32.Insecticide act-Compatibility of pesticides with fertilizers and other Agrochemicals.

Agrochemicals combinations and their significance

Fertilizer-herbicide combinations are extremely popular because they combine two operations. Combinations with pre emergence chemicals are generally effective since both fertilizer and herbicide action are dependent on contact with the soil (requiring rainfall or irrigation). Post emergence herbicide action depends more on absorption by leaves, and granules in such combinations do not adhere well to smooth-surfaced leaves. They will stick better if applied when weed leaves are damp, perhaps with morning dew. “Weed and feed” materials present a conflict in desirable actions. Proper time for weed control often does not coincide with the most desirable time and rates for fertilizing. If used for follow-up fertilizations, there is danger of herbicide overdose.

HERBICIDE - INSECTICIDE COMBINATIONS

Emulsifiable concentrate formulations of insecticides can act like oil adjuvants when applied in combination with a herbicide. Past research has demonstrated that Lorsban in combination with Betanex or Betamix can cause more sugar beet injury than Betanex or Betamix alone. Lorsban should not be applied in combination with normal rates of Betanex, Betamix or Betamix Progress in situations where sugarbeet injury is a concern. The micro rate of Betanex or Betamix + UpBeet + Stinger + methylated seed oil at 0.5 pt/A + 1/8 oz/A + 1.3 fl oz/A + 1.5% v/v already has an oil adjuvant as a part of the system. Therefore, the addition of Lorsban to the micro rate would not be expected to cause an increase in sugarbeet injury.

While Lorsban act like oil adjuvants, the insecticides are not as effective as commercial oil adjuvants and the insecticides should not be substituted for oil adjuvants in herbicide treatments where oil adjuvants are needed for optimum weed control.

Adjuvants for enhancing herbicide performance

An adjuvant is any substance in a herbicide formulation or added to the spray tank to improve herbicidal activity or application characteristics.

Adjuvant selection: should be primarily based on herbicide label._ should consider percent active ingredient as well as cost.

Adjuvants are commonly used in agriculture to improve the performance of pesticides. Broadly defined, “an adjuvant is an ingredient that aids or modifies the action of the principal a ctive ingredient.” The use of adjuvants with agricultural chemicals generally falls into two categories: (1) formulation adjuvants are present in the container when purchased by the dealer or grower; and

(2) spray adjuvants are added alongwith the formulated product to a carrier such as water. The liquid that is sprayed over the top of a crop, weeds, or insect pest often will contain both formulation and spray adjuvants.

Formulation adjuvants are added to the active ingredient fora number of reasons including better mixing and handling,increased effectiveness and safety, better distribution, and drift reduction. These traits are accomplished by altering the solubility, volatility, specific gravity, corrosiveness, shelflife, compatibility, or spreading and penetration characteristics .With the large number of formulation options available(solutions, emulsions, wettable powders, flowables, granules,and encapsulated materials), adjuvants become even morei mportant in assuring consistent performance.

Spray adjuvants are added to the tank to improve pesticide performance. Literally hundreds of chemical additives are now available that fall into this category. Spray additives canbe grouped into two broad categories:

Activator Adjuvant s include surfactants, wetting agents, stickers-spreaders, and penetrants; *special purpose* or utility modifiers such asemulsifiers, dispersants, stabilizing agents, coupling agents,co-solvents, compatibility agents, buffering agents, antifoamagents, drift control agents, and nutritionals.

SPECIAL PURPOSE ADJUVANTS

Compatibility agents allow simultaneous application of two

or more ingredients. They are most often used when herbicides are applied in liquid fertilizer solutions. Unless the pesticide label states that it can be mixed with liquid fertilizers,a compatibility agent should be included.

Buffering agents usually contain a phosphate salt or more

recently citric acid, which maintains a slightly acid pH whenadded to alkaline waters. These are added to higher pHsolutions to prevent alkaline hydrolysis (a chemical reaction)of some organophosphate (OP) and carbamate insecticides.Some acidifying agents are also sold to enhance herbicideuptake and performance. However, there is little evidence tosupport the need for these acidifying agents for this purposewith most herbicides. Some buffering agents are also “water softening” agents that are used to

reduce problems with hardwater. In particular, calcium and magnesium salts mayinterfere with the performance of certain pesticides. Ammonium sulfate (AMS) is sometimes added to reduce hard water problems. Examine the specific pesticide and water source todetermine the need for a buffering agent.

Antifoam agents usually are added to suppress surface foamand minimize air entrapment that can cause pump and sprayproblems. Defoamers often contain silicone.

Drift control agents (thickeners) modify spray characteristicsto reduce spray drift, usually by minimizing small dropletformation. Drift inhibitors are generally polyacrylamide orpolyvinyl polymers to increase droplet size.

Surfactants

The primary purpose of a surfactant or "surface active agent"is to reduce the surface tension of the spray solution to allow more intimate contact between the spray droplet and the plant surface. Any substance that brings a pesticide into closer contact with the leaf surface has the potential to aid absorption. Surface tension is a measure of the surface energy in terms of force measured in dynes/cm. Water has asurface tension of 73 dynes/cm. Surfactants lower the surfacetension of water to that of an oil or solvent, which spreadsmore readily than water on plant surfaces. Surfactants typically lower the surface tension of a solution to between30 and 50 dynes/cm.The interaction between surfactant, herbicide, and plant surface is far more complex than simply lowering the surface tension of the pesticide solution. Surfactant molecules maya lso alter the permeability of the cuticle. Surfactants form abridge between unlike chemicals such as oil and water or water and the wax on a leaf surface. Although there are manyd ifferent types of surfactants, in general, they are constructed of a long chain hydrocarbon group on one end that is considered lipophilic (fat loving) and a more hydrophilic(water loving) group of atoms on the other end.

Surfactants are classified as ***nonionic, anionic, or cationic***.

Nonionic surfactants have no electrical charge and are generally compatible with most pesticides. Nonionic surfactants are most commonly used because of their universal fit. An anionic surfactant possesses a negatively charged functional group and is most often used with acids or salts. Anionic surfactants are more specialized and

sometimes used as dispersants or compatibility agents.
Cationic surfactants are used less frequently, but one group (ethoxylated fatty amines) has been frequently used with theherbicide Roundup.
The ***organosilicone***-based materials are another group of surfactants more recently introduced. These surfactants are used in place of or in addition to more traditional nonionic surfactants. Proponents of these surfactants stress low surface tension, greater rain fastness, and possible stomatal penetration characteristics. Several silicone-based products are currently available for use with postemergence herbicides

Oils

Adjuvants that are primarily oil based are very popular with pesticide applicators. Crop oils are probably the oldest groupwithin this category.*Crop oil* is a misnomer because the material actually is from petroleum (paraffin or naphtha base, not vegetable derivative),a phytobland onphytotoxic), . Crop oils are believed to promote the penetration of pesticide spray through waxy cuticle or the tough chitinous shell of insects. Traditional crop oils are more commonly used in insect and disease control than with herbicides. Crop oils are typically used at 1 to 2 gallons peracre.

Crop oil concentrate contains 80 to 85 percent phytobland emulsifiable crop oil (petroleum based) plus 15 to 20 percent nonionic surfactant. The purpose of the surfactant in this mixture is to emulsify the oil in the spray solution and lower the surface tension of the overall spray solution. Crop oil concentrates attempt to provide the penetration characteristics of the oil, while capturing the surface tension reduction qualities of a surfactant. Crop oil concentrates are also important in helping solubilize less water-soluble herbicides such as Assure, Poast, Fusilade, Select, and atrazine on the leaf surface.

Vegetable oil concentrates have performed less consistently than their petroleum-based counterparts. However, manufacturers are attempting to improve plant or vegetable-based oils by increasing their non polar or lipophilic characteristics. The most common method has been through esterification ofcommon seed oils such as methylated sunflower, soybean,cotton, and linseed oils. The methylated forms of these seed oil concentrates are comparable in performance to traditional(petroleum) crop oil concentrates so their importance has increased. In taking it one step further, organosilicone-basedmethylated vegetable oil concentrates are also available. These adjuvants boast the surface tension-reducing properties

of silicone but have the advantages of a methylated
vegetable oil concentrate.

Nitrogen Fertilizer

Within the last 15 years, nitrogen fertilizers have been more
frequently added to the spray solution as an adjuvant to
increase herbicide activity. Ammonium salts (NH_4^+) appear to be the active component of these fertilizer solutions and have improved the performance consistency on some weeds. It is still unclear how ammonium salts improve herbicide performance. Herbicides that appear to benefit from the addition of ammonium are the relatively polar, weak acid herbicides such as Basagran, the sulfonylureas (Accent,Beacon, Classic, and Pinnacle, etc.), and the imidazolinones(Pursuit and Raptor). Nitrogen fertilizers may replace surfactant or crop oil concentrate with some of the contact type herbicides, but are usually added in addition to surfactant or crop oil concentrate with systemic products. Velvetleaf and some grassy annual weeds in particular have been responsive to the addition of nitrogen fertilizer in the spray mix. In general, velvetleaf control has improved by as much as 10 to 25 percent by the addition of an ammonium based fluid fertilizer compared to crop oil concentrate or surfactant. Some broadleaves and grasses show little or no response with the inclusion of ammonium fertilizer solutions. Ammonium-based fertilizers and, in particular, ammonium sulfate (AMS) are also being promoted to reduce potential antagonism with hard water or antagonism with other pesticides. Both hard water antagonism and pesticide antagonism can occur with some herbicides. Roundup(glyphosate) is one product that specifically recommends omits label the addition of ammonium sulfate (or a higher rateof Roundup) for hard water, cool air temperatures, or drought conditions. Examine the specific pesticide label,water source, and environmental conditions to determine the need for AMS or other adjuvants.

Foliar fertilizers

Many of these products are being used extensively in combination with herbicides. It is important to know the facts before mixing them unregistered with herbicides.

- Certain fertilisers do work effectively with certain herbicides for very specific reasons. It is however highly improbable that it is as a result of more actively growing plants.

- Foliar fertilisers could sometimes even be antagonistic to herbicide activity! Certain companies even warn farmers not to mix these products with their herbicides.
- If you mix unregistered combinations, please keep in mind that it becomes your problem and that the herbicide company will not take responsibility for poor weed control or crop damage. Unregistered combinations are a risk that you take. We don't think it worthwhile to take such a risk.

Tank mixtures

Unregistered tank mixtures are one of the main reasons for poor herbicide efficacy. It is important to keep the following in mind.

- Always stick to label recommendations
- If in doubt, contact the manufacturer for advice

Conditions during and just after spraying

Climatic conditions during application could make or break a herbicide.

- Remember that once the spray solution droplet hits the target, it is exposed to the forces of nature. Try to protect it in every way possible.
- Try to avoid herbicide-limiting factors such as low humidity and other environmental constraints.
- Always include the registered adjuvant as it can compensate somewhat for lower humidity and other environmental limitations.

Retention and absorption

It is important for spray solution droplets to firstly be retained on the leaf surface and then to be absorbed in adequate amounts.

- Remember that both retention and absorption are equally as important. Good wetting and spreading is useless if conditions for absorption are unfavourable.
- Try to avoid herbicide-limiting factors such as low humidity and other environmental constraints as this could detrimentally influence both retention and absorption.

- Always include the registered adjuvant as it ensures adequate retention and absorption.
- Don't follow unregistered practices as this could decrease both retention and absorption.

HERBICIDEMIXTURES AND PROBLEMS IN
MIXING HERBICIDES

The use of herbicide combinations is not new, but it has not received the attention and input that is necessary to fully understand and implement the practice. Although the number of herbicides available is continually increasing, we have to realize that in most cases herbicides are quite specific in their activity toward either grass or broadleaf weeds and even other species within these broad categories. Excellent herbicides have limitations that might be alleviated with the proper addition of another herbicide.

There are several advantages that may be gained from the combination of herbicides over a single herbicide.

Some of these are:

1. Control of a broader spectrum of weeds.
2. More consistent control over a wide range of climatic conditions.
3. Reduced potential of herbicide residue in crops and soils.
4. Lower rates of application resulting in decreased crop injury and lower costs.
5. Unexpected synergistic effects (increased herbicidal effectiveness beyond that expected).

There have been limitations and concern in the past concerning the legal use of herbicide combinations. At no time has the University of Wyoming recommended chemical mixtures unless the herbicides, herbicide-fertilizer mixtures, and other pesticides were registered by the Environmental Protection Agency (EPA) and the state of Wyoming.

EPA's policy on herbicides and herbicide-fertilizer mixtures is as follows:

1. An herbicide or mixture of herbicides may be mixed

with other pesticides and/or with fertilizers if the mixture is not prohibited by the labeling.

2. Two or more herbicides and/or pesticides may be mixed if all the dosages are at or below the recommended label rate.

When making such mixtures it must kept in mind that these pesticide mixtures are applied at the applicator's own risk with respect to effects on crops, application equipment, applicator safety, environmental effects and residue tolerance.

MIXING HERBICIDES

Always be sure the sprayer has been properlycalibrated. Calculate the amount herbicide to add to thesprayer tank based on the active material in each gallon ofherbicide concentrate, or the percentage of active ingredientof dry herbicide formulation. Always read and follow the instructions on the manufacture's label pertaining to personal hazards in handling.

The following steps should be taken when mixing herbicides:

1. Fill the sprayer tank with at least half the volume of wateror fertilizer solution you will ultimately need.
2. Start continuous moderate agitation.
3. Add compatibility agents if needed. For maximum benefit, they must be in solution before herbicides are added.
4. Add, mix, and disperse dry herbicides (wettable powders,dry flowables, or water dispersible granules). Theseformulations contain wetting and dispersing agents that aidin mixing.
5. Add liquid flowables and allow thorough mixing. These also contain wetting and dispersing agents.
6. Add emulsifiable concentrates (EC's) and allow thorough mixing.
7. Finish by adding water soluble formulations (2,4-D amine, etc.).
8. Add any surfactants, crop oil concentrates, etc. last.

Crop oils, especially, do not mix and disperse well if added first.

9. Add remainder of water or liquid fertilizer and maintain agitation while spraying until tank is empty.

Never pour concentrated herbicides into an empty tank.

Never allow a sprayer containing mixed chemicals to stand without agitation, as heavy wettable powders may clog nozzles or settle into corners of the spray tank. Wettable powder herbicides should be pre-slurried before addition to a spray tank. Adding the wettable powder directly to the spray tank can result in globs or unwetted material in the tank where it can clog spray equipment. This is particularly a problem with the more finely ground wettable powders.

Tank mixtures of a wettable powder and an emulsifiable concentrate can cause problems if not properly mixed. The proper procedure is to first pre-slurry the wettable powder and add it to the tank 3/4 full of water.

The emulsifiable concentrate should then be added followed by the necessary water to fill the tank. If the sequence is reversed with the wettable powder added last, problems can arise.

FERTILIZER AND HERBICIDEMIXTURES

The mixing of liquid fertilizers and pesticides and applying at the same time has several advantages. The mixture can save time, labor, fuel, and may help reduce soil compaction.

There could be mixtures of a herbicide + fertilizer = "weed + feed"; fertilizer + insecticide = "feed and worm"; herbicide + insecticide = "weed + worm". The following material will only be concerned with the "weed + feed" concept of mixing herbicides with liquid fertilizers.

Even before checking the compatibility of herbicide + fertilizer mixtures, other factors of importance must be taken into consideration.

1. Do you have the right equipment for application?

Fertilizer application is not as exacting as for applying herbicides.

Uniform application covering every square inch is essential for the effectiveness of herbicides.

The equipment ordinarily used for applying fertilizers does not give the uniform distribution pattern that equipment used for herbicide application provides. Some fertilizer application equipment does not have the agitation necessary to keep herbicides uniformly dispersed. Herbicide application equipment may not be able to withstand the weight and corrosiveness of liquid fertilizers nor apply the necessary volume of liquid fertilizer.

2. Are mixtures of herbicides and fertilizer practical? The applicator must determine if the timing of application, placement and distribution of each component in the mixture are similar enough to be applied as a mixture. Several herbicides and fertilizers can be applied at the same time. For example, AAtrex (atrazine) can be tank mixed with liquid fertilizer and applied to corn either preplant incorporated or broadcast on the soil surface after the corn is planted but before the crop emerges. Placement of the mixture may raise a question of practicality. Suppose a farm operator sprays the herbicide and fertilizer mix over the corn row, in a band, at planting time. By using a nitrogen solution as a carrier for the herbicide the nitrate form of nitrogen will be incorporated by rainfall. If the ammonium (NH_4) form of nitrogen is used as a carrier and soil surface applied, it will react with the soil particles and be held in the top 1/4 inch of soil. This nitrogen will move downward only after being converted to the nitrate form. If the fertilizer carrier for the herbicide is a solution containing nitrogen and phosphorus it will have to be positioned in the soil near the roots for plants to adequately utilize it as phosphorus does not move readily in most soils. If the nitrogen and phosphorus fertilizer solution is banded over the corn at planting time, the corn will not benefit fromthe phosphorus as a starter in early plant growth. Thus, thiscombination would not be practical from a placement standpoint.

3. Distribution of the mixture. Liquid fertilizers are usually broadcast over the entire field. Applying the herbicide in

with the fertilizer means broadcasting of the herbicide also.
Many herbicides can be band applied, a practice which
reduces the total cost of the herbicide per acre in proportion
to the row-spacing and width of the band treated.
Therefore, the total benefits and economics of mixing
should be taken into consideration.
4. Is the fertilizer-herbicide mixture compatible?
Herbicides may not always mix evenly throughout the liquid fertilizer or the components may separate making their use impractical. A simple test should be used before mixing large quantities.

COMPATIBILITY

Even though guidelines have been presented with respect to tank mixes there still remains the question of compatibility when mixing two or more chemicals,especially, when directions for mixing and application are not included on the label.
Both chemical and physical incompatibility are possible. With chemical incompatibility the chemical maybe completely deactivated, resulting in no weed control, or
the chemical might be made highly phytotoxic resulting in
damage to the crop. It is also possible to change the
mammalian toxicity making a normally safe chemical highlytoxic.
Physical incompatibility is most commonly evidenced
by precipitation in the spray solution which takes the form
of crystalline solids, formation of a gelatinous mass, or
separation of components which takes the form of layering.
Lack of compatibility may only result in the formation of a
substance that plugs up screens and nozzles, however,
extreme incompatibility may produce a settling out of
material that can harden like concrete in the bottom of a
tank and in hoses, pumps, and other internal parts of the
sprayer. The result may be total loss of the pesticide and
use of the sprayer.
Chemical compatibility of a mixture is impossible to
determine without extensive research being conducted,
whereas physical compatibility can easily be checked.
You should use only labeled tank mixtures or mixtures
recommended by experienced scientists whose

recommendations are backed by research. For all unlabeled tank mixtures, a jar test is strongly recommended to test for the compatibility of herbicide-herbicide mixtures, herbicide-insecticide mixtures, herbicide -fertilizer mixtures,or any combinations involving pesticides and/or fertilizers.

In some cases, adding a compatibility agent (Complex, Unite, or comparable surfactants) may aid in maintaining component dispersion.

JAR TEST FOR COMPATIBILITY

The jar test may be used to test the compatibility of herbicides with each other or herbicides and other pesticides with liquid fertilizers.

1. Add 1 pint of carrier (water, liquid fertilizer) each to two quart jars. Mark the jars with an identifiable letter, number or other means. Usually "with" and "without" is the most practical (representing with and without compatibility agent).
2. Add 1/4 teaspoon or 1.2 ml of compatibility agent to one jar (equivalent to 2 pints per 100 gallons of spray solution).
3. To each jar add the required amount of pesticide in the order suggested in the section on mixing herbicides Shake well after each pesticide addition to simulate continuous agitation.
4. When all ingredients are added, shake both jars for 15 seconds and let stand for 30 minutes or longer. Then inspect the mixture for flakes, sludge, gels, or non dispersible oils, all of which may indicate incompatibility.

If, after standing 30 minutes, the components in the jar with no compatibility agent are dispersed, the herbicides are compatible and no compatibility agent is needed.

If the components are dispersed only in the jar containing the compatibility agent, the herbicide is compatible only if a compatibility agent is added.

If the components are not dispersed in either jar, the herbicide-carrier mixture is not compatible and should not be used.