioxazin or indaziflam. As these herbicides could not be applied over-the-top of ornamentals, granular formulations could be used as part of an overall rotation program. Growers could still expect to observe 91 to 79% control of bittercress and spurge with flumioxazin and 83 to 79% control of bittercress and spurge with indaziflam. Results could possibly differ depending upon production practices, seed pressure, weather, and other environmental conditions.