Relevancy Statement.

Title: Integrated methods for sustainable control of glyphosate-resistant horseweed (*Conyza canadensis*) and other problematic winter weeds.

Key Personnel-

a. Roles and responsibilities for PDs and collaborators:

Rob Richardson, PD. Coordinate study activities and management; fulfill requirements of all objectives; coordinate associated outreach and extension activities; advise graduate student.

John Wilcut, co-PD. Coordinate study activities and management; fulfill requirements of objectives 1 and 2; co-advise graduate student if necessary. Provide weed science research expertise for corn, cotton, soybeans, and peanut.

Alan York, co-PD. Provide weed science extension expertise for corn, cotton, and soybeans. Fulfill requirements for objective 3 as related to corn, cotton, and soybean production.

David Jordan, co-PD. Provide agronomic expertise and weed science extension expertise in peanut production. Fulfill requirements for objective 3 as related to peanut production.

Cooperation and Institutional Units Involved

North Carolina State University has all necessary resources to complete this project as described.

B. Project Description

Horseweed (*Conyza canadensis*) is a common biennial, summer annual, or winter annual found throughout North America (USDA, NRCS 2005). Germination periods during August through November and during March through May (Hayes et al. 2005; A. C. York, personal communication) coincide with vulnerable times in many cropping systems. Horseweed has high seedling vigor (USDA, NRCS 2005). Summer annual crops like corn, cotton, peanut, and soybean are especially sensitive to early season weed interference (Zimdahl 2004) as would be the case with established horseweed in no-tillage production systems. In the southern United States, horseweed is a common and problematic weed in corn, cotton, peanut, soybean, forestry, small grains, and hay and pasture production (A. C. York, personal communication; Webster 2004, 2005).

The first report of glyphosate-resistant horseweed occurred in 2001 in Delaware where glyphosate-resistant soybean (and glyphosate applied in-crop) had been used less than three years (VanGessel 2001). Glyphosate-resistant horseweed currently infests at least 13 states including Arkansas, California, Indiana, Kentucky, Missouri, Mississippi, North Carolina, Ohio, Pennsylvania, Tennessee, and others (Heap 2005). It is considered one of the most important herbicide resistant species in the country, and potentially the most important in the south (Smith et al. 2005). The evolution and rapid spread of glyphosate-resistant horseweed has been attributed to prolific seed production, wind-dissimination of seeds, and it's ability to colonize many settings including the increasing acreage of reduced tillage crops, no fitness penalty for glyphosate-resistance, heterozygous individuals can still survive glyphosate field applications at recommended rates, horseweed is self-fertile and self-compatible, and resistance is pollen-borne (Koger et al. 2004; VanGessel 2001; Zelaya et al. 2004).

Herbicide resistance is not new regarding horseweed management. Populations of this weed have been reported to be resistant to six herbicide classes including photosystem II inhibitors, bipyridiliums (i.e. paraquat), ureas and amides, acetolactate synthase (ALS) inhibitors, glycines (i.e. glyphosate), and diphenylethers (Heap 2005; Weaver et al. 2004). Four of these populations have resistance to at least two distinct modes of action (Heap 2005; Weaver et al. 2004) making horseweed one of the ten most important herbicide resistant weeds in the world (Heap 2005).

Field observations have indicated that horseweed, and winter weeds such as cutleaf eveningprimrose (*Oenothera laciniata*), are generally problematic in North Carolina in corn fields that have no cover crops and especially with a reduced- or no-tillage crop following corn in rotation. Additionally, these weeds are not typically found in fields following cotton, peanut, or soybean, whether they were produced in conventional or no-tillage systems. For example, surveys of fields in fall and winter of 2004 and the fall of 2005 found that 73, 2, 1, and 2% of corn, cotton, peanut, and soybean fields, respectively, were infested with horseweed and cutleaf eveningprimrose. Cutleaf eveningprimrose is a common and troublesome weed in soybean, corn, and small grain production in areas of the southern United States (Webster 2004, 2005), and is one of the most common and troublesome weeds in North Carolina cotton production (Anonymous 2005). Management of this weed in reduced tillage systems is difficult (Reynolds et al. 2000). Like horseweed, cutleaf eveningprimrose is often more weedy in reduced cropping situations, and both plants can interfere with cotton growth over an entire growing season (Guy 1995). Cutleaf eveningprimose and glyphosate-resistant horseweed are the most common complaint calls to extension weed specialists and county agents in North Carolina during May and early June in North Carolina (A. C. York, personal communication).

The use of integrated cultural techniques to manage weeds may provide many benefits. By shifting the pest management burden from pesticides and tillage to ecological methods, environmental protection may be increased and certain inputs may be reduced (Liebman and Gallandt 1997). Intercrops and cover crops can decrease weed growth and competition by competing for resources and disturbing preferred niches (Liebman and Davis 2000). Cover crops may be used in a wide range of production systems (Bowman et al. 1998; Teasdale 1998; Thurston 1997), and cover crops have many benefits including: improved soil characteristics, reduced leaching and erosion, increased soil nitrogen and organic matter, improved water infiltration, improved moisture retention, and pest suppression (Liebman and Davis 2000; Mallory et al. 1998; Sainju and Singh 1997; Teasdale 1998; Varco et al. 1999; Yenish et al. 1996). A long-term Alabama study has successfully utilized cover crops in a continuous cotton production since 1896 (Mitchell et al. 2002). Cover crops can easily be combined with other management techniques and postemergence herbicide applications have been suggested to complement the early season weed suppression provided by winter rye (*Secale cereale*) cover crops (Reddy 2003).

Objectives

Our overall goal is to determine the effect of summer rotational crop and winter cover crop practices that improve long-term management of glyphosate-resistant horseweed and other problematic winter annual weeds like cutleaf eveningprimrose.

1. Evaluate the effect of various crop canopy heights and time of crop maturity/senescence on horseweed and winter annual and biennial weed germination, establishment, and growth.

2. Evaluate the effects of fall tillage and use of a winter cover crop on horseweed and winter weed germination and establishment.

3. Disseminate research findings.

4.D. Approach and Procedures

The experimental design will be a randomized complete block with a factorial treatment arrangement of four crops (corn, cotton, peanuts, and soybeans), two tillage production systems (no-till and conventional tillage), and two cover crop options (no cover crop and a rye cover crop) for a total of 16 treatments. We hypothesize that soil disturbance by harvesting peanuts, or by planting and establishing the cover crop of winter rye may be interfering with germination and establishment of horseweed in the fall. This methodology will allow us to determine how much horseweed germination and establishment is inhibited by the cover crop and planting (soil disturbance) and how much can be inhibited by the specific rotational crops.

We further hypothesize that horseweed and cutleaf eveningprimrose germinate and successfully establish in corn as opposed to the other crops because corn senescence begins in early August and the resulting open canopy allows successful winter weed germination and establishment. Cotton, peanut, and soybean do not senescence or are harvested till late September/early October (cotton and peanut) or November (soybean). These crops are typical for southeastern coastal plain crop production. The cotton, corn, and soybean varieties will be glyphosate-resistant varieties selected for yield, grade parameters where applicable, and other important appropriate traits based on North Carolina's Official Variety Testing Trials (OVT). The peanut variety will also be selected based on OVT trials.

The treatments will be replicated four times and the study will be repeated in time. The first trial will begin in fall 2006 and end in fall 2008. The study repetition will begin in fall 2007 and end in fall 2008. Crop production systems including fertilization, planting, and general (non-weed) pest management will be managed according to North Carolina Cooperative Extension Service recommendations. Row spacings and plant populations will be in accordance with state extension recommendations. All plots will be 24 by 40 feet and of sufficient size to allow for the potential of appreciable horseweed, cutleaf eveningprimrose, and other winter weed infestations.

Soon after crop emergence and throughout the entire year at biweekly intervals, horseweed and other problematic winter weeds such as cutleaf eveningprimrose populations will be determined for each plot by counting the numbers of plants by species. Data collected will include weed counts and densities by species spatially in each plot throughout the year. Weeds will be mapped by hand with DGPS and seed-rain and weed biomass by species for each treatment will be determined and quantified. To our knowledge, no one has investigated the spatial and temporal relationships of horseweed and other problematic winter weeds as influenced by tillage, crop, and cover crop. These holistic relationships need to be examined to increase our biological and ecological understandings of the horseweed problem and other problematic winter weeds (such as cutleaf eveningprimrose). A better understanding of these relationships will allow for optimization of control inputs while minimizing herbicide use.

Light measurements including quantity and quality will be taken at the same biweekly intervals to assess the effects of different crops and cover crop light interception on horseweed and other winter weed germination and establishment. Light readings will be taken at the soil surface, at the top of the crop or cover crop canopy, and at the average height of the horseweed population. Weather data (daily means, high and low temperatures, relative humidity) will be taken. Additionally soil temperature (daily mean, high, and low temperatures will be taken in one plot of each representative treatment) to provide data for better understanding the temporal relationships of environment on horseweed and other problematic species germination and establishment as influenced by different crops.

This project will use multiple resources to provide growers with the research results and the proper information to implement improved management strategies. We will hold research plot field tours as part of field days hosted by commodity groups. An average of 200 growers are expected to attend at least 3 separate field day events where this research will be displayed. The second extension method will involve creation and distribution of printed materials. Handouts and extension materials will be created and disseminated to growers. Documents will also published online to allow for wider access. Current extension publications, including crop production and pest management guides, will be updated based on the findings of this research. Information from this research will also be shared with extension and research faculty in North Carolina and at regional and national levels. This will allow extension personnel to provide growers with updated information. In addition, research results will be presented at professional meetings and published in Weed Technology, upon completion of this study.

I.B.2. Addressing Regional Priorities.

This project addresses the following Southern Region priority by integrating rotational crop species, winter cover crops, and tillage to develop sustainable management strategies for resistant horseweed biotypes and weed shifts to problematic winter weeds such as cutleaf eveningprimrose.

Southern Region IPM Priority: http://www.sripmc.org/Policy/Priorities/
"**Priority:** Weed resistance, weed shifts, and whole-system resistance management strategies for important Southern crop- and pesticide- rotations.
Submitted By: Carol Somody(carol.somody@syngenta.com) **Organization:** Syngenta Crop Protection
Submitted: Dec 06, 2004
Justification/Rationale: An organized approach is needed to assess the importance of various factors on weed shifts and weed resistance in important Southern crop- and pesticide- rotations, including the short term and long term direct and indirect costs (reduction in yield/tillage options/water quality, etc.)
Supporting Documentation (Organizations, citations, websites, etc):
Herbicide Resistance Action Committee (HRAC), EPA, USDA, Weed Science Society of America"