Herbicide-resistant weed management and status in Iowa

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Weed population collections have been completed for 2011, 2012 and 2013 and are currently being processed for herbicide resistance in a project supported by the Iowa Soybean Association. Approximately 900 waterhemp (*Amaranthus tuberculatus*), horseweed/marestail (*Conyza canadensis*), and giant ragweed (*Ambrosia trifida*) weed populations were sampled across Iowa. An important consideration for the 2011 and 2012 collections was that the field sites were not selected randomly and in fact likely represent a worst case scenario with regard to weed populations with evolved resistance(s) to herbicides. Thus, the lack of random selection precluded any ability to make an assessment about the relative frequency of herbicide resistance in Iowa soybean fields. In order to resolve this problem, 2013 weed population were collected from fields selected randomly across Iowa based on reported Crop Reporting District (CRD) soybean acres.

It was arbitrarily decided that the margin of error for the estimate of all soybean fields with herbicide resistance that was acceptable in these calculations was 5% which provided acceptable precision of herbicide resistance estimates but also accommodated logistical concerns; based on the statistical calculations, 400 fields should be visited in 2013 and the inclusionary probability determined; if the fields were not planted to soybeans and had weeds visible above the soybean canopy, they were not included. The number of fields per CRD that needed to be sampled to support a 5% margin of error was calculated based on the 2011 soybean acres; using 2011 soybean data provided the best opportunity for selecting fields that were likely to be planted again to soybean in 2013. The Iowa State University GIS Laboratory provided the GPS field locations based on 2011 soybean planted acres information and selected 399 fields of 100 acres or larger randomly (Figure 1).

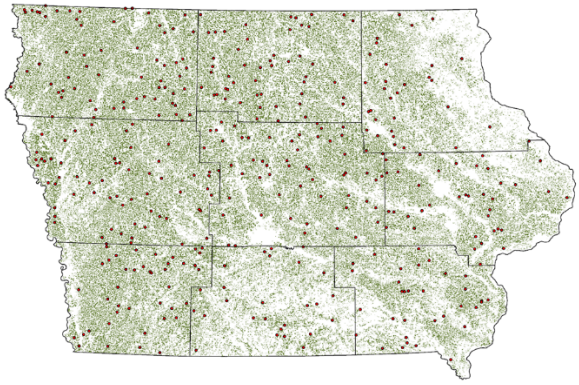

Figure 1. Randomly selected field locations for the 2013 weed population collections. Project supported by the Iowa Soybean Association.

Approximately 98% of the 399 randomly selected fields were visited during the 2013 weed population collections. The first criteria for the inclusionary probability was whether or not the field was planted to soybeans and 79% of the fields visited were soybean fields. Weeds visible above the canopy was the second criteria needed to achieve an inclusionary probability of 1; 69% of the fields visited that met the first criteria also met the second criteria and had weeds visible above the soybean canopy and in 56% of these fields, weed seeds were sampled for assessment of herbicide resistance(s). The percent of fields with weeds visible above the soybean canopy was used to estimate the overall herbicide resistance(s) in Iowa soybean fields based on the 2011 weed seed collections processed thus far. The weed populations collected in 2011, 2012 and 2013 have been or will be screened for resistance to Group 2, 5, 9, 14 and 27 herbicides; the greenhouse evaluations of the 2011 waterhemp populations is about completed.

The levels of herbicide resistance(s) detected in the 2011 waterhemp collections are surprisingly high (Figure 2). Group 2 resistance was detected in 97% of the populations assessed for the 1X Group 2 herbicide (imazethapyr) rate and 92% at the 4x rate. Group 5 (atrazine) resistance for the 2011 waterhemp populations sampled was 69% for both 1X and 4X while Group 9 (glyphosate) resistance was 65% and 34% of the waterhemp populations for the 1X and 4X rates, respectfully. Group 14 (lactofen) resistance was 16% and 13% for the 1X and 4X rates, respectively and Group 27 (mesotrione) resistance was detected in 37% of the waterhemp populations at the 1X rate and 7% at the 4X rate (Figure 2). All herbicides were applied postemergence to waterhemp plants in the greenhouse that were 3 to 4 inches in height.

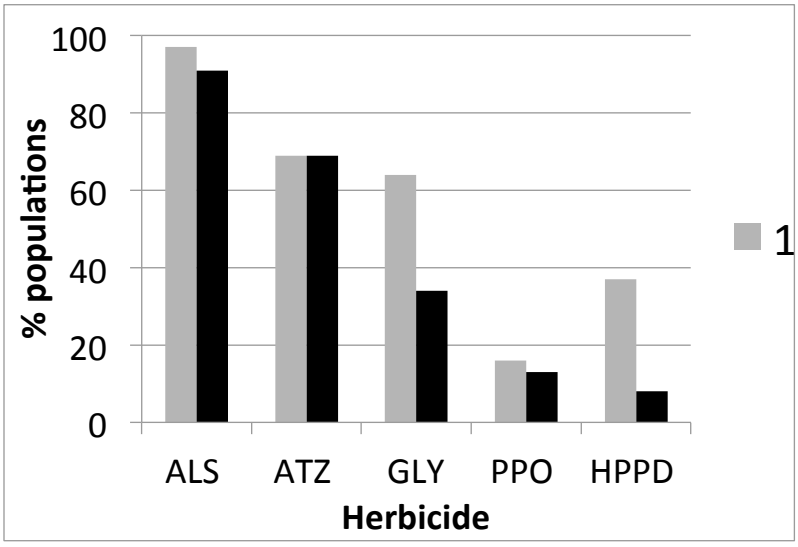

Figure 2. Assessment of herbicide resistance in 2011 waterhemp populations. Project supported by the Iowa Soybean Association.

While these values for herbicide resistance demonstrated by the 2011 weed populations were not from randomly selected field, using the statistics from the randomly selected 2013 fields and the inclusionary probability, an estimate of the percentage of the Iowa soybean fields that

have herbicide resistant waterhemp populations can be made. Based on the statistical assessment of the inclusionary probability at the 95% confidence limit, Iowa fields are likely to have "weeds visible above the canopy of soybean fields" 65% to 74% of the time and thus could be selected for an assessment herbicide resistance(s) (Philip Dixon, personal communication). It could be argued that this range of "weeds visible above the soybean canopy" might be low; consider that growers may have employed more diverse and thus more effective weed management practices in 2013 due to previously observed "weeds visible above the soybean canopy" which could be putatively herbicide resistant. These fields with effective weed management would not be included in the survey based on the failure to meet the inclusionary probability of 1.

Applying these statistics for the percentage of fields with "weeds visible above the soybean canopy" to the 2011 waterhemp collections and extrapolating this to estimate the herbicide resistance(s) for Iowa soybean fields, the Group 2 resistance for the 1X application rate is estimated to be present on 62% to 77% of Iowa soybean fields, Group 5 resistance on 44% to 51%, Group 9 resistance on 42% to 48%, Group 14 resistance on 10% to 12% and Group 27 resistance on 24% to 27% of the Iowa soybean fields (Figure 2).

All of the 2011 waterhemp populations were evaluated for evolved resistance to five herbicide groups and the assessments demonstrated that multiple herbicide resistance was found in 88% of the populations evaluated (Figure 3). This value represents an estimated 56% to 65% of the Iowa soybean fields that likely have waterhemp populations with multiple herbicide resistances based on the statistic generated from the randomly selected 2013 fields. Only 2% of the 2011 waterhemp populations evaluated did not demonstrate any herbicide resistance (Figure 3).

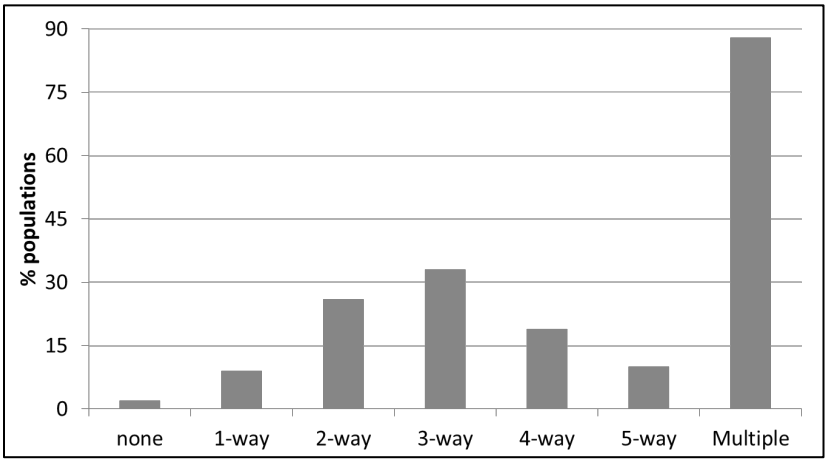

Figure 3. Multiple herbicide resistances in 2011 Iowa waterhemp populations. Project supported by the Iowa Soybean Association.

The most common multiple herbicide resistance was 3-way and was detected in 33% of the 2011 waterhemp populations evaluated. Between 21% and 24% of Iowa soybean fields based on the 2013 statistical program, are suggested to have waterhemp populations with 3-way herbicide resistance; the most common 3-way herbicide resistance is for Group 2, 5, and 9 herbicides. Ten percent of the 2011 waterhemp populations evaluated demonstrated 5-way

herbicide resistance and this problem is estimated to occur on 6% to 7% of Iowa soybean fields, again based on the 2013 random sample of fields.

Management of the herbicide-resistant weeds necessitates a significant change in tactics. Given the dominance of glyphosate-resistant crop cultivars, glyphosate has been the primary herbicide used to control weeds during the last 18 years and the resulting evolution of glyphosate resistance has become a serious problem for farmers. Existing resistances to other widely used herbicides remains in the weed genome and results in the high percentage of waterhemp populations with multiple resistances. Greater diversity in strategies, beyond simply changing herbicides should be adopted in order to manage the current weed problems without contributing further to increasing herbicide-resistant weeds. Mechanical, cultural and biological tactics need to be included as appropriate for individual fields. Tactics that are simple and convenient no longer are effective. Focusing only on herbicide solutions to weed management is no longer an option.