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Efficacy of a petroleum spray oil for the control of citrus pests, spirea aphid (*Aphis citricola*) and two scales (*Icerya purchasi* and *Planococcus cryptus*) in Jeju island

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Abstract : The efficacy of petroleum spray oil (PSO; D-C Tron Plus®) against spirea aphid (*Aphis citricola*) and two scales (*Icerya purchasi* and *Planococcus cryptus*) on citrus was tested in Jeju, Korea. The control value of 0.33% PSO against spirea aphid was over 90% at 3 and 6 days after treatment (DAT), and then decreased to about 80% at 9 and 14 DAT. Spraying of PSO (0.33, 0.66, 1%) against cottony-cushion scale showed a much lower control value (less than 50%) during the investigation period compared to that of the conventional pesticide (Methion). When used against the scale, *Planococcus cryptus*, the control value of 1% PSO was 95%, but that of 0.33% and 0.66% PSO only ranged from 50 to 80%, lower than the conventional pesticide. The results of this study, as with a previous study, suggest that spraying of 0.33% and 0.5% PSO not only controls the spirea aphid, but also reduces the density of two scales (*Icerya purchasi* and *Planococcus cryptus*) on citrus tree in Jeju, without phytotoxic damage.(Received February 8, 2001; accepted March 10, 2001)

Key words : citrus, D-C-Tron Plus®, spirea aphid, scale, petroleum spray oil(PSO).

Introduction

Since the late 1870s, petroleum-derived oils have been used as chemical pesticides for the control of insects, diseases, and weeds in plant culture (Agnello, 1999; Beattie and Smith, 1996; Larew and Locke, 1990; Riehl, 1969). Over the past two decades, there has been much interest in petroleum-derived spray oil due to the occurrence of environmental and health problems associated with the use of synthetic pesticides. Recently, newly developed petroleum spray oils (PSOs, also called mineral, summer and horticultural oils) with the carbon number C19-C25 and narrow-range distillation temperatures play an increasingly important role as pesticidal agent in integrated pest management (IPM) of horticultural crops, especially in citrus, due to low mammalian toxicity and the absence of residual effects against the environment and beneficial enemies in Australia and USA (Herron *et al.*, 1995; Smith *et al.*, 1997; Zwick and Westigard, 1978; Jacques and Kuhlmann, 2000).

PSOs have been applied as curatives especially to small pest species such as mites, scales, leafminers, mealybugs, thrips, aphids and psyllas, etc. in citrus, apple, pea, grapes, and cotton crops (Davidson *et al.*, 1991; Beattie *et al.*, 2000). Recent studies have shown that PSOs have behavioral effects such as preventing infestations, deterring ovipositions of pests (e.g., citrus leafminer), and killing eggs and nymphs as well as adult pests (Rae *et al.*, 1996). Also, PSOs can depress diseases such as powdery mildew in grape and rose, and tomato black spot and citrus greasy spot (Beattie *et al.*, 2000; Beattie and Smith, 1996).

In Jeju island, a kind of petroleum-derived spray oil, has been used for the control of citrus mites and scales during the winter season. Usually, synthetic pesticides are sprayed more than 10 times annually in citrus orchards. Unfortunately, the increasing use of synthetic pesticides has caused many problems such as increase in resistant pest and control cost, as well as threat to the health of the consumers.

In order to minimize synthetic pesticide use in Jeju citrus culture, the use of PSO as a component of the IPM program has been studied. PSOs are widely used in Australia for the citrus and cotton production. In our previous paper (Kim *et al.*, 2000), we reported the efficacy of PSO (D-C-Tron Plus®) against citrus mites,

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appropriate PSO spraying concentration, and occurrence of phytotoxicity. To determine the control efficacy of PSO in controlling other citrus pests, it was tested against spirea aphid and two species of scales that are also major pests in Jeju island.

Materials and Methods

PSO

The PSO tested in this study was *n*C24 (where *n* represents normal, C carbon and 24 the number of median equivalent carbon atoms) D-C-Tron Plus® (Caltex Oil Co.) with 50% distillation temperature of 392℃ and C24 paraffinic oil of 98%. The tested PSO contained 0.06% of a sunscreen safener (Tinuvin 171®) to ultra violet to reduce phytotoxicity. Therefore, it has a higher efficacy but less phytotoxic damage than other PSOs used in the past or with lower carbon number (Beattie, 2000; Hodgkinson, 1998).

Control efficacy to spirea aphid, *Aphis citricola* (Homoptera: Aphididae)

The experiment on the efficacy of PSO against spirea aphid (*Aphis citricola* Van der Goot) was conducted in 1999 in a citrus orchard at the Citrus Experiment Station, National Jeju Agriculture Experiment Station, located in southern Jeju island. On 1 September, 10-year-old citrus trees (cv. Miyakawa-wase) were chosen and then 50 leaves from each tree were collected to check the aphid number prior to treatment. The concentration of PSO tested was 0.33% (v/v) and the spray was applied until run off using a nab-sack sprayer. As the check chemicals, furathiocarb and thiamethoxam were applied based on the each recommended spraying concentration (KACIA, 1999). The number of living aphids were investigated at 3, 6, 9, and 14 days after treatment (DAT) on sprayed and unsprayed trees. Three trees were randomly allocated to each treatment.

Control efficacy to two species of scales : cottony cushion scale, *Icerya purchasi* (Homoptera: Margarodidae) and *Planococcus cryptus* (Homoptera: Pseudococcidae)

The experiment on PSO efficacy against two scales was conducted at the Citrus Experiment Station, NJAES in 2000. Potted 4-year-old citrus trees (mandarin, cv. Miyakawa-wase) were used in the study. The treatments were set up with three concentrations of PSO (0.33%, 0.66% and 1.0%), 1,000 times diluted methion 1000 (check chemical), and water spray (control). These four treatments were randomly allocated to the trees with three replicates of one tree each. Spraying dates were July 13 for cottony-cushion scale and August 14 for *Planococcus cryptus*. Spraying was done until run off using a hand-held sprayer. Number of living scales were counted at one day before treatment, 7, 14, 21, 28 and 35 DAT, respectively.

Results

Control efficacy to spirea aphid on citrus

Compared to the unsprayed control, the living

Table 1. Efficacy of PSO and other pesticide treatments against spirea aphid (*Aphis spiraecola* Patch) on citrus tree

Treatment	Pretreatment	Investigation date			
		3 DAT	6 DAT	9 DAT	14 DAT
	aphid no. per 50 leaves	---------- living aphid rate (%)[a]----------			
PSO 0.33%	52.7	6.0±2.8a[b]	15.5± 5.1a	39.4±12.3a	40.6±6.8a
Furathiocarb	81.7	0.5±0.9a	0.5± 0.9a	0 a	4.3±4.0a
Thiamethoxam	55.7	0.7±1.2a	0.7± 1.2a	0 a	0 a
Unspray	54.0	117.6±9.2b	161.2±52.0b	200.2±64.3b	189.2±64.1b
		---------- control value (%) ----------			
PSO 0.33%	-	94.9	90.4	80.3	78.5
Furathiocarb	-	99.6	99.7	100	97.7
Thiamethoxam	-	99.4	99.6	100	100

[a] percent of living aphid density versus the density of pre-treatment.
[b] Mean±standard deviation followed by the same letters are not significantly different at 5% level by DMRT.

aphid rates were significantly low in all treatments throughout the investigation dates (Table 1). The control values showed over 90% in three treatments at 3 and 6 DAT. In particular, the control values of both conventional pesticides, furathiocarb and thiamethoxam, showed nearly 100% at all investigation dates. The control value of 0.33% PSO spray was over 90% at 3 DAT and 6 DAT, and then decreased to 80.3% and 78. 5% at 9 DAT and 14 DAT, respectively. Acute phytotoxic symptoms on 0.33% PSO sprayed tree were not observed besides weak occurrence of oil-sucked symptoms on leaf.

Control efficacy to cottony-cushion scale

The living rates of cottony-cushion scale in all PSO spraying concentration were significantly lower than the water-sprayed control, but the degree of living rate was much higher than the commercial pesticide, thiamethoxam, showing nearly 0% (Table 2). Meanwhile, the control values of all spraying concentration of PSO showed less than 50% and were much lower than thiamethoxam spray throughout the experiment (Fig. 1). The difference in control value among PSO concentrations was not clear in all the investigation dates.

Control efficacy to the scale: *Planococcus cryptus*

The living rates of scale, *Planococcus cryptus*, in all concentrations of PSO spraying were significantly lower than the water-sprayed control. Increasing concentration of PSO reduced the living scale rate, therefore, spraying of 1% PSO showed the lowest living scale rate similar to the pesticide methion (Table 3). Both spraying treatments of 1% PSO and methion showed over 95% control value until 35 DAT (Fig. 1). The control value in spraying 0.33% and 0.66% PSO ranged from 52% to 73% and 63 to 82%,

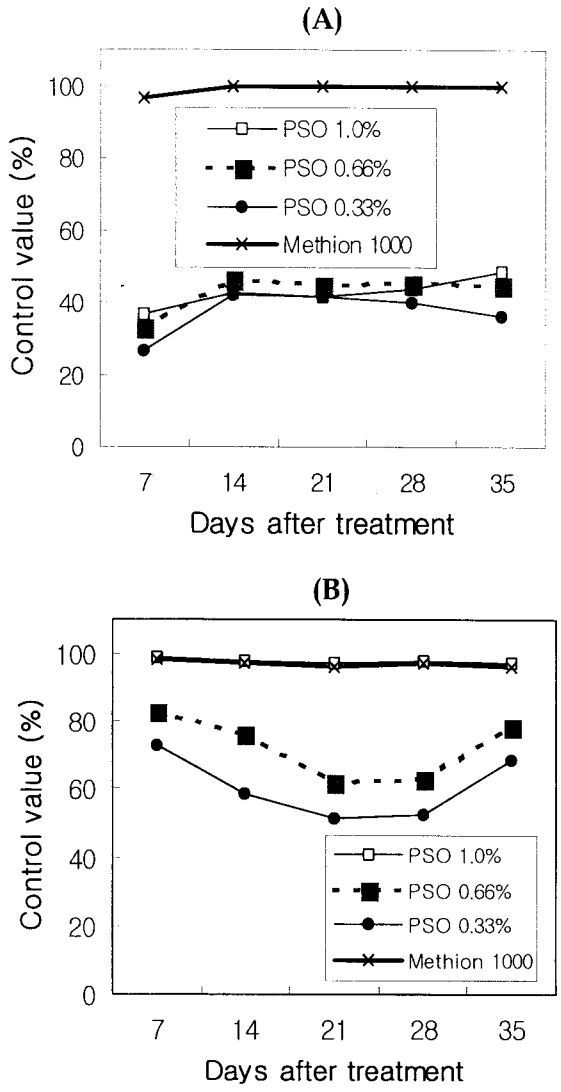

Fig. 1. Changes in the control value of different PSO concentration treatments against two scale species, *Icerya purchasi* (A) and *Planococcus cryptus* (B) on citrus.

Table 2. Effect of PSO treatment against cottony-cushion scale (*Icerya purchasi* Maskell) on citrus, sprayed on July 13, 2000

Treatment	Pretreatment	Days after treatment				
		7	14	21	28	35
	scale no. per shoot	living scale rate (%)[a]				
PSO 1%	118.7	52.3± 7.1b[b]	46.3± 9.2b	42.5± 6.0b	36.1± 3.7b	30.1±5.1b
PSO 0.66%	54.7	55.0±10.2b	43.4±15.1b	40.3±13.0b	35.0±10.7b	32.5±9.2b
PSO 0.33%	101.3	60.6± 8.5b	46.8± 3.0b	42.7± 2.1b	38.5± 2.4b	37.6±2.8b
Methion	93.7	2.9± 1.2a	0± 0 a	0± 0 a	0± 0 a	0±0 a
Unspray	72.0	82.7± 3.0c	81.2± 4.3c	73.4± 9.9c	64.3± 6.3c	59.0±6.7c

[a] percent of living mite density versus the density of pre-treatment.
[b] Mean±standard deviation followed by the same letters are not significantly different at 5% level by DMRT.

Table 3. Effect of PSO treatments against citrus scale (*Planococcus cryptus*) in sprayed on August 14, 2000

Treatment	Pre treatment	Days after treatment				
		7	14	21	28	35
	scale no. per shoot	---------- living scale rate (%)[a)]----------				
PSO 1%	172.0	1.0± 0.3a[b)]	1.9± 2.1a	2.0± 3.4a	2.0± 3.4a	9.4±16.3a
PSO 0.66%	396.7	23.1± 6.7b	22.0±4.6b	28.5± 9.4b	38.4± 9.8b	76.5±31.6a
PSO 0.33%	235.3	36.3± 4.3b	38.6±12.6c	36.2±16.8b	49.2±21.7b	111.5±29.3a
Methion	111.3	2.1± 3.7a	2.4± 4.2a	2.7± 4.0a	2.7± 4.0a	13.4±22.5a
Unspray	158.0	133.2±13.9c	93.5±7.5d	74.7±16.2c	104.0±25.5c	355.6±110.8b

[a)]percent of living mite density versus the density of pre-treatment.
[b)]Mean±standard deviation (n=5) followed by the same letters are not significantly different at 5% level by DMRT.

respectively.

Discussion

In the past, petroleum-derived oils (C14-18) were mainly used to control scale insects in orange (Ackerman, 1923; Ebeling, 1932). Since the 1970s, modern narrow range PSOs with C19-25 (e.g., C19: Total Citrole®, C21: Sunspray Ultrafine® and Caltex Lovis®, C23: Ampol D-C-Tron NR®, C24: D-C-Tron Plus®) have been recommended for the control of various armoured and soft scales as well as mites and leafminer of citrus in Australia (Beattie, 2000; Beattie and Smith, 1996). In the United States of America, PSOs (e.g., C21: Orchex 692®, C23: Orchex 796®) are used to control scales, mites and whitefly, mealybugs, aphids, psylla and fruit-feeding Lepidoptera on citrus (Davidson *et al.*, 1991; Jacques and Kuhlmann, 2000). The efficacy of D-C-Tron Plus® has also tested against citrus leafminer, citrus psylla, Queensland fruit fly, greenhouse thrips, mites and some species of scales including purple and white louse scales (Beattie *et al.*, 2000; Rae *et al.*, 2000). Also, previous study has shown that D-C-Tron Plus® can effectively control green peach aphid in tomato (Beattie *et al.*, 2000) but could not control in black brown aphid in citrus in Malaysia (Rae *et al.*, 2000). Meanwhile, the efficacy of D-C-Tron Plus® against the spirea aphid and two scales tested in this study has not been reported yet.

Spraying of 0.33%~1% PSO (D-C-Tron Plus®) against two scales in this study showed low control value against cottony cushion scale, ranging from 30 to 45%, but high control value against *Planococcus cryptus*. In particular, spraying of 1% PSO showed nearly 100% control value similar to the conventional pesticide (methion). The difference in PSO efficacy between the two scales may have been caused by the difference in their skin structure. The skin of the cottony cushion scale is slightly harder that of the *Planococcus cryptus*, though both species are classified as soft scaled. Spraying of 0.33% PSO significantly suppressed spirea aphid in citrus, although the efficacy of PSO was slightly lower than that of the two conventional pesticides (furathiocab, thiamethoxam). The results of studying suggest that spraying of 0.33~1.0% PSO not only controls the spirea aphid, but also reduces the density of the two scales (*Icerya purchasi* and *Planococcus cryptus*) on citrus tree in Jeju. Because the efficacy of PSO in the control of the two scales was not high, spraying of PSO as a main control pesticide may not be appropriate.

We (Kim *et al.*, 2000) previously reported that spraying of 0.25~1.0% PSO can effectively suppress citrus red mite similar with conventional pesticides (e.g., tebufenpyrad, bifenazate), but spraying of PSO with a concentration higher than 0.5% occasionally induced dropping of leaf and fruit, as well as the occurrence of some oil-sucked symptoms on leaf. Recently, for the effective control of pests, especially citrus leafminer, the use of PSO (D-C-Tron Plus®) has been recommended in multiple spray at lower concentration (0.25~0.5%) and higher volume than the traditional high concentration (1~2%) at one or two sprays per year (Beattie, 2000). Although spraying of PSO 0.33~1.0% caused the some oil-sucked symptoms, problematic phytotoxic symptoms on leaf (burning, necrosis, dropping) were not observed in this study. Hence, spraying of PSO at a concentration lower than

0.5% is recommended to prevent occurrence of phytotoxic symptoms.

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감귤의 조팝나무 진딧물 및 깍지벌레류에 대한 Petroleum Spray Oil의 방제효과

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요약 : 인축독성 및 잔효성이 낮아 환경친화적인 Petroleum spray oil (PSO, D-C-Tron Plus®, Caltex Oil Co.)를 감귤나무에 살포하여 조팝나무진딧물, 이세리아깍지벌레 및 귤애가루깍지벌레에 대한 약효를 검토하였다. 0.33% PSO의 조팝나무진딧물에 대한 방제가는 처리후 6일까지는 90% 이상이었으나, 처리 9일 및 14일후에는 80%정도로 대조약제(furathiocarb, thiamethoxam)보다 낮았다. PSO (0.33, 0.66, 1%) 살포후 5주까지의 이세리아깍지벌레에 대한 방제가는 50% 미만으로 대조약제(메치온)보다 크게 낮았으나, 귤애가루깍지벌레에 대한 방제가는 1% PSO살포시는 95%로 높았고, 0.33% 및 0.66% 살포시에도 50~80%를 보였다. 이러한 결과는 약해를 고려하여 0.5% 이하의 농도를 살포할 경우, PSO는 조팝나무진딧물의 방제는 물론 이세리아 및 애가루깍자벌레의 밀도경감 효과를 얻을수 있을 것으로 보인다.

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