



RESEARCH ARTICLE

# Potential use of petroleum-based mineral oil and fungicide combinations for the management of leaf spot disease caused by *Pseudocercospora eumusae* in banana

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## Abstract

Leaf spot disease, caused by *Pseudocercospora eumusae*, significantly impacts banana production in India. This study evaluates the effectiveness of petroleum oil (Banole®), both alone and in combination with fungicides, in managing leaf spot disease in the banana cultivars Nendran (AAB) and Robusta (AAA) across different growth phases. The results indicate that petroleum oil alone reduced disease severity, achieving reductions of up to 48.18 % in Nendran and 66.60 % in Robusta. When petroleum oil (1.0 %) was combined with half the recommended fungicide dose, disease control was significantly enhanced, with reductions of up to 90.14 % in Nendran and 73.99 % in Robusta. These results were comparable to those achieved with full fungicide doses applied alone. Additionally, the treatments significantly increased the value of Youngest Leaf Spotted-0 (YLS-0) by up to 140.22 % and improved yield by up to 72.69 %. Increasing the petroleum oil concentration from 1.0 % to 2.5 % and 5.0 % further enhanced disease control efficacy; however, it also led to phytotoxicity during the summer period. Therefore, spraying banana plants with 1 % mineral oil, either alone or in combination with half the recommended fungicide dose, is a promising strategy for effectively managing leaf spot disease while ensuring high-quality banana yields.

**Keywords:** banana; Banole®; disease severity; leaf spot; yield

## Introduction

Leaf spot disease complex is a significant constraint in banana farming and one of the most serious threats to global banana production (1). Although there are three different species of *Pseudocercospora* such as *Pseudocercospora fijiensis*, *Pseudocercospora musicola* and *Pseudocercospora eumusae* reported to cause major leaf spot diseases in banana, only the *P. eumusae* which cause eumusae leaf spot disease was reported in India (2, 3). This eumusae leaf spot disease caused a significant threat to banana production in several Asian countries, including India, Sri Lanka, Thailand, Malaysia and Vietnam, as well as some Indian Ocean islands like Mauritius and Nigeria (3-5). The disease often causes premature ripening of the fruits. This presents a major challenge for bananas, which are typically harvested while unripe and later ripened artificially during transport or in controlled industrial greenhouses (6, 7). In India, the disease has spread across major banana-growing regions, including Tamil Nadu, Kerala, Karnataka, Andhra Pradesh, Gujarat, West Bengal and the north-eastern hilly areas, causing substantial losses in banana production (8). Most commercial banana varieties, except Karpuravalli, are highly susceptible to this disease (9). Early symptoms appear as pale yellow or greenish-yellow streaks on the leaves, which darken and

develop into elliptical brown spots. As the disease progresses, these lesions expand, merge and eventually cause leaf drooping, leading to the premature destruction of leaves before the bunch reaches maturity. Additionally, infected bananas are more prone to peel splitting and premature ripening, further reducing their marketability and negatively impacting both the quantity and quality of banana production (10). Beyond directly affecting plant health, leaf spot disease also increases susceptibility to other diseases, such as peduncle rot, particularly during the bunch maturation phase in warmer climates (8, 11). The disease severity has been particularly high in cultivars such as Grand Nain (AAA), Nendran (AAB) and Pachanadan (Pome-AAB), with an infection index ranging from 90 % to 100 % and crop losses varying between 40 % and 76 % (12). Chemical control using fungicides is commonly employed in India to manage the disease. However, widespread fungicide application has raised environmental concerns and led to the development of pathogen resistance, making disease management increasingly challenging (13). The use of mineral oil in the 1960s was found to be effective, but its application was discontinued due to phytotoxicity issues (14). However, recent modifications in the chemical composition, particularly in the length of carbon chains, have shown that mineral oil application no longer causes phytotoxicity to banana crops. Therefore, the present study

evaluates the efficacy of mineral oil (Banole®) at different concentrations, both with and without fungicides, to determine the optimal combination for economically and effectively managing leaf spot disease in banana.

## Materials and Methods

### Field experiments

To evaluate the efficacy of petroleum mineral oil (Banole®) with and without fungicides against eumusae leaf spot disease in banana two field trials were conducted in two different locations viz. Tiruchirapalli and Theni districts of Tamil Nadu, India in the cultivars Robusta (AAA) and Nendran (AAB). A total of 24 treatments which consisted of oil at 1.0 %, 2.5 % and 5.0 %; mancozeb 75 % WP-0.25 %; carbendazim 50 % WP-0.1 %; mancozeb 63 % + carbendazim 12 % WP-0.1 %; propiconazole 25 % EC-0.1 %; mancozeb-0.12 %; carbendazim-0.05 %; mancozeb + carbendazim-0.05 %; propiconazole-0.05 %; oil 1.0 % + mancozeb-0.12 %; oil 1.0 % + carbendazim-0.05 %; oil 1.0 % + (mancozeb + carbendazim)-0.05 %; oil 1.0 % + propiconazole-0.05 %; oil 2.5 % + mancozeb 0.12 %; oil 2.5 % + carbendazim-0.05 %; oil 2.5 % + (mancozeb + carbendazim)-0.05 %; oil 2.5 % + propiconazole-0.05 %; oil 5.0 % + mancozeb-0.12 %; oil 5.0 % + carbendazim-0.05 %; oil 5.0 % + (mancozeb + carbendazim)-0.05 %; oil 5.0 % + propiconazole-0.05 % and control (only water spray) were included in the present study. The experiment was conducted in randomized block design with three replications and each replication consisted of 10 plants.

Spraying of oil, fungicides and their combinations was carried out at 25-day intervals, beginning at fourth month of planting or onset of the disease whichever is earlier. A total of four rounds of sprays were administered. Observations on disease severity and YLS -0 were recorded at three different growth phases: vegetative (6 months after planting), shooting and harvest. Disease severity was assessed according to Gaul's modification of Stover's severity scoring system (INIBAP Technical Guidelines No. 6). The disease was scored using 0–6 scale rating where 0 = no disease symptoms, 1 = < 1 % of leaf with disease symptoms (10 spots per leaf), 2 = 1 %–5 % of leaf area spotted, 3 = 6 %–15 %, 4 = 16 %–33 %, 5 = 34 %–50 % and 6 = > 50 % of leaf area spotted and disease severity index (DSI) was calculated.

$DSI = (\text{Average of disease score of each plant/the highest disease index value}) \times 100$

During harvest, yield per plant (kg) was recorded in all the treatments.

### Statistical analysis

All the recorded data were compiled and subjected to statistical analysis using analysis of variance (ANOVA). Further, mean values were compared utilizing Duncan's Multiple Range Test (DMRT) to determine the significance of differences between treatments.

## Results

### Effect of oil, fungicides and their combinations on leaf spot disease severity

In both Nendran and Robusta banana cultivars, the application of petroleum oil alone, as well as combinations of oil with half the recommended dose of fungicides, significantly reduced the severity of leaf spot disease across all growth phases (vegetative, flowering

and harvest).

For the Nendran cultivar, the percentage reduction in disease severity due to the application of oil alone ranged from 48.18 % during the vegetative phase, to 42.94 % during flowering and 43.41 % at harvest (Table 1). However, when oil was applied at a concentration of 1.0 % in combination with half the recommended dose of fungicides, the reduction in disease severity was significantly higher. Specifically, the disease severity was reduced by 64.78 %, 90.14 % and 63.45 % at the vegetative, flowering and harvest stages respectively, compared to control and the effects were better than treatments with oil or fungicides applied alone (whether at full or half doses). The most substantial reduction was achieved with a combination of 5 % oil and 0.05 % propiconazole, which reduced disease severity by 96.76 % during the vegetative stage, 95.38 % during flowering and 91.66 % at harvest.

Similarly, in the Robusta cultivar, application of oil alone reduced disease severity by 61.58 %, 66.60 % and 34.76 % during the vegetative, flowering and harvest stages respectively (Table 2). As observed in Nendran, the combination of 1.0 % oil with half the recommended dose of fungicides significantly reduced disease severity-by 63.23 % during the vegetative stage, 73.99 % at flowering and 53.06 % at harvest. Notably, increasing the oil concentration to 2.5 % and 5.0 % further enhanced the reduction in disease severity across all growth stages. However, phytotoxicity symptoms were observed on leaves sprayed with either 2.5 % or 5 % oil, whether applied alone or in combination with fungicides.

### Effect of petroleum oil, fungicides and their combinations on youngest leaf spotted-0

In both cultivars, the value of YLS-0, significantly increased in all treated plots compared to the untreated control. In, Nendran, all treated plots (oil, full doses of fungicides and their combinations) recorded an increase in YLS-0 of 40.04 %-58.34 %, 46.63 %-76.95 % and 58.43 %-99.73 % in vegetative, flowering and harvesting stages respectively. The highest increase in the value of YLS-0 occurred in the plot treated with a combination of 2.5 % oil and 0.05 % propiconazole, showing a 127.96 % increase over the control (Table 3). Similar trend was observed in Robusta while the highest increase in YLS-0 occurred with the combination of 5.0 % oil and half the dose of propiconazole (0.05 %), which showed a 207.25 % increase over the control at harvest, followed by the combination of 2.5 % oil and half the dose of propiconazole (Table 4). Overall, combining oil with half the dose of fungicides resulted in higher increases in YLS-0 in both Nendran and Robusta cultivars, compared to individual treatments.

### Effect of petroleum oil, fungicides and their combinations on yield

The results of the observation on the yield in Nendran, oil alone resulted in a yield increase of 7.01 % to 14.60 %, while the greatest yield increase of 48.89 % was observed with a combination of 2.5 % oil and half the dose of propiconazole (0.05 %), which was statistically on par with the combination of 5.0 % oil and 0.05 % propiconazole (Table 5).

In cv. Robusta, the application of oil alone led to a yield increase ranging from 29.34 % to 39.36 %. The highest yield enhancement (105.2 %) was recorded with the combination of 2.5 % oil and half the recommended dose of propiconazole (0.05 %). However, increasing the oil concentration to 5.0 % in combination

**Table 1.** Effect of petroleum oil (Banole®) alone and in combination with certain fungicides on infection index of Sigatoka leaf spot disease in banana cv. Nendran

Sl. no.	Treatments	Vegetative stage			Flowering stage			Harvest stage		
		DSI	PDOC	DSI	PDOC	DSI	PDOC	DSI	PDOC	
1	Oil-1 %	4.28 <sup>j</sup>	32.36 <sup>i</sup> (34.64)	23.11 <sup>f</sup>	35.10 <sup>i</sup> (54.93)	28.00 <sup>i</sup>	37.40 <sup>i</sup> (37.69)			
2	Oil- 2.5 %	2.70 <sup>gf</sup>	57.39 <sup>gh</sup> (49.25)	19.87 <sup>fe</sup>	44.22 <sup>ef</sup> (41.68)	24.47 <sup>h</sup>	45.29 <sup>i</sup> (42.29)			
3	Oil- 5 %	2.86 <sup>hgf</sup>	54.78 <sup>gh</sup> (47.75)	17.99 <sup>ed</sup>	49.49 <sup>def</sup> (44.71)	23.46 <sup>h</sup>	47.55 <sup>i</sup> (42.32)			
	<b>Mean</b>	<b>3.28</b>	<b>48.18</b>	<b>20.32</b>	<b>42.94</b>	<b>25.31</b>	<b>43.41</b>			
4	Mancozeb-0.25 %	2.73 <sup>gf</sup>	56.84 <sup>gh</sup> (48.94)	8.67 <sup>cb</sup>	75.67 <sup>bc</sup> (60.46)	24.15 <sup>h</sup>	46.02 <sup>i</sup> (42.71)			
5	Carbendazim-0.1 %	2.11 <sup>ed</sup>	66.72 <sup>ef</sup> (54.77)	4.91 <sup>ba</sup>	86.23 <sup>ab</sup> (68.22)	14.83 <sup>e</sup>	66.86 <sup>i</sup> (54.86)			
6	Mancozeb + carbendazim-0.1 %	1.59 <sup>c</sup>	74.86 <sup>d</sup> (59.92)	2.02 <sup>a</sup>	94.35 <sup>a</sup> (76.59)	15.20 <sup>e</sup>	66.02 <sup>f</sup> (54.35)			
7	Propiconazole-0.1 %	2.50 <sup>fe</sup>	60.48 <sup>fg</sup> (51.05)	2.88 <sup>ba</sup>	91.93 <sup>a</sup> (73.57)	15.09 <sup>e</sup>	66.26 <sup>f</sup> (54.49)			
	<b>Mean</b>	<b>2.23</b>	<b>64.73</b>	<b>4.62</b>	<b>87.05</b>	<b>17.32</b>	<b>61.29</b>			
8	Mancozeb-0.12 %	2.93 <sup>hg</sup>	53.76 <sup>gh</sup> (47.15)	22.34 <sup>f</sup>	37.28 <sup>f</sup> (37.61)	28.17 <sup>i</sup>	37.04 <sup>i</sup> (37.48)			
9	Carbendazim-0.05 %	2.56 <sup>gf</sup>	59.53 <sup>fg</sup> (50.49)	21.27 <sup>f</sup>	40.28 <sup>ef</sup> (39.40)	20.50 <sup>g</sup>	54.17 <sup>h</sup> (47.39)			
10	Mancozeb + carbendazim -0.05 %	3.22 <sup>h</sup>	49.17 <sup>hi</sup> (44.52)	20.69 <sup>f</sup>	41.89 <sup>ef</sup> (40.33)	20.49 <sup>g</sup>	54.18 <sup>h</sup> (47.40)			
11	Propiconazole-0.05 %	3.75 <sup>i</sup>	40.79 <sup>ij</sup> (39.69)	14.01 <sup>edc</sup>	60.42 <sup>cde</sup> (51.01)	19.89 <sup>g</sup>	55.55 <sup>hi</sup> (48.18)			
	<b>Mean</b>	<b>3.12</b>	<b>50.81</b>	<b>19.58</b>	<b>44.97</b>	<b>22.26</b>	<b>50.24</b>			
12	Oil 1 % + mancozeb- 0.12 %	1.66 <sup>c</sup>	73.83 <sup>de</sup> (59.26)	3.41 <sup>ba</sup>	90.43 <sup>ab</sup> (71.98)	19.25 <sup>g</sup>	56.97 <sup>h</sup> (49.01)			
13	Oil 1 % + carbendazim-0.05 %	1.87 <sup>dc</sup>	70.44 <sup>de</sup> (57.07)	3.29 <sup>ba</sup>	90.77 <sup>a</sup> (72.32)	15.24 <sup>fe</sup>	65.94 <sup>fg</sup> (54.29)			
14	Oil 1 % + (mancozeb + carbendazim) -0.05 %	2.63 <sup>gf</sup>	58.42 <sup>fg</sup> (49.85)	4.02 <sup>ba</sup>	88.73 <sup>ab</sup> (70.38)	17.06 <sup>f</sup>	61.87 <sup>g</sup> (51.87)			
15	Oil 1 % + propiconazole-0.05 %	2.76 <sup>gf</sup>	56.44 <sup>gh</sup> (48.70)	3.34 <sup>ba</sup>	90.62 <sup>ab</sup> (72.17)	13.87 <sup>ed</sup>	69.00 <sup>ef</sup> (56.17)			
	<b>Mean</b>	<b>2.23</b>	<b>64.78</b>	<b>3.52</b>	<b>90.14</b>	<b>16.35</b>	<b>63.45</b>			
16	Oil 2.5 % + mancozeb-0.12 %	1.64 <sup>c</sup>	74.15 <sup>de</sup> (59.47)	2.72 <sup>ba</sup>	92.36 <sup>a</sup> (73.96)	12.90 <sup>d</sup>	71.16 <sup>e</sup> (57.52)			
17	Oil 2.5 % + carbendazim-0.05 %	1.50 <sup>cb</sup>	76.28 <sup>cd</sup> (60.87)	2.52 <sup>ba</sup>	92.94 <sup>a</sup> (74.59)	6.65 <sup>c</sup>	85.14 <sup>d</sup> (67.33)			
18	Oil 2.5 % + (mancozeb + carbendazim) -0.05 %	0.59 <sup>a</sup>	90.67 <sup>b</sup> (72.49)	3.15 <sup>ba</sup>	91.16 <sup>a</sup> (72.70)	6.79 <sup>c</sup>	84.81 <sup>d</sup> (67.07)			
19	Oil 2.5 % + propiconazole-0.05 %	0.30 <sup>a</sup>	95.26 <sup>ab</sup> (77.60)	3.19 <sup>ba</sup>	91.04 <sup>a</sup> (72.58)	6.20 <sup>cb</sup>	86.14 <sup>cd</sup> (68.15)			
	<b>Mean</b>	<b>1.01</b>	<b>84.09</b>	<b>2.90</b>	<b>91.88</b>	<b>8.14</b>	<b>81.81</b>			
20	Oil 5 % + mancozeb-0.12 %	0.54 <sup>a</sup>	91.47 <sup>b</sup> (73.07)	5.08 <sup>ba</sup>	87.75 <sup>ab</sup> (67.82)	5.79 <sup>cb</sup>	87.05 <sup>bcd</sup> (68.92)			
21	Oil 5 % + carbendazim-0.05 %	0.40 <sup>a</sup>	93.67 <sup>ab</sup> (75.91)	2.18 <sup>a</sup>	93.88 <sup>a</sup> (75.68)	4.68 <sup>ba</sup>	89.54 <sup>ab</sup> (71.25)			
22	Oil 5 % + (mancozeb + carbendazim) -0.05 %	1.09 <sup>b</sup>	82.77 <sup>c</sup> (65.50)	3.35 <sup>ba</sup>	90.59 <sup>ab</sup> (72.14)	5.30 <sup>cba</sup>	88.115 <sup>bc</sup> (69.87)			
23	Oil 5 % + propiconazole-0.05 %	0.21 <sup>a</sup>	96.76 <sup>a</sup> (79.92)	1.65 <sup>a</sup>	95.38 <sup>a</sup> (77.59)	3.73 <sup>a</sup>	91.66 <sup>a</sup> (73.25)			
	<b>Mean</b>	<b>0.56</b>	<b>91.17</b>	<b>3.07</b>	<b>91.90</b>	<b>4.88</b>	<b>89.10</b>			
24	Control	6.33 <sup>k</sup>	0.000 <sup>k</sup> (9.58)	35.61 <sup>g</sup>	0.00 <sup>k</sup> (9.13)	44.73 <sup>j</sup>	0.00 <sup>k</sup> (8.27)			
	CV	<b>9.230</b>	<b>4.539</b>	<b>33.644</b>	<b>9.319</b>	<b>5.402</b>	<b>2.241</b>			
	CD (P=0.05 %)	<b>0.419</b>	<b>5.119</b>	<b>6.418</b>	<b>11.750</b>	<b>1.851</b>	<b>2.443</b>			

DSI: Disease severity index; PDOC: Per cent decrease over control; Values in the parentheses are arcsine transformed.

**Table 2.** Effect of petroleum oil (Banole®) alone and in combination with certain fungicides on infection index of Sigatoka leaf spot disease in banana cv. Robusta

Sl. no.	Treatments	Vegetative stage			Flowering stage			Harvest stage		
		DSI	PDOC	DSI	PDOC	DSI	PDOC	DSI	PDOC	
1	Oil-1 %	12.31 <sup>i</sup>	53.57 <sup>i</sup> (47.05)	15.28 <sup>on</sup>	62.46 <sup>mn</sup> (52.22)	39.10 <sup>o</sup>	27.76 <sup>op</sup> (31.79)			
2	Oil-2.5 %	10.50 <sup>hg</sup>	60.40 <sup>hi</sup> (51.01)	13.55 <sup>nm</sup>	66.71 <sup>klm</sup> (54.76)	33.97 <sup>nm</sup>	37.24 <sup>nm</sup> (37.60)			
3	Oil-5 %	7.75 <sup>dc</sup>	70.77 <sup>cd</sup> (57.28)	11.95 <sup>pnj</sup>	70.64 <sup>hk</sup> (57.20)	32.86 <sup>ml</sup>	39.27 <sup>lm</sup> (38.80)			
	<b>Mean</b>	<b>10.19</b>	<b>61.58</b>	<b>13.59</b>	<b>66.60</b>	<b>35.31</b>	<b>34.76</b>			
4	Mancozeb-0.25 %	8.74 <sup>ged</sup>	67.04 <sup>d<sup>g</sup></sup> (54.97)	11.48 <sup>li</sup>	71.78 <sup>ej</sup> (57.91)	31.77 <sup>lk</sup>	41.30 <sup>kl</sup> (39.99)			
5	Carbendazim-0.1 %	4.13 <sup>a</sup>	84.44 <sup>a</sup> (66.77)	9.07 <sup>ff</sup>	77.70 <sup>eg</sup> (60.20)	24.50 <sup>h</sup>	54.73 <sup>h</sup> (47.71)			
6	Mancozeb + carbendazim-0.1 %	7.86 <sup>dc</sup>	70.37 <sup>cd</sup> (57.03)	11.07 <sup>kh</sup>	72.80 <sup>gh</sup> (58.58)	28.95 <sup>ij</sup>	46.51 <sup>ij</sup> (42.99)			
7	Propiconazole-0.1 %	5.77 <sup>b</sup>	78.26 <sup>b</sup> (62.23)	8.30 <sup>he</sup>	79.60 <sup>def</sup> (61.46)	24.47 <sup>h</sup>	54.79 <sup>h</sup> (47.75)			
	<b>Mean</b>	<b>6.63</b>	<b>75.03</b>	<b>9.98</b>	<b>75.47</b>	<b>27.42</b>	<b>49.33</b>			
8	Mancozeb-0.12 %	12.45 <sup>i</sup>	53.05 <sup>i</sup> (46.75)	16.13 <sup>o</sup>	60.36 <sup>n</sup> (50.98)	40.89 <sup>o</sup>	24.44 <sup>q</sup> (29.62)			
9	Carbendazim-0.05 %	10.20 <sup>hg</sup>	61.53 <sup>g<sup>i</sup></sup> (51.68)	13.26 <sup>nl</sup>	67.42 <sup>kl</sup> (55.20)	34.16 <sup>nm</sup>	36.87 <sup>nm</sup> (37.39)			
10	Mancozeb + carbendazim-0.05 %	10.69 <sup>hg</sup>	60.84 <sup>hi</sup> (51.26)	15.72 <sup>o</sup>	61.37 <sup>n</sup> (51.58)	34.04 <sup>nm</sup>	37.11 <sup>nm</sup> (37.53)			
11	Propiconazole-0.05 %	9.87 <sup>hgf</sup>	62.77 <sup>fi</sup> (52.41)	13.75 <sup>nm</sup>	66.21 <sup>lm</sup> (54.46)	34.89 <sup>k</sup>	35.54 <sup>n</sup> (36.59)			
	<b>Mean</b>	<b>10.80</b>	<b>59.55</b>	<b>14.72</b>	<b>63.84</b>	<b>36.00</b>	<b>33.49</b>			
12	Oil 1 % + mancozeb-0.12 %	10.16 <sup>hg</sup>	61.68 <sup>g<sup>i</sup></sup> (51.76)	12.61 <sup>mlk</sup>	69.01 <sup>l</sup> (56.17)	30.29 <sup>kl</sup>	44.04 <sup>jk</sup> (41.57)			
13	Oil 1 % + carbendazim-0.05 %	9.50 <sup>gfe</sup>	64.17 <sup>e-h</sup> (53.24)	10.34 <sup>nm</sup>	74.58 <sup>gh</sup> (59.73)	25.68 <sup>h</sup>	52.55 <sup>h</sup> (46.46)			
14	Oil 1 % + (mancozeb + carbendazim)-0.05 %	11.10 <sup>h</sup>	58.16 <sup>l</sup> (49.71)	10.90 <sup>kh</sup>	73.21 <sup>fi</sup> (58.84)	27.61 <sup>i</sup>	48.98 <sup>l</sup> (44.42)			
15	Oil 1 % + propiconazole-0.05 %	8.25 <sup>ed</sup>	68.91 <sup>d<sup>e</sup></sup> (56.11)	8.48 <sup>fed</sup>	79.16 <sup>d<sup>e</sup></sup> (62.85)	18.03 <sup>ef</sup>	66.68 <sup>g</sup> (54.75)			
	<b>Mean</b>	<b>9.75</b>	<b>63.23</b>	<b>10.58</b>	<b>73.99</b>	<b>25.40</b>	<b>53.06</b>			
16	Oil 2.5 % + mancozeb 0.12 %	8.61 <sup>fed</sup>	67.53 <sup>d<sup>e</sup></sup> (55.26)	11.61 <sup>li</sup>	71.47 <sup>g<sup>i</sup></sup> (57.72)	18.74 <sup>g</sup>	65.37 <sup>g</sup> (53.96)			
17	Oil 2.5 % + carbendazim-0.05 %	7.65 <sup>dc</sup>	71.16 <sup>cd</sup> (57.52)	7.39 <sup>d<sup>a</sup></sup>	81.85 <sup>bc</sup> (64.78)	14.83 <sup>ed</sup>	72.61 <sup>cd</sup> (58.45)			
18	Oil 2.5 % + (mancozeb + carbendazim)-0.05 %	8.17 <sup>ed</sup>	69.18 <sup>d<sup>e</sup></sup> (56.28)	7.83 <sup>d<sup>c</sup></sup>	80.76 <sup>cd</sup> (64.04)	16.54 <sup>e</sup>	69.44 <sup>ef</sup> (56.44)			
19	Oil 2.5 % + propiconazole-0.05 %	7.70 <sup>dc</sup>	70.98 <sup>cd</sup> (57.41)	6.27 <sup>ba</sup>	84.58 <sup>ab</sup> (66.90)	14.26 <sup>d<sup>c</sup></sup>	73.65 <sup>bc</sup> (59.12)			
	<b>Mean</b>	<b>8.03</b>	<b>69.71</b>	<b>8.28</b>	<b>79.67</b>	<b>16.09</b>	<b>70.27</b>			
20	Oil 5 % + mancozeb-0.12 %	6.65 <sup>cb</sup>	74.94 <sup>bc</sup> (59.98)	8.57 <sup>g<sup>fe</sup></sup>	78.94 <sup>d<sup>e</sup></sup> (62.68)	18.12 <sup>ef</sup>	66.52 <sup>fg</sup> (54.65)			
21	Oil 5 % + carbendazim-0.05 %	5.72 <sup>b</sup>	78.45 <sup>b</sup> (62.38)	5.63 <sup>ba</sup>	86.17 <sup>a</sup> (68.17)	11.43 <sup>ba</sup>	78.88 <sup>a</sup> (62.66)			
22	Oil 5 % + (mancozeb + carbendazim)-0.05 %	6.24 <sup>b</sup>	76.46 <sup>b</sup> (61.06)	7.15 <sup>d<sup>a</sup></sup>	82.43 <sup>bc</sup> (65.22)	15.99 <sup>ed</sup>	70.46 <sup>d<sup>e</sup></sup> (57.08)			
23	Oil 5 % + propiconazole-0.05 %	3.94 <sup>a</sup>	85.16 <sup>a</sup> (67.43)	5.73 <sup>ba</sup>	85.92 <sup>a</sup> (67.98)	12.99 <sup>cb<sup>a</sup></sup>	76.01 <sup>b</sup> (60.67)			
	<b>Mean</b>	<b>5.64</b>	<b>78.75</b>	<b>6.77</b>	<b>83.37</b>	<b>14.63</b>	<b>72.97</b>			
24	Control	26.52 <sup>j</sup>	0.00 <sup>k</sup> (7.78)	40.69 <sup>p</sup>	0.00 <sup>q</sup> (10.35)	54.12 <sup>p</sup>	0.00 <sup>r</sup> (8.13)			
	CV	<b>7.332</b>	<b>3.081</b>	<b>7.411</b>	<b>2.303</b>	<b>3.323</b>	<b>2.083</b>			
	CD (P=0.05)	<b>1.391</b>	<b>3.418</b>	<b>1.819</b>	<b>2.720</b>	<b>1.828</b>	<b>1.937</b>			

DSI: Disease severity index; PDOC: Per cent decrease over control; Values in the parentheses are arcsine transformed.

**Table 3.** Effect of petroleum oil (Banole®) alone and in combination with fungicides on the value of YLS-0 in banana cv. Nendran

Sl. no.	Treatments	Vegetative stage			Flowering stage			Harvest stage		
		YLS-0	PIOC	YLS-0	PIOC	YLS-0	PIOC	YLS-0	PIOC	
1	Oil-1 %	10.65 <sup>j</sup>	22.42 <sup>i</sup> (28.11)	11.25 <sup>abc</sup>	59.57 <sup>a-e</sup> (50.62)	7.40 <sup>h</sup>	59.14 <sup>h</sup> (59.69)			
2	Oil-2.5 %	12.8 <sup>a-g</sup>	47.13 <sup>a-g</sup> (43.33)	12.15 <sup>abc</sup>	72.34 <sup>a-d</sup> (58.71)	7.25 <sup>h</sup>	55.92 <sup>h</sup> (55.48)			
3	Oil-5 %	13.1 <sup>a-f</sup>	50.58 <sup>a-f</sup> (45.33)	12.40 <sup>ab</sup>	75.88 <sup>a-d</sup> (60.75)	7.45 <sup>h</sup>	60.22 <sup>h</sup> (60.75)			
	<b>Mean</b>	<b>12.18</b>	<b>40.04</b>	<b>11.93</b>	<b>69.26</b>	<b>7.37</b>	<b>58.43</b>			
4	Mancozeb -0.25 %	14.05 <sup>ab</sup>	61.49 <sup>ab</sup> (51.70)	11.95 <sup>abc</sup>	69.51 <sup>a-d</sup> (56.59)	8.45 <sup>ef</sup>	81.72 <sup>ef</sup> (79.04)			
5	Carbendazim-0.1 %	12.3 <sup>c-i</sup>	41.38 <sup>c-i</sup> (39.97)	12.00 <sup>abc</sup>	70.22 <sup>a-d</sup> (56.95)	8.30 <sup>ef</sup>	78.49 <sup>ef</sup> (78.86)			
6	Mancozeb + carbendazim-0.1 %	14.15 <sup>a</sup>	62.64 <sup>a</sup> (52.48)	12.10 <sup>abc</sup>	71.63 <sup>a-d</sup> (57.82)	8.20 <sup>f</sup>	76.35 <sup>f</sup> (78.72)			
7	Propiconazole-0.1 %	13.3 <sup>a-e</sup>	52.88 <sup>a-d</sup> (46.66)	12.55 <sup>ab</sup>	78.02 <sup>abc</sup> (63.25)	8.65 <sup>def</sup>	86.03 <sup>c-f</sup> (87.27)			
	<b>Mean</b>	<b>13.45</b>	<b>54.60</b>	<b>12.15</b>	<b>72.35</b>	<b>8.40</b>	<b>80.65</b>			
8	Mancozeb-0.12 %	10.95 <sup>ij</sup>	25.87 <sup>ij</sup> (30.50)	8.55 <sup>ef</sup>	21.27 <sup>f</sup> (27.21)	7.10 <sup>h</sup>	52.69 <sup>h</sup> (53.26)			
9	Carbendazim-0.05 %	11.65 <sup>f-j</sup>	33.91 <sup>e-j</sup> (35.61)	10.95 <sup>bcd</sup>	55.32 <sup>a-e</sup> (48.15)	7.55 <sup>gh</sup>	62.37 <sup>ef</sup> (61.89)			
10	Mancozeb + carbendazim-0.05 %	12 <sup>d-j</sup>	37.93 <sup>d-i</sup> (37.98)	10.45 <sup>cd</sup>	48.23 <sup>def</sup> (43.97)	7.50 <sup>h</sup>	61.29 <sup>gh</sup> (60.82)			
11	Propiconazole-0.05 %	11.15 <sup>hij</sup>	28.16 <sup>hij</sup> (31.91)	11.40 <sup>abc</sup>	61.70 <sup>a-d</sup> (51.88)	8.15 <sup>fg</sup>	75.26 <sup>f</sup> (78.67)			
	<b>Mean</b>	<b>11.44</b>	<b>31.47</b>	<b>10.34</b>	<b>46.63</b>	<b>7.58</b>	<b>62.90</b>			
12	Oil 1 % + mancozeb-0.12 %	11.35 <sup>g-j</sup>	30.46 <sup>g-i</sup> (33.28)	9.25 <sup>de</sup>	31.21 <sup>ef</sup> (33.64)	7.30 <sup>h</sup>	56.99 <sup>gh</sup> (57.54)			
13	Oil 1 % + carbendazim-0.05 %	11.95 <sup>e-j</sup>	37.36 <sup>d-i</sup> (37.59)	11.45 <sup>abc</sup>	62.42 <sup>a-d</sup> (52.49)	8.55 <sup>ef</sup>	83.88 <sup>def</sup> (84.90)			
14	Oil 1 % + (mancozeb + carbendazim)-0.05 %	13.2 <sup>a-e</sup>	51.723 <sup>a-e</sup> (45.99)	10.75 <sup>bcd</sup>	52.49 <sup>cde</sup> (46.43)	8.65 <sup>def</sup>	86.03 <sup>c-f</sup> (85.27)			
15	Oil 1 % + propiconazole-0.05 %	11.6 <sup>f-j</sup>	33.34 <sup>f-i</sup> (35.16)	12.10 <sup>abc</sup>	71.63 <sup>a-d</sup> (57.99)	9.35 <sup>bc</sup>	101.1 <sup>b-c</sup> (108.2)			
	<b>Mean</b>	<b>12.03</b>	<b>38.22</b>	<b>10.89</b>	<b>54.44</b>	<b>8.46</b>	<b>82.00</b>			
16	Oil 2.5 % + mancozeb 0.12 %	12.55 <sup>b-h</sup>	44.26 <sup>b-h</sup> (41.68)	10.85 <sup>bcd</sup>	53.90 <sup>b-e</sup> (47.26)	8.35 <sup>ef</sup>	79.57 <sup>ef</sup> (78.92)			
17	Oil 2.5 % + carbendazim-0.05 %	14.15 <sup>a</sup>	62.65 <sup>a</sup> (52.35)	11.95 <sup>abc</sup>	69.50 <sup>a-d</sup> (56.73)	8.60 <sup>def</sup>	84.95 <sup>def</sup> (83.21)			
18	Oil 2.5 % + (mancozeb + carbendazim)-0.05 %	12.85 <sup>a-g</sup>	47.70 <sup>a-f</sup> (43.65)	11.10 <sup>abcd</sup>	57.45 <sup>a-e</sup> (49.35)	9.40 <sup>bc</sup>	102.15 <sup>b</sup> (101.0)			
19	Oil 2.5 % + propiconazole-0.05 %	13.25 <sup>a-e</sup>	52.30 <sup>a-d</sup> (46.34)	12.15 <sup>abc</sup>	72.34 <sup>a-d</sup> (58.49)	10.60 <sup>a</sup>	127.96 <sup>a</sup> (123.1)			
	<b>Mean</b>	<b>13.20</b>	<b>51.73</b>	<b>11.51</b>	<b>63.30</b>	<b>9.24</b>	<b>98.66</b>			
20	Oil 5 % + mancozeb -0.12 %	13.9 <sup>ab</sup>	59.77 <sup>ab</sup> (50.66)	11.95 <sup>abc</sup>	69.51 <sup>a-d</sup> (56.93)	9.20 <sup>bcd</sup>	97.85 <sup>bcd</sup> (98.89)			
21	Oil 5 % + carbendazim-0.05 %	13.5 <sup>a-d</sup>	55.18 <sup>a-c</sup> (48.02)	12.85 <sup>a</sup>	82.27 <sup>a</sup> (65.20)	9.60 <sup>b</sup>	106.45 <sup>b</sup> (103.2)			
22	Oil 5 % + (mancozeb + carbendazim)-0.05 %	14.1 <sup>a</sup>	62.07 <sup>ab</sup> (51.99)	12.00 <sup>abc</sup>	70.21 <sup>a-d</sup> (57.23)	8.85 <sup>cde</sup>	90.33 <sup>b-e</sup> (90.5)			
23	Oil 5 % + propiconazole-0.05 %	13.6 <sup>abc</sup>	56.33 <sup>abc</sup> (48.69)	13.10 <sup>a</sup>	85.81 <sup>a</sup> (63.97)	9.50 <sup>b</sup>	104.30 <sup>b</sup> (102.1)			
	<b>Mean</b>	<b>13.78</b>	<b>58.34</b>	<b>12.48</b>	<b>76.95</b>	<b>9.29</b>	<b>99.73</b>			
24	Control	8.7 <sup>k</sup>	0.00 <sup>k</sup> (15.23)	7.05 <sup>f</sup>	0.00 <sup>g</sup> (4.83)	4.65 <sup>f</sup>	0.000 <sup>f</sup> (1.79)			
	CV	<b>5.961</b>	<b>12.415</b>	<b>7.912</b>	<b>16.534</b>	<b>3.695</b>	<b>15.22</b>			
	CD (P=0.05)	<b>1.546</b>	<b>10.483</b>	<b>1.853</b>	<b>17.418</b>	<b>0.633</b>	<b>9.213</b>			

PDIC: Per cent increase over control; Values in the parentheses are arcsine transformed.

**Table 4.** Effect of petroleum oil (Banole®) alone and in combination with certain fungicides on the value of YLS-0 in banana cv. Robusta

Sl.no.	Treatments	Vegetative stage			Flowering stage			Harvest stage		
		YLS-0	PIOC	YLS-0	PIOC	YLS-0	PIOC	YLS-0	PIOC	
1	Oil-1 %	11.60 <sup>dh</sup>	27.47 <sup>d-g</sup> (31.57)	8.45 <sup>f</sup>	14.18(22.12)	6.40 <sup>k</sup>	85.505 <sup>k</sup> (84.36)			
2	Oil-2.5 %	11.50 <sup>e-h</sup>	26.37 <sup>e-fg</sup> (30.89)	8.45 <sup>f</sup>	14.19(21.98)	6.50 <sup>k</sup>	88.405 <sup>k</sup> (87.95)			
3	Oil-5 %	11.85 <sup>d-h</sup>	30.22 <sup>d-g</sup> (33.35)	9.15 <sup>ij</sup>	23.65 <sup>hi</sup> (29.07)	7.80 <sup>gij</sup>	126.09 <sup>ei</sup> (121.00)			
4	<b>Mean</b>	<b>11.65</b>	<b>28.02</b>	<b>8.68</b>	<b>17.34</b>	<b>6.90</b>	<b>100.00</b>			
5	Mancozeb-0.25 %	12.90 <sup>abc</sup>	41.76 <sup>abc</sup> (40.22)	10.65 <sup>c-f</sup>	43.92 <sup>c-f</sup> (41.51)	8.35 <sup>e-fg</sup>	142.03 <sup>e-fg</sup> (142.16)			
6	Carbendazim-0.1 %	12.25 <sup>a-f</sup>	34.62 <sup>a-f</sup> (36.03)	11.30 <sup>bc</sup>	52.71 <sup>bc</sup> (46.55)	8.70 <sup>d-e</sup>	152.17 <sup>d-e</sup> (152.18)			
7	Mancozeb + carbendazim-0.1 %	12.00 <sup>c-g</sup>	31.87 <sup>c-f</sup> (34.37)	11.10 <sup>b-e</sup>	50.00 <sup>b-e</sup> (45)	8.05 <sup>f-i</sup>	133.33 <sup>g-hi</sup> (129.13)			
8	Propiconazole-0.1 %	13.10 <sup>ab</sup>	43.96 <sup>ab</sup> (41.52)	11.70 <sup>ab</sup>	58.11 <sup>ab</sup> (49.68)	9.20 <sup>cd</sup>	166.67 <sup>bcd</sup> (165.22)			
9	<b>Mean</b>	<b>12.56</b>	<b>38.05</b>	<b>11.19</b>	<b>51.19</b>	<b>8.58</b>	<b>148.55</b>			
10	Mancozeb-0.12 %	10.40 <sup>i</sup>	14.91 <sup>hi</sup> (22.68)	8.85 <sup>ij</sup>	19.59 <sup>ij</sup> (26.25)	7.30 <sup>j</sup>	111.59 <sup>i</sup> (112.05)			
11	Carbendazim-0.05 %	10.95 <sup>hi</sup>	20.33 <sup>gh</sup> (26.80)	10.05 <sup>fgh</sup>	35.81 <sup>fg</sup> (36.74)	7.45 <sup>j</sup>	115.94 <sup>il</sup> (114.07)			
12	Mancozeb + carbendazim-0.05 %	11.00 <sup>ghi</sup>	20.88 <sup>gh</sup> (27.12)	9.35 <sup>hi</sup>	26.35 <sup>hi</sup> (30.84)	7.50 <sup>ij</sup>	117.39 <sup>ij</sup> (115.07)			
13	Propiconazole-0.05 %	11.45 <sup>e-h</sup>	25.83 <sup>e-fg</sup> (30.53)	9.50 <sup>ghi</sup>	28.37 <sup>eh</sup> (32.13)	7.70 <sup>hij</sup>	123.19 <sup>hij</sup> (122.09)			
14	<b>Mean</b>	<b>10.95</b>	<b>20.49</b>	<b>9.44</b>	<b>27.53</b>	<b>7.49</b>	<b>117.03</b>			
15	Oil 1 % + mancozeb-0.12 %	12.10 <sup>bf</sup>	32.97 <sup>b-f</sup> (35.02)	10.50 <sup>def</sup>	41.89 <sup>def</sup> (40.33)	8.30 <sup>e-fg</sup>	140.58 <sup>e-fg</sup> (142.15)			
16	Oil 1 % + carbendazim-0.05 %	11.40 <sup>fi</sup>	25.28 <sup>fg</sup> (30.13)	10.45 <sup>ef</sup>	41.220 <sup>ef</sup> (39.92)	8.35 <sup>e-fg</sup>	142.03 <sup>e-fg</sup> (140.16)			
17	Oil 1 % + (mancozeb + carbendazim)-0.05 %	11.55 <sup>dh</sup>	26.93 <sup>e-fg</sup> (31.16)	10.20 <sup>fg</sup>	37.84 <sup>f</sup> (37.91)	8.15 <sup>eh</sup>	136.23 <sup>e-h</sup> (135.14)			
18	Oil 1 % + propiconazole-0.05 %	11.55 <sup>dh</sup>	26.92 <sup>e-fg</sup> (31.16)	10.65 <sup>c-f</sup>	43.92 <sup>c-f</sup> (41.5)	8.35 <sup>e-fg</sup>	142.03 <sup>e-fg</sup> (142.16)			
19	<b>Mean</b>	<b>11.65</b>	<b>28.03</b>	<b>10.45</b>	<b>41.22</b>	<b>8.29</b>	<b>140.22</b>			
20	Oil 2.5 % + mancozeb-0.12 %	12.45 <sup>a-e</sup>	36.82 <sup>a-e</sup> (37.29)	11.20 <sup>bcd</sup>	51.35 <sup>bcd</sup> (45.77)	7.65 <sup>hij</sup>	121.74 <sup>hij</sup> (122.08)			
21	Oil 2.5 % + carbendazim-0.05 %	12.40 <sup>a-f</sup>	36.27 <sup>a-e</sup> (37.01)	11.40 <sup>ab</sup>	54.06 <sup>ab</sup> (47.33)	8.45 <sup>ef</sup>	144.93 <sup>ef</sup> (145.16)			
22	Oil 2.5 % + (mancozeb + carbendazim)-0.05 %	11.60 <sup>d-h</sup>	27.48 <sup>d-g</sup> (31.54)	11.25 <sup>bc</sup>	52.03 <sup>bc</sup> (46.17)	9.15 <sup>d</sup>	165.22 <sup>cd</sup> (165.22)			
23	Oil 2.5 % + propiconazole-0.05 %	12.55 <sup>a-d</sup>	37.91 <sup>a-d</sup> (37.99)	11.70 <sup>ab</sup>	58.11 <sup>ab</sup> (49.67)	9.95 <sup>b</sup>	188.41 <sup>ab</sup> (187.28)			
24	<b>Mean</b>	<b>12.25</b>	<b>34.62</b>	<b>11.39</b>	<b>53.89</b>	<b>8.80</b>	<b>155.08</b>			
25	Oil 5 % + mancozeb-0.12 %	12.15 <sup>a-f</sup>	33.52 <sup>a-f</sup> (35.37)	11.50 <sup>ab</sup>	55.41 <sup>ab</sup> (48.10)	8.70 <sup>d-e</sup>	152.17 <sup>d-e</sup> (151.18)			
26	Oil 5 % + carbendazim-0.05 %	13.10 <sup>ab</sup>	43.96 <sup>ab</sup> (41.52)	12.10 <sup>a</sup>	63.51 <sup>a</sup> (52.84)	9.70 <sup>bc</sup>	181.16 <sup>b-c</sup> (182.26)			
27	Oil 5 % + (mancozeb + carbendazim)-0.05 %	12.15 <sup>a-f</sup>	33.52 <sup>a-f</sup> (35.18)	11.25 <sup>bc</sup>	52.03 <sup>bc</sup> (46.17)	9.60 <sup>bc</sup>	178.26 <sup>b-c</sup> (176.25)			
28	Oil 5 % + propiconazole-0.05 %	13.15 <sup>a</sup>	44.51 <sup>a</sup> (41.84)	11.55 <sup>ab</sup>	56.08 <sup>ab</sup> (48.51)	10.60 <sup>a</sup>	207.25 <sup>a</sup> (206.2)			
29	<b>Mean</b>	<b>12.64</b>	<b>38.88</b>	<b>11.60</b>	<b>56.76</b>	<b>9.65</b>	<b>179.71</b>			
30	Control	9.10 <sup>j</sup>	0.00 <sup>k</sup> (0.414)	7.40 <sup>k</sup>	0.00 <sup>k</sup> (0.41)	3.45 <sup>l</sup>	0.00 <sup>l</sup> (0.140)			
31	CV	<b>4.093</b>	<b>10.117</b>	<b>3.305</b>	<b>7.232</b>	<b>3.418</b>	<b>14.65</b>			
32	CD (P=0.05)	<b>1.003</b>	<b>6.809</b>	<b>0.712</b>	<b>5.776</b>	<b>0.576</b>	<b>12.44</b>			

PDIC: Per cent increase over control; Values in the parentheses are arcsine transformed.

**Table 5.** Effect of petroleum oil (Banole®) alone and in combination with fungicides on the yield of banana in cvs. Nendran and Robusta

Sl. no.	Treatments	Yield (kg)	
		Nendran	Robusta
1	Oil-1 %	12.10 <sup>m</sup> (7.01)	15.87 <sup>m</sup> (29.34)
2	Oil-2.5 %	12.38 <sup>lm</sup> (9.56)	17.10 <sup>kl</sup> (39.36)
3	Oil- 5 %	12.95 <sup>kl</sup> (14.60)	17.00 <sup>l</sup> (38.55)
	<b>Mean</b>	<b>12.48(10.99)</b>	<b>16.66(35.75)</b>
4	Mancozeb-0.25 %	16.17 <sup>b-e</sup> (43.05)	22.00 <sup>c-f</sup> (79.30)
5	Carbendazim-0.1 %	15.97 <sup>cde</sup> (41.28)	22.67 <sup>cd</sup> (84.76)
6	Mancozeb + carbendazim-0.1 %	16.70 <sup>ab</sup> (47.79)	21.50 <sup>ef</sup> (75.22)
7	Propiconazole-0.1 %	16.74 <sup>ab</sup> (48.10)	22.16 <sup>cde</sup> (80.60)
	<b>Mean</b>	<b>16.40(45.06)</b>	<b>22.08(79.95)</b>
8	Mancozeb-0.12 %	12.95 <sup>kl</sup> (14.60)	16.90 <sup>l</sup> (37.73)
9	Carbendazim-0.05 %	13.48 <sup>jk</sup> (19.25)	18.65 <sup>ij</sup> (51.10)
10	Mancozeb + carbendazim-0.05 %	13.25 <sup>jk</sup> (17.26)	18.15 <sup>jk</sup> (47.92)
11	Propiconazole-0.05 %	13.70 <sup>ij</sup> (21.24)	20.46 <sup>gh</sup> (66.75)
	<b>Mean</b>	<b>13.35(18.09)</b>	<b>18.54(51.10)</b>
12	Oil 1 % + mancozeb-0.12 %	14.30 <sup>hi</sup> (26.55)	20.40 <sup>h</sup> (66.26)
13	Oil 1 % + carbendazim-0.05 %	15.73 <sup>def</sup> (39.16)	21.70 <sup>def</sup> (76.85)
14	Oil 1 % + (mancozeb + carbendazim)-0.05 %	15.15 <sup>fg</sup> (34.07)	21.05 <sup>gh</sup> (71.56)
15	Oil 1 % + propiconazole-0.05 %	16.15 <sup>b-e</sup> (42.92)	21.59 <sup>ef</sup> (75.95)
	<b>Mean</b>	<b>15.33(35.68)</b>	<b>21.19(72.69)</b>
16	Oil 2.5 % + mancozeb 0.12 %	15.88 <sup>cde</sup> (40.49)	22.46 <sup>cde</sup> (83.10)
17	Oil 2.5 % + carbendazim-0.05 %	14.88 <sup>gh</sup> (31.63)	23.97 <sup>b</sup> (95.35)
18	Oil 2.5 % + (mancozeb + carbendazim)-0.05 %	16.25 <sup>a-e</sup> (43.81)	22.90 <sup>c</sup> (86.63)
19	Oil 2.5 % + propiconazole-0.05 %	16.83 <sup>a</sup> (48.89)	25.19 <sup>a</sup> (105.30)
	<b>Mean</b>	<b>15.96(41.21)</b>	<b>23.63(92.58)</b>
20	Oil 5 % + mancozeb -0.12 %	15.63 <sup>ef</sup> (38.27)	22.76 <sup>cd</sup> (85.49)
21	Oil 5 % + carbendazim-0.05 %	16.35 <sup>a-d</sup> (44.69)	22.68 <sup>cd</sup> (84.84)
22	Oil 5 % + (mancozeb + carbendazim)-0.05 %	14.95 <sup>g</sup> (32.30)	22.73 <sup>cd</sup> (85.25)
23	Oil 5 % + propiconazole-0.05 %	16.43 <sup>abc</sup> (45.35)	23.54 <sup>d</sup> (91.85)
	<b>Mean</b>	<b>15.84(40.15)</b>	<b>22.50(83.37)</b>
24	Control	11.30 <sup>n</sup> (0)	12.27 <sup>m</sup> (0)
	CV	<b>2.060</b>	<b>2.459</b>
	CD (p=0.05)	<b>0.632</b>	<b>1.060</b>

Values in the parentheses are per cent increase over control

with the same fungicide dose resulted in a lower yield of 23.54 kg/plant, compared to 25.19 kg/plant with the 2.5 % oil treatment.

## Discussion

The present study evaluates the effectiveness of petroleum oil (Banole®) alone and in combination with fungicides in controlling leaf spot disease in banana cultivars Nendran and Robusta. The results of this study highlight the significant role of petroleum oil, fungicides and their combinations in managing leaf spot disease severity in both Nendran and Robusta banana cultivars. The findings suggest that petroleum oil, both when used alone and in combination with half doses of fungicides, can be an effective strategy for disease management and this effect is observed consistently across different growth stages: vegetative, flowering and harvest. The application of oil alone resulted in a moderate reduction in disease severity. For instance, in Nendran, oil alone reduced disease severity by 48.18 % during the vegetative phase and similar reductions were observed at flowering and harvest stages though there was increase in disease severity in untreated plots in flowering and harvest stages. These reductions were further enhanced significantly when oil was combined with half the recommended dose of fungicides. A similar trend was observed in Robusta cultivar also when oil alone or combined with half dose of fungicides. This clearly indicates that mineral oil has a positive influence on leaf spot control and further enhancement in disease control achieved when combined with half doses fungicides. Use of mineral oil in leaf spot control was widely adopted among banana growers (15). Mechanism of the disease control by oil (Banole®) is mainly due to

slow down the development of the disease by enhancing the incubation period of the fungus and increasing the development time between one stage to another, ensuring fast penetration of the active ingredient of fungicides due to its high paraffinic content and facilitates even distribution of fungicides on the leaves which will promote effective control of the leaf spot pathogen (Banole®). Besides, the oil application inhibits fungal spore germination, germ tube growth and sporulation (16). Further, as it forms a coat on leave surface, the disease development is impeded and the efficacy of the fungicides is improved as the oil enables YLS-0 is one of the crucial factors which decides bunch yield as a higher number of healthy (less-spotted) leaves have been found to positively influence bunch weight (17, 18). The results in the present study for the YLS-0 are equally interesting. The significant increase in YLS-0 in oil alone or in combination with fungicides indicates that the treatments could contribute to maintain more viable leaves with less spot which help in synthesizing more photosynthates in the plants (18). The highest increase in YLS-0 in both cultivars was observed when oil was combined with propiconazole, particularly in the Robusta cultivar, whereas 5.0 % oil combined with half the dose of propiconazole resulted in a 207.25 % increase over the control at the harvest phase. This suggests that while disease severity was reduced, the treatment could potentially delay or reduce the visible effects of disease on younger leaves, thereby improving the overall health of the plant.

In terms of yield, the combination of oil with half doses of fungicides generally resulted in enhanced yields compared to untreated control plants. In both Robusta and Nendran cultivars, the highest yield increase was observed with 2.5 % oil combined with half the recommended dose of propiconazole, leading to yield increases of 105.3 % and 48.89 % respectively. However, higher oil concentrations (5.0 %) combined with half doses of fungicides

resulted in lower yields, likely due to phytotoxic effects at these higher oil concentrations. Mineral oil formulations at higher concentrations can affect yield by disrupting gaseous exchange in banana plants and causing phytotoxicity (19). Therefore, selecting the ideal concentration of mineral oil is crucial for achieving better yield in bananas. As demonstrated in the present study (1.0 %-2.5 % mineral oil with half doses of fungicides) and in previous reports, the optimal mineral oil concentration, when combined with fungicides especially systemic fungicides can effectively control leaf spot disease (20-22).

## Conclusion

In conclusion, the combination of petroleum oil with half the recommended dose of fungicides consistently resulted in significant reductions in leaf spot disease severity across both cultivars and growth stages, comparable to the efficacy of the full recommended dose of fungicides. Moreover, this combination also contributed to the increased yields, with optimal results achieved at lower oil concentrations (1.0 %-2.5 %) when used alongside half doses of fungicides. Given that petroleum oil is biodegradable, environmentally safe, compatible with most fungicides and characterized by rapid penetration into plant tissues, it presents a viable and cost-effective strategy for the sustainable management of leaf spot disease in banana (23).

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## Authors' contributions

RT was responsible for the design and execution of the research. ML handled data analysis and drafted the manuscript. RS<sup>1</sup> contributed to the statistical analysis, while RS<sup>2</sup> assisted with editing the manuscript. AG carried out data collection and compilation. RT and ML contributed equally to the work. NM contributed to field experiment. All authors read and approved the final manuscript. [RS<sup>1</sup> stands for R Saranya and RS<sup>2</sup> stands for R Selvarajan]

## Compliance with ethical standards

**Conflict of interest:** Authors do not have any conflict of interests to declare.

**Ethical issues:** None.

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