Department of Primary Industries and Regional Development
GOVERNMENT OF WESTERN AUSTRALIA

Journal of the Department of Agriculture, Western Australia, Series 3

Volume 8
Number 5 *September-October, 1959*

Article 17

10-1959

Some experiments on San Jose scale control

G. D. Rimes

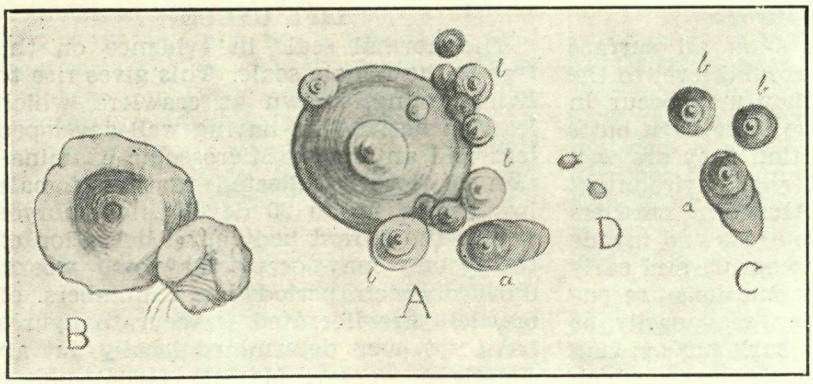

Fig. 1.—Various stages of San José Scale, all enlarged about 15 times. A—Adult female scale with immature young of various stages settles around and upon her; B—An adult female scale turned over revealing the insect herself with the bristle-like mouthparts exposed; C—An adult male scale with two immature winter-stage scales; D—Young crawlers soon after birth

Some Experiments on San José Scale Control

By G. D. RIMES, B.Sc., Entomologist.

WITH the rejection by export fruit inspectors of 13,500 cases of apples during 1959, due to the presence of San José Scale, attention has suddenly been focussed on the importance of San José Scale to the W.A. fruit grower.

San José Scale (*Quadraspidiotus perniciosis*) was originally introduced from China to America about 1870. It was described from this country and was thus given an American name. As late as 1926 it was described as the most destructive fruit pest in several states of the U.S.A. and was one of the causes for rapid development of spray machinery. The transport of infested nursery stock over long distances has made this pest almost universal in distribution. However, a few European countries have escaped infestation and these have placed strict quarantine barriers against the entry of San José infested fruit. As a result of this the control of scale has become a first priority in orchard practice.

DESCRIPTION

The San José Scale attacks all parts of the tree, including the fruit, as well as the bark from the base of the tree to the terminal twigs. On the bark the female scale is the one usually seen, and is grey and circular in appearance, with a central raised nipple which may be of a lighter or darker nature than the surrounding area. The size of the scales will vary due to the presence of several generations at different stages of development, the mature female being approximately 1/10th of an inch in diameter. Smaller, elongate male scales are occasionally interspersed with the females. The scale is readily detached to show a small shield-shaped, legless insect attached to the underlying plant tissue. This approximates in texture and colour a minute piece of lemon fruit tissue. Occasionally upon removal, the long thread-like mouthparts, which are embedded in the plant tissue, are shown, but usually they are severed when the insect body is moved.

The male insect on development is a free-living winged form, and exhibits thread-like plumes which form a tail characteristic of many scale insects. They are very weak intermittent fliers. When jarred from their host material, they fly to the ground in a descending spiral course. Walking is the chief form of locomotion.

HOST PLANTS

San José Scale has been listed from some 700 host plants. The most commonly-infested trees are apple, pear, peach, plum, nectarine and cherry. However almost all deciduous trees and shrubs may be hosts at some time or another and should always be sprayed, if adjoining an orchard property. Rose bushes and pussy willow have been found bearing San José Scale in local areas.

INJURY TO HOSTS

San José Scale occurs on all surface parts of the host from ground level to the tips of the shoots. They may occur in large numbers under the loose bark butts of trees, in which situation they are well protected from the external environment and spray materials. Ascending crawlers may disperse from these areas and invade suitable wood during the spring and early summer. Where high populations are encountered the infestation may easily be overlooked as the entire bark surface may be covered with the scurfy layer, which superficially resembles the natural bark. Up to 100 scales per square inch have been counted from locally infested trees. Heavily infested trees shed their leaves and gradually die. More often certain limbs become infested and die, before the whole tree is affected. This death process has been observed in the Roleystone area on peach trees, and follows a definite pattern. The leaves turn a lighter colour and are shed, this quite often being followed by cracks in the bark which exude large masses of gum. A secondary fungal infection may follow. Any suspected die-back in an orchard should be carefully examined for the presence of San José Scale. Following the successful eradication of scale from the heavily infested tree or limb, the branches and buds may be weakened to the extent, that no fruit is borne for a season or two.

Where crawlers settle on fruits to mature, a characteristic halo-like red discoloration rapidly appears. This red ring remains in evidence after the scale has been removed and is a telltale sign of the scale's presence at one time or another. The calyx and stem cavities of apples and pears are preferred by the scale. A reddish discoloration is also seen occasionally on the tender Yates and peach wood. Where suspected scale is seen, removal of the outer layers of bark, in these two varieties, will show a bright red discoloration of underlying plant tissue.

The normal orchard practice of dormant spraying keeps San José Scale to such low levels of population that no damage is suffered by trees. However due to the stringent quarantine regulations of some overseas countries the presence of a single scale is sufficient to cause the rejection of an export line.

LIFE CYCLE

The normal scale in evidence on the tree is the female scale. This gives rise to living young, known as crawlers, which lead an active life, having well-developed legs and antennae. Microscopic examination of locally-collected mature female has shown up to 20 developing embryos within the parent body. The liberation of the young may occur for some weeks, during which period large numbers of crawlers are liberated. Accurate figures have not been determined locally but an American worker, Marlatt (1906) places the average figure at approximately 400 in U.S.A., while Ludicke (1950) found that from 50 to 200 crawlers were produced per female in Germany. The young spend some time under the parent scale before assuming a free life. Under local conditions crawlers have been traced from the butt of peach trees to the upper limbs, a distance of some 6 ft. The distance travelled is no doubt influenced to a large degree by the nature of the surface and temperature and humidity of the day. Many crawlers however will settle in the immediate vicinity of the parent, or beneath the parent scale.

The free life may last up to two days but the majority of crawlers become attached in a much shorter time. A loose protective wax-like scale has been observed, in local orchards, to be deposited with 24 hours from birth. At this stage the legs and antennae are folded beneath the body. The scale gradually becomes darker and after two to three weeks becomes black, at which stage it is known as the black-capped stage. A moult occurs at this stage and the body appendages are shed. This first stage nymph has a uniform dark scale without any irregularities, and it is this stage that is the main overwintering stage in Western Australian orchards. The first stage nymph undergoes a second moult before reaching maturity. The total life cycle occupies approximately six weeks from crawler to adult in peak summer conditions in Western Australia.

Under local conditions the overwintering stages were found to be females containing partially-developed embryos, as well as first stage nymphs formed from the last summer generation. These gravid females liberate crawlers in mid to late October, crawler activity being readily observed in the Bridgetown area during the period

13/10/58 to 23/10/58. The overwintering first stage nymphs begin rapid development with the onset of the warm weather and reach maturity in December. The October crawlers also mature during December, thus giving two overlapping generations which give rise to the economic menace.

It appears that four generations occur during the summer months with gravid females from the fourth generation overwintering, as well as first stage nymphs from an abbreviated fifth generation.

Unusual climatic conditions may considerably change the above generation postulate. The abnormally long summer experienced during 1959 has resulted in successive generations being developed during what would normally be considered a dormant period. Crawler emergence has been observed as late as July 3. This means a much greater initial population threat to the approaching 1959-1960 season.

The males are free living winged forms and developed beneath a scale in a similar fashion to the female scales. When fully developed the male emerges from the scale covering and assumes a free life. The males copulate with the fully-developed female scale.

DISPERSAL

San José has become almost universally distributed by the shipment of infected nursery stock and fruit. Distribution in local areas by its own means is limited, due to its very short free-living stage, and its rudimentary locomotion. Adjoining trees may infect one another where branches touch.

There is no doubt that the main methods of dispersal within orchards and neighbouring localities are due to wind, birds, insects and orchard personnel.

SOME EXPERIMENTS AND TRIALS ON SAN JOSÉ CONTROL

Dormant Spraying Trial.

The universally-accepted materials for San José Scale control being either lime-sulphur or dormant oil, it was decided to test these materials in large-scale field trials. Three commercial orchards were obtained in various apple-growing areas, viz. Pickering Brook, Bridgetown and Manjimup, the total area being 32 acres comprising mixed apple varieties and stone fruits. These orchards were sprayed by Departmental officers in late August with lime-sulphur 32°—33° Beaume diluted at 14 gallons to 100 gallons water. This was followed in mid-September with Superior dormant oil at the rate of 3 gallons to 100 gallons of water. All trees were sprayed to "run off" approximately 2 gallons per tree being applied.

The harvest from the Pickering Brook and Bridgetown orchards were thoroughly examined and the effectiveness of the materials assessed. The majority of export lines were clear of scale, although an occasional line was rejected. The Yates varieties from both properties was most seriously affected. A noted reduction in scale occurrence was obtained in both orchards, probaly due to the amounts of material used and the unusually thorough application of the spray material. However the dormant treatments used, although giving an excellent economic control of San José Scale, were not sufficiently effective to achieve the almost total eradication necessary, to meet the strict export requirements.

Malathion—Sumer Treatment Experiment.

A block of 60 Yates trees were selected with uniform infestation of San José Scale. Two dormant treatments, one of lime-sulphur and one of superior oil were applied. A summer treatment in mid-February of malathion at the rate of two pints of 20 per cent. per 100 gallons was applied without any white spraying oil to alternate trees. Spraying oil was omitted due to the uncertainty of the reaction of malathion with white oil in the spraying vat. There is a tendency for organic phosphates to undergo hydrolysis in alkaline conditions, such as are encountered when they are mixed with white oil. This matter was later investigated by the Government Analyst and the degree of hydrolysis found to be negligible under normal working conditions. However insecticides of this nature must not be left mixed overnight and to avoid anything untoward, it would be advisable to use one of the newer neutral pH. superior summer spraying oils.

The trees were sampled by picking two cases of fruit from each tree, which could be readily reached from ground level.

Each apple was examined for the presence of scale. Thirty trees from the centre of the block were sampled.

Treatment	Scales Present per Sample															Total	Total $\sqrt{x + \frac{3}{8}}$
Malathion 0·05%	0	0	0	1	0	1	0	0	2	0	0	1	0	1	1	7	12·914
Control....	3	1	2	2	1	1	2	2	3	3	2	2	0	2	0	26	21·041

Analysis of Variance ($\sqrt{x + \frac{3}{8}}$ Transformation)

Variance Due to	D.F.	S.S.	M.S.	V.R.
Sprayed *v* Unsprayed	1	2·201604	2·201604	17·05***
Error	28	3·615566	0·129127	....
Total	29	5·817170	....	....

Conclusion.

The numbers of San José Scale on the fruit from the sprayed trees were significantly less than the numbers of scale on the fruit from the unsprayed trees.

Summer Control Experiment.

A replicated experiment was laid out at Stoneville Research Station to test the effectiveness of Parathion, Gusathion, and Diazinon as summer controls. Dormant treatments of lime-sulphur and Superior oil had been applied in August and September. The summer treatments consisted of the above materials at 0.05 per cent. conc. together with white oil at the rate of 1¼ gallons per 100 gallons spray. The experiment was laid out on a block of Granny Smith apple trees and consisted of the three insecticidal treatments plus control, replicated 12 times, in a randomised block design.

The summer treatments were applied in the 1st week of December and repeated during mid-January.

Two hundred cases of fruit were picked during the sampling of the experiment and each apple examined for the presence of scale. No live scales were present.

At the time of sampling many trees had live scale present on their limbs. This indicated that the sampling technique of examining apples for the presence of scale was of little value in testing these insecticides, when Granny Smith varieties are used. The problem of varietal susceptibility in apples needs investigation. A similar population on Yates and Granny Smiths, will yield a high incidence of scale attack on the Yates fruit, and little or none on the Granny Smith variety.

Summer Control Experiment.

A replicated experiment was laid out at Roleystone on December 2, 1958 to test various insecticides as summer controls. The orchard had been given a dormant treatment of lime-sulphur. Uniformly infested apple trees were selected and divided into blocks. Six treatments were replicated five times. The following insecticidal treatments were applied at a 0.05 per cent. conc. together with summer spraying oil at 1 gallon to 80 gallons spray:—Malathion, Diazinon, Parathion, Trithion, Gusathion.

Sampling was carried out six weeks later by counting the live scales from four twigs from the four compass points on each tree.

It was decided that it would be more appropriate to apply a range test to these treatment means rather than a direct comparison of individual means using a "t" test.

An $\sqrt{x + \frac{1}{2}}$ transformation yielded the following data.

———	Control	Parathion	Malathion	Gusathion	Diazinon	Trithion	Total
Total Scales all blocks	563	20	162	46	50	192	....
Total $\sqrt{x + \frac{1}{2}}$	99·5234	18·3684	45·7943	28·0921	27·8432	54·7022	274·3236
Mean	4·9762	0·9184	2·2897	1·4046	1·3922	2·7351	2·2860

L.S.D. treatment means: $P < .05 = 1.2869$. $P < .01 = 1.7551$ $P < .001 = 2.3751$.

Conclusion.

All treatments are significantly better than the control at the 1 per cent. level. Parathion is significantly better than the

Malathion and Trithion treatments at the 5 per cent. level but not significantly better than the Gusathion or Diazinon treatments.

Metasystox Summer Control Trial.

An experiment was laid out during January 1959 to determine the value of Metasystox as a summer control for San José Scale. An area of heavily-infested peach trees was selected at a Roleystone orchard and divided into eight blocks. Four blocks were treated with metasystox at a concentration of 2 pints per 125 gallons, and four blocks were left untreated as a control.

Sampling was commenced four weeks later and consisted of counting live and dead scale from a selected number of twigs from each tree.

The complete trial was not sampled as it rapidly became obvious that the mortality was so slight, when compared to previous tested materials, as to have little, if any, commercial application.

Post-harvest Spraying Experiment.

Three blocks of Yates trees were selected in a commercial orchard in the Karragullen area for the post-harvest spraying trial. A continuous infestation occurred through out each block. Block A was treated with Diazinon at the rate of 0.05 per cent. plus Superior oil at the rate of 3 gallons per 100 gallons. Block B was used as control, and Block C treated with Gusathion at 0.05 per cent. plus Superior oil at 3 gallons to 100 gallons. The treatments were applied during the week May 6 to 12, 1959, some two weeks after the final harvest.

Sampling was carried out four weeks after spraying and consisted of cutting four twigs from each tree at the four compass points and counting the numbers of live and dead scales on each twig. The 27 trees of each block were sampled.

The following table gives total scales per block, alive and dead.

	Dead Scales	Live Scales	Chi-Squared
Block A Diazinon	131	34	42·1426
Block B Control	159	555	33·6227
Block C Gusathion	371	18	44·1114

A chi-squared analysis was used for comparison.

Test of significance of Treatment Effects

Chi ²due to	D.F.	²	$\frac{x^2}{D.F.}$	V.R.
Treatments	2	595·7669	297·88345	193·82***
Diaz, *v* Gusathion	1	11·8539	11·85390	7·71**
Control × D & G.	1	583·9130	583·91300	379·94***
Heterogeneity	78	119·8767	1·53687	....

Conclusions.

The Gusathion and oil treatment was associated with a significantly higher proportion of dead scale than either the Diazinon or control treatments and both positive treatments were better than the nil treatments in this regard.

As for the total numbers of scale associated with each treatment, an $\sqrt{x \times \frac{1}{2}}$ transformation was carried out and an Analysis of Variance performed.

As indicated the total numbers of scale associated with the nil treatment was significantly higher than that associated with either the Diazinon of Gusathion treatments. The numbers of scales associated with the latter two treatments were not significantly different.

Discussion.

The high degree of mortality associated with the above treatments, particularly the Gusathion and oil treatment, illustrates the possibility of achieving commercial control of San José Scale with a post-harvest spray. At this time of the year the scale is mostly of an immature nature and very susceptible to insecticidal treatment. Without further experimental work general spraying during the post-harvest period cannot be recommended at this stage, but the value of treating isolated trees or limited areas known to be infested, is obvious.

Summary.

1. Some observations have been made on the life cycle and habits of San José Scale under West Australian conditions. Five generations may occur, but this is subject to climatic variation.

2. Large scale field trials of dormant sprays, viz., lime-sulphur followed by Superior dormant oil, have shown that while these materials give good control of scale, they are not sufficiently effective to meet the recently imposed phyto-sanitary export requirements.

3. Post-harvest sprays have been shown to cause a large reduction in the scale population, Gusathion at 0.05 per cent. plus dormant oil at 3 gallons to 100 gallons, being more effective than Diazinon at 0.05 per cent. plus dormant oil at 3 gallons to 100 gallons.

4. Summer treatments of Parathion, Gusathion and Diazinon at 0.05 per cent. plus a summer spraying oil, have been demonstrated to be more effective than the previously recommended Malathion which was shown to have exerted a considerable degree of control.

DISCUSSION

The efficiency of Parathion, Gusathion and Diazinon as summer controls and Gusathion and Diazinon as post-harvest sprays has been clearly demonstrated. The Gusathion and Superior oil treatment in the post-harvest spraying experiment gave a 95 per cent. kill of scale present. The conditions existing at post-harvest spraying are closely akin to those experienced during the normal dormant spraying schedule.

It is reasonable to assume that the efficiency of dormant oil spray would be greatly enhanced by the addition of Parathion, Gusathion or Diazinon at a 0.05 per cent. concentration.

Spray equipment must be in first class condition and adequate coverage of trees obtained. This may involve the use of long lances and the removal of loose bark from the butts of trees.

Where concentrate sprayers are used, particular attention should be paid to observe the recommended speed of travel. In this case the trees at the ends of each row should be paid careful attention, as these are often incompletely sprayed, due to an early cut-off.

CONTROL RECOMMENDATIONS

APPLES AND PEARS

Dormant Treatments.

Superior Oil.—Three gallons to 100 gallons water. The efficiency of the dormant oil spray will be increased by adding Gusathion, Diazinon or Parathion as recommended for summer treatments.

—*or*—

Lime-Sulphur.—Ten gallons to 100 gallons water. Applications to be made in late August or early September. When the oil spray is used this should approximate as close as possible to a fortnight prior to bud burst.

Where infestation is severe, two sprayings are required as follows:—

Lime-sulphur during August, followed approximately one month later with Superior oil. The final spraying to be completed by the first week in September.

Summer Treatments.

In the case of severe scale infestation one or more summer treatments may be necessary and the following are recommended:—

Superior Summer oil or white oil 1¼ gallons to 100 gallons water. Plus Gusathion 25 per cent. wettable powder 2 lb. to 100 gallons.

—*or*—

Diazinon 20 per cent. concentrate two pints per 100 gallons.

—*or*—

Parathion 20 per cent. concentrate two pints per 100 gallons.

(The above materials have been found superior to 1¼ pints 5 per cent. Malathion to 100 gallons.)

Application times—

Late November to early December.
Mid-January.
Late February.

STONE FRUITS

Winter.—Lime Sulphur or Superior oil prior to budburst as recommended for apples and pears.

Summer.—As for apples.

N.B.—Parathion is a highly dangerous material and all safety precautions recommended by the manufacturers should be carefully followed. Application of Parathion should not be made within four weeks of harvesting; Gusathion within three weeks and Diazinon within two weeks

or harvesting. When using Gusathion or Diazinon the precautions prescribed for the use of organic insecticides must be observed. Concentrate should not be allowed to come in contact with the skin and protective clothing must be worn at all times while spraying.

ACKNOWLEDGMENTS

The author wishes to thank the Government Entomologist, Mr. C. F. H. Jenkins, for help and advice received while this work was being carried out.

The author also wishes to record his appreciation of the willing co-operation received from Mr. W. G. Jones, Bridgetown, Mr. D. Gwynne, Roleystone and Mr. G. Neaves, Carilla, who made their orchards and equipment available for experimental work.

REFERENCES

Disselkamp, C., 1954.—The scale formation of San José Scale (*Quadraspidiotus perniciousus Comst.*) Höfchen—Briefe. 7, 105-154.

Flint, W. P., 1923.—Shall we change our recommendations for San José Scale. J.E.E. 16. 209.

Hamilton, D. W., 1953.—Distribution and control of Forbes Scale in the Mid-West. J.E.E. Vol. 46. 496.

Jenkins, C. F. H., 1957.—The San José Scale *Quadraspidiotus perniciosis* (*Comst.*) Journ. Agric. W.A. 6. 2.

Lanchester, H. P., 1957.—Control of San José Scale on Fruit trees during the pre-bloom period of pears. J.E.E. 50. 14.

Ludicke, M., 1950.—Uber biologische. Bersonderheiten der San José Schildlaus in Zusammenhang nut der Wirkung von Phosphorsäureestern. Höfchen-Briefe. 3. 17-32.

Marek, J., 1952.—Uber passive Verbreitung der San José Schildlaus durch einheimische Ameisen. Ztschr. F. Pflanzenbau und Pflanzenschutz 3. 254.

Melander, A. L. 1914.—Can insects become Resistant to Sprays. J.E.E. 7. 167.

Newman, L. J., 1934.—The San José Scale *Aspidiotus perniciosis* (*Comst.*) Journ. Agric. W.A. 10. 495-502.

O'Kane, W. C., 1930.—Lime-Sulphur in relation to San José and Oyster Shell Scales. N.H. Agr. Exp. Sta. Tech. Bull. 40. 15.

O'Neill, W. J., 1951.—DDT and Parathion for San José Scale control. J.E.E. 44. 711.