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Rubber Seed Oil for Partial Substitution of Mineral Oil Used as Carrier for Copper Fungicide in the Management of Abnormal Leaf Fall Disease of Rubber

C.K. JACOB*#, P. SRINIVAS*, E.E. PREM*, M.J. MANJU*,
S.K. MUSHRIF* AND S.P. IDICULA*

Rubber seed oil (RSO) was evaluated for its potential use in oil-based spray formulations against abnormal leaf fall disease of rubber (Hevea brasiliensis) *which could influence the economics of disease management. A mixture of RSO and mineral spray oil (SO) in a proportion of 1:2 was assessed as a carrier for the fungicide copper oxychloride (COC), in comparison with SO alone. The scope for reducing the dosage of COC, when RSO and SO were mixed (1:2 proportion) for spraying against abnormal leaf fall disease, was investigated in field trials in two endemic locations over six years. Results indicated that the use of RSO for partial substitution of SO was promising and resulted in similar disease control as provided by the use of SO. Lower dosage (6 kg/ha) of COC was found to be comparable to the recommended dosage of COC (8 kg/ha) when RSO + SO was used as carrier. RSO had no phytotoxic effect on the rubber leaves either alone or in combination with spray oil. Reduction in cost was evident when a combination of partial complementation with RSO and a reduced dosage of COC was applied.*

Key words: *Hevea brasiliensis*; rubber seed oil; abnormal leaf fall; copper oxychloride; spraying; disease control; properties; *phytophthora* spp.

Abnormal leaf fall (ALF) disease caused by *Phytophthora* spp. is the most damaging disease of rubber (*Hevea brasiliensis*) plantations in South India. The high crop loss due to this disease[1–3] necessitates protective measures every year[4]. Prophylactic spraying of copper fungicide is a recommended practice in South India for protection against the disease. Expenditure on disease management in rubber cultivation is an important component of the total crop production cost in the region. Abnormal leaf fall disease warrants prophylactic fungicidal protection every year and reduction in cost of ALF protection needs to be achieved.

The small growers resort to high volume spraying of Bordeaux mixture (1%) which is a labour intensive method with a daily coverage of only 0.4 ha involving 10–20 workers[5]. A low volume spraying of oil-based copper fungicide using micron sprayers is recommended to

*Rubber Research Institute of India, Rubber Board P.O., Kottayam-686009, India
Corresponding author (e-mail: kuruvilla@rubberboard.org.in)

reduce the labour requirements and to improve the daily coverage. The low volume spraying of copper oxychloride (COC) dispersed in spray oil, significantly reduces labour and fungicide costs and the average daily coverage is 5 ha using six workers[4]. Furthermore, high rainfall during the disease season necessitates the use of oil-based fungicides which can provide prolonged protection of the crop with a single prophylactic spraying. The spray fluid requires high tenacity for adhesion of fungicides on leaves. Prophylactic spraying with copper fungicide is the recommended crop protection practice against ALF disease and at present a majority of the areas under small and medium holdings are sprayed by oil-based fungicides using the micron sprayer[6].

Although most agricultural oils currently in use are petroleum distillates, applicability of vegetable and animal oils have been increasingly examined to meet certain crop protection needs[7]. Due to the increasing prices of mineral spray oil (SO), its partial complementation by rubber seed oil (RSO) as a carrier for oil-based copper fungicide was attempted to bring down the cost without compromising on the efficacy of disease control. Rubber seed oil is a by-product of rubber plantations and its cost is comparatively lower than the mineral spray oil presently used. Reduction in dosage of the fungicide, if possible, would also reduce the overall cost of crop protection.

In the present study an attempt was made to reduce the cost of spraying by partially supplementing the spray oil with RSO in combination with lower dosages of COC.

MATERIALS AND METHODS

The experiments for partial complementation of mineral oil with RSO and effect of low dosages of copper oxychloride 56% oil dispersable powder (ODP) alone and in combination with RSO were carried out in a sequential manner. The experiments were laid out in mature-rubber plantations at ALF disease endemic areas.

The treatments were imposed in blocks of one hectare each. The micron sprayer fitted with the Micronair AU 8120 atomiser[6] was used for spraying in all the experimental plots. The spraying was carried out by four workers carrying the sprayer on their shoulders and walking between each row of trees at a speed of 2 km/h to 3 km/h. Spraying was carried out in the morning before 11 a.m. to avoid air turbulence. Trials were carried out during May prior to the onset of the South West monsoon in all experimental locations. The efficacy of spraying was evaluated for leaf retention assessment by tagging four branches per tree from 10 trees in each block[5]. The experimental plots received all the agro-management practices uniformly as per recommendation[8]. Each sampling tree was treated as a replicate and the data were statistically analysed in a completely randomised design.

Evaluation of Chemical and Physical Properties of Rubber Seed Oil

Evaluation of RSO and its combinations with mineral oil for viscosity, vertical discharge and phytotoxicity was carried out at Rubber Research Institute of India (RRII), Kottayam. The RSO was evaluated for its possible phytotoxic effect by spraying on rubber leaves at different phenological stages. Changes in the viscosity levels due to mixing of RSO were also observed using a viscometer. Vertical discharge of different combinations namely COC with SO, RSO and SO + RSO was assessed. The height of spray was assessed by observing the spray deposits on clean microscopic

slides, horizontally hung from the top of sampling trees at distances of 30 cm each down to the ground. Unsulphonated residue (USR), viscosity, specific gravity, pour point and suspensibility were also analysed using standard laboratory procedures (*ASTM D483*; *ASTM D446*; *ASTM D1298*; *ASTM D97* and *IS 12873*, 1990).

Disease Control with Partial Complementation of Mineral Oil with RSO

RSO was evaluated as a carrier for oil dispersable COC at two locations, namely Pudukad Estate in Mooply Valley, Trissur District and the other in a low rainfall region, the Central Experiment Station of the Rubber Research Institute of India at Chethackal, Ranni in clones RRIM 600, RRII 105 and GT 1. As RSO has[9] high viscosity it was not possible to use it directly for spraying due to clogging of spray nozzles[9]. RSO could be used to replace spray oil by one-third of the volume[10]. COC was used at a recommended dosage (8 kg/ha) at the ratio of 1:5 (fungicide to oil or mixture of oils). A 1:2 mixture of RSO and spray oil (40 L/ha) was compared with COC at the recommended dosage in spray oil and unsprayed plots served as controls.

Effect of Low Dosages of COC

Evaluation of the effect of lower dosages (than currently recommended 8 kg/ha) of COC on disease severity in comparison with the recommended dose was carried out at Chemoni Estate, Mooply Valley, Trichur on the clone RRII 105. The treatment consisted of one pre-monsoon (prophylactic) micron spraying with four different doses of COC *viz*. 2, 4, 6 and 8 kg/ha each in one-hectare treatment plots, respectively. The spraying was carried out during May, prior to the monsoon using SO (40 L/ha) as carrier.

Effect of Low Dosage of COC in Combination with RSO

To evaluate the effect of reducing the dosage of COC in combination of RSO and SO for protection against abnormal leaf fall disease, the experiment was carried out on two clones *viz*. RRIM 600 and RRII 105 at both Pudukad and Chemoni Estates, respectively, in Mooply Valley, Trichur. Treatments with different dosages of COC at rates of 4 kg, 6 kg and 8 kg per hectare dispersed in 40 litres of SO and RSO, mixed in 2:1 ratio were tried. SO + RSO (2:1) with no COC served as a control.

Estimation of Cost Benefits Achieved by RSO Complementation

The cost benefits achieved by partial supplementation of RSO was calculated by using the prices of different input during April/ May 2006 on a per hectare basis.

RESULTS AND DISCUSSION

Evaluation of Chemical and Physical Properties of Rubber Seed Oil

The evaluation of viscosity indicated increasing viscosity for spray oil, spray oil + RSO (2:1) and RSO alone. There was a reduction in the viscosity for RSO + SO when compared with RSO alone (*Table 1*).

The vertical discharge of spray fluid (on micron spraying) using different combinations of oil was comparable for SO and RSO + SO combination. When compared to spray oil with COC dispersed in it, the vertical spray-throw of RSO + SO along with COC was lower by just 30 cm (*Table 2*). The spraying of RSO and its combination with SO for assessment of phytotoxicity on light green

and dark green stages of leaves did not induce any symptoms of phytotoxicity on *H. brasiliensis*.

The chemical and physical properties like USR, viscosity, specific gravity, flash point, pour point and suspensibility (*Table 3*) were comparable for the combination of RSO + SO to SO alone and were well within the specified limits for spray oils[7,11].

Disease Control under Partial Complementation of Mineral Oil with RSO

The results of leaf retention assessment (during 2000–2001) from the experimental plots on clone RRIM 600 in Pudukad Estate (*Table 4*) revealed that the treatment with RSO + SO accounted for maximum leaf retention of 51.78%, followed by spray oil alone (38.03%). The unsprayed control plot had the least leaf retention (13.06%).

In the Central Experimental Station, the highest leaf retention in clone RRII 105 was observed for the treatment with SO alone (71.66%) followed by the RSO + SO treatment (66.88%) and the least leaf retention was in the unsprayed plot (55.88%). However, these differences were not statistically significant. Interestingly for the clone GT 1 the maximum protection to ALF disease was observed in the plot sprayed using RSO + SO mixture with 59.40% leaf retention, while unsprayed control and spray oil plots showed 48.8% and 42.75% retention, respectively.

During the year 2001–2002, RSO + SO mediated COC spray resulted in higher leaf retention across the locations and in all clones tested, followed by SO when compared with unsprayed experimental plots.

Effect of Low Dosages of COC

In 2000–2001, the effect of dosage of COC on disease severity showed no difference in leaf retention of RRII 105 between 6 kg/ha (73.08%) and 8 kg/ha (73.34%) treatments (*Table 5*). The dosage of 4 kg/ha also gave good leaf retention (70.9%), considerably higher than that in the lowest dose of 2 kg/ha (60.14 %). The recommended dose of 8 kg/ha displayed highest disease control with maximum leaf retention (78.28%) closely followed by 6 kg/ha (66.2%) while significantly lower leaf retention was observed with 4 kg/ha (59.2%) and 2 kg/ha (53.61%) treatments during year

TABLE 1. EVALUATION OF VISCOSITY OF OILS

Combination	Viscometric observation (Mean time – min:sec)
SO alone	0:18
SO + RSO (2:1)	0:45
RSO alone	3:50

TABLE 2. EVALUATION OF DIFFERENT COMBINATIONS OF OILS FOR VERTICAL DISCHARGE AND PHYTOTOXICITY

Combination	Vertical spray discharge (m)	Phytotoxicity
SO + COC	16.8	Absent
SO + RSO + COC	16.5	Absent

TABLE 3. QUALITY PARAMETERS OF THE OILS AND THEIR COMBINATION

Treatment	USR (%)	Viscosity (37.8ºC)	Specific gravity (25ºC)	Pour point (ºC)	Suspensibility (%)
RSO alone	Frothing not done	53.93	0.9187	–6	92.81
SO + RSO (2:1)	45.17	10.24	0.8709	< –8	97.69
Spray oil (SO)	77.55	3.56	0.8449	< –8	99.20

TABLE 4. ALF DISEASE CONTROL USING COC DISPERSED IN RSO + SO OR SO ALONE

Location	Clone	Treatment	Leaf retention (%) 2000–2001	2001–2002
Pudukad Estate, Trichur	RRIM 600	Rubber seed oil + spray oil	51.78	48.08
		Spray oil	38.03	42.58
		Unsprayed (control)	13.06	5.93
		CD (P≤0.05)	0.26	22.93
Central Experimental Station, Chethackal, Ranni	RRII 105	Rubber seed oil + spray oil	66.88	75.97
		Spray oil	71.66	71.38
		Unsprayed (control)	55.88	52.83
		CD (P≤0.05)	NS	14.68
	GT 1	Rubber seed oil + spray oil	59.40	65.50z
		Spray oil	42.75	63.16
		Unsprayed (control)	48.80	41.54
		CD (P≤0.05)	NS	16.05

NS = Not significant

2001–2002, with the same clone. The results revealed scope for reduction in dosage of COC for the clone RRII 105.

Effect of Low Dosage of COC in Combination with RSO

In both locations of experimentation, it was observed that lower dosage of COC were comparable to the recommended dose (8 kg/ha) when RSO + SO was used as carrier during 2003–2004, though RSO + SO alone was not effective in disease control (*Table 6*), for both the clones in 2003–2004. During the following year, however, highest leaf retention of 81.73% was observed for 8 kg/ha COC treatment, followed by 6 kg/ha and 4 kg/ha COC (73.8% and 67.4%) as compared to the lowest leaf retention (48.3%) for control plot in Pudukkad Estate (RRIM 600). Interestingly in clone RRII 105, in Chemony Estate, highest leaf retention was observed in treatments with 8 kg/ha and 6 kg/ha COC (~71%) followed by 4 kg/ha COC treatment (64.5%) as compared to 39.6% leaf retention in control (SO + RSO alone). Thus the use of RSO for partial substitution of SO resulted in satisfactory disease control with lower dosage of COC even for the highly diseased susceptible clone, RRIM 600. The synergistic effect of RSO in disease control could be due to the presence of fungitoxic hydrogen cyanide in it[12].

TABLE 5. EFFECT OF LOW DOSES OF COC ON CONTROL OF ABNORMAL LEAF FALL DISEASE IN CLONE RRII 105 USING SO AS CARRIER

Treatment (COC kg/ha)	Leaf retention (%)	
	2000–2001	2001–2002
2 kg	60.14	53.61
4 kg	70.90	59.20
6 kg	73.08	66.20
8 kg	73.34	78.28
CD (P≤0.05)	NS	17.33

NS = Not significant

TABLE 6. EFFECT OF DIFFERENT DOSAGES OF COC, SPRAYED USING RSO + SO AS CARRIER ON ABNORMAL LEAF FALL DISEASE CONTROL

Location	Clone	Treatment	Leaf retention (%)	
			2003-2004	2004-2005
Pudukad Estate Trichur	RRIM 600	RSO + SO+ 8 kg COC/ha	50.94	81.73
		RSO + SO+ 6 kg COC/ha	45.39	73.77
		RSO + SO+ 4 kg COC/ha	41.25	67.43
		RSO + SO	29.33	48.30
		Unsprayed	7.92	–
		CD (P≤0.05)	12.62	8.091
Chemoni Estate, Trichur	RRII 105	RSO + SO + 8 kg COC/ha	65.32	71.99
		RSO + SO + 6 kg COC/ha	59.53	71.38
		RSO + SO + 4 kg COC/ha	50.65	64.58
		RSO + SO	22.08	39.64
		CD (P≤0.05)	13.74	16.65

Estimation of Cost Benefits Achieved by RSO Complementation

The cost benefits achieved by partial supplementation RSO was calculated by using the latest prices available for different input on per hectare basis (*Table 7*). It was clearly indicated that a sum of Rs. 808/- could be saved (18.82%) on the cost of crop protection against ALF disease, per hectare.

In India, rubber seed collection remains unorganised and commercial exploitation by planters is not up to the desired extent. Major contributing factors for it are the low price of the seed in the market compared to the cost of labour involved in collection and the difficulty in storage. The two major products processed from rubber seeds are RSO and rubber seed cake. The weight of rubber seed varies from 3 g to 5 g of which 40% is kernel, 35% shell and 25% moisture. Oil content of the kernel is 42%. The rubber seed and its oil are generally utilised for the soap industry, alkyd resin and cattle and chicken feed[12–14]. An alternative use as carrier for spraying COC in combination with regular mineral spray oil opens up a new avenue for

TABLE 7. ESTIMATED COST AND SAVINGS PER HECTARE FOR ANNUAL SPRAYING AGAINST ALF DUE TO USE OF LOW DOSAGE OF COC IN COMBINATION WITH RSO + SO

Micron spraying	Unit cost[a]	Cost /ha			
		SO alone		RSO + SO	
Copper oxychloride	Rs. 300/kg	8 kg	2400	6 kg	1800
Spray oil	Rs. 40.48/litre	40 litres	1620	26.66 litres	1080
Labour	Rs. 105.34/day	1.2[b] mandays	127	1.2 mandays	127
Petrol	Rs. 46/litre	1 litre	46	1 litre	46
Rubber seed oil	Rs. 25/litre	–	–	13.33 litres	332
Capital investments	Rs. 100/annum	–	100		100
Total cost per hectare/annum		Rs. 4293		Rs. 3485	
Savings/ha				Rs. 808	

[a]At the prevailing rates in April/May; [b]Six workers covering 5 ha per day.

the utilisation and promotion of RSO. Oil based formulations have less specific gravity in the spray fluid resulting in spray particles rising high up in the canopy for better coverage[6].

The protection of trees from ALF disease results in better growth and increased tree girth besides increased rubber yield[2–3]. The higher wood volume thus obtained also contributed to the additional income. Considerable savings on cost of weeding in sprayed plots has also been reported[2]. In the present study a successful attempt was made to use RSO for spraying oil-based COC against ALF disease. Besides reduction in cost, the RSO has the advantage that it is an environmentally friendly product from the rubber estate. If oil is extracted locally the cost can be reduced further.

CONCLUSION

The present investigation revealed that adequate control of ALF disease could be achieved economically by replacing one third of the spray volume with RSO and reducing the dosage of COC from 8 kg/ha to 6 kg/ha for micron spraying under normal disease incidence.

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