

IV. FUNGICIDES AND THEIR APPLICATION

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Crop protection now has claims as a separate science and has made tremendous advances in recent years. The first International Crop Protection Congress was held in 1949. The meeting was held in London and was attended by representatives from all over the world.

The main divisions of the subject are:—

1. Control of insect pests.
2. Control of fungus diseases.
3. Control of weeds.

Although our main concern is with the control of fungus diseases, I will attempt to give you some sense of perspective.

Control of Insect Pests.

On the whole this mainly involves eradication, although prophylaxis has a place in crop protection against insect pests.

1. The most desirable approach is by biological control. An example of this is the control of locusts by *Macrocentrus*.

2. In recent years great strides have been made in the development of amazingly effective chemicals which, at extremely low concentrations, kill a wide range of insects and which leave deposits from spraying or dusting which persist in their toxic effects. Gammexane and D.D.T. are two examples of insecticides with persistent effect.

Insecticides also vary greatly in their effect on different groups of insects. Gammexane and D.D.T. are particularly effective on caterpillars, mosquito larvae and flies.

Some insecticides are mere stomach poisons and have to be eaten — lead arsenate is an example. Gammexane and D.D.T. can act as stomach poisons.

Some kill by contact — Gammexane and D.D.T. are also contact poisons. Other contact poisons depend on volatility and act as respiratory poisons. Nicotine is an example of this class.

Some are gases such as hydrocyanic acid which is used for fumigation.

3. Insecticides based on oil emulsions suffocate insects.

4. The latest development is in systemic insecticides which are absorbed by plants and render their juices toxic to sucking insects for a prolonged period. Some insects, such as scales and aphids, concentrate large amounts of sap and gradually accumulate toxic doses of systemic poisons which are present in the plant in very low concentrations.

Prophylactic insecticides mainly rely on destruction of eggs, as with winter washes, although some leave a toxic deposit which also acts as a prophylactic.

Control of Weeds.

This branch of crop protection has developed enormously in recent years. Modern weedicides or herbicides, as they are now called, are usually cell poisons and cause distorted reproduction or cell division. They are generally absorbed from wet sprays and are highly specific.

In general they have been developed for their toxicity to dicotyledonous plants, or weeds, which grow in monocotyledonous crops — mainly cereals. Cereals belong to the same family as grasses, and since our problem is to control "monocots" in a "dicot" crop, they have not been of much value to us so far.

There are some general weedicides such as sodium chlorate and sodium arsenite, but these are only really useful in fallows and are difficult to apply to standing crops.

Control of Fungicides Diseases.

Fungicides are much more akin to weedicides than insecticides. A fungus is a weed growing on the crop itself instead of in the soil. There is hope of development through weedicides. Some chemicals are known to be absorbed through the leaves and stems of higher plants without ill effects but are showing signs of being toxic to lower plants or fungi. We therefore hope that fungicides with systemic action will soon become available.

Insects move about and more generally live on the surface of plants and the problem of eradicating them is relatively simple. They walk into the poison traps laid for them. Fungi, on the other hand, are generally only vulnerable during the disposal of infective material — usually spores. Once a fungus has gained entry into the plant tissue it is not usually susceptible to control methods. Fungicides are therefore mainly prophylactic and a fine film of fungicide has to be spread over the entire surface of the susceptible tissue of the plant to give protection.

Similar difficulties do occur with insects, and I give you the example of the shot-hole borer in tea which lives in galleries remote from normal control by insecticides.

The difficulties involved in controlling fungus diseases are therefore considerable and there have been few developments in fungicides comparable with the discovery of the insecticides Gammexane and D.D.T.

However, we hope for developments in the not distant future. Possibilities are —

1. Fungicides with systemic action.
2. Micro fungi parasitic on the fungi to be controlled. This would constitute biological control and, to some extent, brown blight does exercise a control of blister blight. It can only gain entry to tea through damaged tissue and crowds out blister blight and prevents sporing. Unfortunately, when it does gain entry it damages more tissue than the comparatively circumscribed blister.

At the present time fungicides are mainly inorganic.

I. Inorganic Fungicides.

Inorganic fungicides are most often compounds of mercury, sulphur or copper.

1. **Mercury Salts.** Mercury salts are generally extremely poisonous. They are usually too poisonous to both higher plants, and animals which consume them, to be used as sprays. Mercuric chloride, in concentrations as low as 1/10,000, is very toxic to most fungi but scorches badly. It is also very soluble and washes off in rain.

Complex organic compounds containing mercury are widely used as seed dressings to check seed borne disease and to afford protection during germination.

(Culture tubes with dressed and undressed tea seeds were demonstrated.)

2. **Sulphur.** Sulphur in the elementary form is very toxic to many fungi. It has very little action on most higher plants and is insoluble and rainfast. Various compounds of sulphur are much more effective than elementary sulphur but are more liable to cause scorch. Elementary sulphur does not control blister blight but lime sulphur gives a reasonable degree of control. Lime sulphur however causes very marked taints in tea.

3. **Copper.** Copper salts are very toxic to most fungi but soluble forms such as copper sulphate scorch plants and are not rainfast. Insoluble compounds such as cuprous oxide and copper oxychloride retain their toxicity, are innocuous to most higher plants, and are highly insoluble in water. They are presumably sufficiently soluble in dew and rain to kill spores at some distance from the actual particles of copper.

This is illustrated by the control of fungus growth on culture plates at some distance from a small spot of copper fungicide.

(Petri dish cultures were demonstrated).

The blister blight fungus, *Exobasidium vexans*, is extremely susceptible to copper fungicides. Provided they are finely divided, and evenly distributed, copper fungicides give a very high degree of control.

II. Organic Fungicides.

The number of organic fungicides becoming available is increasing almost daily. They are proving to be highly specific in action, i.e. to control only one fungus disease, and have important applications in the control of diseases which are not particularly susceptible to copper or sulphur compounds. They are more likely to be absorbed than insoluble inorganic fungicides and are being closely examined for systemic action.

Blister blight is so susceptible to copper fungicides that it will be difficult to find organics which are more effective than copper compounds.

I will therefore now confine myself to a description of copper fungicides.

Copper Fungicides. The first use of copper fungicides was (generally supposed to be) in the wine growing district of Bordeaux. The toxic or scorching effect of copper sulphate was greatly reduced by forming a complex insoluble compound with lime.

Freshly made Bordeaux mixture is still one of the most effective copper fungicides. Its efficiency falls off rapidly after mixing and it settles very rapidly. Bordeaux mixture adheres to foliage very well but does not spread easily.

(Demonstration).

Burgundy mixture is made by substituting washing soda for lime. This spreads more easily but does not stick so well. A similar fungicide may also be made with ammonia or ammonium carbonate. These home-made mixtures are troublesome and have to be made up carefully. They deteriorate quickly, settle rapidly and are very corrosive to equipment.

Modern proprietary formulations are more satisfactory in commercial practice. They are mostly manufactured from the insoluble compounds cuprous oxide and copper oxychloride.

The manufacture of fungicides from cuprous oxide and oxychloride is a matter of technical skill and control.

1. They must be extremely finely ground. It is obvious that for 5 ozs. of fungicide to be able to spread evenly over all the upper leaves in an acre of tea it must be ground to an extremely fine state of division. The chemical

activity of most substances increases with grinding and this is apparently the case with fungicides.

2. They must disperse in water quickly and easily and remain in suspension for long periods. This is again a matter of grinding but the incorporation of wetting agents is of considerable assistance.

(Demonstration).

3. They must spread easily over plants when sprayed in water suspension. The incorporation of wetting agents assists them to spread. The wetting agent also causes the water in which the fungicide is suspended to form smaller droplets, i.e., increase atomisation. Fine atomisation is essential where low volume spraying technique is employed.

4. They must stick to plant surfaces and not wash off too easily in rain. Again the finer the state of division, the better the adherence but chemicals known as "stickers" are also added in many preparations.

So far, I have assumed that the fungicide is to be dispersed in water. When water is used as a vehicle, I must stress the importance of fine atomisation to obtain the full benefit of the processing into fine particles. The full benefit of extremely fine grinding cannot be obtained with coarse sprays and I will deal further with this matter in my lecture on application. The incorporation of wetting agents with the fungicide helps to improve atomisation.

(Demonstration).

Dusts. Instead of water, substances also finely ground, such as china clay or kaolin and french chalk or talc may also be used as vehicles for copper fungicides.

The requirements in this case are:—

1. A finely ground carrier which floats in wind currents and which adheres to plant foliage.

2. Processing in such a way that the copper compounds adhere to the carrier and do not merely winnow out.

Unless these requirements are met, control will be very poor and the distribution very faulty.

Mists. Although suspensions of finely ground copper fungicides may be finely atomised and blown in air blasts as mists there are two complications.

(a) Fine atomisation of water is difficult.

(b) Finely atomised water evaporates very quickly.

There are possibilities for mechanical ejection of mists from power operated machines but effective ranges will be limited. The most favourable conditions will exist in the south west monsoon when humidity is high and wind currents are available to carry the mist.

A further possible development of this technique is the oil mist. Clean Crops Ltd.'s Micron sprayer is at present based on the possibilities of very fine atomised oil. Light oils atomise much more easily than water and do not evaporate at the same speed. We are exploring the possibilities of oil soluble copper compounds. Materials in solution are divided into molecules, which state of division is impossible by mechanical grinding. Copper naphthate which has limited solubility in oil is at present under test. We hope that other oil soluble copper compounds will be available this year.

(A film entitled Modern Copper Fungicides, loaned by Plant Protection Limited, was shown at this stage of the lecture).

The Application of Fungicides.

The film called "Atomization", loaned to us by Shell Company, which is to follow this lecture, will explain many points much more clearly than I can hope to do by lecturing. The point I wish to make is that low volume spraying is an exact technique and that the equipment must be carefully chosen and operated under controlled conditions. Above all, I wish to emphasise that a spray nozzle is not merely a hole drilled into a piece of brass.

The main difficulties with the application of fungicides at low volumes are:—

- (a) we wish to distribute 5 ounces of extremely finely ground fungicide particles as evenly as possible over an enormous surface area.
- (b) to do this, we must have very fine droplets to get the best distribution possible and to get a quick dry, if possible.
- (c) since water is heavy, and not always readily available, we wish to use as little as possible.
- (d) as we are frequently up against high winds, the spray must not be so fine as to drift away too easily.

At the present moment the most practical compromise is the pressure retaining knapsack equipment fitted with a nozzle which will give a moderately fine spray at an output of 10—12 gallons per acre. The main disadvantage of the knapsack type of equipment is that as the spray fluid is exhausted, so the pressure within the knapsack gradually falls. The nozzles to be used with such equipment in Ceylon are designed to operate over a pressure range of from 40 to 80 lbs. per square inch. It is most important that you should realise that the spray nozzles are specially designed to give uniform results over this specific range of pressure. Figure 1 illustrates a simple type of spray nozzle.

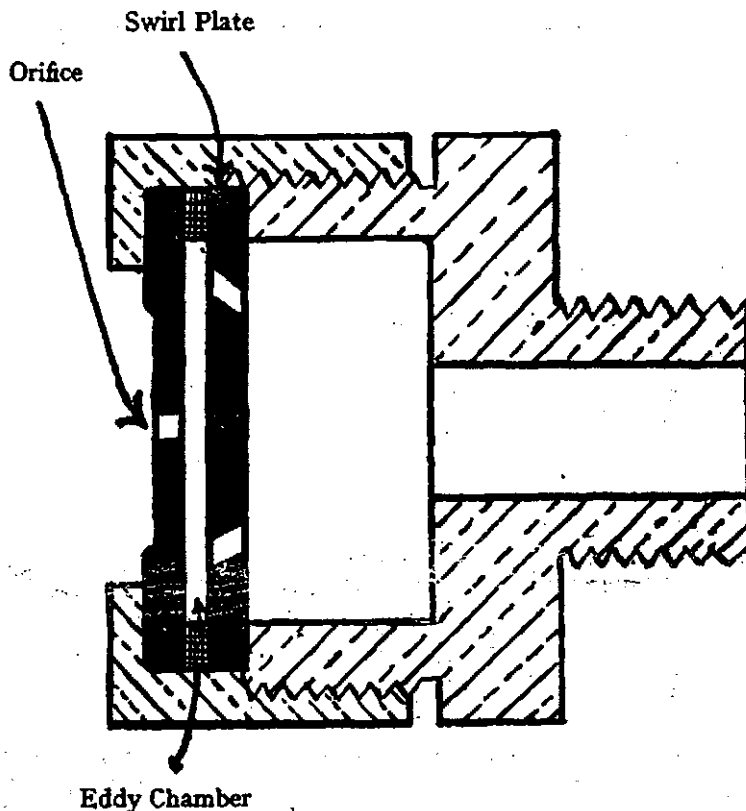


Fig. 1. A simple type of spray nozzle.

There are many variations and modifications of this so called "swirl atomization" type of nozzle but the basic principles are the same for all types. In Table 1 are given a list of the various factors which influence the character of the spray issuing from a swirl type of atomiser.

Table 1. *Spray Factors.*

I. Amount	...	...	(a) Orifice (b) Pressure (c) Depth of Eddy Chamber
II. Droplet size	...	...	(a) Pressure (b) Swirl plate (c) Depth of Eddy Chamber
III. "Carry"	...	...	(a) Pressure (b) Droplet size (c) Swirl Plate
IV. Shape	...	...	Orifice

I am indebted to Mr. F. W. J. Lane of Plant Protection Limited for the following summary of the principal points in connection with swirl atomisers:—

(A) Output.

A number of simple factors contribute to the amount of spray passing through the nozzle in any given period of time. These are:—

- (1) *The size of the orifice.* The only function of the size is the control of the amount of fluid passed. It does *not* determine the droplet size of the spray.
- (2) *The pressure.* The greater this is, then the greater the output and *vice versa*. This is, however, not in direct proportion. For example:—

Pressure in lbs. per square inch.	30	60	90
Output in gallons per hour.	7.2	9.00	10.5
	← diff. 1.8 →		← diff. 1.5 →
Diameter of orifice	.032"		

As the pressure increase so does the output, for each successive increase, decrease.

- (3) *Depth of eddy chamber.* The greater this depth the greater the rate of flow and *vice versa*.

(B) Droplet Size.

Factors determining droplet size are:—

- (1) *Pressure.* Increased pressure will cause increased atomisation.
- (2) *Design of swirl plate.* A swirl plate drilled or slotted with small holes round the periphery will place a greater interference on the straight flow of the fluid than will larger holes and will result in a finer spray being projected, i.e., the swirling effect is increased.
- (3) *Depth of eddy or swirl chamber.* The greater the depth of this chamber then the less will be the interference in the flow of the liquid to the orifice. In this case larger droplets will emerge from the nozzle than would be the case if the depth of the chamber was small.

(C) **Carry.**

Factors determining "carry" of spray:—

- (1) *Pressure.* The higher the pressure the greater the "carry" for any given size of droplet.
- (2) *Droplet size.* Large droplets will "carry" very much further than small droplets if the same amount of energy is imparted to each. Try throwing a pebble and then a grain of sand.
- (3) *Design of swirl plate.* If a central hole is drilled in a swirl plate, already fitted with holes round the periphery, it will be found that the droplets will be coarser and the spray will carry further.

(D) **Shape.**

- (1) There are two types in common use. Firstly, the simplest in design which gives a flat fan shaped spray and the second, a little more complex, which can be made to give sprays ranging from a wide hollow cone to a straight jet of water.
- (2) For the nozzle giving a flat fan shaped spray it is claimed, correctly, that a wider distribution of the spray is given for each gallon of liquid passed through it. The hollow cone type enables a wider variation in types of spray pattern to be achieved but the swathe width is narrower than is the case with the fan shaped spray. There is normally less drift with this type of nozzle.
- (3) The nozzle giving the flat fan shaped spray consists of a body to hold the component parts, a fine mesh filter and a filter body and an orifice tip. The orifice itself is usually elliptical in shape and this determines the shape of the spray.
- (4) The hollow cone nozzle consists of a body for the components. A metal orifice disc which, in the better made equipment, is usually of hardened stainless steel. A brass (usually) disc is positioned immediately behind the orifice disc and separated from it by a brass or rubber washer. This is known as a swirl plate and there are many designs to give a variety of types of spray. The space between the orifice disc and swirl plate is known as the swirl or eddy chamber and is an extremely important item in determining the ultimate shape of the spray.

It is therefore obvious that the nozzles used with knapsack spraying equipment must be specially chosen. They must be designed to operate efficiently over a chosen range of pressures. The washers and fittings, in components such as eddy or swirl chambers, are of exact dimensions and must be replaced with correct spare parts. Assemblies must be kept in good order and orifices must on no account be cleared, if blocked, by hard wire or steel needles which are liable to distort the shape. A blocked orifice plate or tip should be replaced in the field, by a spare part and later cleaned by soaking or boiling.

Orifice plates or tips should be replaced as soon as they show signs of wear, as it is very false economy to use them once the output or character of the spray shows a marked change.

The employment of suitable equipment is of paramount importance. Pressure retaining equipment is more efficient because the mechanical efficiency in pumping a non-compressible fluid such as water is much higher than in pumping a highly compressible fluid such as air. When recharging with fluid is carried out with a central charge pump the correct pressure is much more likely to be maintained than when individuals are responsible for pumping a recharge of air with a "built-in" pump.