RECENT DEVELOPMENTS OF MACHINERY FOR APPLICATION OF WEED-KILLERS

by
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MR. RIDDOLLS: This paper reviews briefly the different methods of applying weed-killers by machinery that have been developed overseas recently, particularly in the United States of America and gives details of design and operating principles of the equipment.

Weed Control by spraying with various chemicals has been practised for many years. One of the disadvantages of the older methods of spraying was that the materials used required large quantities of liquid to be applied, often several hundreds of gallons per acre. The utility of this process was greatly limited by the necessity for frequent refilling of the tanks, the cartage of large quantities of water to the sprayer, the waste of power and weight of equipment necessary for hauling the large tanks of liquid over the fields, and the damage to the soil and crops caused by this heavy equipment.

The latest hormone weed-killers require only very small quantities of spray liquid per acre, as low as 2 or 3 gallons per acre. Spraying equipment has also recently been devised to apply these small quantities exactly with great accuracy. This is often called the low volume method. The effect of this development has made spraying for weed control much more practicable, by greatly simplifying the equipment and making it much lighter and more convenient to operate. This has been a most important development indeed. Another advantage of this method is that only low pressures are required of the order of 20 to 40 lbs. per sq. inch, and, with low volume also, very little power is required to drive the pumps.

Carriage of Equipment: The tanks of liquid and the spraying equipment have to be transported over the fields to apply the spray liquid. This can be done either over the ground surface or from the air. Ground spraying equipment takes several different forms. Probably the most common type is the tractor drawn trailer. The trailer carries the tanks of liquid, the pump and controls, and a boom fitted with nozzles. A two wheel trailer with 600 x 16 inch tyres is usually quite satisfactory. The pump is usually driven by a separate petrol motor, but may be driven from the tractor power-take-off. This equipment may also be mounted on a light truck. Another method is to carry the equipment on the tractor itself, when the pump is usually driven from the power take-off of the tractor. Then there is the light barrow type outfit for small gardens and playing areas, and also the hand sprayer, often of the knapsack type, or a bucket pump.

A method of spraying large areas much favoured in the U.S.A. is the carrying of the equipment in an aeroplane or helicopter. The helicopter is the type of aircraft that gives the most accurate spread, due to its low air speed, but they are very costly aircraft, costing 3 to 5 times as much as the normal type of aeroplane of comparable performance.

Generally, ground spraying is favoured in flattish land where a tractor or truck can operate, due to its greater accuracy and the fact that the spray doesn't drift so much and possibly damage crops or trees in adjacent areas. Aircraft spraying is much faster, however, and may be the only possible method over large areas and rough hilly country. The following are some details of the various parts of the sprayer.

Tanks: Metal tanks, sheet iron, stainless steel or aluminium are recommended. Wooden tanks are difficult to clean if it is desired to spray different material. The volume of the tank should suit the desired rate of spraying. For the more concentrated sprays, requiring only a few gallons per acre, one or two 44 gallon drums may be enough, but for larger quantities, tanks of from 150 to 300 gallon capacity are used. Two 44 gallon drums can easily be mounted on a tractor to carry the spray liquid.

Pumps: Two types of pumps are found on sprayers. First the positive type such as plunger, piston or gear pumps. These pumps cannot pump into a closed line without damage to pump or line, therefore when the shut-off valve

is closed a by-pass must be provided for the liquid to return to the tank. Second. There are centrifugal and turbine type pumps which are not positive in action, and do not require a by-pass. The main types of pumps in use on sprayers include:

- (1) Plunger or Piston Pumps: These are positive in action, and therefore require a by-pass. These pumps are typical of the orchard type sprayer, delivering a large volume at high pressure. Although high pressure sprayers are needed for penetration into trees and tall scrub, as for instance when spraying willows, they are not considered necessary for pasture and rowcrops. It may be possible to set the pressure regulators for low pressure, but as the high pressure orchard equipment, with powerful pump and motor, is costly, this type would not normally be selected for spraying weeds in pasture, rowcrops, etc. alone. Provided the regulators can be adjusted for low pressure, they would be useful for dual high and low pressure spraying. Great care should be taken if it is desired to use a high pressure orchard sprayer for weed spraying. It should be most thoroughly cleaned after using the selective weed-killers, or else great damage can be caused when orchard trees are sprayed for pest control.
- (2) Gear Pumps: Gear pumps are very simple, consisting of two gear wheels, one driven by the other. They are positive in action, & thus require a by-pass. They wear rapidly when pumping liquids with abrasive materials in suspension but are otherwise excellent for low pressure spraying. The gears should be made of bronze or other corrosion resistant alloys.
- (3) Centrifugal Pumps: In this type a motor is driven at fairly high speed. They are quite simple in construction, and single stage pumps are suitable for low pressure spraying. They are not positive in action, and thus do not require a by-pass, and can run with the shut-off valve closed.
- (4) Turbine Pumps: These are similar to centrifugals, but can produce the same pressure at lower speeds. They have the same characteristics as centrifugals, and are very suitable for low volume sprayers.
- (5) Power Unit: The pump may be driven by a separate petrol engine, or by power take-off. For low-pressure sprayers the power requirements are comparatively small - $\frac{3}{4}$, 1 and $1\frac{1}{2}$ h.p. motors being quite common. High pressure sprayers may have 6 or 9 h.p. motors.
- (6) Air Compressor: The hydropneumatic or air pressure system has an air compressor that pumps air into an air tight tank above the spray liquid, which is forced out to the nozzles. There is thus no difficulty in handling gritty liquids, and the pressure regulator and by-pass is replaced by a simple pressure relief valve. On the other hand, a relatively heavy and costly pressure tank is required.
- (7) Pressure Regulator: The pump itself is usually designed to provide more than adequate pressure at the nozzles at the maximum discharge at which it is desired to spray. Some means must then be provided for reducing the pressure at the nozzles to that required for spraying. For positive pumps, such as plunger and gear pumps, a spring-loaded regulator, typical of that fitted to high pressure orchard sprayers, is provided, of either the unloading or by-pass type. This can be set to maintain the pressure at the nozzles at any desired value, surplus liquid being discharged back through the by-pass to the tank. This also relieves the pump when the shut-off valve is closed. With centrifugal pumps, not positive in action, a simple control valve can be substituted for the pressure regulator, and no by-pass to the tank is required. The shut-off valve can be closed without harm to the pump.
- (8) Line Strainer: A line strainer is often provided on the line to the boom to prevent blockage of the nozzles. The ordinary cylindrical bronze gauge type strainer is quite satisfactory. It should be of 100 mesh gauge, and should be readily accessible for cleaning. A strainer is also often provided on the suction pipe where it leaves the tank.
- (9) Pressure Gauge: An accurate pressure gauge should be mounted on the line between the shut-off valve and the boom, in such a position that it can be easily read by the operator. It is most important that pressure should be kept constant in operation, and the operator must

have a ready means of checking this.

(10) Shut-off Valve: A good quick-shut-off valve must be provided in the line to the boom. A spring-loaded poppet type valve operated by a cord, is being used on many sprayers.

(11) Booms: Spray booms may be of galvanised iron, black iron or aluminium pipe. High pressure pipe is not needed on low volume sprayers. It is best to have pipe not less than 1 inch in diameter for long booms, as smaller pipe is not sufficiently rigid and has too great a friction loss. Also large pipe is easier to cut holes in for welding on the nozzles. The length of boom depends on the number of acres to be covered per hour, and booms are now being made up to 60 ft. long. They should be strongly supported, yet must be made so that they can fold back to pass through gates. Some booms are spring loaded so as to fold back on striking an obstruction and then swing forward into line again. They must be readily adjustable for height. Long booms may have outrigger wheels to support them. Nipples or sockets are welded into the boom for screwing in the nozzles, usually from the top or side, so as to form a settling space for dirt particles, and to prevent all the spray liquid draining out of the boom when the shut-off valve is closed. It is rather important that there should be no dripping of spray from the nozzles when they are shut off. Some nozzles contain spring-loaded ball valves to prevent this, or the shut-off valve may be of a special type that causes suction to be applied to the nozzles from a venture, through which the flow is discharged when the boom is shut off.

Hand booms of a light metal alloy can be provided instead of the main boom for spraying trees, hedges, ditch banks or roadsides. They are usually provided with from 25 feet to 50 feet of hose and two or three nozzles are usually fitted to the boom.

The boom can also be mounted on a mower, of either the cutter bar or cylinder type, so as to spray the liquid on to the weeds, as they are being cut. This is said to give good results. Another method that has been used is to attach the nozzles to the beam of a plough, and so apply the spray material direct on to twitch when ploughing.

(12) Nozzles: Nozzles are a very important part of the sprayer. It is possible to vary discharge from any given nozzle by varying the pressure at the nozzle, but this method is limited by the fact that at too low a pressure the nozzle discharge doesn't fan out properly, while at too high a pressure the droplets are too fine and don't penetrate adequately. Larger variations in discharge are provided for by using different sized nozzles. The nozzles used for low volume work are different in design from those used in orchard spraying and a flat fan discharge is considered to give the most uniform coverage. The nozzles are accurately made, and are calibrated to give a definite discharge at stated pressures. They are made in sizes low enough to give a discharge of one gallon per hour, when the size of the hole in the nozzle will be of the order of 1/50 of an inch. The importance of the line strainer is thus seen, and in addition it is usual to fit in each nozzle a cylindrical bronze gauze strainer of 100 or 200 mesh.

The height of the boom should be adjusted so that the spray fans from the nozzles overlap slightly. The width of the fan increases with increased pressure, so it may be necessary to alter the boom height if the pressure is altered. It is possible to raise the boom, so as to get double coverage from the fans. This doesn't increase the quantity per acre, but causes each swath to be hit by two nozzles instead of one. This reduces the possibility of skipping when operating on rough ground.

Booms for rowcrop spraying may have the nozzles adjusted to suit the rows. For spraying grassland, usual spacings are either 12 inches or 18 inches.

Adjusting Rate of Spraying: For any given boom type sprayer, three factors determine the rate of spraying per acre, viz.:

(1) the speed of the sprayer, (2) the pressure (3) the nozzle size.

Of these three factors, (1) the speed of the sprayer is determined by the method of transport, i.e., tractor, truck or aeroplane. In the case of tractor or truck, operated sprayers, ground conditions limit variation in speed.

(2) the pressure can be varied only within small limits, or the character of the spray will be affected adversely.

(3) the nozzle size is varied by fitting different nozzles. This is therefore the main factor in varying the rate of spraying.

Nozzle manufacturers can provide tables showing the discharge rates in gallons per minute or gallons per hour at different pressures.

The rate of delivery in gallons per acre can be determined as follows:

Let S = speed of travel in m.p.h.
G = discharge of each nozzle in g.p.h.
D = distance between nozzles in inches.

Then delivery of sprayer in gallons per acre = $\frac{99G}{S D}$ FORMULA (a)

This formula can, of course, be inverted to find what size nozzle is required for any desired gallonage per acre.

As an example, using this formula, if it is desired to spray at 4 gallons per acre at 5 m.p.h. nozzle spacing 12 inches, a nozzle discharge of 2.4 gals. p.h. would be required. A nozzle of this discharge would be selected from the makers' catalogues.

However, manufacturers of nozzles and spray outfits usually supply tables by which, for different nozzles, the delivery in gallons per acre can be found quite readily for different nozzle spacings and speeds.

A check on the gallonage per acre should always be made by running the sprayer over a known acreage and measuring how many gallons are required to refill the tank, thus finding the spraying rate in gallons per acre. In the case of water soluble spray materials, this check could be made with water only in the tank, but for sprays containing oil or materials in suspension, this check must be made while operating with the actual spray material in the tank, as these materials give a different discharge through the nozzle to that of water or solutions.

Pump Delivery: The required delivery of the pump is got by first deciding how many acres per hour you desire to spray, and multiplying this by the number of gallons per acre that it is intended to apply; i.e.,

Delivery of pump in gallons per hour: = Gallons per acre x acres per hour.
FORMULA (b)

Boom Length: The necessary length of boom to cover the desired number of acres per hour at a given tractor speed is also a matter of simple calculation.

A well-known formula for all field machines is:

Acres per hour = $\frac{\text{Working width inches} \times \text{m.p.h.}}{100}$

∴ length of boom in inches = $\frac{100 \times \text{Acres per hour}}{\text{m.p.h.}}$ FORMULA (c)

Example: Find boom length and pump delivery to spray 8 acres per hour at 4 gal. per acre. Speed of tractor 5 m.p.h.

By Formula (b) pump deliv. = 32 g.p.h.
By Formula (c) boom length = 160 inches.

Filling the Sprayer: It is better to mix the spray liquid in a separate tank. On some sprayers there is an arrangement that allows the pump to be run and draw liquid up into the sprayer tank from the mixing tank, or from a well or stream.

Aircraft Spraying: A fairly low speed aeroplane or helicopter is required. It is fitted with tank, pump, agitator boom and nozzles. Skilled pilots are required, and they should fly as low as possible cross-wind. Aeroplanes should not be expected to operate economically more than 5 miles from the landing strip. In this respect, helicopters, which require only a small area for landing and taking off, have the advantage of aeroplanes.

The work has to be carefully organized, and flagmen are required to co-operate with the plane in flagging the strip to be sprayed. Planes can spray up to 1000 acres in a day.

Dusting: Weed-killers can be applied in the form of dust. The methods of transporting the equipment and dust are the same as those used for spraying. The dust container, fitted with an agitator, feeds the dust into the air stream produced by a blower or fan. One form of dusting machine uses the exhaust gases of a tractor to spread the dust. Without going into the pros and cons of the efficiency of dusting as against spraying, from the mechanical point of view there is some advantage in dusting as the weight of material to be transported may be less than for spraying. On the other hand, due to drift of fine divided dusts, evenness of application is not so certain, and there is greater risk of damage to plants in adjacent areas. In fact, some States in the U.S.A. have passed laws prohibiting dusting from aircraft for this reason.

DISCUSSION:

MR. CROSBIE (Department of Agriculture): Our Department will be building a pressure sprayer. We will build a sprayer fitted with a boom. That is what I imagine the farmers will build themselves - with an 18 feet boom. When we build the sprayer we will be going out into the field with it and laying down full size trials, and as a result of those trials - the department carries two headers - we will harvest those trials and be able to tell you just what the yields are from crops treated with 2-4D. That spraying machine will be going out into the field and if any farmer has a crop and is willing to let us spray it, if he contacts us we will be only too pleased to come out and lay down a trial. At the same time, the Department of Agriculture is an advisory service. We have four instructors constantly in the main centres - Auckland, Palmerston North, Christchurch and Dunedin. Those instructors have a qualified engineer so if farmers have any problem in connection with spraying fields or any other general problem, we can advise them. There is a service there farmers can avail themselves of. Furthermore, when we get the sprayer working, blueprints will be available from the Department to the farmers to build up their own sprayers. We had in mind from the commencement of this sprayer that the imported models from overseas are outside the scope of individual farmers from the financial side, so that our main consideration has been to keep the cost as low as possible. The approximate cost will be one quarter of that of the imported models. There we have the advisory service, and if you like to avail yourself of it we will give you full co-operation.

MR. BLACK: Is any information available about the cost of these machines and also the value of nozzles and pumps?

MR. RIDDOLLS: I am afraid that I have no information on that at all. I do not see why they cannot be made here. The local engineering firms should be able to make them. Mr. King of our staff saw the design and in a very short time he had made one. I do not see why they could not be mass produced here in New Zealand. As regards availability and costs, Mr. Watkins might be able to enlighten us on that.

MR. WATKINS: We have spent a lot of time trying to develop this unit following advice given by Dr. Pridham and seeing the units working in the United States last year. The units shown to-day will cost in the vicinity of £140 tractor mounted, and the small unit in the vicinity of £45 complete. The large unit we would recommend for large scale use. We tried both out and that is our own personal recommendation. Regarding the nozzles, we have had quotes from nine engineering companies and unless the nozzles are ordered in the vicinity of 5,000 each, the price would be somewhere in the vicinity of £2 per nozzle, whereas the imported nozzles would be 10/- per nozzle. The explanation is that the nozzles need to be exactly the same as the other nozzles and they feel that unless they could get a very large order they would not be prepared to mass produce those particular nozzles. That does not mean that other nozzles could not be developed. I think that as far as manufacturing in bulk is concerned, I am a little wary, but I may be wrong. In the U.S.A. last year, one manufacturer concerned threw out 10,000 of these nozzles because of inaccuracies of 1/100 of an inch. I think these machines could be manufactured in New Zealand. Small units could be manufactured by farmers. A licence was granted for importations to make up 45 units covering a 12 foot spray width. A further licence has been applied for and the results will not be known for a few months. There is a

field for the use of these machines and it is gratifying that the farmers have taken up their use. It may be used in market gardens and for insectidal control where liquids do not contain a high volume of solid matter so the use of the machines is not restricted to the weed control only. It has been used in Australia for applying weedicides. Where they used to have 100 gallons to a mile of track they now can apply 5 gallons to the mile.

MR. MACHIN: Mr. Riddolls could obtain costs from you which can be appended to the report of this conference.

MR. RIDDOLLS: There is just one point that struck me and that is the necessity for a very accurate pressure gauge and the necessity for the gauge to be as near to the boom as possible, particularly on small diameter pipes. That brings up another point - the pipes should be as large as they possibly can be because of the pressure loss you would have in small pipes. The larger the pipes of course, the less the pressure. A 1" pipe gives almost exactly what you should get at the nozzles themselves. With these nozzles the pressure should be exactly the one they are designed for.

DR. M. M. BURNS: It struck me that drift was a problem of major importance, and I personally cannot see why paper or canvas cannot be spread round the nozzles in the same way as they do in England and America in connection with dusting. I think it is a problem that will be dealt with. I think it is not nearly as hard to solve.

MR. MACHIN: There is no question about it that the drift we have experienced on a still day like this - if there had been dye stuffs in the tank we would have been coloured pretty well. One point that has been raised is the high country wanting to know what we can do for the man who has these weeds on very steep country, and there seems very little answer to that except by using manual appliances, and I am wondering whether there could be some means by which the High Country Committee could use their influence to enlist some help in what is undoubtedly a great problem on steep country where they cannot get these machines like they can on the flatter country. Possibly some attention could be given to getting some sort of liaison with high countrymen to see if we could find a solution. I make that as a suggestion.

MR. WATKINS: There is a unit being manufactured in this country based on a design from overseas. It is an ordinary round pressure knapsack sprayer. Attached to the side is a CO₂ pressure container holding 10½ ounces of CO₂. It holds 3 gallons of liquid and there is a relief valve on the top adjusting the pressure which is 80 lbs. and letting it out at a rate where on hill country two men could spray 8 acres a day by just walking over the country. That may be a help. It would save carrying water and save time and pumping. The information will be available for the asking.

MR. MACHIN: I have no doubt that a combination of science and industry will overcome this problem. There are certain things to be studied as a result of this conference, and I am wondering whether it might be the most expeditious way to ask Mr. Bevin who has been listening patiently, to most of the discussions. He has been gathering up the main threads and we might ask him to say a few words which might make other people suggest things as to what we could do next. Obviously, we cannot come here with contributions of such an excellent character and leave it at that. What we must do is to see that there is some continuous work. Not that I desire to create machinery for the sake of machinery, but I think Mr. Bevin will be able to lead your thoughts in a direction that we do not want to lose what we have gained at the moment.

MR. BEVIN: We have had an interesting two days and I think it would be a pity, as the Chairman said, if we were to suddenly finish up and fade out altogether. When the idea of a conference was proposed and when we undertook to organize it, it was thought that we might be able to have something in the nature of a conference resembling the Grasslands conference which has been so successful over a great many years in New Zealand. I suggest as a conference gathering, we decide whether we are going to go on with the holding of future conferences, and if so when and how often they might be held, and further, whether we can place in the hands of somebody the recommendations that a conference be held with the understanding that the body would undertake to carry out the organization necessary to bring members together. This year we have held the conference at this college. It was suggested it should be

held here, and ultimately we were persuaded to hold it here. There is in existence at the present time, a Weeds Committee which meets in Wellington and on which are represented a number of Departments and the College to consider these problems throughout the Dominion. Mr. Lynch clearly outlined their activities and my opinion is that if we take action in regard to further recommendations regarding such conferences, we have in that body - and incidentally its chairman is our friend Mr. Black who has been one of my colleagues - I am quite sure they will be prepared to offer any assistance and suggestions that might help you. We can decide upon who organizes it. The other point is that as a result of our deliberations it may be within our province to consider whether any recommendations should go from this conference to the various bodies who are concerned with weed control.

MR. SCHNACKENBERG: I have only spoken once before, however I would like to say that as a representative of the Soil Conservation Council and Ministry of Works Department, that this conference has been an intensely interesting one to me, because the Soil Conservation Council is interested in every part of this particular conference. The Soil Conservation Council is financially interested in aquatic weeds and willows in streams, but is vitally interested in every type of cover on every section in New Zealand. The Council believes that soil conservation can be achieved by the best soil cover, and we believe that there is a corollary that with the best soil cover, production in this country must increase. I would suggest that the first thing necessary is a central advisory weeds organization. There is the Weeds Committee. It is necessary to have such a central body and it should do the organizing of such conferences as this. Its first task might be to issue a publication which will describe our principal weeds so that on our farms we can recognize the weed as soon as we see it. As well, the weeds might be located in regard to distribution, locality, soil types, rainfall, soil moisture, soil temperature, fertility, etc. I think it is highly desirable that such a publication be issued as soon as possible. The next thing is to formulate a programme of work; this I think is essential in any research that is carried out on weed control.

RESOLUTIONS AND DISCUSSIONS:

Moved by Mr. D. Watkins, seconded by Dr. C. Yeates:

"THAT a further Weed Control Conference be called at a suitable date next year by the parties interested in weed control."

The motion was carried after some discussion.

DR. BURNS suggested that as there was a close relationship between weeds and grasslands, the Weeds Conference might either immediately precede or follow the annual Grasslands Conference.

MR. Y. T. SHAND: There is a Weed Act on the stocks that seems in some respects very drastic and liable to give rise to a good deal of stirring up and that could be used profitably in a conference in 12 months' time. I thought that early draft might have been valuable at this Conference. I think I am right in saying that this Act is about to come before Parliament. It looks to me as if we will want a conference very badly.

Discussion for some time centred around the nature of the Committee which should be responsible for the convening and organizing of the next conference.

MR. COOKSLEY suggested that the Weeds Sub-Committee of the Inter-Departmental Field Crops Committee should extend its personnel to include representatives of the primary producers and horticulturists. Other delegates supported this suggestion.

MR. LYNCH pointed out that the expanding of the Committee too greatly would make it too cumbersome.

After much further discussion it was finally decided to adopt the following resolution moved by Mr. R. H. Bevin, seconded by Mr. M. Fleming:

"THAT it be a strong recommendation from the Conference that the Weeds Sub-Committee of the Field Crops Committee should-