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IMPROVING THE EFFICACY OF PONGAMIA OIL WITH COMBINATIONS OF BOTANICAL OILS AGAINST SUCKING PESTS OF CHILLI

A S Gadge*, Venkateshalu, J B Gopali [1], H P Hadimani[2], V P Singh[3], Raghavendra[4] and Vijaymahantesh[5]

Department of Entomology; [1]Department of Vegetable Science, College of Horticulture, Bagalkote 587104, Karnataka, India
[2]Department of Entomology, RHREC, Dharwad 580001, Karnataka, India
[3]Department of PSMA, College of Horticulture, Bidar 585401, Karnataka, India
[4]Department of Biochemistry, College of Agriculture, Shimoga 577201, Karnataka, India
[5]Directorate of Extension, University of Horticultural Sciences, Bagalkote 587104, Karnataka, India
*Email: ankushgadge66@gmail.com (corresponding author)

ABSTRACT

The study evaluated the efficacy of various oils and combinations against sucking pests of chilli. The concentration of emulsifier for efficient emulsification of oils was also studied. Detergent powder @ 0.3% effectively emulsified pongamia oil @ 2.5, 5.0 and 10%. Combination of pongamia oil + neem oil + cotton seed oil + citronella oil (50:25:15:10 ratio) @ 2.0% was superior in management of sucking pests followed by pongamia oil + neem oil (50:50 ratio) @ 2.0%. Botanical oils and their combinations had no direct impact on pollinators and natural enemies except citronella oil. Pongamia oil + neem oil + cotton seed oil + citronella oil (50:25:15:10 ratio) and pongamia oil + neem oil (50:50 ratio) yielded significantly higher yield over other treatments.

Key words: Chilli, pongamia oil, botanical oils, emulsification, sucking pests, pollinators, natural enemies, efficacy, spreader, murda

In chilli (*Capsicum annuum* L.) *Scirtothrips dorsalis* Hood and *Polyphagotarsonemus latus* Banks have been identified as key sucking pests that cause upward and downward leaf curl symptoms, respectively. In terms of crop loss, *S. dorsalis* causes 30 to 50% and *P. latus* about 30 to 70% loss. These pests along with *Myzus persicae* Sulzer and *Aphis gossypii* Glover cause serious damage to the chilli crop by feeding and transmitting serious viral diseases leading to "Murda complex". Biopesticides can reduce the dependence on chemical pesticides for the management of insect pests. Among biopesticides, botanicals have enormous potential as an alternative to chemical pesticides. Botanicals are endowed with a spectrum of insecticidal activities such as repellence, insect behavior modifier and antifeedant activity in insects, mites, snails, slugs, nematodes and other agricultural pests. Botanicals are now emerging as one of the prime means to protect crops (Kovarikova and Pavela, 2019). Pongamia oil, rich in karanjin has shown excellent biological activity. Pongamia is a good synergist and has antifeedant, oviposition deterrent, ovicidal and insecticidal properties against a wide range of insect pests (Kumar et al., 2006). Combination of botanical oils have greater efficacy and broader mode of action than their individual usage (Kumar et al., 2007). Hence, this study for standardization of emulsifier concentration and evaluating the efficacy of newly formulated botanical oil combinations against sucking pests of chilli.

MATERIALS AND METHODS

Laboratory standardization of detergent powder concentration @ 0, 0.05, 0.1, 0.2 and 0.3% for emulsification of different pongamia oil concentrations @ 0.5, 1.0, 2.5, 5.0 and 10%, respectively was carried out by mixing all combinations. Totally, 25 combinations were evaluated with three replications in the laboratory in test tubes at the Department of Entomology, College of Horticulture, Bagalkote. After mixing and thorough shaking, the test tubes were placed in a test tube stand. The observations on the height of the oil film floating on the top were measured at 0, 2, 6 and 12 hr after mixing and grades were given by visual observation (Grades 0- No opaqueness, 1- 1 to 20% opaqueness, 2- 21 to 40% opaqueness, 3- 41 to 60% opaqueness, 4- 61 to 80% opaqueness and 5- 81 to 100% opaqueness). From this trial, a standard emulsifier concentration for each pongamia oil concentration was determined.

Field experiment was laid out at the College of Horticulture, Bagalkote, Karnataka (16°9’52”N, 75°36’51”E, 542 masl) during kharif, 2019. The experiment was carried in a randomized block design (RBD) with twelve treatments and three replications, with a plot size of 3.6 x 2.1 m leaving a gangway of 1 m around the plots. Thirty days old chilli seedlings of the variety Sitara Gold (Monsanto) were transplanted at a spacing of 60x 30 cm. The crop was raised by following recommended package of practices of UHS, Bagalkote (Anonymous, 2018) except for management against sucking pests. The treatments were imposed using a knapsack hydraulic sprayer at a spray volume of 500 l/ ha. The first spray was given at ten days after transplanting (DAT) after noticing the incidence of sucking pests and subsequent sprays were at an interval of 10 days. Pongamia, neem, cotton seed and citronella oils were procured from market. Spray solution of oils were prepared by mixing the required proportion of each oil together with the emulsifier @ 0.3% as per the treatment details mentioned in Table 1. Observations from 10 randomly tagged plants leaving the border rows, were recorded a day before, 3, 7 and 10 days after each spray. Incidence of *S. dorsalis* was observed from top 3 leaves; *P. latus* counts were made in 1 cm^2 area each on the lower surface from top 3 leaves using 10x lens. Leaf curl index score for *S. dorsalis* and *P. latus* was recorded from visual observations on a 0-4 scale as per the standard scoring procedure given by Niles (1980). Population of *M. persicae*, *A. gossypii* and *Bemisia tabaci* (Genn.) was counted from top three leaves. Natural enemies viz., coccinellids, spiders, *Chrysoperla* and preying mantids were counted/ plant. Occurrence of pollinators like honey bees were counted as no. of bees/ plant. Reduction in incidence after spray in treatment in comparison with control was calculated after Henderson and Tilton (1955). Data were subjected to square root transformation before ANOVA, and the treatment means were compared by Duncan’s Multiple Range Test (DMRT, p=0.05).

RESULTS AND DISCUSSION

Results of laboratory studies on standardization of emulsifier concentration infer that, emulsification of pongamia oil was highest with by 0.3% detergent powder. Grade of opaqueness was 5 at 0.3% at all the tested concentrations of pongamia oil. These findings are in very close conformity with study of Kamba et al. (2013) who revealed that, the more concentration of emulsifier, the more stable the emulsion. Detergent has a large non-polar hydrocarbon end and water-soluble polar end (Swarbrick, 2002). From the laboratory studies 0.3% spreader concentration (producing lowest height of oil film floating with highest grade) was selected for emulsification of 2.0% oil, further which was used for bioefficacy study (Aliakbarpour et al., 2011; Stanley et al., 2014; Sridharan et al., 2015).

All the botanical oils and their combinations evaluated against sucking pests of chilli were found effective under field condition (Table 1). Plots treated with T_8 (Pongamia oil + neem oil + cotton seed oil + citronella oil - 50:25:15:10 ratio) recorded significantly higher reduction of *S. dorsalis* (53.92%) followed by T_6 (pongamia oil + neem oil - 50:50 ratio) and T_{10} (diafenthiuron 50WP) with 43.84 and 41.07% reduction, respectively. Lowest reduction was recorded in T_4 (cotton seed oil) with 10.33%. Treatment, T_8 recorded a significantly lower incidence of *S. dorsalis* on top three leaves (0.68) followed by T_6 and T_{10} with 0.76 and 0.89 thrips, respectively. Oil combinations were superior over their sole treatments of pongamia seed, citronella, neem seed and cotton seed oil treated plots that recorded 1.12, 1.18, 1.19 and 1.24 thrips, respectively. Reduction of leaf curl due to *S. dorsalis* was significantly higher with T_8 followed by T_6 and lowest reduction in leaf curl was with treatment T_4. Similar to the reduction in *S. dorsalis*, T_8 recorded significantly more reduction of *P. latus* (62.53%) followed by T_6 (58.14%) and T_{10} (49.25%); and cotton seed oil (T_4) recorded the lowest reduction. Treatments differed significantly in reducing the mean number of *P. latus* in 1 cm^2 area/ top three leaves- T_8 recorded the lowest number of *P. latus* (0.93) followed by T_6 and T_7 with 1.03 and 1.36 mites, respectively. Combinations of oils were superior over their sole treatments of neem, citronella, pongamia and cotton seed oil treated plots that showed 1.59, 1.75, 1.87 and 2.04 mites, respectively. Leaf curl due to *P. latus* significantly reduced with T_8 (57.95%) followed by T_{10} and T_6. Incidence of *M. persicae* and *A. gossypii* significantly reduced with treatments T_8 followed by T_6 and T_{10}. Significant reduction in *B. tabaci* was observed with T_6 followed by T_8 and T_5.

Superiority of combinations of botanical oils over their sole applications in reducing the sucking pests indicated that, multiple modes of action and their efficacy when combined may be harnessed due to oils with multi-components. Strong antifeedant effects in neem oil and repellent properties in citronella oil will have greater impact on sucking pests of chilli. According to Abdelatti and Hartbauer (2020) combined formulation of carway, orange peel and winter green

Table 1. Efficacy of botanical oils against sucking pests and their impact on beneficial organisms on chilli (2019-20)

T. No.	Treatment details	Dosage	Mean no. of sucking pests/ top three leaves						Mean no. of beneficial organisms/plant				Green chilli yield (t/ ha)	BCR
			Thrips	Thrips LCI	Mites	Mites LCI	Aphids	White-flies	Cocci-nellids	Spiders	Other preda-tors	Honey bees		
T_1	Neem oil (NO)	2.0%	1.19 (1.09)^{c}	0.61 (0.78)^{bc}	1.59 (1.25)^{f}	0.47 (0.69)^{cd}	6.36 (2.62)^{def}	0.18 (0.82)^{b}	1.36 (1.36)^{cd}	2.27 (1.66)^{e}	0.20 (0.84)^{b}	2.00 (1.58)^{bc}	15.30^{cd}	1.57
T_2	Pongamia oil (PO)	2.0%	1.12 (1.05)^{de}	0.61 (0.78)^{bc}	1.87 (1.37)^{d}	0.51 (0.71)^{c}	6.82 (2.71)^{cde}	0.13 (0.80)^{c}	1.18 (1.30)^{e}	2.13 (1.62)^{e}	0.18 (0.82)^{bc}	2.16 (1.63)^{b}	13.71^{de}	1.33
T_3	Citronella oil (CO)	2.0%	1.18 (1.08)^{cd}	0.62 (0.79)^{bc}	1.75 (1.33)^{e}	0.51 (0.71)^{c}	7.76 (2.87)^{bc}	0.12 (0.79)^{c}	0.42 (0.96)^{f}	1.71 (1.49)^{f}	0.09 (0.77)^{f}	0.69 (1.09)^{f}	4.75^{f}	0.41
T_4	Cotton seed oil (CSO)	2.0%	1.24 (1.11)c	0.67 (0.81)^{b}	2.04 (1.42)^{c}	0.42 (0.66)^{e}	8.16 (2.94)^{b}	0.18 (0.82)^{b}	1.33 (1.35)^{cd}	2.09 (1.61)^{e}	0.20 (0.84)^{b}	2.60 (1.76)^{a}	14.85^{cd}	1.28
T_5	PO + NO (75:25)	2.0%	1.08 (1.03)^{e}	0.52 (0.72)^{de}	1.66 (1.28)^{ef}	0.41 (0.64)^{e}	6.50 (2.65)^{def}	0.07 (0.75)^{e}	1.33 (1.35)^{cd}	3.29 (1.95)^{b}	0.20 (0.84)^{b}	1.51 (1.42)^{de}	16.47^{bcd}	1.67
T_6	PO + NO (50:50)	2.0%	0.76 (0.87)^{g}	0.48 (0.69)^{ef}	1.03 (1.02)^{h}	0.44 (0.66)^{de}	5.73 (2.50)^{f}	0.00 (0.71)^{g}	1.29 (1.34)^{de}	2.80 (1.82)^{cd}	0.11 (0.78)^{e}	1.56 (1.43)^{d}	23.16^{a}	2.31
T_7	PO + NO + CSO + CO (75:10:10:05)	2.0%	1.09 (1.05)^{e}	0.56 (0.75)^{cd}	1.36 (1.16)^{g}	0.48 (0.70)^{cd}	6.29 (2.61)^{def}	0.04 (0.74)^{f}	1.49 (1.41)^{ab}	3.42 (1.98)^{b}	0.20 (0.84)^{b}	1.98 (1.57)^{c}	16.87^{bc}	1.68
T_8	PO + NO + CSO + CO (50:25:15:10)	2.0%	0.68 (0.83)^{h}	0.45 (0.67)^{f}	0.93 (0.97)^{i}	0.29 (0.53)^{f}	5.60 (2.47)^{f}	0.01 (0.71)^{g}	1.19 (1.30)^{e}	3.11 (1.90)^{bc}	0.13 (0.80)^{d}	1.50 (1.41)^{de}	24.07^{a}	2.33
T_9	Azadirachtin 10000 ppm (Standard check)	1 ml/L	1.35 (1.17)^{b}	0.65 (0.81)^{b}	2.40 (1.55)^{b}	0.49 (0.71)^{c}	7.69 (2.86)^{bc}	0.13 (0.80)^{c}	1.40 (1.38)^{bcd}	3.09 (1.89)^{bc}	0.09 (0.77)^{f}	2.16 (1.63)^{b}	14.42^{cde}	1.49
T_{10}	Diafenthiuron 50WP	1g/L	0.89 (0.95)^{f}	0.53 (0.72)^{de}	1.42 (1.19)^{g}	0.31 (0.55)^{f}	5.91 (2.53)^{ef}	0.07 (0.75)^{e}	1.42 (1.39)^{bc}	2.69 (1.78)^{d}	0.16 (0.81)^{cd}	2.04 (1.60)^{bc}	22.06^{a}	2.26
T_{11}	NSPE	5.0%	1.11 (1.06)^{de}	0.62 (0.79)^{bc}	2.40 (1.54)^{b}	0.57 (0.76)^{b}	6.93 (2.72)^{cd}	0.11 (0.78)^{d}	1.29 (1.34)^{cde}	2.04 (1.59)^{e}	0.16 (0.81)^{cd}	1.38 (1.37)^{e}	18.50^{b}	1.93
T_{12}	Untreated control	-	2.04 (1.42)^{a}	1.48 (1.22)^{a}	3.58 (1.89)^{a}	0.91 (0.95)^{a}	9.67 (3.19)^{a}	0.37 (0.93)^{a}	1.62 (1.46)^{a}	4.33 (2.20)^{a}	0.31 (0.90)^{a}	2.73 (1.80)^{a}	11.52^{e}	1.20
SEm±			0.03	0.03	0.03	0.02	0.06	0.00	0.01	0.03	0.01	0.02	1.04	-
CD (p=0.05)			0.08	0.08	0.09	0.05	0.18	0.01	0.04	0.09	0.02	0.05	3.05	-
CV (%)			4.06	7.35	2.95	6.33	3.84	0.98	1.86	3.09	1.45	2.11	11.04	-

Figures in parentheses square root transformed values; Means followed by same letters in column not statistically different (DMRT, p=0.05); LCI- Leaf Curling Index; NSPE-Neem Seed Powder Extract; Others- Preying mantids, *Chrysoperla*; BCR- Benefit Cost Ratio oils showed 80 and 100% mean mortality of desert and migratory locusts, respectively. The mode of action of the botanical oils attributed to physical impediments on sucking pests, which was observed under microscope in the laboratory in post application examinations of clipped off leaves containing sucking pests. Insecticidal property of botanical oils and their combinations against sucking pests of chilli is also attributed to the broad-spectrum activity as toxicants and physical poisons causing mortality of sucking pests. Kumar and Singh (2002) reported the broad-spectrum activity of pongamia oil against wide range of insect pests. Rajput et al. (2017) found that, neem oil and cotton seed oil were superior in reducing sucking pests of cotton. Zeeshan and Kudada (2019) found that, leaf curl disease incidence of chilli was reduced to 24.63 and 32.9% by application of neem and karanj oil @ 0.5%, respectively. Kumar et al. (2007) reported the combined formulations of neem oil and pongamia oil showed synergism against chrysanthemum aphid causing 100% mortality compared to 68.4 and 52.9% mortality in neem oil and pongamia oil alone, respectively after 48 hr at 0.5%.

Maximum number of natural enemies (coccinellids, spiders, preying mantids, *Chrysoperla*) were observed from T_{12} (Table 1); and least counts were observed in T_3, it may be attributed repellent property of citronella oil for active stages of predators and, then plant canopy compared to other treatments. There is likely shift in the predator population from treated plots as a result of botanical repellency and reduction in pest density. Vanisree et al. (2011) found that, every increase in number of thrips caused a corresponding increase of spiders and ladybird beetles in chilli. Maximum number of honey bees were observed in T_{12} on par with T_4 (2.73); and the least with T_3 (0.69), it may be due to repellent property of oils as well as poor availability of flowers to bees for foraging as evidence by low flower density in this treatment. This is because high phytotoxic effect of citronella oil which causes the leaf deformation, stunted growth and reduced flowering. There is likely shift in the bees' occurrence from treated plots as a result of botanical oils repellency. Aliakbarpour et al. (2011) reported that 2.0% neem oil was effective and brought 59.8% reduction in thrips along with 24.9% mortality of pollinators and concluded that, proper timing of neem oil application such as, at midday when pollinators are least active would prove less detrimental to mango pollinators and at the same time can control thrips.

Observations on the influence of botanical oils and their combinations on green chilli yield revealed that, T_8 treated plots gave maximum yield (24.07 t/ ha) which was statistically on par with T_6 and T_{10} with 23.16 and 22.06 t/ ha. This may be due to efficient management of major sucking pest complex of chilli with botanical oils and their combination. Lowest yield of 11.52 and 4.75 t/ ha was recorded in T_{12} and T_3 respectively. Phytotoxic effect of citronella oil causing plant deformity resulted in decrease in yield. Highest BC ratio recorded in T_8 treated plots (2.33) followed by T_6 (2.31) and T_{10} (2.26). Whereas, least BC ratio (0.41) was recorded in the plots treated with T_3. Difference in the BC ratio is may be due to differences in the cost of botanical oils. Meena and Tayde (2017) obtained maximum yield and BC ratio with pongamia oil @ 4% followed by neem oil @ 2.5ml/ l. Similarly, Zeeshan and Kudada (2019) also obtained more chilli yield with neem oil @ 0.03 and karanj oil @ 0.15%.

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