

**Biology and control of *Amaranthus palmeri*  
in *Glycine max***

by

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**TABLE OF CONTENTS**

	Page
Introduction.....	3
Topic Selection .....	4
Why A Learning Module? .....	5
About the Learning Module.....	5
Value of the Module .....	10
Summary.....	11
References.....	12

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## INTRODUCTION

Challenges with weed management in soybean [*Glycine max* (L.) Merr.] fields have gone hand in hand since the introduction of the glyphosate system was made available to growers in 1996. Since that time, the American farmers have become accustomed to reduced rates having the same effectiveness as full rates and ignoring the biology of the weed species they were trying to control. This learning module is to help understand the biology of one weed species, *Amaranthus palmeri* S. Watson, also known as Palmer amaranth, and its effect on our soybean management systems across the United States. Another name for this species is carelessweed.

This particular weed species has also plagued many other crops including maize (*Zea mays* L.), cotton (*Gossypium herbaceum* L.), and peanut (*Arachis hypogaea* L.), however, this module will focus on the weed species role in soybean production, particularly in the Northern Plains growing region (Legleiter and Johnson, 2013).

This species makes life challenging in commercial crops, particularly in the state of Nebraska, due to its ability to overcome numerous challenges within the landscape such as elevation, aridity, humidity, and changes in soil texture. Palmer amaranth is very adaptable and thus makes the task of controlling it with herbicides a nightmare for the Northern Plains farmer. Palmer amaranth can emerge as early as March and as late as October and still produce an adequate supply of viable seed to fill the seed bank in that field for the next growing season. With its physiological adaptability, it is almost impossible to spray Palmer amaranth plants at the correct time for an herbicide application. Under correct nutritional and water conditions, Palmer amaranth plants can add two to six inches of new growth in a single day and can be on and off herbicide label specifications within hours (Sprague, 2014). With so many plants being at different heights and stages of growth, they will also require different quantities of herbicide chemistry to deliver a lethal dose of herbicide. Bigger plants can tolerate more active ingredient, and thus require a large dose to kill the weed.

Weed resistance increased when agriculturalists started using off-labeled rates to control weed populations because it was less expensive and was still very effective,

at the time. Now, especially in Palmer amaranth populations, growers understand that reducing herbicide rates were allowing the species to tolerate more and more active ingredient. We now find ourselves in the predicament of not having enough chemistry options to control Palmer amaranth effectively in soybean.

### **TOPIC SELECTION**

I selected this topic because I am passionate about helping growers control weed species in their crops. While growing up in southeastern South Dakota, I never had a chance to interact with Palmer amaranth before moving to Nebraska. By being in the retail ag sale sector, I understand the impressive threat this particular weed species brings to multiple crops across the Northern Plains and the economic impact it can have on growers' bottom lines.

Another reason for selecting this topic is that when a person is trying to control a new weed, I believe it is important to study what they are trying to control and see if the biology of that species can be used against itself. That could be earlier emergence of the weed in the spring or that it is easier to control Palmer at a specific growth stage. This weed is well known across the state but is new since it arrived from the southern region of the United States.

As mentioned earlier, one of many challenges with this species is the adaptability it exhibits to topography, soil type, and moisture level. This weed species needs to be monitored as to what counties have the highest population densities due to its ability to hybridize with other Amaranthaceae family members. Research has shown that Palmer amaranth populations were detrimental in the southern region of the United States on cotton and peanut acres, with losses of up to \$85/acre (Legleiter and Johnson, 2013). Another point is that if herbicide chemistry plans fail, many times roguing crews are required to hand weed the remaining plants, which can add more unneeded expense to the grower.

## WHY A LEARNING MODULE?

The idea behind this creative component is to help those who want to understand not only how to control *Amaranthus palmeri* in soybean, but also want to understand the biology of the plant itself. By approaching a weed species that needs to be controlled in a certain crop, the best way is to understand its biology.

Understanding the Palmer amaranth lifecycle in turn will help us understand what weaknesses it has and how to use those weaknesses to ensure maximum effectiveness of our control efforts. Being able to identify especially this plant species early, gives us a better chance of controlling it with a chemical application and reducing the production of viable seed for the soil seed bank. A mature Palmer amaranth plant can produce on average around 600,000 seeds (Sprague, 2014), so it is important to understand that every plant that we have the ability to control could pay big dividends in weed control in future years.

## ABOUT THE MODULE

This module will outline how Palmer amaranth traveled to Nebraska, the anatomy and biology of the weed species, the environment it thrives in, the relationship between the weed species and *Glycine max*, and the best control methods in soybeans that we have available today. The presentation will help the reader identify between different species, understand weed seed travel carriers, biology of Palmer amaranth, and why soybean makes such a great host for this weed species. It will also include herbicide management plans that have proven effective in the state of Nebraska.

### *History*

*Amaranthus palmeri* or Palmer amaranth is an aggressive, invasive species that originated in the desert regions of the southwestern United States. It has rapidly become one of the largest weed threats to soybean and cotton producers around the United States (Sprague, 2017).

Palmer amaranth owes its name to *Amaranthus* which is Greek for unfading, in this case evergreen. *Palmeri*, was named back in 1877 after the plant explorer Edward

Palmer. Edward Palmer collected some 100,000-plant specimens and discovered 1,000 new plant species after landing in the new world (Bradke, 2017).

Palmer amaranth was originally used as a food source by the Yuma, Navajo, Mohave, and Pima tribes who would cook the leaves and grind the seeds into a meal for cooking and baking. In contrast with other grains, Palmer amaranth has a much higher content of calcium, magnesium, iron, and the amino acid lysine. Many health food stores have begun carrying the flour and cereal made from the seeds of Palmer amaranth (Deane, 2018).

#### *Anatomy*

There are many pigweed species having different physiological characteristics and management control tactics. These include redroot pigweed (*Amaranthus retroflexus* L.), prostrate pigweed (*Amaranthus blitoides* S. Watson), tumble pigweed (*Amaranthus albus* L.), Palmer amaranth (*Amaranthus palmeri* S. Watson), and common waterhemp (*Amaranthus tuberculatus* (Moq.) Sauer).

One of the many challenging aspects of Palmer amaranth is that its appearance is similar to that of other members of the Amaranthaceae family. This causes many challenges for growers and agronomists who try to identify the weed species they hope to control with their herbicide programs.

#### *Biology*

A plant out of place, also known as a weed, always has negative implications on an actively growing crop.

Since first being discovered in cotton in the southern United States, the spread of Palmer amaranth has occurred at an alarming rate. The ability of this weed to adapt to new climates and environments has multiple herbicide companies scrambling to come up with new options for growers to control Palmer amaranth. Palmer amaranth has an enormous taproot that is proficient of robbing soil solutions of plant available water and in some cases draining it out of the zone of interception for plant roots. According to a study done in southern Georgia, a single Palmer amaranth plant can induce soil water deficits to surrounding cotton plants as far as 4 meters away (Berger,

2015). This causes detrimental effects on agronomic plant's ability to photosynthesize and in turn inhibits yield potential.

Palmer amaranth is no different from any other plant species, as it always prefers a fertile environment. Since it began, moving north from its origin in the desert southwest, Palmer amaranth has become a master at utilizing the many or few fertility resources from its environment.

For example, one study has shown that in a low fertility environment most of the population of Palmer plants were taller but lacked other characteristics such as branching and leaf area index (LAI) that high fertility plants express (Bravo et. al., 2018).

A single, mature adult female Palmer amaranth plant can produce over 600,000 seeds (Legleiter and Johnson, 2013). These seeds can remain viable in the soil solution for up to 5 years in the top one inch of soil. At a depth below the top inch of soil, seed viability drops drastically. Seeds are typically dark black and shiny in appearance and can vary in size.

#### *Physiology and Development*

When comparing Palmer amaranth to other pigweed species, it is important to note that Palmer has longer petioles than other pigweed species, such as redroot pigweed. The Palmer leaf petiole will fold past the top of the leaf blade. While there are some acute differences in leaf shape and size to differentiate species for an herbicide recommendation, it is the length of the leaf petiole to tell the difference between these species.

Palmer amaranth must be present in the top inch of the soil solution and be under the correct moisture conditions in order to germinate. The challenge with pigweed species, especially at early vegetative or cotyledonary growth stages, is that they are almost identical in appearance, leaf shape, and color.

At this early stage of plant growth, most pigweed species are controlled through many of the same herbicide programs being utilized by growers. The plants are small

enough to still be controlled by herbicides because of their limited ability to metabolize herbicides and limited number of growing points.

Under optimal growing conditions, seedlings can grow anywhere from 2 to 4 inches per day (5-10 cm), and can grow up to 6 feet (1.83 m) tall in two months (Legleiter and Johnson, 2015). The other challenge with this weed species is that they will emerge in Nebraska from mid-May until September, giving them multiple opportunities to reproduce and replenish the seed bank in different fields.

Palmer amaranth plants are dioecious and have male and female inflorescences on different plants. The female plant inflorescence has prickly bracts in which offers protection of the seed head from predators. The male flower inflorescence is softer, and has the function of producing anthers and pollen and thus does not need a protective cover.

### *Management*

One of the challenges with the recent rise in Palmer amaranth populations has been the popularity of strip tillage and no-tillage management systems. While these systems do a great job in reducing soil erosion, they do make it difficult for managing weed populations.

Palmer amaranth has to be present in the top inch (2.54 cm) of soil solution in order to germinate, which make tillage operations helpful in controlling the early stages of this weed's life cycle. Operations like plowing, disking, and row cultivation help immensely in reducing their weed populations in a field.

Growers understand that Palmer amaranth is a problem, and that if not managed, it can become a large economic challenge to their operation. If allowed to compete throughout the growing season as few as 2.5 Palmer plants per foot (30.5 cm) of row can rob up to 79% of soybean yield by the end of the growing season (Legleiter and Johnson, 2015).

Herbicide resistance can occur when herbicide rates lower than the product's labeled rate are sprayed on the weed species. Farmers began using herbicides at rates below the labelled rates and had success in controlling weed populations. When a

lower than lethal rate was applied, Palmer amaranth was able to metabolize the active ingredient and still perform its normal growth and development (Sprague, 2014).

Many growers and agronomists have had to drastically adjust their chemical programs from what was used to effectively control Palmer amaranth on their acres. This was due to the lack of effectiveness of some of the chemistries that had once had good control of the weed species. Some common chemical trade names used for Palmer control in soybean were glyphosate (Roundup PowerMax<sup>®</sup>), imazethapyr (Pursuit<sup>®</sup>), and trifluralin (Treflan<sup>®</sup>). Challenges with resistance have prevented these chemistries from being as effective as they once were for controlling Palmer amaranth.

Some key management factors must change to be able to control this weed species in the future. Starting with no or minimal weed pressure is the first step to solve many of the issues with a weed species, especially Palmer amaranth, in a field. A tillage pass or a chemical burndown can accomplish this prior to planting. Burndowns of glyphosate and 2,4-D can be effective on smaller plants but lose efficacy once the plants become four inches and taller in height.

By planting Liberty Link<sup>®</sup> soybeans, the grower has the option to spray post-emergence with Liberty<sup>®</sup> (glufosinate) herbicide. Liberty has shown good control of small Palmer amaranth plants and adds an additional possibility for control in your post-emergence spray tank. This will reduce the pressure on PPO (protoporphyrinogen oxidase inhibiting) herbicide chemistries to control Palmer populations. Liberty also offers flexible rates and an increased number of applications for post-emergence application over a crop.

Utilizing an effective soil applied chemical is crucial in obtaining good control of Palmer amaranth in soybeans. As stated earlier, Palmer amaranth seeds thrive in the top inch of soil, which is why it is important to have herbicide activity in that top inch of soil. Some proven preemergence herbicide chemistries are sulfentrazone (Authority First<sup>®</sup> and Sonic<sup>®</sup>), flumioxazin (Valor<sup>®</sup>), saflufenacil (Sharpen<sup>®</sup>).

The easiest time to control a weed species is before emergence, as stated earlier in the importance of soil-applied chemistries before the crop is above ground. Another

important factor is to be timely in the postemergence application, and to be sure to control the weed species when they are small. Smaller weeds mean that they are easier to control since they have thinner cuticle, healthy metabolism to translocate active ingredients to their sites of action, and fewer growing points to be controlled than plants that are four inches or taller.

Since Palmer amaranth can emerge later in the growing season, adding a residual herbicide product, such as a Group 15 herbicide (long chain fatty acid inhibitor) can greatly increase the success of a postemergence herbicide weed control program. Some common Group 15 trade names are Dual<sup>®</sup>, Warrant<sup>®</sup>, Outlook<sup>®</sup>, and Zidua<sup>®</sup>. These herbicides initially provide an herbicide barrier in the soil solution for weed seeds that germinate after the postemergence application has occurred.

If late-season moisture helps a new flush of Palmer amaranth to germinate, fomesafen (Flexstar<sup>®</sup>) may be required to control late germinating Palmer. It is important to note that if fomesafen (Flexstar<sup>®</sup>) was applied in the first application; either lactofen (Cobra<sup>®</sup>) or aciflorofen (Avalanche Ultra<sup>®</sup>) can be used in a second application due to rotational restrictions with corn.

### **VALUE OF THE MODULE**

The value of this module is to help growers, new salespeople, and agronomic consultants to understand the importance of weed biology in an effort to control this species in their own actively growing crop. It helps the reader to understand correct management techniques in how to control the weed species in their own production and prevent the spread of Palmer amaranth to other fields. This module can help many people in the agriculture world to understand how much Palmer amaranth costs growers in terms of water, nutrition, and ultimately yield. The module describes where the species originated, the environments it can adapt to and thrive in. and ultimately how-to best control Palmer amaranth in a soybean field. These types of modules would be great to develop for every weed species so that not only could one understand how to control the weed, one could better understand why you control at the specific time to prevent more seed from being produced for the future growing seasons.

## **SUMMARY**

Weed management systems have become a wonderful tool for producers to use in their management techniques to control certain species. By understanding the biology of the weed species, farmers and agronomists can determine what application timing needs to occur to have the most significant control of the weed population. The tactic used to control weeds, and Palmer amaranth, needs to be comprised of labeled rates of the herbicide chemistry and have overlapping residual control to ensure that one does not have any breaks in coverage of the field. In addition, using herbicide chemistries with multiple sites of action is critical to avoid any potential challenges to herbicide resistance. This will be the best way to have good control of Palmer amaranth and to ensure the yield potential of the commercial crop.

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