When You Buy or Build

A Field Sprayer

Circular 249

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When You Buy or Build A Field Sprayer

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Small field sprayers, tractor mounted or of the trailer type, have become important pieces of farm equipment.

These sprayers develop pressure from 25 to 100 pounds per square inch and apply volumes from 10 to 25 gallons per acre. They have been used widely for applying 2, 4-D in weed control. With simple modification they can also be used to apply insect and fungus control chemicals.

The purpose of this circular is to suggest adjustments you can make to "get the most" out of a small field sprayer. Each basic unit of a field sprayer is discussed in turn. Information is provided on selecting the parts for building a sprayer along with a brief word about checking your sprayer for accurate pressures and volumes.

TANKS

Tractor-mounted spray tanks frequently are 55-gallon petroleum drums placed horizontally, one on each side of the tractor. These tanks may also be mounted in a vertical position on the hydraulic lift at the back of the tractor. With this arrangement the boom can be adjusted for proper height by raising or lowering the entire sprayer with the hydraulic system. This latter arrangement is perhaps the easiest one to mount.

On trailer-type rigs, a cylindrical tank of 100 to 250 gallons capacity is frequently used. The tank can be mounted either cross-wise or fore and aft on the frame.

Cylindrical iron tanks or those with well-rounded bottoms are desirable to prevent dead spots during mixing and agitation. Black iron of 12 to 18 gage remains the most popular tank material.

A relatively new plastic material referred to as an epoxy resin is available for coating metal surfaces to prevent corrosion. It comes in a liquid form and can be brushed or sprayed on. In the case of sprayer tanks it can be placed in the tank and splashed or rolled on.

Between spraying jobs, you can minimize corrosion of the tanks and working parts by placing a few gallons of diesel or lubricating oil in the empty tank and circulating this through the sprayer. Most agricultural chemical formulations — whether for control of weeds, insects, or fungi — can be cleaned from the spray tank by using cleaning soda or lye followed by a thorough rinsing.

However, if the sprayer has been used with 2, 4-D, it cannot be used safely to apply insecticides or fungicides to highly sensitive broad-leafed crops, such as cotton, grapes, alfalfa for seed, sugar beets, tomatoes and beans. With less sensitive crops, a thorough cleaning of the tank and system with lye (2 pounds per 100 gallons of water for water soluble materials, or lye plus kerosene for oil soluble materials) will be satisfactory.

MIXING & AGITATION

Chemical spray materials must be mixed thoroughly with the proper proportions of diluting water before they are applied. These materials are formulated as solutions, emulsions, or wettable powders. A mild agitation is all that is required to mix and maintain solutions containing adequate emulsions. However, the powders of wettable suspension readily "settle out" if not continuously agitated, and the emulsion without emulsifiers will separate if agitation is stopped.

Tanks can be agitated by either mechanical paddles or by hydraulic jet means. Agitation systems usually are not standard equipment on the light, inexpensive sprayers. Unsatisfactory agitation is the usual result of putting a nozzle or other restriction in the tank end of the hose line from the by-pass regulator valve. Most of the pressure energy in the liquid is lost in passing through the regulator. The job of the by-pass regulator is to provide relief for the positive displacement pump when the boom is shut off and to regulate pressure on the boom. Pumps can be severely damaged and regulator troubles can develop if the regulator line is restricted in any way.

Jet agitation is inexpensive and

easy to install and does a satisfactory job when properly used. The illustration in Figure 1 shows how to place the agitation jets in a horizontal cylindrical tank for best results. Note that for the agitation a separate line takes off from the immediate discharge side of the pump with a valve to reduce the intensity after initial mixing. Table 1 indicates the jet size required for satisfactory mixing and agitation of given horizontal tank sizes. The jets may be made by drilling the proper size hole in a pipe plug or cap, or may be purchased as the tip used in certain nozzles. *(Fig 1, Table I - Table II.)*

TABLE I

Required Jet Size for Jet Agitation
Tank dimensions and pressures as shown

Tank diameter feet	System pressure psi*	One jet of size shown is required for each foot of tank length
2	25	3/32"
	75	2/32"
2.5	25	4/32"
	75	2/32"
3	25	5/32"
	75	3/32"

*pound per square inch
Table based on horizontal, round, or rounded bottom tanks, for solutions, emulsions with emulsifiers and wettable suspensions not over 1/10 pound per gallon. With no emulsifiers, or wettables, from 1/10 to 1 pound per gallon double the volume of flow as found from Table II below See Figure 1 for further details.

TABLE II

Approximate Discharge (gallons per minute) for Single Jet

Pressure	Jet Diameter inches						
psi	2/32	3/32	4/32	5/32	6/32	7/32	8/32
25	.75	1.25	2.25	3.5	5	7.0	9
50	1.25	1.75	3.00	4.5	7	9.5	12
75	1.50	2.25	3.75	6.0	8	12.0	15

Use this table, multiplying by the number of nozzles used, to obtain total volume flow for jet agitation.

When the vertical 55-gallon oil drum (22 x 36 inches) is used as a sprayer tank, the installation of jet agitation is made as in Figure 2. The jets are about 2 inches above the tank bottom and aimed directly across the tank. More liquid must be recirculated in the vertical tank than the horizontal, for sufficient agitation. About 2 gpm (gallons per minte) at 50 psi (pounds per square inch) are required from each of the 2 nozzles when using spraying solutions, emulsions with emulsifiers, and wettables not exceeding 1/10 pound per gallon. This requirement can be met by two, 3/32 inch drill holes or jets. Such a hole will pass about 1-¾ gpm at 50 psi. *(Table II)*

When the emulsions used are without emulsifiers, or wettable concentrations of from 1/10 to 1 pound per gallon, then each jet must discharge about 3 gpm at 50 psi. Two 1/8-inch jets or drill holes will fill this requirement.

PUMPS

Because of the abrasive or corrosive action of certain spray formulations there isn't a single inexpensive pump which will handle them all. Pump types include rotary (gear, cam, vane, or roller) centrifugal, piston and diaphragm. All of these are, with the exception of the centrifugal, available for direct power - take - off operation. The centrifugal pump requires a speed step-up drive in order to obtain the necessary spray pressure.

Be sure your pump has sufficient capacity for any spraying job you may have. The total capacity is the sum of (1) spray discharge (2) jet agitation (3) safety or wear factor.

Power-take-off driven pumps on commercially available light-weight rigs are frequently limited to the inexpensive brass, or iron gear-types. These pumps normally operate at maximum pressures of 75

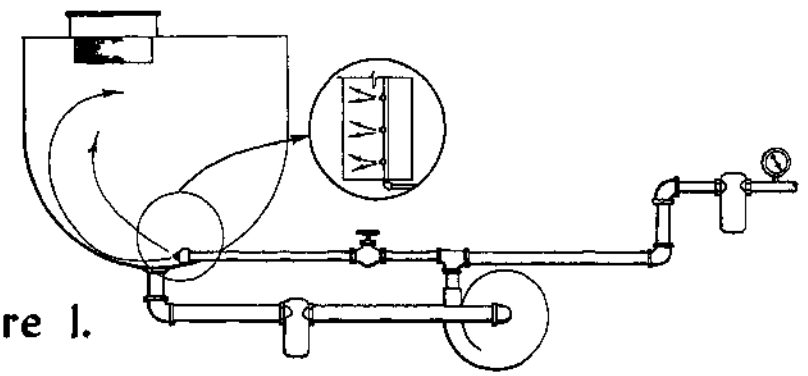


Figure 1.

Figure 1.
Diagram of the spraying equipment with jet agitation and a centrifugal pump which does not require a by-pass regulator. Insert shows view of tank from above. Jets are spaced 12 inches or less from one another and ½ that amount from tank ends.

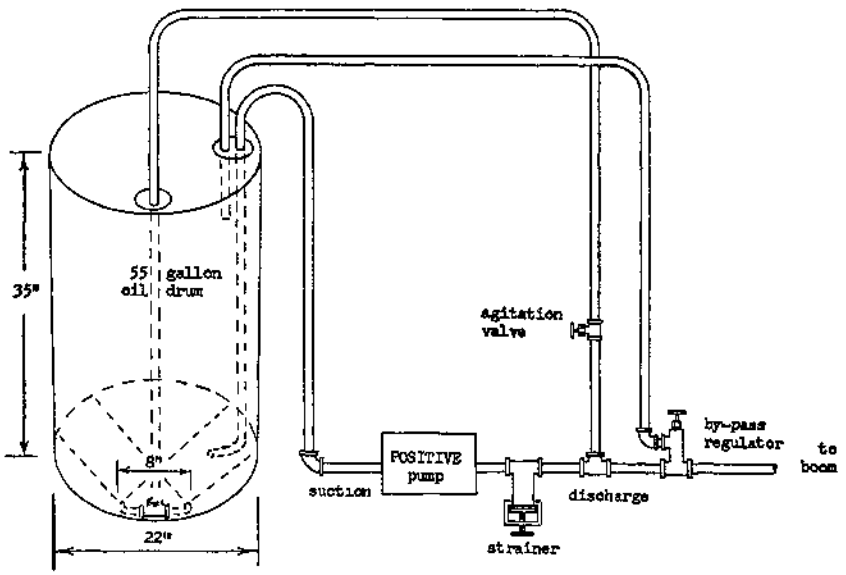


Figure 2. Schematic Diagram of a Low Volume Sprayer

to 100 lbs. per square inch and flow rates ranging from 5 to 11 gallons per minute. Gear pumps should not be used to pump wettable suspensions and care should be used to keep dirty water out of them.

(Refer to Table VI, page 13 for discussion of various pump types)

NOZZLES

The flat fan-type nozzle is best for field application. The spray distribution from any one nozzle is shown in Figure 3. The solid lines show the spray fans as arranged on the boom . The dotted lines illustrate the volume of spray material from each nozzle. This

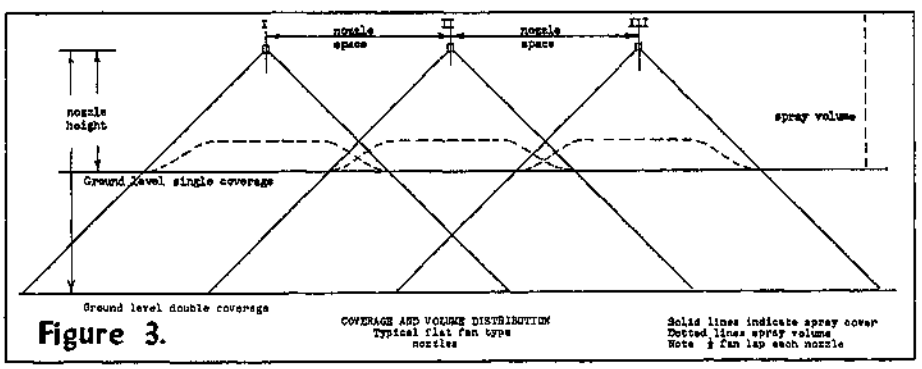


Figure 3.

TABLE III

Nozzle Spacing, Inches	Height of nozzle above ground in inches. Flat Fan type nozzles, Uniform coverage 1/2 lap			
	60° Fan	80° Fan	90° Fan	110° Fan
12	19	15	14	11
16	23	18	16	13
18	26	19	17	14
20	28	21	19	15
24	32	24	21	16

Figures are for uniform coverage at a point 6 inches above the ground. For uniform coverage at ground level, subtract 6 inches.

shows why the nozzles cannot be arranged to have the edges of the spray fans just meet. A certain amount of overlap is necessary for uniform coverage. Single coverage requires a total lap of ½, or ¼ lap between each pair of spray fans.

Double coverage may be obtained by raising the boom to twice the height without changing the nozzles or nozzle spacing as shown in Figure 3. The amount of material applied per acre remains the same. Double coverage may also be accomplished by decreasing the nozzle spacing by one half on the boom with the same boom height. If this is done, the size of the nozzles must be reduced to maintain the same rate of application. Reducing the nozzle size increases the possibility of clogging.

Table III shows the relationship between nozzle spacing, nozzle fan angle, and nozzle height. The table is made for uniform coverage at a height of 6 inches above ground. The adjustments indicated should take care of alfalfa or plants of a similar height. For coverage at other heights, add or subtract from the figures given.

The droplet size generally should be kept small. This is accomplished by using small orifice-sized nozzles with wide fan angles. A wide fan angle tends to produce small droplet size rather than force, the latter of which is not important when material is released close to the plant (as with ground rigs). Another method for decreasing droplet size is by increasing pressure. About four times as much pressure is required to cut droplet size in half. Hence, it is more practical to obtain small drops by nozzle design rather than pressure.

Volume of flow is directly related to the area of the nozzle orifice (the square of the diameter). The best way to make any significant change in the rate of flow is to change the nozzle tips. (Pressure will also increase the rate of flow but as with droplet size the effect is less direct. The pressure will have to be increased by about four times to double the flow.)

BOOMS

Pipe size for the boom is determined largely by structural strength rather than capacity.

No material is entirely non-corrosive. Stainless steel is highly resistant to corrosion but is expensive. Copper pipe or polyethylene tubing supported by angle iron makes a very corrosion-resistant boom. Galvanized iron pipe (not less than ¾ inch diameter) with nozzles tapped off the side or top, is most widely used for booms.

The end of any boom should be fitted with a plug for draining.

Boom length is determined largely by the size of operation and the width of irrigation borders. For light-weight rigs, 20 or 30 feet is about the maximum.

BOOMLESS OR BROADCAST SPRAYERS

Considerable interest has been shown in the boomless or broadcast rigs, principally because they offer the least expensive rig. They have no boom or small nozzles which require a certain amount of care in keeping clean. The rest of the machine is much the same as the one for the boom-nozzle type rig.

Accurate placement and uniform coverage are difficult to maintain with the boomless rigs in a day-by-day operation of the sprayer. The slightest air motion disrupts the calibration and the spray pattern making it difficult to match the swaths. The relatively coarse drop size necessary to obtain wide swaths does not give good coverage.

SCREENS

Screening is essential to keep dirt and rust particles out of the fine spray nozzles. All material entering the tanks should be screened through a 12- to 18-mesh fly screen at the tank opening. If this cannot be done the same size screen should be placed between the pump and tank. A finer screen of 25- to 40-mesh, 20 to 30 square inches in size, should be placed between pump and boom. Nozzle screens are desirable to reduce stoppage by nozzle plugging.

SELECTION OF COMPONENT PARTS

Here are the steps to follow in selecting the parts for building your own sprayer:

1. Decide on the length of boom, application rate in gallons per acre, nozzle spacing, nozzle pressure, and operating speed in mph (miles per hour).

2. From Table IV determine total flow from all nozzles in gallons per minute. Find the flow rate per nozzle by dividing total flow by the number of nozzles.

3. Select nozzles which will give desired flow rate. Use Table III to determine boom height.

4. Select the pump. The pump must have the capacity to deliver the material at the rate required and at the desired operating pressure.

The minimum pumping rate in gallons per minute for the pump is the sum of nozzles output plus agitation requirements. Thirty percent should be added to the pump capacity to compensate for wear.

TABLE IV

Total Sprayer Output-Gallons Per Minute
(Divide by Number of Nozzles to Obtain Flow per Nozzle)

Speed MPH	Gallons Per Acre	Swath Width				
		10 ft.	15 ft.	20 ft.	25 ft.	30 ft.
2	10	.4	.6	.8	1.0	1.2
	15	.6	.9	1.2	1.5	1.8
	20	.8	1.2	1.6	2.0	2.4
2.5	10	.5	.7	1.0	1.2	1.5
	15	.7	1.1	1.4	1.7	2.1
	20	1.0	1.5	2.0	2.5	3.0
3.0	10	.6	.9	1.2	1.5	1.8
	15	.9	1.3	1.8*	2.2	2.7
	20	1.2	1.8	2.4	3.0	3.6
3.5	10	.7	1.1	1.4	1.7	2.1
	15	1.1	1.6	2.2	2.7	3.3
	20	1.4	2.1	2.8	3.5	4.2
4.0	10	.8	1.2	1.6	2.0	2.4
	15	1.2	1.8	2.4	3.0	3.6
	20	1.6	2.4	3.2	4.0	4.8

*Example: With a swath width of 20 feet, a sprayer must apply material from all nozzles at the rate of 1.8 gallons per minute to apply 15 gallons per acre at 3 miles per hour.
For twice the speed, swath width or gallons per acre the total output figure would be doubled.

Let us use an example in selecting the component parts for a particular job.

1/ We have decided on a 30-foot swath, 18-inch nozzle spacing, application rate of 15 gallons per acre, nozzle pressure of 50 psi and an operating speed of 4 miles per hour.

2/ From Table IV the total nozzle flow is 3.6 gallons per minute. An 18-inch nozzle spacing on a 30 foot swath gives a total of 20 nozzles. Dividing 3.6 by 20 gives us a flow rate for each nozzle of 0.18 gallons per minute.

3/ Consult a nozzle dealer or dealer handbook to select nozzles with a flow of 0.18 gallons per minute. From Table III using a 90 degree fan angle and a spacing of 18 inches we get a nozzle height of 17 inches.

4/ Assume we use 4 gallons per minute for agitation. Then the total required pump capacity will

be 30 percent more than the sum of nozzle flow and the gpm required for agitation in the tank. (The capacity is 4 + 3.6 increased by 30 percent to compensate for wear.) We can write it:

$$7.6 \times 1.3 = 10.$$

Our pump must handle 10 gpm at our operating pressure of 50 psi.

CALIBRATION

Check your rig for accuracy. Whether you buy or build your rig it should be checked to be sure

TABLE V

CALIBRATION
Based on Number of Seconds to Fill Pint Jar

Speed MPH	Gallons Per Acre	Nozzle Spacing				
		12 in.	16 in.	18 in.	20 in.	24 in.
2	10	186*	139	124	111	93
	15	139	104	93	83	70
	20	93	70	62	56	46
2.5	10	149	112	100	89	74
	15	111	83	74	67	55
	20	74	55	49	44	37
3.0	10	124	83	83	74	62
	15	92	69	61	55	46
	20	62	46	41	37	31
3.5	10	106	80	71	65	53
	15	79	59	53	47	39
	20	53	40	35	32	26
4.0	10	93	70	62**	56	46
	15	69	52	46	41	34
	20	46	35	31	28	23

*An example of how to use the table. If it took you 186 seconds to fill a pint jar at one nozzle, and you know that your ground speed will be 2 miles per hour and your nozzle spacing is 12 inches you can ascertain that you will be delivering 10 gallons per acre.

**Another example might be to run your machine at 4 miles per hour with a nozzle spacing of 18 inches. If it takes you 62 seconds to fill a pint jar with one nozzle you can estimate you will be delivering 10 gallons per acre also.

For higher speeds or gallons per acre the time to fill the jar is proportionally less.

it is applying material at the proper rate.

1. Check your ground speed. If you don't have a speedometer on your tractor, time the tractor over a distance of 500 feet. Divide 500 by the number of seconds and multiply by 1.46 to get miles per hour. Another method is to pace the tractor for 20 seconds. The number of steps in 20 seconds divided by 10 gives miles per hour.

2. Check the flow rate of some of the nozzles, one at a time. Make sure the operating pressure is at the desired setting. Time the filling of a pint jar from a nozzle. Divide 7.5 by the number of seconds to fill the jar, in order to obtain gallons per minute from the nozzle. For converting directly to gallons per acre use Table V.

How Many Acres Per Day?

You can estimate the number of acres your sprayer will cover per hour by the following formula:

$$\frac{\text{Width of the swath (ft)} \times \text{MPH}}{10}$$

For example, a 30 foot wide boom traveling 4 miles per hour would cover $\frac{30 \times 4}{10}$ or 12 acres per hour. The above rig would cover 120 acres in a 10 hour working day. This figure allows for the operator to spend 20 percent of the total field time in non-spraying operations such as turning, refilling the tank, etc.

TABLE VI

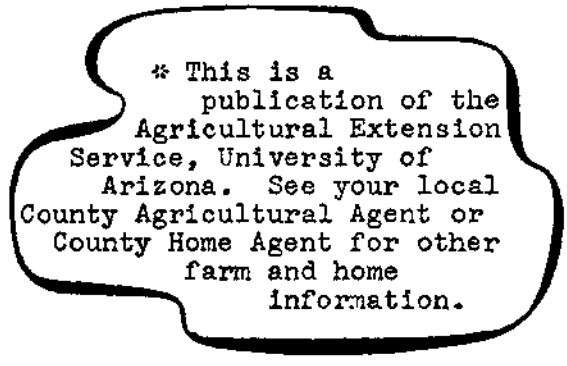
The following chart lists the pump types with a brief comment on each.

Pump Type	Some Principal Features	
	Advantages	Disadvantages
Centrifugal	Universally adaptable for use with all sprayer formulations. Low wear with abrasive materials. High volume.	Expensive. Relatively low pressure. Not self-priming.
Piston	Universally adaptable for use with all sprayer formulations. High pressure. Easily replaceable parts.	Expensive. Heavy. Low volume.
Diaphragm	Low wear with abrasive materials. Easily replaceable parts. Medium price. Medium pressure.	Low volume. Synthetic rubber diaphragm non-resistant to weed oil.
Roller	Medium price. Durable when made of non-corrosive steels and plastics except when used with wettable suspensions. Medium volume.	Pump life shortened when used with wettable suspensions.
Gears (non-corrosive steel)	Inexpensive. Medium pressure.	Low volume, medium pressure. Wears rapidly when used with wettable suspensions.
Gears (iron, brass, bronze)	Least expensive. Medium pressure.	Short lived. Unsatisfactory for wettable suspensions.

Quantity of Commercial Formulation Needed to Provide Exact Amounts of Technical Insecticides Per Acre

TABLE VII (From Arizona Extension Circular No.239)

Insecticide Formulation. (% by weight of actual chemical)	1/8 pound technical	½ pound technical	¾ pound technical	1 pound technical	1½ pounds technical	2 pounds technical	3 pounds technical	5 pounds technical
15-20% Emulsifiable concentrate (1½ lbs. per gal.)	1/3 quart 10 2/3 fl. ounces	1 1/3 quarts	2 quarts	2 2/3 quarts	1 gallon	5 1/3 quarts	2 gallons	3 2/5 gallons
23-25% Emulsion concentrate. 2 lbs. per gallon	½ pint (1 cup)	1 quart	1½ quarts	2 quarts	3 quarts	1 gallon	1½ gallons	2½ gallons
42-50%. 4 pounds per gallon	¼ pint (4 fl. oz.)	1 pint	1½ pints	1 quart	1½ quarts	2 quarts	3 quarts	5 quarts
60-65%. 6 pounds per gallon	1/6 pint 2 2/3 oz.	2/3 pint	1 pint	1½ pints	2 pints	2 2/3 pints	2 quarts	3 1/3 quarts
72-80%. 8 pounds per gallon	1/8 pint 2 fl. oz.	½ pint	¾ pint	1 pint	1½ pints	1 quart	1½ quarts	2½ quarts
15% Wettable powder	13½ ounces	3½ pounds	5 pounds	6 2/3 pounds	10 pounds	13½ pounds	20 pounds	33 1/3 pounds
25% Wettable powder	½ pound	2 pounds	3 pounds	4 pounds	6 pounds	8 pounds	12 pounds	20 pounds
40% Wettable powder	5 ounces	1¼ pounds	1 7/8 pounds	2½ pounds	3¾ pounds	5 pounds	7½ pounds	12½ pounds
50% Wettable powder	¼ pound 4 ounces	1 pound	1½ pounds	2 pounds	3 pounds	4 pounds	6 pounds	10 pounds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