Final Report

The Evaluation of Alternative Herbicides to Glyphosate For Use in and Around Wheat Fields

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Glyphosate is the most widely used herbicide in Arizona, the USA and worldwide. That may be coming to an end and it is probably not too early to start to consider alternatives. Glyphosate was developed in the early 60's as an industrial solvent to clean pipes and boilers. Monsanto registered it as a herbicide in 1974 and sold it for around $100/gal. It now sells for $30 to $50/gal and is used by people everywhere. It has fallen in popularity in recent years for a few reasons: 1) A couple lawsuits were decided last year in favor of a groundskeeper and a homeowner who claimed they had contracted cancer as a result of glyphosate use and thousands of similar lawsuits are now underway. The EPA and other public and private organizations have found it to be safe although other studies have found it to be "a likely carcinogen". and 2) More than 40 separate weed species have been identified that have developed resistance to Glyphosate over the last 40 years. This has caused serious problems in many parts of the country. Only one resistant species, palmer amaranth, has been identified in Arizona and careful management will be needed to avoid more. Some counties and some municipalities have already banned the use of glyphosate. The reasons why Glyphosate is so popular in commercial agriculture are that 1) it is systemic and effective on most weeds including those that have become well established, 2) It is used postemergence to the weeds and has little soil residual activity and will not hurt most crops that are planted soon after application and 3) it has been off of patent

for several years and is relativity affordable and 4) It is not volatile and will not drift to sensitive crops in the vicinity There are not many herbicides that have these same characteristics. There are several contact herbicides that are broad spectrum with little soil residual that are not volatile but they are normally only effective on small seedlings. Several of these are used in combination with Glyphosate but they are can be inconsistent when weeds get beyond the seedling stage. These include
bromoxynil(Buctril,Maestro),Paraquat(Gramoxone),Pyraflufen(ET),Carfentrazone (Aim,Shark) Caprylic acid (suppress),Pelargonic acid (Scythe) and others. Some contact herbicides have soil activity (Goal and Chateau). The Plant growth regulators like Dicamba (Clarity), 2,4-D and MCPA are volatile and dangerous to use around many crops. We conducted trials this year to find alternatives to Glyphosate that are used postemergence and have the same characteristics as Glyphosate. Our trials focused on postemergence weed control ,soil residual and volatility. So far, our list is fairly short and includes Glufosinate,(Rely, Liberty,Finale,Cheetah), Indaziflam (Alion, Specticle, Marengo), and Pyroxasulfone (Zidua),

Procedure

We evaluated 15 herbicides this season to determine how well they would fit these criteria. These included herbicides that used 5 different modes of action to kill weeds . The trials were conducted between October and December this year at the Yuma Agriculture Center. The herbicides that were tested and their mode of action are listed in the table below.

Cell Membrane Disruptors

Paraquat
Carfentrazone
Pyraflufen
Caprylic acid
Pelargonic acid
Saflufenacil
Sulfentrazone

Plant Growth Regulators

2,4-D
Dicamba
Arylex
Quinclorac

Photosynthesis Inhibitors

Bromoxynil

Protein Synthesis Inhibitors

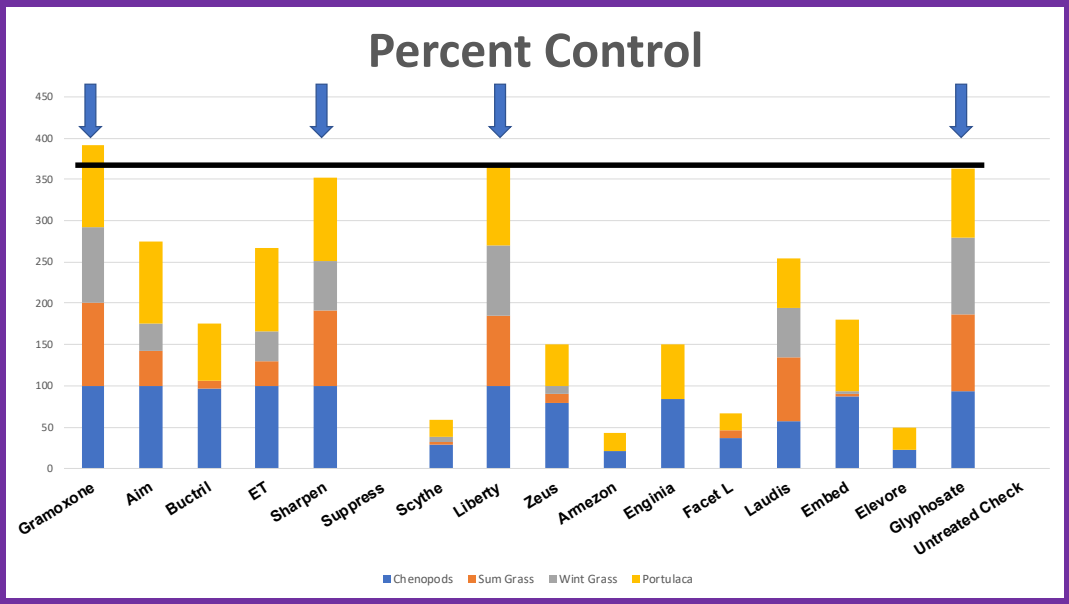
Glufosinate
Topramezone

Pigment Inhibitors

Tembotrione

Weed Control

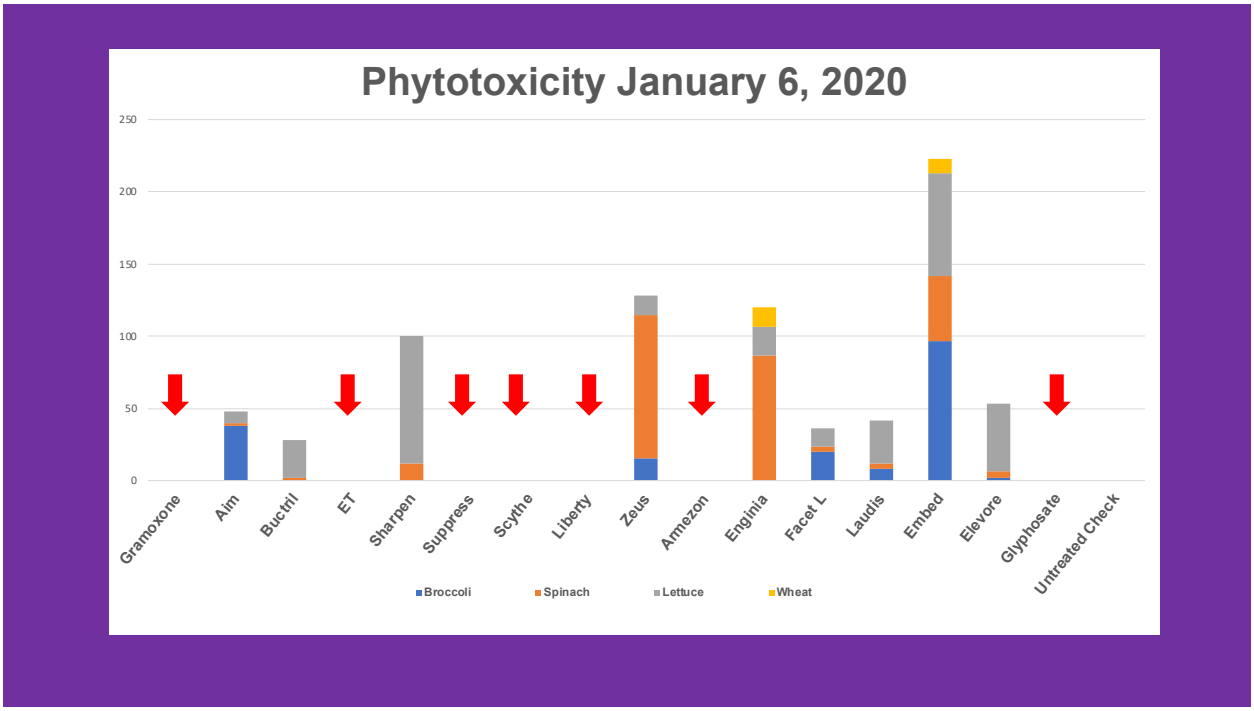
The weeds that were present in these trials were nettleleaf goosefoot, lambsquarters,common purslane, summer annual grasses and winter annual grasses. The following graph illustrates the levels of control we achieved with these weeds compared to Glyphosate.



There were only 3 of the tested products that controlled all of these weeds as well as Glyphosate (arrows). These were Paraquat (Gramoxone), Salflufenacil(Sharpen) and Glufosinate(Liberty,Rely). Several of the others were good on broadleaves but weak on grasses. This could be overcome by combining them with a grass herbicide.

Soil Residual

One of the characteristics of Glyphosate that make it so popular is that it does not stay around in the soil except in very rare situations. Soil gets moved around with equipment,wind and water and soil activity can be a negative even on field edges. Soil residual herbicides are commonly used here but most have fairly short activity. We planted wheat, lettuce, broccoli and spinach into plots that we had treated with the 15 herbicides we evaluated. Four of them injured at least one of the crops. These were 2,4-D choline (Embed), Dicamba (Enginia),Sujlfentrazone+Carfentrazone (Zeus) Carfentrazone(Aim,Shark).



In terms of broad spectrum weed control with no soil activity, only two of the fifteen herbicides we evaluated were comparable to Glyohosate. It is likely that a combination of a grass and broadleaf herbicides will be necessary.

Measuring Herbicide Volatility

The volatility of herbicides, or the change from a solid or liquid to a gas, is dependent on several environmental factors and is extremely variable. We have been working on finding a replacement for Glyphosate for non-crop weed control and have tried to determine the stability of the potential herbicide alternatives. There are various methods used to measure herbicide volatility. All herbicides are initially tested in the **laboratory** to determine volatility and other properties. Volatility is specifically measured by placing a given volume of herbicide in a container,, exposing it to various temperatures and humidities and then weighing how much is left. This is done under very controlled conditions. Another technique that is often the next step is to conduct bioassay studies in a **greenhouse.** This usually involves placing a

container with the herbicide spray solution in a closed environment with sensitive plants. Injury to the bioassay plants are measured visually or by some other means. **Field Studies** are often conducted to measure herbicide volatility. This technique is the most applied but the results are often imprecise and variable depending n environmental conditions. This commonly involves spraying an isolated area in the field and after the spray has settled placing sensitive plants at variable distances and directions away. Injury is observed or measured at variable time periods. We used this technique on June 10 to June 15 this year at the Yuma Valley Agriculture Center to measure volatility of 13 herbicides we are evaluating as alternatives to Glyphosate. Seven X 10 Ft. plots were sprayed and tomato plants were placed 25Ft. away from each sprayed area on the north, south, east and west corners 1 hours after application A 50 Ft. buffer separated each sprayed plot. Visual injury was measured to the tomato plants at 24 and 48 hours after they were placed in the field. The 13 herbicides were used in this trial included 5 modes of action and are listed below.

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The temperature reached above 100 F, the humidity was 10 to 20% and wind was 5 to 10 MPH during the trial. No injury symptoms were observed to any of the tomato plants from any of the herbicide treatments. The trial included low volatility formulations of the plant growth regulators, 2-4-D (Embed) and Dicamba(Enginia) which are often volatile under these hot and dry conditions. Neither of these two, or any of the other included herbicides, moved 25 ft or more in this one trial. We know, however, that in other trials that the results have sometimes been different. Volatility is variable and difficult to measure in field trials.

Discussion

Fifteen herbicides were evaluated that we thought might be viable alternatives to glyphosate for us in and around wheat fields. The characteristics that we were looking for were 1-broad spectrum weed control ,2- No soil residual activity that might hurt rotational crops and 3- low volatility and movement to off target sites. Only two of the 15 met this criteria; Glufosinate and Paraquat. There are other potential problems with both of these , however that may reduce their utility. Paraquat can be toxic to human health if it is not handled properly. This herbicide has been used since 1959 although new regulations have recently been in place which include the requirement that all handlers and applicators be tested and certified to use it. The problem with Glufosinate is that it has a 70 day plantback restriction to many desert crops. There was little residual activity in our trials and work is underway to change this.

These reults indicate that one herbicide alone may be insufficient to duplicate the benefits of Glyphosate. A combination of treatments may be necessary.

Acknowledgement

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