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Herbicide Resistance Risk Calculator

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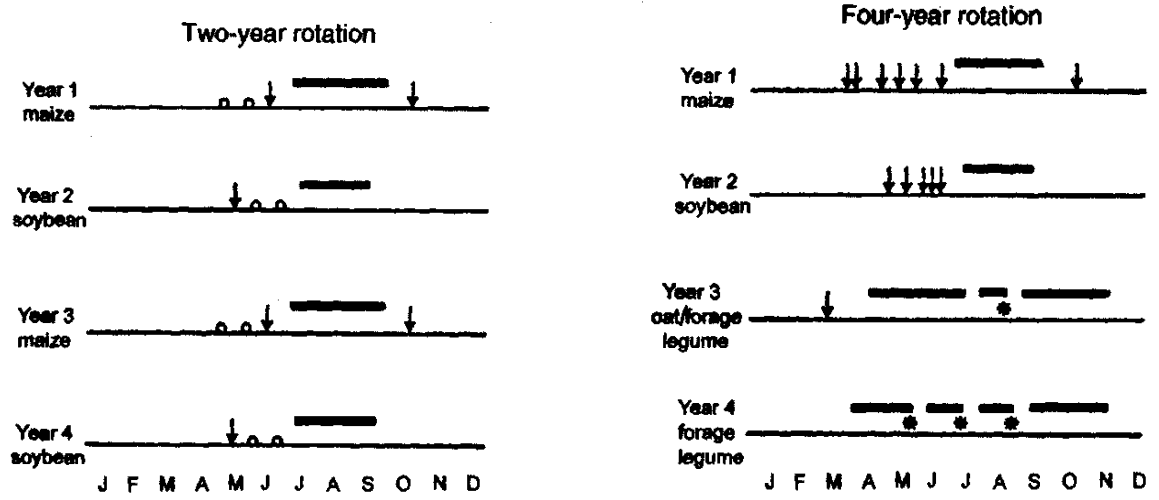

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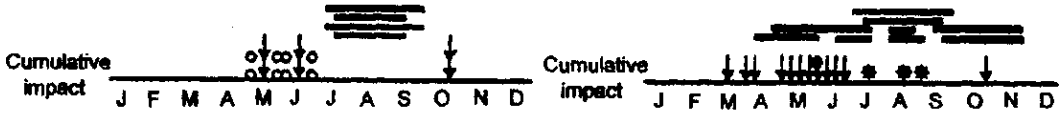

1. To prevent weeds from adapting, we you just need to add diversity.

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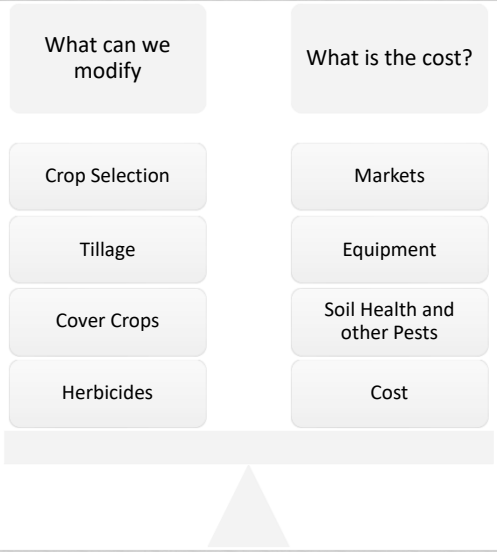

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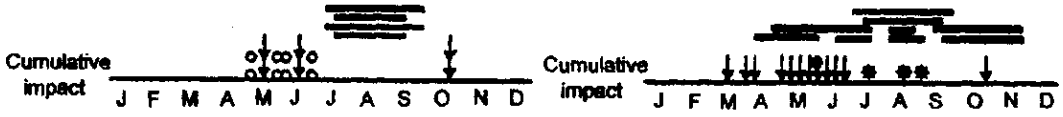

1. To prevent weeds from adapting, we you just need to add diversity.
2. Everything in agriculture is a compromise.

- Herbicides are the easiest weed management tool to manipulate. How do we add diversity?

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- Evans et al. 2016
- Survey of weed management practices and occurrence of glyphosate-resistance at 106 farms in Illinois.
- Three relevant results were found:
  - Distance to a resistant field wasn't relevant,
  - Rotating herbicides increased the likelihood of resistance.
  - Mixing herbicides of different MOA decreased the likelihood of resistance. **2=83x, 3=57x**

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1. To prevent weeds from adapting, we you just need to add diversity.
2. We add diversity to our herbicide management program by applying more modes of action.

- Is this possible?
- Is it cost effective?

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Corn on Corn	Corn Before Dry Beans	Corn Before Sugar Beets	Dry Beans	Sugar Beets
What does Not Work				
POST				
ALS: Permit Resolve Q, etc…			Raptor, Pursuit, Varisto	Glyphosate
Glyphosate			Basagran,	UpBeet
What Works				
PRE				
Group 15s: Warrant, Dual, etc…	Group 15s: Warrant, Dual, etc…	Group 15s: Warrant, Dual, etc…	Outlook, Dual, Eptam	
Acuron (15+5+27)	Accuron (15+5+27)		Sonolan, Prowl	
Atrazine				
Group 27 (Callisto, Balance)				
Group 14 (Sharpen, Valor)	Group 14 (Sharpen, Valor)	Group 14 (Sharpen, Valor)		
POST				
Dicamba / Atrazine / 27	Dicamba	Dicamba	Reflex*	Group 15s as a layby

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1. To prevent weeds from adapting, we you just need to add diversity.
2. We add diversity to our herbicide management program by applying more modes of action.

- Is this possible?

  Sometimes

- Is it cost effective?

  Maybe

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The Herbicide Resistance Risk Calculator

- Weed of concern
- Four-year rotation
- Herbicide program

- Herbicide efficacy
- Resistance risk
- Herbicide cost

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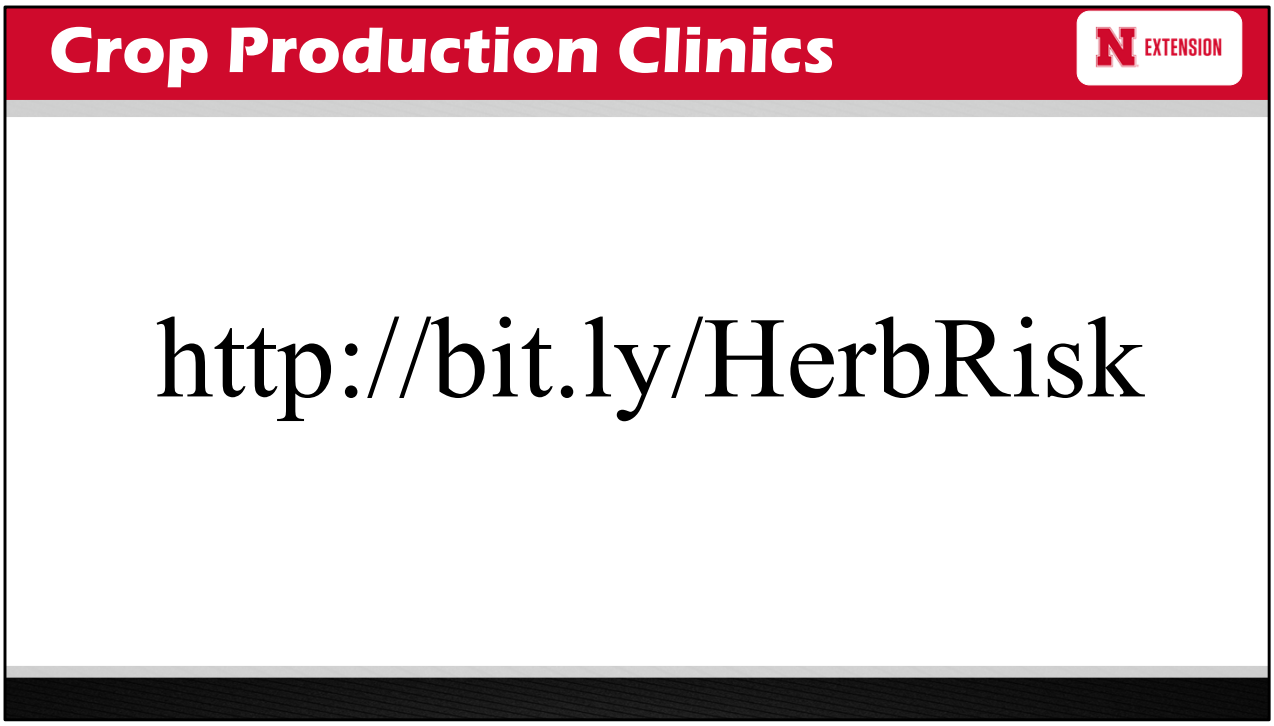
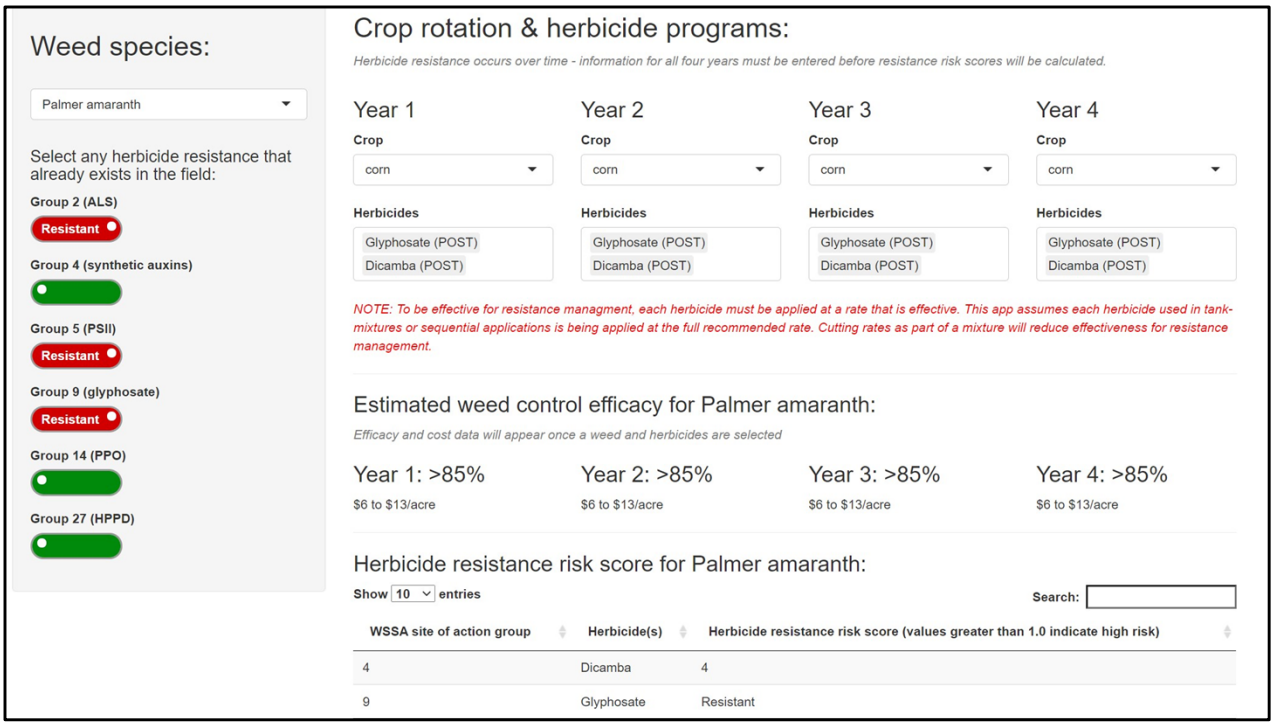
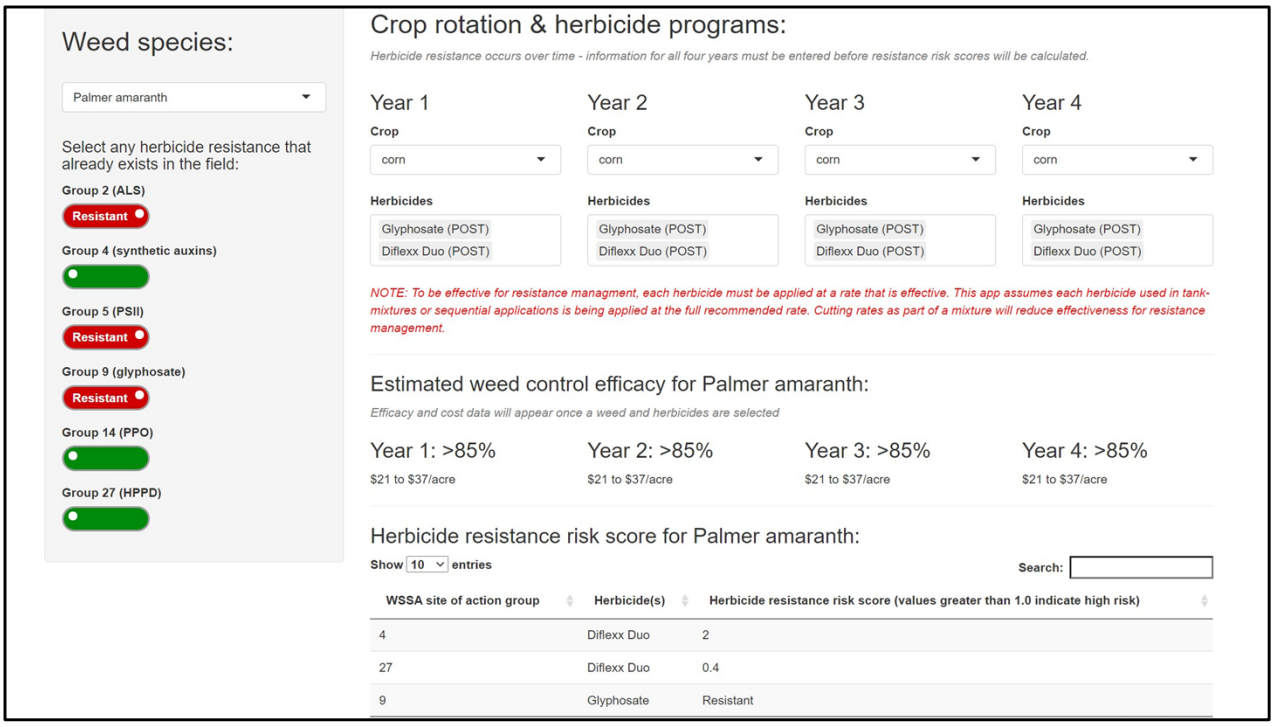


Risk scores are estimated on a scale of 0 to 4. A minimum score of 0 means the herbicide site of action was never used during the four-year period (and thus those sites of action are not presented in the table). Each year during the rotation an effective herbicide is used on the target weed, that herbicide site of action is initially given a score of 1; however, this score is reduced if a second effective site of action is applied in the same year. If an effective site of action is applied alone in each of the four years, it would result in the maximum risk score of 4.

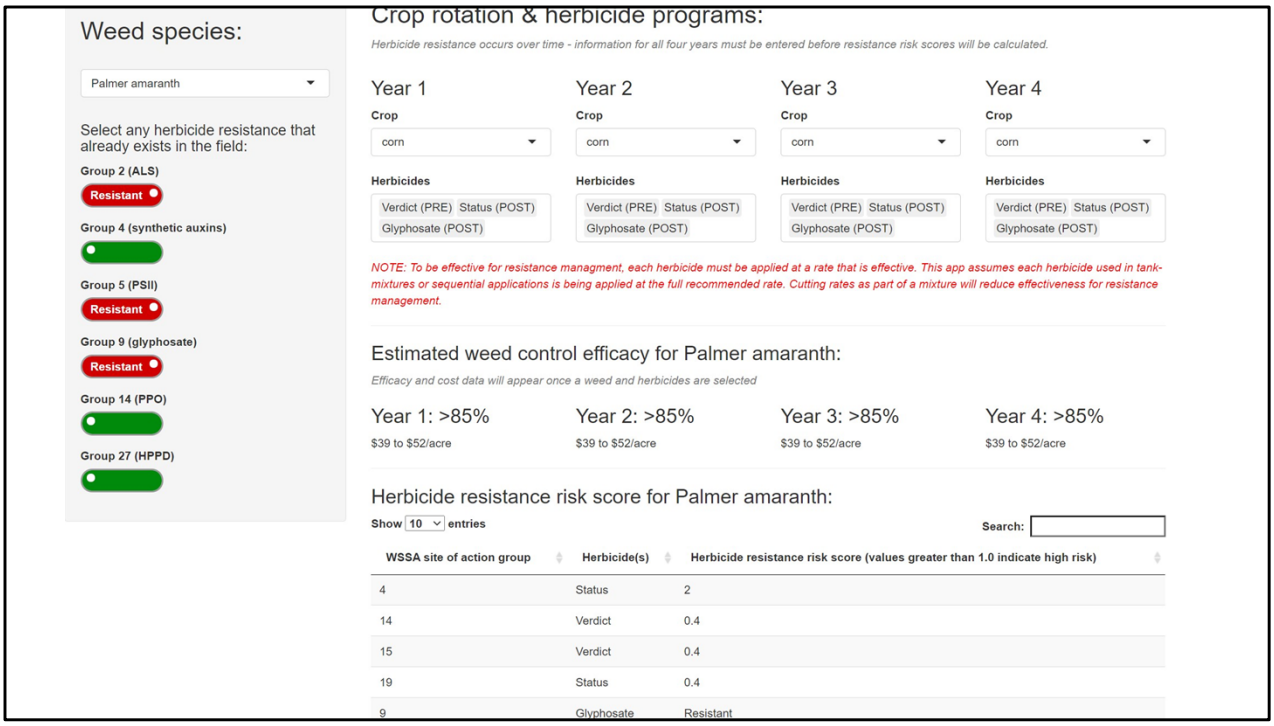
The lower the risk score, the less likely it is the weed population will become resistant. **From a practical resistance management perspective, the goal when selecting herbicides should be to keep the total four-year risk score below 1.0.** To accomplish this, the user must ensure that each time an effective herbicide is used, it is combined with a second herbicide site of action that is also effective on the target weed. Risk values less than 1 indicate a SOA was never used without a second effective site of action, and therefore, the risk of resistance is relatively low.



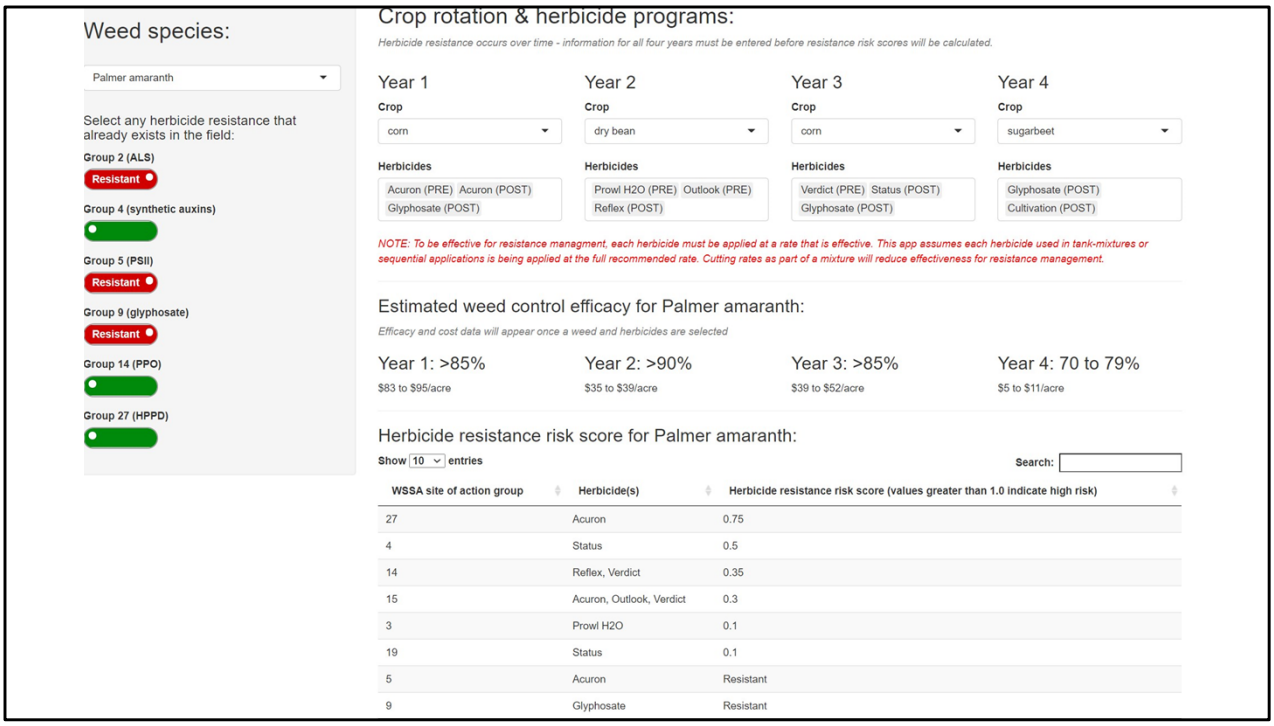
A four-year rotation of continuous corn is chosen, and an herbicide program for each year is also selected. In this example a single POST application of glyphosate + dicamba is chosen (**Figure 1**). For each herbicide program, a weed control efficacy and a risk score of developing herbicide resistance to any mode of action used are calculated. Weed control efficacy ranges from 0% to 100%. For any given year in the rotation, the risk of development of herbicide resistance for a mode of action ranges from “0” (low risk because the herbicide is not used), to “1” (high risk, because the herbicide is the only effective herbicide on the target weed). The Palmer amaranth in this example is already resistant to glyphosate, so a resistant risk score isn’t calculated for that site of action, and glyphosate does not contribute to the estimated weed control efficacy. The estimated weed control efficacy is calculated exclusively from the control estimated from dicamba and is greater than 85%. In this case, only having one effective herbicide being used gives an herbicide resistance risk score of “1” for each year for dicamba-resistance developing. As dicamba is the only herbicide used for all four years, the cumulative resistance risk is “4”, which is the highest possible score. There is a very high likelihood of Palmer amaranth developing dicamba-resistance in this scenario.



The first thing to note is that both herbicides do not provide the same level of control. Tembotrione does not control Palmer amaranth as well as dicamba alone. When multiple modes of action are applied at the same time, the web app selects the herbicide which provides the greatest amount of control, in this case dicamba, and uses that rating to estimate the level of control. Therefore, control did not increase even though an additional mode of action was added compared to the first example. In this way, the weed control estimates from herbicide mixtures are fairly conservative. However, the cost per acre and the herbicide resistance risk score did change (**Figure 2**). In the first scenario, dicamba was applied without any other effective mode of action, resulting in the highest possible score of “4”. Now that dicamba is being applied with another mode of action each year, that risk was reduced by half to “2” over four years – still greater than the ideal score of less than 1, but an improvement over dicamba used alone. The resistance risk score for group 27 herbicides, however, is much lower, at “0.4” over four years. This is largely because the second herbicide in the mixture (dicamba) is effective on the target weed, and is likely to control any individuals that survive the tembotrione.



Once again glyphosate is ineffective as the Palmer population is resistant and we see no calculation of an herbicide resistance risk score for glyphosate. Status® is a premix of dicamba (Group 4) and diflufenzopyr (Group 19). The risk of resistance developing resistance to the group 4 mode of action in this example is the same as that of the example 2. Again, dicamba is providing the bulk of Palmer control in the Status® premix compared to the diflufenzopyr, and consequently, the risk of resistance is biased towards the herbicide which provides more of the control. The risk of resistance for the components of Verdict®, saflufenacil (Group 14) and dimethenamid-p (Group 15) is relatively low. This is because both herbicides are being 'protected' as both herbicides have a high efficacy independent of one another. To lower the resistance score, we should choose two equally effective modes of action in the same application.



In this crop rotation example, herbicide options exist to manage herbicide-resistant Palmer amaranth in every crop but sugarbeet. In the sugarbeet crop cultivation is used for weed control, and assigned a control value of around 70% with the assumption that in-crop cultivation will eliminate about 70% of the weeds . We see that there are no herbicide resistance risk scores given for cultivation, and herbicide groups 9 (glyphosate) and 5 (atrazine in Acuron®) are marked as already resistant in the herbicide resistance risk score. With a four-year rotation of three different crops, there is a greater number of herbicide modes of action used compared to previous examples with continuous corn. Having a more diverse cropping system is lessening the cumulative use of particular herbicide sites of action, and consequently decreases herbicide resistant risk scores. In general, as cropping system diversity increases, the number of herbicide resistant weed populations decrease. We see the highest risk calculated for group 27 herbicides, as one component of Acuron® is used twice in the first year, group 4 herbicides as the site of action is used once in year three without any other effective site of action, and group 14 herbicides as they are used both in year 2 and year 3. But because all risk scores are less than 1, this appears to be a low-risk program for developing additional herbicide resistance in Palmer amaranth. It should be noted, however, that in the sugarbeet crop, Palmer amaranth control is only being provided by the tillage operation, and therefore, high weed densities will

require additional weed control operations.

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All of the weed control efficacy data and price estimates were taken from the Guide for Weed Management in Nebraska

The app does not currently calculate rotations restrictions.

Many of the herbicide options a user can plug into this program will lead to crop injury and yield loss if label restrictions are not followed.

http://bit.ly/HerbRisk