2017 Greenhouse Screening of Potential Herbicides for Wildflower Plantings

Introduction

Successfully establishing and maintaining primarily perennial plant pollinator / wildflower plots is a challenge. The seed mix developed by Roundstone Native Seed for KYTC (Kentucky Transportation Cabinet) is a diverse mixture of plants and it can take 70 to 80 days for most of the seeds to germinate and establish. Good site preparation is important to reduce early competition from annual weeds and one of the management options could be the use of selective pre-and post-emergence herbicides. Annual weedy grasses, such as giant foxtail and yellow foxtail, can become dominant in newly planted pollinator plots. The objective of this study was find potential herbicides that could be used for establishing pollinator/wildflower plantings by screening in the greenhouse. This information would then be used to inform management decisions.

Materials and Methods

These tests were performed in a greenhouse at the University of Kentucky. The pre-emergent herbicide tests used a 1:1 mix of soil:sand in 10 inch square and 2 inch deep flats, with added Osmocote (3 grams per L) for fertility. High levels of clay and organic matter can bind herbicide molecules and reduce the efficacy of the pre-emergence treatment. The post-emergent herbicide tests used a soilless mix, ProMix, in 10 inch square x 9 inch deep fiber pots, with added Osmocote, for better plant growth, as the amount of organic matter was not a concern for these herbicide treatments. The Pollinator/Monarch Seed Mix (Tables 1 and 2) was sown at 20X field seeding rate (1 gram seed mix per flat or fiber pot) on the surface. Giant foxtail (*Setaria faberi*) seed (Azlin Seed Service, Leland, MS) was sown onto the same media as the Pollinator mix pre and post emergence trials but were in 4 inch square x 3.5 inch deep plastic pots. Because this was an initial screen for suitable herbicides, only a single replication of each treatment was done.

The herbicide treatments were applied at 26 gal/a using a spray chamber equipped with a single nozzle. All treatments contained the adjuvant Activator 90 at 0.25% v/v. The flats and pots were watered after the pre-emergence treatments were applied to “activate” the herbicide. The first set of pre-emerge treatments were sown January 6, 2017 with the second set sown April 11, 2017. Data for visual ratings taken 16 days after treatment (DAT) are presented in the tables (Tables 3b and 5b). The first set of post-emerge treatments were planted December 19, 2016 and sprayed January 17, 2017. The second set were planted April 11 and sprayed May 11, 2017. The ratings for taken 11 DAT for the first set and 26 DAT for the second set are presented in the tables (Tables 4b and 6b).

The treatments and rates for the first set of pre-emerge treatments (Table 3a) were selected as ones with potential utility for application at planting or used to control weeds after the pollinator plants were already established. The second set of treatments included different rates of Plateau and Pendulum Aquacap as well as Command and Outlook. All these herbicides have different mechanisms of action (Table 5a).

The treatments and rates for the first set of post-emerge treatments (Table 4a) were selected for their potential utility for selective control of broadleaves or grasses in pollinator plots. The second set of

treatments included more products and mechanisms of action plus a higher rate of Dual and the same rate of Pendulum as in the first set (Table 6a).

Results and Discussion

Pre-emergence herbicides are an important component of weed management. To be effective, they need to be applied at the correct rate on the soil surface and require rainfall or irrigation to be "activated". This is when the herbicides move into the soil layer where the weed seeds are. Most need to be applied before the weed seeds germinate to be effective. In many cases, emerged weeds are not affected by pre-emerge herbicides and will continue to grow. The most pre-emergence herbicides last in the soil for a period of time (soil residual activity) because weed seeds germinate over a period of time.

For the first set of pre-emerge treatments screened in this study(Table 3a), a series of products were included. Dual II Magnum (s-metolachlor) is used pre-emerge for early season control of annual grasses and small seeded broadleaf weeds in many agronomic and horticultural crops. Tenacity (turf label) or Callisto (agronomic label) (mesotrione) is used pre-and post-emerge for control of broadleaf weeds and some grasses in ornamental turfgrasses and in some agronomic crops. Pendulum Aquacap (pendimethalin) is used on established turf and horticultural plantings to prevent germination of many weeds. Plateau (imazapic) has pre-and post- emerge activity on a range of weed species. There are a number of plant species, especially prairie forbs and warm-season grasses, which are tolerant to this herbicide. The Pendulum label lists some wildflower species that are tolerant to an application of Pendulum + Plateau at planting. Esplanade (indaziflam) is used as a pre-emerge herbicide for control of annual grasses and broadleaf weeds in landscapes, horticultural crops and rights of way. Gallery (isoxaben) is also a pre-emerge herbicide used to control certain broadleaf weeds in established turf, ornamentals and non-cropland.

At 16 DAT, the pollinator mix in the Pendulum treatment had the highest emergence (90% emergence) (Table 3b) and a very low emergence of giant foxtail (5% emergence). However, as this was only a single replication, it cannot be tested statistically and many of the species in the mix had not emerged yet in the untreated control. Dual was effective against foxtail (only 2% emergence) but also reduced emergence of much of the pollinator mix. Tenacity was not effective against foxtail (95% emergence) and also reduced the pollinator mix emergence (only 10%). Plateau reduced emergence of both the pollinator mix and foxtail but not to the same extent as Milestone. Esplanade and Gallery had no or very little emergence of either the pollinator mix or foxtail.

For the first set of post-emergence treatments (Table 4a), the same products as the pre-emergence treatments were included plus Proclipse and a number of selective grass herbicides. Proclipse (prodiamine) has no post-emergence activity and is used on established turf and horticultural crops as well as rights of way to control annual grass and broadleaf weeds. Fusilade II (fluazifop), Select Max (clethodim), Poast Plus (sethoxydim) and Acclaim Extra (fenoxaprop) have good safety on broadleaf plants and are effective at selectively controlling grasses.

The grass herbicides had 70-85% damage on foxtail 11 DAT (Table 4b) with almost no damage to the pollinator mix broadleaf plants. Plateau damaged both the pollinator mix and foxtail. While Dual

controlled foxtail pre-emergence, it did not damage emerged foxtail. Milestone damaged the pollinator mix broadleaves (80%) far more than foxtail (10%). Pendulum, Gallery, and Proclipse showed little or no damage to either emerged pollinator or foxtail plants.

For the second set of pre-emergence treatments (Table 5a), different rates of Plateau and Pendulum were tested along with Command and Outlook. Command (clomazone) is a pre-emergence herbicide which taken up by roots that is used on tobacco and horticultural crops (soybeans, cotton too?). Outlook (dimethenamid) is a selective residual herbicide used to control annual grass and broadleaf weeds along with sedges. It is used on field and row crops, like corn and soybeans.

Plateau and Pendulum treatments reduced emergence of both the pollinator mix and foxtail plants. The reduction was greater with Plateau (Table 5b). There was little to no emergence of the pollinator mix or foxtail in the Command or Outlook treated flats.

For the second set of post-emergence treatments (Table 6a), the same rate of Pendulum and a higher rate of Dual than in the first set were used. Additions to the screen included Aim, Permit, Cadet and Clearcast. Aim (carfentrazone) is a contact herbicide used on a wide range of agronomic and horticultural crops. Permit (halosulfuron-methyl) is used to control broadleaf weeds and nutsedge in certain crops. Cadet (fluthiacet-methyl) is used as a burndown and post emerge control of broadleaf weeds in field crops. Clearcast (imazamox) can be used in and around aquatic areas and on non-cropland sites.

Clearcast was the only herbicide to injure foxtail (95%) 26 DAT but also injured (80%) the pollinator mix plants (Table 6b). Permit also injured (70%) the pollinator mix considerably. The other herbicides had less injury (5-10%).

We were unable to identify any ideal herbicide options for application at the time of seeding for the pollinator mix in this study. There are Plateau Safe seed mixes that are compatible with Plateau use that one may want to consider. There are a number of options for pre-emergence control of weeds after all the pollinator/wildflower species have emerged and established. These include Pendulum Aquacap, Proclipse, Esplanade, Gallery and, possibly, Dual II Magnum. For selective control of grasses in plots with established pollinator plants, which are predominantly broadleaves, one can use Fusilade II, Select Max, Poast Plus or Acclaim Extra.

Table 1. Pollinator/Monarch Seed Mix from Roundstone Seed for KYTC

Kind	Botanical Name	[1] PLS oz/ac	PLS lbs/ac	PLS lbs
Butterfly Milkweed	*Asclepias tuberosa*	18.91	1.182	1.182
Common Milkweed	*Asclepias syriaca*	17.92	1.12	1.12
Swamp Milkweed	*Asclepias incarnata*	10.00	0.625	0.625
Whorled Milkweed	*Asclepias verticillata*	1.15	0.072	0.072
Smooth Beardtongue	*Penstemon digitalis*	1.95	0.122	0.122
Lance Leaved Coreopsis	*Coreopsis lanceolata*	4.05	0.253	0.253
Blackeyed Susan	*Rudbeckia hirta*	3.35	0.209	0.209
Hoary Mountain Mint	*Pycnanthemum incanum*	1.25	0.078	0.078
Slender Mountain Mint	*Pycnanthemum tenuifolium*	1.25	0.078	0.078
Early Goldenrod	*Solidago juncea*	2.65	0.166	0.166
Bergamot	*Monarda fistulosa*	2.65	0.166	0.166
Spiked Blazing Star	*Liatris spicata*	3.35	0.209	0.209
Greyheaded Coneflower	*Ratibida pinnata*	3.00	0.188	0.188
Purple Coneflower	*Echinacea purpurea*	4.05	0.253	0.253
False Sunflower	*Heliopsis helianthoides*	3.00	0.188	0.188
Browneyed Susan	*Rudbeckia triloba*	3.00	0.188	0.188
Joe-Pye Weed	*Eupatorium fistulosum*	1.60	0.10	0.10
Iron Weed	*Vernonia altissima*	1.95	0.122	0.122
Sneezeweed	*Helenium autumnale*	1.95	0.122	0.122
Narrow-Leaved Sunflower	*Helianthus angustifolius*	1.95	0.122	0.122
New England Aster	*Aster novae-angliae*	2.30	0.144	0.144
White Wingstem	*Verbesina virginica*	2.65	0.166	0.166
Indian grass	*Sorghastrum nutans*	3.35	0.209	0.209
Little bluestem	*Schizachyrium scoparium*	6.85	0.428	0.428
Partridge Pea	*Cassia fasciculata*	1.25	0.078	0.078
Compass Plant	*Silphium laciniatum*	3.00	0.188	0.188
Cardinal Flower	*Lobelia cardinalis*	0.90	0.056	0.056
Lance-Leaved Goldenrod	*Euthamia graminifolia*	1.35	0.084	0.084
Boneset	*Eupatorium perfoliatum*	1.35	0.084	0.084
[2] Spring Oats	*Avena sativa*			20.0
Lbs/acre of Forbs				7.0
Total Lbs/ac.				27.0

[1] Pure Live Seed (PLS)
[2] Spring oats are for an early nurse crop

Table 2: Characteristics of seed mix

Species list for Pollinator / Monarch Seed Mix

Common Name	Species	Life Cycle	Flower Color
Swamp Milkweed	*Asclepias incarnata*	Perennial	Pink
Common Milkweed	*Asclepias syriaca*	Perennial	Pink
Butterfly Milkweed	*Asclepias tuberosa*	Perennial	Orange
Whorled Milkweed	*Asclepias verticillata*	Perennial	White
New England Aster	*Aster novae-angliae*	Perennial	Purple
Partridge Pea	*Cassia fasciculata*	Annual	Yellow
Lance Leaved Coreopsis	*Coreopsis lanceolata*	Perennial	Yellow
Purple Coneflower	*Echinacea purpurea*	Perennial	Lavender
Joe-Pye Weed	*Eupatorium fistulosum*	Perennial	Pink
Boneset	*Eupatorium perfoliatum*	Perennial	White
Lance-Leaved Goldenrod	*Euthamia graminifolia*	Perennial	Yellow
Sneezeweed	*Helenium autumnale*	Perennial	Yellow
Narrow-Leaved Sunflower	*Helianthus angustifolius*	Perennial	Yellow
False Sunflower	*Heliopsis helianthoides*	Perennial	Yellow
Spiked Blazing Star	*Liatris spicata*	Perennial	Pink
Cardinal Flower	*Lobelia cardinalis*	Perennial	Red
Bergamot	*Monarda fistulosa*	Perennial	Lavender
Smooth Beardtongue	*Penstemon digitalis*	Perennial	White
Hoary Mountain Mint	*Pycnanthemum incanum*	Perennial	White
Slender Mountain Mint	*Pycnanthemum tenuifolium*	Perennial	White
Greyheaded Coneflower	*Ratibida pinnata*	Perennial	Yellow
Blackeyed Susan	*Rudbeckia hirta*	Biennial	Yellow
Browneyed Susan	*Rudbeckia triloba*	Biennial	Yellow
Little bluestem	*Schizachyrium scoparium*	Perennial	Green
Compass Plant	*Silphium laciniatum*	Perennial	Yellow
Early Goldenrod	*Solidago juncea*	Perennial	Yellow
Indian grass	*Sorghastrum nutans*	Perennial	Green
White Windstem	*Verbesina virginica*	Perennial	White
Iron Weed	*Vernonia altissima*	Perennial	Purple

Table 3a: First Set of Pre-Emerge Treatments with Rates, Active Ingredients and Mechanisms of Action

Product (s)	Rate (per Acre)	Active Ingredient(s)	Mechanism of Action
Dual II Magnum	1.33 pt	metolachlor	Inhibitor of growth & division (Group 15)
Tenacity	5 fl oz	mesotrione	Inhibitor of pigment biosynthesis (Group 27)
Pendulum Aquacap	4 pt	pendimethalin	Inhibitor of microtubule assembly (Group 3)
Plateau	4 fl oz	imazapic	ALS Inhibitor (Group 2)
Milestone	5 fl oz	aminopyralid	Synthetic Auxin (Group 4)
Esplanade	3.5 fl oz	indaziflam	Cellulose Synthesis Inhibitor (Group 29)
Gallery	0.66 lb	isoxaben	Cell Wall Synthesis Inhibitor (Group 21)

Table 3b: First Set of Pre-Emerge Treatments with Rates, Active Ingredients and % Emergence of Pollinator Mix and Giant Foxtail 16 Days After Treatment (DAT)

Product (s)	Rate (per Acre)	Active Ingredient(s)	% Emergence (16 DAT)	% Emergence & Growth on Giant Foxtail (16 DAT)
Control			100	100
Dual II Magnum	1.33 pt	metolachlor	30	2
Tenacity	5 fl oz	mesotrione	10	95
Pendulum Aquacap	4 pt	pendimethalin	90	5
Plateau	4 fl oz	imazapic	40	50
Milestone	5 fl oz	aminopyralid	15	10
Esplanade	3.5 fl oz	indaziflam	0	0
Gallery	0.66 lb	isoxaben	0	2

Table 4a: First Set of Post-Emerge Treatments with Rates, Active Ingredients and Mechanisms of Action

Product (s)	Rate (per Acre)	Active Ingredient(s)	Mode of Action
Dual II Magnum	1.33 pt	metolachlor	Inhibit growth & division (Group 15)
Fusilade II	16 fl oz	fluazifop	ACC Inhibitor (Group 1)
Pendulum Aquacap	4 pt	pendimethalin	Inhibitor of microtubule assembly (Group 3)
Plateau	4 fl oz	imazapic	ALS Inhibitor (Group 2)
Milestone	5 fl oz	aminopyralid	Synthetic Auxin (Group 4)
Esplanade	3.5 fl oz	indaziflam	Cellulose Synthesis Inhibitor (Group 29)
Gallery*	0.66 lb	isoxaben	Cell Wall Synthesis Inhibitor (Group 21)
Select Max	12 fl oz	clethodim	ACC Inhibitor (Group 1)
Poast Plus	1.5 pt	sethoxydim	ACC Inhibitor (Group 1)
Acclaim Extra	20 fl oz	fenoxaprop	ACC Inhibitor (Group 1)
Proclipse	2 lb	prodiamine	Inhibitor of microtubule assembly (Group 3)

Note: Mistake with the sprayer resulted in 2X application for Gallery (1.32 lb/ac)

Table 4b: First Set of Post-Emerge Treatments with Rates, Active Ingredients and % Damage of Pollinator Mix and Giant Foxtail 11 Days After Treatment (DAT)

Product (s)	Rate (per Acre)	Active Ingredient(s)	Damage (%) 11 DAT	Injury Rating (%) on Giant Foxtail (11 DAT)
Control			0	0
Dual II Magnum	1.33 pt	metolachlor	5	0
Fusilade II	16 fl oz	fluazifop	1	70
Pendulum Aquacap	4 pt	pendimethalin	2	0
Plateau	4 fl oz	imazapic	40	50
Milestone	5 fl oz	aminopyralid	80	10
Esplanade	3.5 fl oz	indaziflam	20	10
Gallery*	0.66 lb	isoxaben	1	20
Select Max	12 fl oz	clethodim	0	80
Poast Plus	1.5 pt	sethoxydim	1	85
Acclaim Extra	20 fl oz	fenoxaprop	2	80
Proclipse	2 lb	prodiamine	5	0

Note: Mistake with the sprayer resulted in 2X application for Gallery (1.32 lb/ac)

Table 5a: Second Set of Pre-Emerge Treatments with Rates, Active Ingredients and Mechanisms of Action

Product (s)	Rate (per Acre)	Active Ingredient(s)	Mechanism of Action
Plateau	2 fl oz	imazapic	ALS Inhibitor (Group 2)
Plateau	4 fl oz		
Pendulum Aquacap	2 pt	pendimethalin	Inhibitor of microtubule assembly (Group 3)
Pendulum Aquacap	3 pt		
Pendulum Aquacap	4 pt		
Command	2 pt	clomazone	Inhibitor of DOXP synthase (Group 13)
Outlook	12 fl oz	dimethenamid	Inhibitor of VLCFA synthesis (Group 15)

Table 5b: Second Set of Pre-Emerge Treatments with Rates, Active Ingredients and % Emergence of Pollinator Mix and Giant Foxtail 16 Days After Treatment (DAT)

Product (s)	Rate (per Acre)	Active Ingredient(s)	% Emergence (16 DAT)	% Emergence & Growth on Giant Foxtail (16 DAT)
Control			100	100
Plateau	2 fl oz	imazapic	20	25
Plateau	4 fl oz		10	25
Pendulum Aquacap	2 pt	pendimethalin	40	50
Pendulum Aquacap	3 pt		50	50
Pendulum Aquacap	4 pt		40	50
Command	2 pt	clomazone	2	10
Outlook	12 fl oz	dimethenamid	5	0

Table 6a: Second Set of Post-Emerge Treatments with Rates, Active Ingredients and Mechanisms of Action

Product (s)	Rate (per Acre)	Active Ingredient(s)	Mode of Action
Aim	1 fl oz	carfentrazone	PPO Inhibitor (Group 14)
Permit	1 oz	halosulfuron-methyl	ALS Inhibitor (Group 2)
Cadet	0.6 fl oz	fluthiacet-methyl	PPO Inhibitor (Group 14)
Clearcast	32 fl oz	imazamox	ALS Inhibitor (Group 2)
Pendulum Aquacap	4 pt	pendimethalin	Inhibitor of microtubule assembly (Group 3)
Dual II Magnum	1.67 pt	metolachlor	Inhibit growth & division (Group 15)

Table 6b: Second Set of Post-Emerge Treatments with Rates, Active Ingredients and % Damage of Pollinator Mix and Giant Foxtail 26 Days After Treatment (DAT)

Product (s)	Rate (per Acre)	Active Ingredient(s)	Injury Rating (%) 26 DAT	Injury Rating (%) on Giant Foxtail
Control			0	0
Aim	1 fl oz	carfentrazone	10	0
Permit	1 oz	halosulfuron-methyl	70	0
Cadet	0.6 fl oz	fluthiacet-methyl	5	0
Clearcast	32 fl oz	imazamox	80	95
Pendulum Aquacap	4 pt	pendimethalin	20	0
Dual II Magnum	1.67 pt	metolachlor	10	0