

TEST SPRAYING EXPERIMENTS ON YOUNG RUBBER PLANTS.

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The main object of the experiments described in this paper was to determine the concentrations at which various spray fluids might be used on one to two year old plants in the nursery without burning or damaging the leaves or stems.

A secondary object was to determine the efficiency of a single application of a fungicide in controlling leaf diseases (*Helminthosporium Heveae*—Bird's Eye Spot) and mite attack.

The following spray fluids commonly used in horticulture and fruit gardens were tried. A description of the method of preparation of the non-proprietary fluids is given.

AMMONIUM POLYSULPHIDE.

This is a commercial product containing approximately 21 per cent. of polysulphide sulphur and 19 per cent. of ammonia. It is a liquid which may be diluted to any required concentration by the addition of water. Concentrations up to 2 per cent. of ammonium polysulphide in water may safely be sprayed on young rubber trees.

BORDEAUX MIXTURE.

This preparation is a valuable fungicide for combatting various plant diseases and consists of a mixture of copper sulphate and quicklime slaked in water.

The two standard mixtures in use are prepared according to the 4: 4: 50, and the 5: 5: 50 formulae.

Bordeaux Mixture 4 : 4 : 50.—Two separate solutions are first made as follows:—

No. 1. 4 lbs. of quicklime are slaked with a little water in a wooden or earthenware vessel and 24 gallons of water are then added.

No. 2. In a separate wooden or earthenware vessel 4 lbs of copper sulphate crystals are dissolved in 25 gallons of water.

Each solution is stirred separately, allowed to settle, and stored separately.

When required for use a known volume of solution No. 1, is slowly added to an equal volume of solution No. 2, in a wooden or

earthenware vessel stirring all the time. The mixed solutions must be well stirred immediately before using. Any excess of copper is ascertained by plunging a clean bright steel knife blade into the mixture. If copper is deposited on the steel more of solution No. 1. must be added until no deposition of copper occurs on the knife blade. If only a part of each preparation is to be used the lime mixture (No. 1.) can be preserved by adding 6 ozs. of sugar per 25 gallons of liquid and stirring until dissolved.

Bordeaux Mixture 5 : 5 : 50.—This is prepared in a similar way except that 5 lbs. of quicklime and 5 lbs. of copper sulphate are used in making up the solutions Nos. 1 and 2, resulting in a slightly stronger mixture.

KEROSENE EMULSION.

Though possessing only weak fungicidal properties a kerosene emulsion is of great value as an insecticide for combatting Scale insects on the leaves and stems of nursery plants.

A 2 per cent. emulsion is prepared by dissolving one pound of common soap in one gallon of water by boiling. When the soap is completely dissolved and while the solution is still hot one pint of kerosene is added with continual stirring. The mixture must be stirred vigorously or churned with a syringe until a complete emulsion is obtained. Four gallons of hot water are then added with vigorous stirring.

The emulsion is ready for use when cooled but must be well stirred before application.

A 4 per cent. Kerosene Emulsion is prepared as above by using double the quantity of kerosene with the same quantity of soap as is used in the preparation of a 2 per cent. emulsion.

KEROSENE EMULSION (2 PER CENT) AND LEAD ARSENATE (0.5 PER CENT).

This mixture is considered an excellent insecticide and is made by adding 4 ozs. of Lead arsenate to each five gallons of the 2 per cent. Kerosene Emulsion prepared as above.

A stronger insecticidal and fungicidal spray fluid is made by adding 8 ozs. of lead arsenate per five gallons of kerosene emulsion. The latter strength has, however, been found to cause considerable burning of rubber leaves and is not recommended for general use in rubber nurseries.

LIME SULPHUR.

A lime-sulphur preparation, besides being a good fungicide, is also one of the best known scale insecticides. Various proprietary

lime-sulphur mixtures are on the market, but the mixture may easily be prepared on the estate.

14 ozs. of quicklime are slaked and a little more water is added to make milk of lime. The mixture is strained and 35 ozs. of flowers of sulphur are stirred in and the mixture is diluted to one gallon by addition of water.

The mixture is boiled for one hour and the upper clear liquid is decanted from the sludge. The liquid thus prepared contains about 10 per cent. of polysulphide sulphur.

A 1 per cent. Polysulphide mixture is obtained by diluting to 10 gallons with water. This strength is satisfactory for disease control in rubber nurseries.

Owing to the fact that lime-sulphur mixtures tend to crystallise on standing for some time it is better not to prepare more than can be used on the same day. If, however, lime-sulphur mixtures, either home-made or proprietary, are to be stored for some time, the surface of the liquid should be covered with a layer ($\frac{1}{8}$ inch thick) of kerosene oil or, preferably, a mixture of four parts of kerosene oil to one part of lubricating oil. This will prevent evaporation and the formation of a crust on the surface of the fluid. The liquid must be kept in a closed vessel.

LIME SULPHUR AND GLYCERINE.

This mixture is prepared by adding 1 per cent. of crude glycerine to the above lime-sulphur mixture containing 1 per cent. of polysulphide sulphur in order to give a slightly more adhesive fluid. In the trials so far conducted the glycerine mixture has proved very little better than the ordinary lime-sulphur mixture.

LIVER OF SULPHUR.

This is a commercial product in the form of a deliquescent solid packed in sealed tins. The commercial solid contains potassium polysulphide and on analysis shows an average content of 27 per cent. of polysulphide sulphur. A solution containing 1 lb. of solid liver of sulphur in 10 gallons of water, i.e. a 1 per cent. solution, is found to be most practicable, having at that strength a strong fungicidal action against leaf mildews.

SOLBAR.

This is a proprietary substance containing metallic polysulphides and carbon. It is stated to have both fungicidal and insecticidal properties when used in concentrations of 1—2 per cent. in water, carbon being left behind as a sludge in the mixing tank.

S 75.

This proprietary substance is a bluish white powder containing copper salts. It is a substitute for Bordeaux mixture and is more stable under ordinary atmospheric conditions. It may be used as a fungicide to combat leaf mildews by dissolving in water in concentrations of 1 to 4 per cent.

SULPHUR.

Sulphur dust has proved effective in the control of leaf mildews and mites. Finely powdered quicklime may be added to the extent of 10 to 20 per cent. of the final mixture to act both as a drying agent and insecticide. The most efficient and economical mixture is prepared by using very dry and fine powders.

SULFINETTE.

Sulfinette is a proprietary lime-sulphur mixture. It is a liquid which may be diluted to any strength by adding the required amount of water. The mixture if stored must be kept tightly sealed, otherwise sulphur and calcium sulphide crystallise out to form a thick crust while the efficiency of the fungicide becomes seriously impaired by decomposition and loss of the polysulphides which it contains.

EXPERIMENTAL INVESTIGATIONS.

DESCRIPTION OF PLOTS.

The plots for the experiments consisted each of 200 nursery plants. Each plant was 1 year 9 months old and had been pruned to 4 feet some three months before the spraying was commenced. During these three months a luxuriant crown of foliage had developed to a height which rendered easy observation of the leaves.

METHOD OF APPLICATION OF SPRAY FLUIDS.

The spray fluids were carried to the nursery blocks in buckets, and applied to the trees by means of mist sprayers of the hand type. One gallon of liquid mixture was applied to each plot.

On the sulphur dusted areas 5 lbs. of the sulphur and lime powder were applied to each plot by means of a foot duster.

EFFECT OF A SINGLE SPRAYING ON THE TISSUES OF THE RUBBER PLANTS.

From Table I, which gives a summary of the results it will be seen that, although in no case did the spray liquids adversely affect

the stems, several of the liquids burned the leaves, and in a few cases to such an extent as to cause the burned leaves to fall. It was observed that the chief seat of burning was on the lower sheltered leaves, the upper exposed leaves washed by the rains did not suffer so much damage.

BURNING OF LEAVES.

The burning was of two types:—(1) rapid—visible in the form of light brown angular blotches within two to three days of the application of the spray fluid. If a quarter or more of the leaf surface is so burned the leaf invariably falls within a few days.

Fungicides causing this type of burning are Kerosene Emulsion plus Lead arsenate at a strength of 0.5 per cent. or over, Lime Sulphur in 5 per cent. solution and to a less extent Kerosene Emulsion of 4 per cent. strength, Lime Sulphur of 2 per cent. strength and Bordeaux mixture 5 : 5 : 50.

(2) Slow—visible in the form of pale green circular spots beneath a dried deposit of the spray fluid after 9—10 days from the date of application of spray. This effect is probably due to a slow poisoning of leaf tissues by the chemical deposit from the fungicide. Such leaves rarely fall but remain mottled in appearance.

Fungicides causing this type of burning are Liver of sulphur of 1 per cent. and 2 per cent. strength, Solbar of 2 per cent. strength, S. 75 of 2 per cent. strength, and a 5 per cent. solution of ammonium polysulphide.

INTENSITY OF DEPOSIT.

A rough indication of the power of adhesion to leaf surfaces and of the durability of the fungicide is given by the intensity of the deposit on the leaves after a period of 26 days. It is not, however, a measure of the fungicidal properties of the spray fluid. Too heavy a deposit may induce leaf fall.

INDUCED LEAF FALL.

This occurred in four of the plots sprayed respectively with kerosene emulsion (2 per cent.) plus lead arsenate (0.5 per cent.), kerosene emulsion (2 per cent.) plus lead arsenate (1.0 per cent.), lime sulphur mixture containing 5 per cent. of polysulphide sulphur and ammonium polysulphide of 5 per cent. strength. Spray fluids of this strength are therefore not to be recommended for use in rubber nurseries. Since a 5 per cent. solution in water of commercial ammonium polysulphide contains only 1 per cent. of polysulphide sulphur it is probable that the burning effect and leaf fall is due to the

ammonia content which is also 1 per cent., as lime sulphur mixtures containing up to 2 per cent. of polysulphide sulphur do not induce leaf fall.

CONTROL OF MITE ATTACK AND DISEASE.

The apparently close connection between mite attack and fungus diseases of leaves of nursery plants makes it difficult to differentiate between the efficiencies of a spray mixture: (a), as an insecticide, (b) as a fungicide. However, in nurseries it is often essential to have a dual purpose spray mixture.

Table 1. gives a summary of the results of the spraying experiment. The columns headed "Mites" and "Remarks" deal chiefly with the condition of the young flush of leaves developed since the spray mixtures were applied. In practically every case excellent control of both mites and disease was obtained on the leaves present previous to the application of the spray mixture.

It will be seen also from Table 1. that the three plots Nos. 23, 24 and 25 sprayed with the stronger concentrations of ammonium polysulphide solution showed excellent control of mites and disease on the young leaves. Nos. 13 and 14 sprayed with Bordeaux mixtures show complete control of mites but only partial control of disease on the young leaves.

Liver of Sulphur, Kerosene Emulsion and Sulphur-Lime mixtures also exhibit strong insecticidal properties while the fungicidal properties are not so good. S. 75 should prove efficient as both an insecticide and fungicide for application to nursery plants providing it can be supplied cheaply.

Kerosene Emulsion + 1.0 per cent lead arsenate proved efficient as a dual purpose spray fluid but its tendency to burn the leaves and its poisonous nature make it undesirable for general use.

Solbar at 2—3 per cent. strength should prove a good spray mixture for Hevea nurseries though it has a slight tendency to cause burning of the leaves.

Sulfinette at concentrations between 3 and 5 per cent. is a good dual purpose mixture, ranking closely to the home-made lime-sulphur mixtures.

It should here be pointed out that Goodwin and Martin (Ann: Applied: Biol: 1930. Vol. xvii, No. 1, pp. 127—136), after a prolonged investigation of the fungicidal properties of solutions containing sulphur in polysulphide form on the hop powdery mildews conclude that, in all cases, the fungicidal efficiency is determined solely by the content of polysulphide sulphur of the spray fluid. Hence the purchase and use of proprietary spray fluids of this type, such as ammonium polysulphide, Sulfinette, Solbar, Liver of Sulphur and Lime Sulphur, should be based upon the percentage content of polysulphide sulphur and not upon the total sulphur content.

**Comparative Prices of Spray mixtures per 10 gallons
of diluted fluid.**

Ammonium Polysulphide	1 per cent. solution	...	\$0.30
" "	1 per cent. polysulphide sulphur	...	1.43
Sulfinette	1 per cent. solution	...	0.16
" 4 per cent	5 per cent. solution	...	0.80
" solution	1 per cent. Polysulphide sulphur	...	0.64
Lime Sulphur (Monro)	1 per cent. Polysulphide sulphur	...	0.40
Lime Sulphur (B)	1 per cent. Polysulphide sulphur	...	0.33
Liver of Sulphur	1 per cent. solution	...	1.00
Kerosene Emulsion	2 per cent.	...	0.57
" "	4 per cent.	...	0.77
Solbar	1 per cent. solution	...	0.25
Bordeaux	4 : 4 : 50	...	0.33
"	5 : 5 : 50	...	0.36
Sulphur dust + 10 per cent. of Lime	per 10 lbs.	...	0.61
Sulphur dust + 20 per cent. of Lime	per 10 lbs.	...	0.50

The above prices are based on the prices in Malaya of the products given below.

Bulk Prices in Malaya.

Ammonium Polysulphide...	\$3.00 per gallon.
Sulfinette ...	8.00 per 5 gallon drum.
Copper Sulphate ...	17.50 per cwt.
Liver of Sulphur ...	1.00 per lb.
Lime Sulphur (Monro) ...	1.00 per gallon.
Lime ...	16.00 per ton.
Glycerine ...	7.50 per gallon.
Soap ...	0.15 per lb.
Kerosene ...	0.63 per gallon.
Sulphur ...	130.00 per ton (6 cents per lb.)
Solbar ...	2.70 per 11 lbs. tin.
S. 75 ...	Not quoted (\$7.00 per 56 lbs.?)
Arsenate of Lead ...	0.75 per lb.

CONCLUSIONS.

From the above results it appears that although a single application of a spray mixture is sufficient to decide within two or three days whether or not the concentration is so high as to cause damage to the leaves, it is insufficient to give adequate control of the diseases affecting the leaves.

It is suggested, therefore, that, in order to effect such control, two or even three applications at intervals of 14 days be given. By this means protection is given to such leaves as may develop immediately following the first spraying.

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SUMMARY.

1. A list of available spray fluids together with methods of preparation of non-proprietary articles is given.
2. The effect of the spray fluids at different concentrations is given in tabulated form while the efficiency of a single application of spray fluids is discussed from the point of view of disease control.
3. Comparative prices of the spray fluids are included for guidance.

TABLE 1.

EXPERIMENTAL SPRAYING TO DETERMINE EFFECT OF SOLUTIONS AT DIFFERENT STRENGTHS ON LEAVES.

Sprayed one gallon of mixture to 200, 2 year old plants. Examined (1) after 5 days, (2) after 13 days, (3) after 26 days from time of spraying.

Dusted 5 lbs. of dust mixture to 200, 2 year old plants. x, +, -, represent much, little, and no burning respectively.

Plot No.	Spraying Mixture.	Concentration of Spray Mixture per cent.	Burning.			Where burnt or damaged.	Deposit of mixture on leaf surface.	Leaf Fall.	Mites.	Remarks. Condition of leaves which developed after spraying.
			1	2	3					
1	Sulfinette -	1	-	-	-		Negligible		Many	Young leaves diseased.
2	Sulfinette -	2	-	-	-		"		Few	Young leaves diseased.
3	Sulfinette -	5	-	-	-		Slight			Young leaves diseased.
4	Lime Sulphur "B" Polysulphide -	1	-	-	-		"		Few	Young leaves diseased.
5	Liver of Sulphur -	1	-	-	-	Fairly evenly in spots -	Very slight			Young leaves diseased.
6	Liver of Sulphur -	2	+	+	+	In spots over surface of leaf -	"			Fairly healthy leaves.
7	Kerosene Emulsion -	2	-	-	-	Pale spots -	None			Young leaves diseased.
8	Kerosene Emulsion -	4	+	+	+	Occasional leaves in blotches -	None			Fairly healthy leaves.

TABLE I.—(Contd.)

Plot No.	Spraying Mixture.	Concentration of Spray Mixture per cent.	Burning.			Where burnt or damaged.	Deposit of mixture on leaf surface.	Leaf Fall.	Mites.	Remarks.
			1	2	3					
9	Kerosene Emulsion Lead arsenate	2 0.5 }	+	×	+	Blotches on large im- mature leaves	Slight	Slight	Few	Young leaves diseased.
10	Kerosene Emulsion Lead arsenate	2 1 }	×	×	×	In blotches, leaf sub- sequently falls	Slight	Slight	Few	Young leaves healthy. Stems not affected. Much disease in young leaves.
11	Solbar	1	-	-	-	In spots on tender leaves	Slight			Fairly healthy leaves.
12	"	2	-	+	+	Slight burning in spots on few leaves	Slight			Fairly healthy leaves.
13	Bordeaux Mixture 4-4-50	-	-	-	-	Slight burning in spots on few leaves	Slight			Fairly healthy leaves.
14	Bordeaux Mixture 5-5-50	-	+	+	+	Slight in blotches on tender leaves	Slight			Fairly healthy leaves.
15	Lime Sulphur B	2	+	+	+	Burned in blotches at edge	Slight			Slight disease in young leaves.

TABLE I.—(Contd.)

Plot No.	Spraying Mixture.	Concentration of Spray Mixture per cent.	Burning.			Where burnt or damaged.	Deposit of mixture on leaf surface.	Leaf Fall.	Mites.	Remarks.
			1	2	3					
16	Lime Sulphur B	5	+	+	+	Over all leaf surface in spots	Heavy	Slight		Remaining foliage good and healthy.
17	Sulphur Dust + 10 per cent Lime	-	-	-	-		None			Slight disease, some appear eaten by insects.
18	Sulphur Dust + 20 per cent Lime	-	-	-	-		None			Slight disease in young leaves.
19	Lime Sulphur B (1 per cent) + 1 per cent Glycerine	-	-	-	-		Slight		Few	Slight disease in young leaves.
20	S. 75	1	-	-	-		None		Few	Young leaves diseased.
21	"	2	-	-	+	Slight in few lower leaves	None			Appear eaten by insects, slight disease.
22	"	5	-	+	+	Slight on lower leaves.	None			Young leaves healthy and vigorous.

TABLE 1.—(Contd.)

Plot No.	Spraying Mixture.	Concentration of Spray Mixture per cent.	Burning.			Where burnt or damaged.	Deposit of mixture on leaf surface	Leaf Fall.	Mites.	Remarks.
			1	2	3					
23	Ammonium polysulphide	1	-	-	+	Slight in spots	-			Young leaves healthy and vigorous.
24	Ammonium polysulphide	2	-	-	+	Slight in spots	Slight			Young leaves healthy and vigorous.
25	Ammonium polysulphide	5	-	+	+	Burnt in blotches which drop out	Medium	Slight		Leaves appear eaten by insects, young leaves mainly healthy.