Design of Farm Machinery

Prof. Hifjur Raheman
Agricultural and Food Engineering Department
Indian Institute of Technology Kharagpur
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Lecture 40 : Liquid chemical applicators

Hi everyone, this is Professor H. Raheman. I welcome you all to this SWAYAM NPTEL course on Design of Farm Machinery. This is lecture 40, where I will try to cover liquid chemical applicators. The concepts which will be covered include the need for pesticide application and the classification of sprayers. Let us now see what the different pesticides available are.

Pesticides could be fungicides, herbicides, growth-regulating hormones, rodenticides, larvicides, or insecticides. These are so many options available. Again, the pesticides may be water emulsions, solutions, or suspensions of wettable powders. Liquid pesticides may be applied for use in direct contact type or systemic type.

That means there are two versions: either you use direct contact type or systemic type. Direct contact type means it will kill insects, fungi, etc., by coming into direct contact. That means the chemical you apply has to come into direct contact with these insects or fungi. So, to be effective, full coverage of the target is necessary. That means the crop must be properly covered with chemicals; only then can you carry out this by contact, and only then can the insect be killed.

To do this we have to have smaller droplets, so that you can uniformly cover the crop canopy. Then in systemic pesticides application, we apply at the soil surface. So, the roots will take up and then it will translocate within the plant. Full coverage of plant is not required. So, there you can go for larger droplets.

So, no physical contact is there between insects and liquids. So, you can go for bigger droplet size. And when you go for bigger bigger droplet size obviously, there will be less prone to drift. Let us now see what are the different - how do you classify this liquid chemical application based on application rate. So, there are five classifications. I have given one for field crop, the other one is for - this side is for field crop, the other side is for trees and bushes. When I said high volume, high volume spraying that means, the

application rate is greater than 600 liter per hectare. when it is medium volume it is between 200 to 600 liter per hectare and if it is low volume this is 50 to 200 liter per hectare, if it is very low volume 5 to 50 liter per hectare and if it is ultra low volume less than 5 liters per hectare. So, this is applicable to field crops. Now, if you go for trees and bushes, the same high volume spraying the quantity you can see is greater than 1000, 1000 liter per hectare and for medium volume, 500 to 1000 and for low volume, 200 to 500 and for very low volume, 50 to 200 and for ultra low volume, it is less than 50.

So, depending on the type of crop or the trees, we have to select what should be the values of high volume, what should be the values of low volume, or what should be the value of ultra-low volume. Then, the other method of classification is by the method which you follow to carry out this application - either you can apply pre-planting, or you can apply during planting, or you can apply post-planting. Just like in dry granular application, the same thing. In pre-planting applications, generally, we apply fertilizers and herbicides, and they may include subsurface or surface application. So, the applications of aqua ammonia and anhydrous ammonia fertilizers - these are usually subsurface applications. Their application is accomplished by a specially designed knife or chisel injector. So, when you apply liquid chemicals during planting, usually it includes fertilizer and herbicides. Post-planting chemical application includes fertilizer and all types of pesticides.

Liquid chemical application methods may be further divided based on the area covered. Based on the area covered, we can divide it into three types: one is broadcasting, banded, and direct spray. So, let us see: what is broadcasting? So, if you look at the figure, this is the broadcasting method - that means the crop is getting liquid chemicals uniformly, that the chemical is applied uniformly on the ground or on the crop. So, if you see this is the case. Now, the second one is banded application. Banded application means we apply chemicals in narrow strips. So, if you look at this one there is a spray band here. You can see there is one row we are only applying in this row. We are not covering this area. Row to row spacing is there, one row is here the other row is here. So, you are just applying to cover this much area not the entire row. So, thereby you can minimize the chemical application. So, the chemical is applied in narrow bands or strips.

The third one is directed apply. Directed apply means, the crop is getting sprayed from different directions. So, several nozzles are used and they are directed to spray for row crop applications. So that you can have complete coverage this is suitable for direct contact type spraying.

Then let us see what are the equipment available for liquid chemical application. One is subsurface application, surface subsurface application is usually used for liquid chemical fertilizer in the form of anhydrous ammonia or aqua ammonia. These are pressure liquids because they have a vapour - high vapour pressure which will create the flow - flow of ammonia. Usually anhydrous ammonia contains about 82 per cent of nitrogen and its boiling point is minus 28 degree Fahrenheit. When you add water to this then it becomes aqua ammonia. It will reduce the vapor pressure and it contains only 20 to 25 per cent of nitrogen. It has higher boiling point and low pressure.

So, with anhydrous ammonia and aqua ammonia, it is essential that the material be released in narrow furrows because if you allow it to be applied on the soil surface, the ammonia will be lost to the atmosphere and will not be utilized by the plant. So, immediately we have to cover it. So, that is why you have to always apply this, whether it is aqua ammonia or anhydrous ammonia - below the soil surface. So, we have to have a special opening device, and then we have to close the furrow after application.

If you are utilizing anhydrous ammonia, it should be released at a greater depth - 10 to 15 centimeters. If you are applying aqua ammonia, it has to be applied at a depth of 5 centimeters because it has less vapor pressure and is less volatile. A loose, friable soil with adequate moisture is important for good sealing, meaning it will trap the available ammonia. Otherwise, if you do not apply it below the soil surface, the ammonia will be lost. In a few cases, press wheels are also used to completely trap the nitrogen present in the applied solution.

This is a schematic diagram for an ammonia applicator. You can see there is a tank where the liquid ammonia is stored, and the ammonia will come out due to the vapor pressure. Once you open the valve, the ammonia will come out. Then there is a distribution system to regulate where it goes. There are different outlets, and at the end, this is the unit operated below the soil surface, with a tube that applies the ammonia. The soil surface has to be closed immediately after application; otherwise, the ammonia will be lost. So, the applicator blade or furrow opener is the unit for applying anhydrous ammonia.

For applying anhydrous ammonia. There is an outlet you can see through which you can apply. The tube will be connected, and since this is operating at this depth, the soil will be covered. So, ammonia will not be lost. Then you come forward to classify the sprayers. So, this classification is based only on the basis of pressure - the pressure at which the liquid applicators are operating.

So, when there is no pressure, the flow is by gravity. Then we call it a non-pressure liquid chemical applicator. OK. Then, low-pressure sprayers, high-pressure sprayers, then air-carrier sprayers. So, the classification is: non-pressure liquid applicator, where you do not maintain any pressure that means the flow is due to gravity. Then, low-pressure sprayers, very low-pressure sprayers, and then high-pressure, a little above and the air-carrier sprayers. We will discuss them one by one. The non-pressure liquid applicator, as I said, is a non-pressure liquid applicator, meaning the flow is by gravity. So, how do you control it - the flow rate - by increasing or decreasing the opening size of the orifice.

So, the setup usually will look like this. There will be a bowl which will be used for storing liquid and at the end there is an inlet through which liquid will be kept inside and there is an outlet and the cut-off device that means, shut-off device which will control the flow whether you want flow or you do not want any flow. Then there is the opening size which is opened due to this cut-off valve or the shut-off valve. That opening size will decide what will be the flow rate.

The only problem associated with this type is when the liquid is filled up to this level, then the pressure is different, the flow rate is different. Now, once you start carrying out the spraying action then the liquid level will come down. So, the discharge will reduce that is the only problem associated with this kind of non-pressure liquid chemical applicator. So, to get rid of that we have to provide an inverse siphoning system which is otherwise a bent tube which would be inserted into the tank, where the liquid is stored and the bottom of that pipe is very close to the bottom of the tank on which the liquid is stored. So that the discharge rate is now with respect to this head. Not with respect to this head. So, this head which I have indicated is very close to the bottom of the tank, hence we try to get rid of the variation which is there due to this change in height of liquid inside the tank. So, whenever you use this type of arrangement you have to have a bend tube to overcome this difficulty. So, the typical components of a liquid non-pressure liquid chemical applicator are a sediment bowl which will store the liquid, then there will be one or two orifices, then the orifice could be of different sizes, then shut-off valve. These are the three major components. As I said significant variations in flow rate can occur due to change in head, unless the tank has a high elevation relative to its depth of or uses of bottom venting. So, unless the tank has a high elevation relative to its depth of or uses of bottom venting. And the bottom venting is nothing but a bent tube which will be put into the tank, and this portion should be sealed; otherwise, we want to maintain this pressure with respect to that. Then, with a given orifice size and head, the application rate per hectare is inversely

proportional to the forward speed. So, the other version of a non-pressure liquid applicator is a pump. We can see it is a pump, but it is rotated by taking power from the ground wheel. It is simply rotating, which is called a squeeze pump. These are available with 20, maybe 20 or more tubes, each serving for one applicator. This is a positive displacement, ground-wheel-driven pump which produces a flow rate that is proportional to the ground speed. If you increase the speed, the flow rate will increase, okay. So, the application rate is adjusted by changing the speed ratio between the reel and the ground wheel. And this can be utilized directly for applying liquid on the soil surface, okay, or on solid-planted crops.

The banded application of non-pressure liquids is sometimes made during a row-crop planting operation or as later side dressing. You can have one tank provided for two rows. Then, the liquid which is discharged close to the furrow is with the help of smaller tubes. Then comes your low-pressure sprayers. Low-pressure sprayers usually operate in the range of 150 to 350 kilo Pascals, and the application rate is between 50 to 200 liters per hectare. However, in some ultra-low-volume applications, the rates may be as low as 10 liters per hectare or a few milliliters per hectare.

The sprayers are used to apply pre and post-emergent chemicals to control weeds, insects and diseases. The examples are boom type sprayer, the boom type sprayer mounted on the tractors, on the trucks, the trailers and the air-craft mounted low pressure sprayers, the knapsack sprayers these are low pressure sprayers. The tank on the tractor-mounted sprayers, they can hold 575 to 1000 liter capacity. So, the tank - the maximum capacity is 1000 liter for application in standing row crop, high-clearance sprayers have been developed. That means, you can raise or lower the height so that it can accommodate the height of crops. The spray boom may be raised or lowered depending on the crop height as this is mounted to the three-point linkage. So, you can easily - hydraulically you can lift it or lower it. The other possibility is, the sprayer can be mounted on a trailer or wheels and it can be pulled through in the field by a tractor. Again the tank capacity can go up to 3750 liters and the boom width is varying from 4 to 12 meter that is a higher coverage. These are some of the pictures related to boom type sprayers, various types of power-operated hydraulic sprayers you can see.

The boom is made up of different sections. You can fold this. Suppose you do not want spraying in all these sections, then you can cut off the supply of liquid. So that you can only target in particular sections. These are to be mounted to the tractor three-point linkage. You can see here it is mounted to the tractor three-point linkage. The entire weight is

supported on the tractor, not an external wheel, which is used, and the power is taken from the PTO to run the pump.

Then, the aircraft-mounted low-pressure sprayers have the advantage of rapid coverage and applying chemicals when conditions are otherwise unsuitable for ground rigs. The lifting capacity is another problem. Because of the limited weight-carrying capacity, aircraft-mounted sprayers are most suited for low application rates, less than 50 liters per hectare. And the speed can vary from 50 to 125 kilometers per hour for airplanes and 175 to 250 kilometers per hour for helicopters. So, you can carry out this spraying at a height of 1 to 8 meters above the crop.

Then comes the high-pressure type sprayers. These are usually suited for orchard spraying. We require a pressure of up to 7000 kilo Pascals, and they do not have a boom, just like in low-pressure sprayers. The high-pressure sprayers do not have a boom; only one or two nozzles or multiple nozzles are provided. So, the target is to cover the crop canopy - the mangoes, the guavas, the sapotas. If these kinds of crop orchards are there, then these are the best-suited sprayers. These are expensive because you have to incorporate high pressure. To create high pressure, we need more engine power, and there will be more engine vibration. So, high pressure will be developed.

Then comes your air-carrier sprayers, as the name says, air-carrier sprayer. So, that means what we do here is the liquid is first atomized with the help of a nozzle. It could be a hollow cone nozzle, a fan-type nozzle, or a solid cone nozzle. So, a nozzle is used to atomize the liquid first, then the atomized liquid is carried by a blast of air. The air has to be forced to carry these liquid droplets. So, we need a centrifugal kind of - centrifugal blower to carry the liquid droplets which are formed because of the nozzle. The air flow rates can range from 2.5 to 30 m^3 per second and the speeds can range up to 125 to 240 kilometer per hour. Since, air is used to carry the pesticide to the target, concentrated pesticides can be used. So, resulting in a substantial saving in the amount of water needed to carry out the liquid spraying. Then these are some of the pictures which I showed you - tractor-operated air blast sprayers and then air-carrier sprayer utilizing a cross-flow fan and a rotary control droplet atomizer. So, this is the unit which will atomize. Then air is blown. This is a centrifugal blower with air will blow and the liquid which are formed - droplets are formed that will be carried away by the air. The other way of classifying is on the basis of energy utilized, energy utilized for atomizing the liquid. Energy utilized let us see what are these energy utilized one is hydraulic energy, the other one is pneumatic energy, the third one is rotary rotary that means, centrifugal force. The first one is hydraulic energy. The hydraulic

energy sprayers are devices that use hydraulic pressure to atomize and distribute liquids as a fine mist.

Now, they work by forcing the liquid through a high pressure pump and through a nozzle. Finally, the pressurized liquid is to be forced through a nozzle where it will be broken into smaller droplets. We require to break the liquid into finer droplets so that more area can be covered. Then the gaseous energy sprayer which is otherwise your air. So, the air is used to carry out this.

So, compressed gas such as air is used to atomize the dispersed liquid into a fine mist. That is the concept. Unlike hydraulic sprayers, which rely on liquid pressure, these sprayers utilize gas pressure to propel the liquid through a nozzle, breaking it into smaller droplets. Then, the centrifugal energy sprayers - sprayers that use centrifugal energy use a rapidly spinning disk or cup to atomize liquids into fine droplets or a fine mist. The liquid is fed onto the spinning surface, meaning you can feed it on top. This disk has to be rotated, and because of centrifugal force, the droplets will be flung outward, breaking into tiny droplets. You can have serrated edges or plain edges. I am talking about cups. So, that will further make the droplets finer, and if you have a serrated edge, it will have better uniformity in droplets.

So, these are some of the references we use. In summary, I can say we discussed the need for chemical liquid application and the ways by which you can apply liquid chemicals. Then, we tried to cover the classification of equipment used for chemical application, different ways of classification, and the different equipment available under each category. That's all.

Thank you.