HERBICIDE RESISTANT WEEDS AND THEIR MANAGEMENT

(slide script)

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1) The following slide set provides general information about herbicide resistant weeds and their management.

2) Herbicide resistance is defined as the inherited ability of a weed or crop biotype to survive a herbicide application to which the original population was susceptible. A biotype is defined as a group of plants within a species that has biological traits that are not common to the population as a whole.

3) There are two types of herbicide resistance, cross resistance and multiple resistance. Cross resistance occurs when a weed biotype has gained resistance to more than 1 herbicide with the same mode of action. This can occur with herbicides in the same or in different families. For example, imidazolinone (Cadre, Pursuit, Scepter) and sulfonylurea herbicides (Accent, Classic, Envoke) have the same mode of action but are in different families. Multiple resistance occurs when a weed biotype has developed resistance to more than one herbicide brought about by different selection pressures. In other words, weeds that have developed resistance to herbicides with different modes of action. For example, some barnyardgrass (*Echinochloa crus-galli*) populations in California rice fields have been reported to be resistant to both the ACC-ase inhibitors (Clincher, Whip) and thiocarbamates (Ordram, Bolero). Consequently, multiple resistance can be a more difficult problem to address.

4) There are 3 known mechanisms by which plants develop resistance to herbicides. The first and most common mechanism is an altered site of action. Most herbicides have a specific site of action in the plant and any change in this site will cause the herbicide to be inactive *(more information in slide 5)*. The second mechanism is enhanced metabolism. Simply put, enhanced metabolism means that the plants have the natural ability to degrade or metabolize the herbicide into a non-active compound. The third and least common mechanism for resistance is called sequestration. With sequestration, the plant has the ability to prevent the herbicide from reaching its site of action by limiting its movement. This mechanism is also called compartmentalization.

5) This diagram provides an illustration of the altered site of action mechanism for herbicide resistance to atrazine. In this illustration, it is obvious that the site of action in the resistant biotype of common lambsquarters is different that the site of action for the susceptible biotype.

6) How does herbicide resistance occur? Many people believe that the use of herbicides leads to the development of "Super" or "Franken" weeds. This is not the case.

7) Herbicide resistance develops in a field because of a process known as selection pressure. Herbicide resistant weed biotypes already exist in any given population of weeds but usually are not present in large numbers. The resistant population becomes dominant only after the repeated use of a single herbicide or herbicides with the same mode of action removes the susceptible population and allows the resistant population to survive and produce seed.

8) Currently, there are more than 304 herbicide resistant weed biotypes around the world. This includes 182 different species of plants (109 dicots and 73 monocots). It is estimated that more than 270,000 fields around the world have resistant weed problems.

9) The phenomenon of weed resistance was first observed in 1968 in Washington State (USA). Common groundsel (*Senecio vulgaris*) was discovered to be resistant to the triazine herbicides after multiple exposure to simazine and atrazine in a nursery crop situation.

10) Since groundsel was first discovered to be resistant to the triazine herbicides in the latter 1960's, there has been a steady increase in the number of herbicide resistant weeds worldwide. A significant increase in the number of resistant weed biotypes has occurred since the 1990's when the trend in herbicide discovery was to develop low use rate, environmentally friendly herbicides with single sites of action.

11) Characteristics of weeds that favor the development of herbicide resistance include a high reproductive capability and unique or multiple mechanisms of dispersal. Weeds that produce large numbers of seeds that can be easily distributed by wind, water, man, or animal are most likely to become the weeds that develop herbicide resistance.

12) This slide lists the most important herbicide resistant weed species in the world at this point in time. These weeds are included in this list because of the number of herbicides that they have developed resistance to and/or the speed at which they developed the resistance. It is interesting to note that most of these weeds produce large amounts of seed and have unique dispersal mechanisms. Also, two of the ten species in this list are in the genus *Amaranthus*.

13) This chart illustrates the potential seed production of the top 4 herbicide resistant weeds in the U.S. It is interesting to note that these weeds produce significantly more seed than cultivated crops such as peanut, cotton, and corn.

14) Herbicide characteristics that influence the development of weed resistance include the following: 1) herbicides with a single site of action; 2) herbicides used multiple times during the growing season; 3) herbicides used for consecutive growing seasons; and 4) herbicides used without other weed control strategies. It has been documented that the repeated use of a single product for only 2 years could lead to the development of a herbicide resistant weed problem.

15) This slides illustrates the increase in the number of herbicide resistant weed biotypes by herbicide family. The two herbicide families with the most resistant biotypes are the triazines and the ALS-inhibitors. This is due to the fact that the triazine herbicides have been used for more than 46 years while the ALS herbicides have single sites of action and are among the most popular herbicides used today.

16) This slide lists the most commonly used ALS herbicides in the southeastern United States. As indicated in the previous slide, more species of weeds have developed resistance to the ALS herbicides than any other type. Herbicides with this mode of action are very popular and used on a large number of acres. Generally, this is due to the fact these herbicides are used at low rates and are environmentally friendly.

17) Herbicide resistance in Georgia was first identified in 1992 when a population of goosegrass (*Eleusine indica*) was discovered to be resistant to the dinitroaniline (DNA) herbicides (Treflan, Prowl, Sonalan). Since that time, additional weeds such as prickly sida (*Sida spinosa*), Italian ryegrass (*Lolium multiflorum*), and Palmer amaranth (*Amaranthus palmeri*) have been found to be resistant to other herbicides in Georgia.

18) In 2005, BASF identified the presence of ALS-resistant Palmer amaranth in the following counties in Georgia: Colquitt, Cook, and Mitchell. Also, UGA weed scientists collected pigweed seed from 175 locations around the state to test for glyphosate and ALS resistance. Results of these tests will be made available as soon as possible.

19) Glyphosate is the most popular herbicide ever discovered. Its broad spectrum of activity combined with its safe environmental package make it a favorite herbicide choice in many situations on the farm and around the home. Because this herbicide is used on such a wide scale, there has been increased concern about the potential development of weed resistance. Unfortunately at this time, at least 8 weed species around the world have developed resistance to glyphosate. In the United States, populations of horseweed or marestail (*Conyza canadensis*) rigid ryegrass (*Lolium rigidum*), Italian ryegrass (*Lolium multiflorum*) and Palmer amaranth (*Amaranthus palmeri*) have been found to be resistant to glyphosate *(highlighted in blue)***.** It is interesting to note that glyphosate was first commercially available in 1974 but the first case of weed resistance to this herbicide was not reported until 1996 (22 years).

20) Glyphosate resistant horseweed in the U.S. was first discovered in Delaware in 2000. Since that time, resistant populations have been identified in 11 other states (12 total).

21) Pictures of other weeds in the U.S. that have confirmed populations with resistance to glyphosate. (State and year of discovery)

22) One of the main reasons for the development of glyphosate resistant horseweed and Palmer amaranth in the U.S. is the fact that a large portion of crop acres are treated with glyphosate. This chart provides an illustration on the use of glyphosate in corn, cotton, and soybean from

1996 to 2003. The significant increase in glyphosate use in cotton and soybean over the past several years can be attributed to the rapid adoption and utilization of "Roundup Ready" crop varieties. Soybean data for 2003 was unavailable.

23) How do you know if you have a herbicide resistance problem? Herbicide resistance should only be suspected when 1) other causes of herbicide failure have been ruled out; 2) the same herbicide or herbicides with the same mode of action have been used year after year; 3) one weed that is normally controlled is not controlled while other weeds are; 4) healthy weeds are mixed with controlled weeds (same species); and 5) a patch of uncontrolled weeds is spreading. Herbicide resistance should be confirmed by collecting seed from a suspect plant and subjecting the plants grown from this seed to various rates of the suspect herbicide(s) by your local extension or research specialist.

24) This slide shows an MSMA resistant common cocklebur population in North Carolina. Notice that some treated plants are dead while others are not injured. This is a classic field example of a herbicide resistant weed population.

25) Since herbicide resistance is not a problem that affects every crop acre, most herbicide failures can be attributed to other factors. Usually, herbicide failures are the result of unfavorable environmental conditions and/or untimely application *(i.e. large weeds)* rather than herbicide resistance. All possible reasons for poor performance should be investigated before herbicide resistance is considered!

26) Strategies for the control or prevention of herbicide resistant weeds need to be pro-active instead of reactive. It is much easier to prevent resistance than to deal with it after it has already occurred. Some suggested methods for the control or prevention of herbicide resistant weeds are as follows:

a) utilize other weed control strategies, such as mechanical cultivation, row spacing, etc., in combination with traditional herbicide programs
b) rotate herbicides with different modes of action
c) rotate crops
d) scout fields
e) prevent seed production of escaped weeds
f) clean tillage/harvesting equipment when moving equipment from field to field

27) One of the most frequent questions that gets asked regarding the issue of herbicide resistant weeds is "How long does resistance last in absence of further selection pressure?". Some studies have shown that resistant biotypes can continue to dominant a weed population for at least 7 years after selection pressure is reduced. Thus, limiting the use of a particular herbicide or family of herbicides is not enough in itself to help minimize problems with resistant weeds. Additional control strategies will be required. Another good reason why the response to herbicide resistant weed problems should be pro-active rather than reactive!

28) Another question about herbicide resistant weeds that frequently gets asked is "Does the use of reduced rates influence the rate of herbicide resistance development?". This question has been and will continue to be debated by most weed scientists. Some scientists agree that the use of reduced rates may hasten the development of resistant weeds while others do not. Some believe that reduced rates could possibly play more of a role in resistance when the resistance is due to many genes (multi-genic) as opposed to a single gene. At this time, it is probably more important to remember that selection pressure, not herbicide rate, is the most important factor that contributes to the development of herbicide resistant weeds. The goal of herbicide use as it relates to resistance management should be infrequent applications of the lowest rate that provides effective control.

29) This slide set provides only a fraction of information regarding the problem of herbicide resistant weeds. New information is developed every day. More information about herbicide resistance can be obtained by visiting the following web-sites:

a) University of Georgia Weed Science Web-Page (http://www.gaweed.com))
b) International Survey of Resistant Weeds (http://www.weedscience.org/in.asp)