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The use of Plain Bordeaux Mixture for the successful control of fruit rot *(Mahali)* of Arecanuts caused by *Phytophthora Arecae (P. Palmivora)*

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Introduction. In a previous paper Thomas and Marudarajan (1938) discussed the importance of the fruit rot (*mahali*) of arecanuts in the Malabar and South Canara districts of the Madras Province and the steps that led to the initiation of field experiments to assess the relative values of different spreaders and stickers then in vogue. The experiments conducted in 1937—38 and recorded in that paper showed that plain Bordeaux mixture prepared by the addition of dilute copper sulphate solution to the milk of lime without using any adhesive was as effective in controlling the disease as Bordeaux mixture to which adhesives were added and that the use of resin as an adhesive to Bordeaux mixture made the mixture less effective than the others. These results were very important because they showed the possibilities for breaking an established practice of using resin Bordeaux mixture for *mahali* control which owing to its prolonged usage through three decades had acquired a wide popularity among the cultivators.

The finding that adhesives which were invariably a source of additional expenditure and labour were unnecessary was of far-reaching importance to the areca growers in the *mahali* infected tract. Considering the importance of the problem, the experiments were continued up to 1941—42 to establish beyond all doubt the findings of 1937—38 experiments regarding plain Bordeaux mixture, so that, the change over from an age long practice may be safely and easily effected among the cultivators.

The experiments were repeated in 1938—39 and in 1939—40 in Vittal village of Puttur taluk of the South Kanara district. These two years, however, proved to be very unfavourable for the spread of *Phytophthora* infection with the result that the experiment had to be abandoned by the month of September for lack of sufficient infection in the unsprayed controls.

With the experience of two disappointing seasons, the venue of the experiments was changed from Vittal to Mundaje, a village situated in the *malnad* of Puttur taluk, where the disease had been consistently reported to have been causing serious damage. The rainfall in this area ranges from 200 inches to 240 inches per year. During the monsoon

months of June, July and August the showers are heavy and almost continuous providing ideal conditions for the spread of the disease. The results of the experiments conducted at Mundaje are recorded in this paper.

Objects. The Mundaje experiments were carried out with the following objects in view:

1. To test the efficacy of plain Bordeaux mixture, i. e., Bordeaux mixture without adhesive, in comparison with Bordeaux mixture to which were added adhesives hitherto advocated by the Department of Agriculture for the control of *mahali* disease.

2. To find out whether one percent plain Bordeaux mixture, the cost of preparation of which is only a third of that of two percent resin Bordeaux mixture, would effectively control the disease in heavy rainfall areas like Mundaje where the annual rainfall exceeds 200 inches, and the number of sprayings which will result in optimum efficiency.

3. To compare the efficacy of the *Jet* method of spraying which is in vogue in certain parts of the South Canara district with the *fine* spray. In Malabar, Mysore and other areca growing areas the *fine* spray is usually adopted. The climbers reach the very top of the areca palm and pull towards them the neighbouring bunches with a bamboo hook and direct the *fine* spray to cover the entire bunch with the Bordeaux mixture. But in some parts of the South Canara district, especially in places where, owing to close planting, the stem of the areca palm does not attain its maximum girth and strength, there are risks involved in accidents due to breaking of the trunks. In such places it is customary to use the *jet* method of spraying wherein the climber gets up to about half or three fourths the height of the tree and directs a *jet* of Bordeaux mixture to the bunches all round.

Experimental methods. In May 1940 three gardens in different parts of Mundaje village were chosen for the experiments. In two of these gardens viz., *Anaikallu* (Garden A), and *Theppathagundi* (Garden B) 165 trees were selected in each and in the third garden *Kapinabagalu* (Garden C) 110 trees were selected. Ideal gardens with trees planted in lines and of uniform age and growth were not available in this tract; hence trees of roughly the same height were chosen. These selected groups of trees were divided into a number of linear blocks and the trees were numbered serially from one end. Individual trees were taken as units for treatments. Fifteen trees were taken for each treatment in Garden A and Garden B and ten trees in Garden C. Groups of eleven trees were marked from one end and the eleven treatments detailed below were randomised so that in each of these groups all the treatments including one control were obtained. Thus, the lay

out of the experiment was in randomised blocks, the groups serving as blocks. The details of treatments for the experiments conducted in 1940—41 are given in Table 1.

TABLE I.

Showing strength of fungicides and adhesives 1940—41 Experiments.

Treatment Number.	Fungicides		Adhesive used per 100 gallons of mixture.
	First spray.	Second spray.	
T—1	2% B. M.	2% B. M.	Resin 8 lb.
T—2	do.	do.	Resin 4 lb.
T—3	do.	do.	Resin 2 lb.
T—4	do.	do.	Casein 2 lb.
T—5	do.	do.	Niger oil 80 oz.
T—6	do.	do.	Niger oil 80 oz. *Jet* spray
T—7	do.	do.	No adhesive.
T—8	1% B. M.	do.	Resin 8 lb.
T—9	do.	do.	Casein 2 lb.
T-10	do.	do.	Niger oil 80 oz.
T-11	Control (unsprayed.)	do.	

In the following year (1941—42) the experiment was slightly modified and laid out in Garden B and Garden D (*Bathrabail*) of Mundaje village. The important modification effected was the inclusion of one percent plain Bordeaux mixture. The resin mixtures were omitted. The effect of three sprays as against two sprays was studied. Mixtures of weaker strength (1% mixtures) were included for trial in the monsoon also. The method adopted for the selection of trees and the lay out was on the same lines as in the previous year (1940—41). In Garden B 260 trees were selected and in Garden D, 65 trees. The treatments numbered thirteen as detailed below. There were thus twenty trees under each treatment in Garden B and five trees in Garden D. The details of treatments for the experiments conducted in 1941—42 are given in Table 2.

TABLE II.

Showing strength of fungicides and adhesives 1941—42 Experiments.

Treatment Number.	Fungicides			Adhesive used per 100 gallons of mixture.
	First spray	Second spray	Third spray	
T—1	2% B. M.	2% B. M.	...	Casein 2 lb.
T—2	1% B. M.	do.	...	do.
T—3	do.	1% B. M.	...	do.
T—4	do.	do.	1% B. M.	do.
T—5	2% B. M.	2% B. M.	...	Niger oil 80 oz.
T—6	1% B. M.	do.	...	do.
T—7	do.	1% B. M.	...	do.
T—8	do.	do.	1% B. M.	do.
T—9	2% B. M.	2% B. M.	...	No adhesive.
T-10	1% B. M.	do.	...	do.
T-11	do.	1% B. M.	...	do.
T-12	do.	do.	1% B. M.	do.
T-13	Control (unsprayed.)			

The pre-monsoon spraying in 1940—41 experiments was commenced on the 28th May 1940 and completed on the 2nd June. The monsoon spraying which was commenced on the 12th July 1940, about six weeks from the time of the first spraying, could not be completed till the 31st July on account of the unprecedentedly heavy rains which prevented spraying operations. In the subsequent year (1941—42) the pre-monsoon spraying of both the experimental plots (Gardens B and C) was conducted on the 1st and 2nd June and the second spraying between the 14th and 19th July, about six weeks after the first spraying. The third spraying for the series with three-spray treatment was given between the 1st and 3rd September, about six weeks later than the second spraying.

Observations. In all the experiments observations were recorded in the following manner. Weekly counts of nutfall were recorded from the time of the first appearance of disease till harvest for each individual experimental tree in all the plots and classified as nutfall due to *Phytophthora* infection and nutfall due to other causes. The degree of infection was expressed as percentage of nutfall on the total number of nuts comprising ripe fruit and diseased nut and nuts shedding due to physiological and other causes.

The first signs of the disease in 1940—41 were noted in the 1st week of July 1940 in Garden C and in the last week of July in Gardens A and B. In 1941—42, the first signs of the disease were noted during the second week of July 1941 in Garden B and as late as in the second week of September in Garden D. For want of sufficient spread of natural infection, the Garden D experiment was abandoned during the progress of the experiment. In Garden B where there was wide-spread natural infection observations were recorded till harvest.

The amounts of rainfall recorded during the two years of experiments at Mundaje are given in Table 3.

TABLE III.

Showing record of rainfall in Mundaje from June 1940 to May 1942.

	Rainfall in inches.	
	1940—41	1941—42.
June	44·51	51·36
July	78·84	49·86
August	56·79	55·96
September to May	52·98	41·77
Total for 12 months.	233·12	198·95

Results. The results of these experiments and their statistical analyses are furnished below.

1. *1940—41 experiments — Garden A.* The lay out of the experiment was in randomised block. Fifteen trees were made available for each of the eleven treatments including the control. The summary of the results is given in Table 4.

TABLE IV.

Showing summary of results – Garden A (1940—41.)

Treatment Number.	Fungicides		Adhesive per 100 gallons.	Mean percentage of infection.
	First spray	Second spray		
T—1	2% B. M.	2% B. M.	Resin 8 lb.	Nil.
T—2	do.	do.	Resin 4 lb.	Nil.
T—3	do.	do.	Resin 2 lb.	0·7
T—4	do.	do.	Casein 2 lb.	Nil.
T—5	do.	do.	Niger oil 80 oz.	Nil.
T—6	do.	do.	do. *Jet* spray.	1·4
T—7	do.	do.	No adhesive.	Nil
T—8	1% B. M.	2% B. M.	Resin 8 lb.	Nil
T—9	do.	do.	Casein 2 lb.	1·1
T-10	do.	do.	Niger oil 80 oz.	Nil.
T-11	Control (unsprayed)			60·6
Standard Error	...	...	...	3·0
Critical difference	...	...	...	8·44
Significant	...	...	...	Yes.

Conclusion. $\overline{T_1\ T_2\ T_4\ T_5\ T_7\ T_8\ T_{10}\ T_3\ T_9\ T_6\ T_{11}}$

The analysis of variance was used to see whether or not there existed any treatment effect on percentage of infection. Testing the ratio of variance it was found that the treatment effect as a whole was highly significant. There was also no group to group variation. The critical difference showed that all the treatments were better than the control and that between the different treatments the variation was not significant, so far as the intensity of infection was concerned.

2. *1940—41 experiment — Garden B.* In this experiment also fifteen trees were taken for each of the eleven treatments. The lay out was similar and the statistical analysis of the data worked out on the same lines as for Garden A. The summary of the results is given in Table 5.

TABLE V.

Showing summary of results - Garden B (1940—41.)

Treatment Number.	Fungicides. First spray	Second spray	Adhesive per 100 gallons.	Mean percentage of infection.
T—1	2% B. M.	2% B. M.	Resin 8 lb.	Nil
T—2	do.	do.	Resin 4 lb.	5·0
T—3	do.	do.	Resin 2 lb.	Nil
T—4	do.	do.	Casein 2 lb.	Nil
T—5	do.	do.	Niger oil 80 oz.	Nil
T—6	do.	do.	do. *Jet* spray	Nil
T—7	do.	do.	No adhesive.	Nil
T—8	1% B. M.	2% B. M.	Resin 80 lb.	Nil
T—9	do.	do.	Casein . 2 lb.	5·5
T-10	do.	do.	Niger oil 80 oz.	3·6
T-11	Cotrol (unsprayed)			50·3
Standard Error		...	... ...	3·8
Critical difference		...	... ...	10·53
Significant		...	... ...	Yes

Conclusion. $\overline{T_1\ T_3\ T_4\ T_5\ T_6\ T_7\ T_8\ T_{10}\ T_9\ T_2\ T_{11}}$

The analysis of the figures showed exactly the same conclusions as arrived at in Garden A experiment viz., that all the treatments were better than the control and that between the different sprayings the variation was not significant in the intensity of infection.

3. *1940—41 experiments - Garden C.* Ten trees were taken for each of the eleven treatments. A summary of the results and the statistical analysis are furnished in Table 6.

TABLE VI.

Showing summary of results - Garden C (1940—41.)

Treatment Number	Fungicides First spray	Second spray	Adhesive per 100 gallons	Mean percentage of infection.
T—1	2% B. M.	2% B. M.	Resin 8 lb.	15·9
T—2	do.	do.	Resin 4 lb.	7·7
T—3	do.	do.	Resin 9 lb.	9·1
T—4	do.	do.	Casein 2 lb.	10·6
T—5	do.	do.	Niger oil 80 oz.	21·1
T—6	do.	do.	do. *Jet* spray	11·3
T—7	do.	do.	No adhesive	2·4
T—8	1% B. M.	2% B. M.	Resin 8 lb.	32·7
T—9	do.	do.	Casein 2 lb.	20·9
T-10	do.	do.	Niger oil 80 oz.	Nil
T-11	Control (unsprayed)			78·0
Standard Error		...	... ...	6·4
Critical difference		...	... ...	23·71
Significant		...	... ...	Yes

Conclusion. $\overline{T_{10}\ T_7\ T_2\ T_3\ T_4\ T_6\ T_1\ T_9\ T_5\ T_8\ T_{11}}$

The results of the analysis showed the same conclusions as in Gardens A and B except in the case of T-8 (one percent resin' Bordeaux mixture) which was significantly superior to the control but inferior to all other treatments.

4. *1941—42 experiments - Garden B.* There were 260 trees under the experiment. The treatments as detailed earlier numbered thirteen. There were thus twenty trees under each treatment. The summary of the results are given in Table 7.

TABLE VII.

Showing Summary of results – Garden B (1941—42.)

Treatment Number	Fungicides First spray	Second spray	Third spray	Adhesive per 100 gallons	Mean percentage of infection
T—1	2% B.M.	2% B. M.	...	Casein 2 lbs.	2·72
T—2	1% B.M.	do.	...	do.	5·81
T—3	do.	1% B. M.	...	do.	4·92
T—4	do.	do.	1% B.M.	do.	7·86
T—5	2% B.M.	2% B. M.	...	Niger oil 80 oz.	4·12
T—6	1% B.M.	do.	...	do.	6·00
T—7	do.	1% B. M.	...	do.	17·32
T—8	do.	do.	1% B.M.	do.	6·94
T—9	2% B.M.	2% B. M.	...	No adhesive	0·93
T-10	1% B.M.	do.	...	do.	4·79
T-11	do.	1% B. M.	...	do.	3·87
T-12	do.	do.	1% B.M.	do.	9·57
T-13	Control	(unsprayed)	...		38·59
Standard Error		...	...	...	4·3
Critical difference		...	...	...	11·93
Significant		...	...	...	Yes.

Conclusion. $\overline{T \quad T_1 \quad T_{11} \quad T_5 \quad T_{10} \quad T_3 \quad T_2 \quad T_6 \quad T_8 \quad T_4 \quad T_{12} \quad T_7} \quad T_{13}$

From the analysis of the data it was found that the treatment effect as a whole was highly significant and that there was no group to group variation.

Discussion. As a result of the analysis of the data obtained from the three experiments conducted in 1940—41 the following conclusions are evident.

1. The control shows the heaviest infection.
2. All the spray treatments effectively control the disease.

3. There is no significant difference between the spray treatments except in the Garden C experiment where one percent resin Bordeaux mixture is significantly less effective than the other treatments.

These findings are of extreme economic importance, particularly with regard to the plain Bordeaux mixture, because the use of plain Bordeaux mixture effects a considerable saving in the cost of chemicals and labour.

The *Jet* method of spraying which has been compared with the *fine spray* in the case of oil Bordeaux mixture shows that it is equally effective in so far as disease control is concerned. But, although it is conceded that the use of *Jet* in spraying operations has some practical value in the *malnad* areas from the point of view of the climbers' risks, it is to be noted, however, that it is highly uneconomical. Secondly, the possibilities of Bordeaux injury to the trees cannot be overlooked when large quantities of the mixture are allowed to flow down the trunks by using the *Jet*.

The Garden B experiment of 1941—42 in addition to proving the findings of the previous year shows the following conclusions,

1. There is no significant difference within the spray treatments except T-7 (two sprays with one percent oil Bordeaux mixture).

2. The results of two sprays are not significantly different from those of three sprays; hence two sprays are enough to control the disease.

3. Spraying with one percent Bordeaux mixture excepting one percent oil Bordeaux mixture is not significantly different from two percent Bordeaux mixture.

4. Plain Bordeaux mixture both one percent and two percent are not significantly less effective than the corresponding strengths of the mixture with adhesives.

The above results confirm those obtained in 1937—38 regarding the unassailable position of plain Bordeaux mixture and that no adhesives of any kind are necessary for effective control of the disease even under conditions of heavy rainfall. In addition, it has also been proved that one percent Bordeaux mixture is quite efficient and is in no way inferior to the two percent mixture with or without adhesives.

Economics of Spraying. It will be seen from the results of the experiments conducted between 1937 and 1942 that the old assumption that some spray adhesive like resin or casein is necessary in places of heavy rainfall is not correct. It would appear that the natural adhesiveness of

Bordeaux mixture was thought insufficient to withstand the heavy rains. The very first experiment conducted in 1937—38 showed that two percent plain Bordeaux mixture was quite as efficient as Bordeaux mixture of the same strength with adhesive. The subsequent trial of the same mixture in a heavier rainfall area like Mundaje conclusively established its worth. It was thus clear that the cost of spraying could be considerably reduced by effecting a saving in the expenditure on adhesives and the labour involved in their preparation. In the experiments conducted in 1941—42 one percent plain Bordeaux mixture was included both for the pre-monsoon and monsoon sprayings in order to compare its efficacy with the two percent mixture. Very interesting results were obtained from this experiment. Two sprays with one percent plain Bordeaux mixture ranked equal in efficiency with two sprays with two percent mixture. In addition, it was also proved that two sprays with one percent plain Bordeaux mixture were enough to control the disease and that three sprays were unnecessary even in places of heavy rainfall. Table 8 gives the comparative costs of the treatments tried.

TABLE VIII.

Showing comparative costs of spray treatments.

Serial number.	Nature of mixture.	Chemicals required.	Rate per lb.	Two per cent mixture			One per cent mixture.		
				Quantity.		Cost.	Quantity		Cost.
			Rs. as. ps.	lb.	oz.	Rs. as. ps.	lb.	oz.	Rs. as. ps.
1.	Resin B. M.	Copper sulphate	0—6—6	25	0	10— 2—6	12	8	5— 1—6
		Quick lime ...	0—0—6	25	0	0—12—6	12	8	0— 6—3
		Resin ...	0—5—0	10	0	3— 2—0	10	0	3— 2—0
		Soda ...	0—3—0	5	0	0—15—0	5	0	0—15—0
		Total Rs.				15—0—0			9— 8—6
2.	Casein B.M.	Copper sulphate	0—6—6	25	0	10— 2—6	12	8	5— 1—6
		Quick lime ...	0—0—6	25	0	0—12—6	12	8	0— 6—3
		Casein ...	0—6—0	2	8	0—15—0	2	8	0—15—0
		Total Rs.				11—14—0			6— 6—9
3.	Oil B. M.	Copper sulphate	0—6—6	25	0	10— 2—6	12	8	5— 1—6
		Quick lime ...	0—0—6	25	0	0—12—6	12	8	0— 6—3
		Niger oil ...	0—4—0	6	4	1— 9—0	6	4	1— 9—0
		Total Rs.				12— 8—0			7— 0—9
4.	Plain B. M.	Copper sulphate	0—6—6	25	0	10— 2—6	12	8	5— 1—6
		Quick lime ...	0—0—6	25	0	0—12—6	12	8	0— 6—3
		Total Rs.				10—15—0			5— 7—9

It will be seen from the above statement that the cost of one percent plain Bordeaux mixture is about only one third of the cost of two percent resin Bordeaux mixture which was in vogue in the Malabar and South Canara districts prior to the inception of these experiments.

Summary.

The use of plain Bordeaux mixture without any adhesive for the control of *mahali* disease of arecanuts was studied. The results of the experiments showed that one percent Bordeaux mixture without adhesives for both the pre-monsoon and monsoon spraying was as efficient as the two percent mixture with or without adhesives. A comparison between the results of two sprays and three sprays with one percent plain Bordeaux mixture showed that two sprays were quite enough for the control of the disease and that three sprays were unnecessary. The cost of the chemicals has been reduced by about two-thirds by substituting one percent plain Bordeaux mixture for the two percent resin Bordeaux mixture.

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Reference.

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