

Palmer Amaranth from the North Carolina Coastal Plain: More Cause for Concern with the Herbicide Toolbox?

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Introduction

Palmer amaranth (*Amaranthus palmeri* S. Wats.) is one of the most problematic weeds in the United States. It is a highly competitive weed with immense fecundity and has the ability to replenish the soil-seed bank in one generation (Ward et al. 2013). Palmer amaranth is an obligate cross-pollinator, possesses a high amount of genetic variation and its pollen has been shown to move significant distances. Along with immense herbicide selection pressure, these characteristics have led to Palmer amaranth populations resistant to several mechanisms of action (MOA) with some populations expressing multiple resistance (Ward et al. 2013). In North Carolina (NC), resistance to acetolactate synthase (ALS) and 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase inhibitors is widespread and suspicion of resistance to protoporphyrinogen oxidase (PPO) inhibitors within Palmer amaranth exists (Poirier et al. 2014). Palmer amaranth populations from NC were previously screened for resistance with various MOA, but the collections were completed in 2010 (Poirier et al. 2014). With its rapid growth rates, genetic variability, significant pollen dispersal, and immense fecundity, herbicide resistance in Palmer amaranth from NC may have increased since the previous screening.

Objective

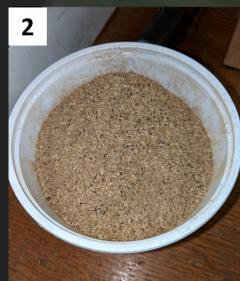
Determine the presence and distribution of Palmer amaranth populations from the NC Coastal Plain expressing possible resistance to multiple herbicide MOA.

Materials and Methods

- Palmer amaranth populations (110 total) were collected in 55-gallon bags from various agronomic fields, including cotton (12), peanut (27), soybean (50), and sweet potato (21), primarily in the NC Coastal Plain during the fall of 2016 (Photo 1).
- Female plants (10 – 15) were sampled from a random 10 x 10 m area within a field.
- Inflorescences were dried, threshed, cleaned, and cold stored at NC State University Method Road Greenhouse Complex (Photos 2 – 4).
- Seeds were then sown into 28 x 54 cm cellular trays containing potting soil mix and watered daily.
- Plants were thinned to one plant cell⁻¹, with 10 cells equaling one replication (Photo 5).
- The experiment was conducted in a randomized completed block design with five replications.
- When plants reached the 2- to 4-leaf stage (Photo 6), herbicides (Table 1) were applied with a CO₂-pressurized backpack sprayer (8002EVS nozzle) calibrated to deliver 187 L ha⁻¹ at 207 kPa.
- Herbicides were applied in separate experiments and repeated in time.
- Survivors were counted and visually rated 21 days after treatment.

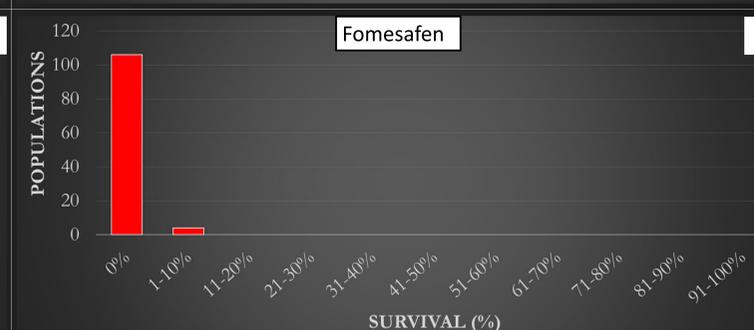
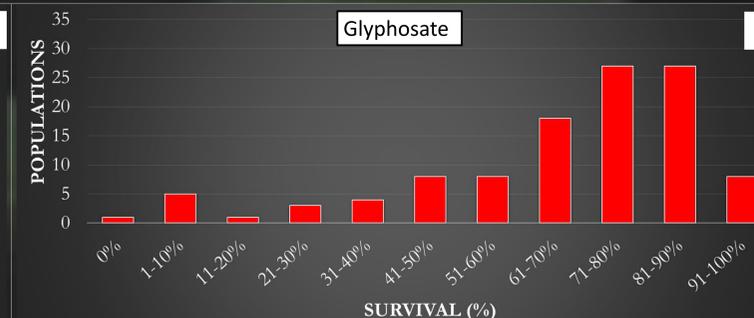
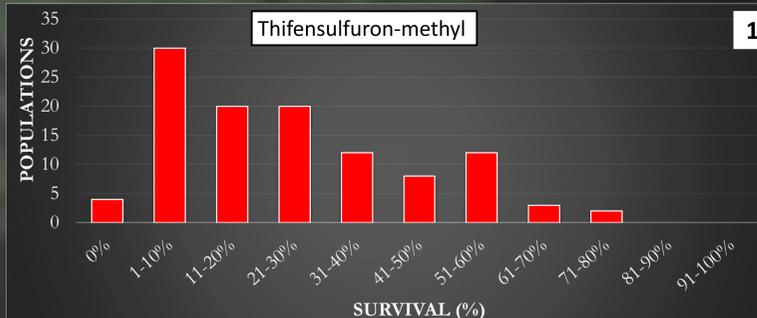
Table 1. Herbicides and rates tested.

MOA (Group)	Active ingredient	Product	Rate (g ai/ae ha ⁻¹)	Additives
ALS (2)	Thifensulfuron-methyl	Harmony 50 SG	17.5	0.25% NIS + UAN (32%) 4.7 L ha ⁻¹
EPSPS (9)	Glyphosate	Roundup PowerMax II	840	-----
GS (10)	Glufosinate	Liberty 280 SL	451	-----
HPPD (27)	Mesotrione	Callisto	105	1% COC + 2.5% UAN (32%)
PPO (14)	Fomesafen	Reflex	280	0.25% NIS



Photos 1-6 – Palmer amaranth plants were collected from the field (1) and dried in the greenhouse. Seeds were threshed (2) and sent through a cleaner (3) to remove the chaff (4). Seeds were then planted and thinned (5) and sprayed when reaching the 2- to 4-leaf stage (6).

Results and Discussion



Figures 1-5 – Survival frequencies for the 110 Palmer amaranth populations collected from the NC Coastal Plain following application of thifensulfuron-methyl (1; 17.5 g ai ha⁻¹), glyphosate (2; 840 g ae ha⁻¹), mesotrione (3; 105 g ai ha⁻¹), and fomesafen (4; 280 g ai ha⁻¹) when plants reached the 2- to 4-leaf stage. Figure 5 illustrates the number of total MOAs the populations survived.

- All populations were completely controlled following glufosinate application (Data not shown).
- Four populations were completely controlled with thifensulfuron-methyl (Figure 1). Eighty-nine populations had survival frequencies ≤ 50% with 17 being > 50%.
- Following glyphosate application, one population was completely controlled while 21 populations had survival frequencies ≤ 50% with 88 being > 50% (Figure 2).
- The above responses following glufosinate, glyphosate, and thifensulfuron-methyl is in agreement with Poirier et al. (2014). The authors reported that 98% and 97% of the 134 tested Palmer amaranth populations from NC were resistant to glyphosate and thifensulfuron-methyl, respectively, with 95% possessing resistance to both herbicides. In the current study, 99% and 96% of tested population had survivors following glyphosate and thifensulfuron-methyl treatment with 95% having survivors to both (Figures 1 and 2).
- With respect to mesotrione, 67 populations were completely controlled following application (Figure 3). Forty-two populations had survival ranging from 1 – 10%; however, 37 of these populations survival frequencies were ≤ 5%. One population had a 17% survival frequency. This is the first reported population of Palmer amaranth survivors following an application of a 4-hydroxyphenylpyruvate dioxxygenase (HPPD) inhibitor in NC.
- Fomesafen completely controlled 106 populations with four having survivors in the 1 – 10% range. In the screening of 134 populations from NC collected in 2010, no populations had survivors following fomesafen application at a similar rate used in the current study (Poirier et al. 2014). Resistance to protoporphyrinogen oxidase (PPO) inhibitors has previously been reported in Arkansas, Illinois, and Tennessee and is conferred by genetic mutations within the PPX2 gene and metabolic mechanisms by P-450s and glutathione S-transferase. (Giacomini et al. 2017; Salas et al. 2016).
- In total, none of the tested populations were completely controlled by all herbicides and only three survived a single MOA. Within the other 107 populations, 65, 40, and 2 populations had survivors to 2, 3, and 4 MOA, respectively. Both populations with survivors to 4 MOA are from Edgecombe county.

Implications for North Carolina and Future Research

- These data suggest that Palmer amaranth resistant to EPSP synthase and ALS inhibitors remains commonplace throughout the NC Coastal Plain.
- Populations which have individuals surviving PPO- and HPPD-inhibitors is cause for concern, particularly when considering future use of HPPD-tolerant crops.
- Technology stewardship should be implemented prior to the release of HPPD-tolerant cotton and soybean to extend the longevity of this technology.
- Populations surviving three or four MOA illustrate the need for mixing herbicide MOAs and utilizing other management techniques in addition to herbicides.
- While glufosinate currently remains active on these populations, extra caution should be taken to ensure proper application timing as decreased efficacy of this herbicide would be detrimental for many row crop systems in NC.
- Future work will include full dose response assays with fomesafen and mesotrione on those populations with survivors. Additionally, KASP assays will be completed to determine if the known genetic mutations are conferring resistance to ALS- and PPO-inhibiting herbicides.

Literature Cited

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