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Comparative efficacy of water jetting and chemical measures against major sucking pests of mulberry and their safety to natural enemies

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ABSTRACT

Comparative efficacy of user friendly water jetting technique by diverting a portion of irrigation water through a garden hose and chemical measures [0.1 % dichlorvos (76EC) / 0.05% dimethoate (30 EC)] practised by farmers against the major sucking pests of mulberry was studied. Two treatments with water jetting at 15 and 25 days after pruning (DAP) of mulberry plants was more effective in control of papaya mealybug than all concurrent chemical measures *viz.* two sprays of dichlorvos, dichlorvos followed by dimethoate, dimethoate followed by dichlorvos and two sprays of dimethoate. Against spiralling whitefly and jassid water jetting exhibited at par results with two sprays of dimethoate and dimethoate followed by dichlorvos but superior to the rest of the chemical measures. But against thrips, it was recorded lower efficacy than two sprays of dimethoate and dimethoate followed by dichlorvos, at par with dichlorvos followed by dimethoate and better than two spray of dichlorvos. Water jetting in mulberry garden showed slight or no deleterious effect on predatory coccinellids and spiders whereas there was drastic reduction in their population on chemical measures. However, the additional treatment of water jetting a third time at 35 DAP supported to reduce the population of all sucking pests in a greater extent constantly till 45 DAP and the highest population of natural enemies in the water jetted plots also worked to keep the pest population reduced which resulted in higher leaf yield and economy than all chemical measures.

Key words: Water jetting, mulberry, sucking pests, natural enemies, predatory coccinellids, spiders, economics.

INTRODUCTION

Mulberry (*Morus alba* L.) is the sole food plant of silkworm (*Bombyx mori* L.) in cultivated about 1.8 lakh hectares in India. Silk productivity is mainly depends upon the quantum as well as quality of mulberry leaves produced as the former influences the rearing capacity of silkworms and the latter, their growth and development. Cultural operations, application of fertilizers, foliar spray of micronutrients etc after each leaf harvest in mulberry garden are recommended (Dandin *et al*., 2003) and are practised by the farmers regularly to obtain optimum leaf yield and quality. However luxuriant growth of mulberry plants invites infestation of a number of insect species which adversely affects the crop (Sakthivel and Qadri, 2010). Hence, routine application of insecticides is also unavoidable to protect the plants from pests within short period to take up silkworm rearing in a month.

At the same time application of insecticides with high toxicity and prolonged residual effects in mulberry gardens is restricted because of their hazardous effect on silkworms. The chemicals *viz*. dichlorvos and alternately dimethoate are generally recommended for management of pests in mulberry (Dandin *et al*., 2003; Rajadurai and Thiagarajan, 2003). However, the chemical measures invariably used by the farmers do not yield considerable degree of success due to development of resistance to the insecticides, especially in sucking pests. At the same time natural enemy complex in mulberry ecosystem is wiped out because of their high sensitivity to the chemicals. Therefore, repeated chemical measures often result in the outbreak of sucking pests in mulberry.

Sucking pests are naturally controlled in rainy season (Everly, (1960; Horowitz, 1986; Rashid *et al*., 2003; Galanihe *et al.*, 2010). When it rains heavily, many small insects get dislodged from plant surfaces by the combined effect of wetness and the kinetic energy of the rain drops as well as strong winds (Banjo, 2010).This observation suggests that by directing a powerful jet of water at infested plant parts, the pest could be controlled successfully. However, this practice has not become popular because fetching bulk quantity of water for jetting is cumbersome, time taking and expensive. Sakthivel *et al.* (2011) developed an effective and user friendly water jetting system for control of papaya mealybug in mulberry garden in which a portion of irrigation water from the main pipeline was diverted through a garden hose for jetting. Therefore, studies were undertaken to find out the efficacy of this water jetting package against major sucking pests of mulberry and its bio-safety to the natural enemies compared to the chemical measures practised by the farmers.

MATERIALS AND METHODS

Potential sericulture clusters in Erode, Salem and Namakkal districts of Tamil Nadu were selected for the study. The experiments were conducted in the farmer's field during January – September 2011 on mulberry variety V1 under irrigated condition in different locations where peak incidence of major sucking pest *viz.*, Papaya mealybug *Paracoccus marginatus*, mulberry thrips, *Pseudodendrothrips mori*, spiralling whitefly, *Aleurodicus dispersus* and jassid *Empoasca flavescens* was noticed.

Establishment of water jetting system

The water jetting system was arranged in the selected mulberry garden by simple modification in the existing irrigation system i.e. in main pipeline with an additional attachment. The provision for water out lets from the main pipeline was done by fixing a suitable PVC adapter which facilitated to connect one inch garden hose to divert a portion of irrigation water for jetting. The pump-set was operated for flow of water in the main pipeline into irrigation channel. The main pipeline was blocked partially using a gate valve to get adequate water flow in the hose i.e. @ 25 litres per minute. Water jetting was done by attaching a high volume spray (jet) gun to the hose (Sakthivel *et al*., 2011).

Treatment particulars

The treatments, six in number, comprised water jetting, spraying of insecticides [dichlorvos 76EC (0.1%) and dimethoate 30 EC (0.05%)] as per the farmer's practices and a control as T1- Water Jetting by diverting a portion of irrigation water through a garden hose (Sakthivel *et al*., 2011), three times @ 15, 25 and 35 days after pruning (DAP) T2- Two spray of dichlorvos @15 and 25 DAP, T3- Spray of dichlorvos @ 15 DAP followed by dimethoate @ 25 DAP, T4- Spray of dimethoate @ 15 DAP followed by dichlorvos @ 25 DAP, T5- Two spray of dimethoate @15 and 25 DAP and T6- Control.

Randomized block design was followed and each plot measured 100 m^2 area consisting of 8 rows of plants cultivated in paired row system [5'+ (3'x 2')] so that each plot contained 128 plants and replicated five times. Population of the pests were recorded a day prior to the treatment (14 DAP) and the post treatment counts at 17, 20, 25, 27, 30, 35, 37, 40 and 45 DAP on five randomly selected plants from each replication during cooler hours preferably 6AM-7AM (Naranjo and Flint, 1995). The population of spiralling whitefly, jassid and thrips were recorded from leaves representing the top, middle and bottom portion of the plants whereas the population of papaya mealybug was made from 10 cm twig portion. Population of the predatory coccinellids and spiders irrespective of species was also recorded from five randomly selected plants per plot. The border rows of the plots were avoided for the population count. The per cent reductions in the population of the pests and natural enemies over the control were calculated and the data were analyzed statistically.

RESULTS

The data on the effect of water jetting and spraying of insecticides on the population of major sucking pests of mulberry and natural enemies are presented in Tables 1-6.

Paracoccus marginatus

The data on population reduction of papaya mealybug after the first and the second spray revealed that water jetting was superior to chemicals at all days after each spray (Table 1). Dichlorvos and dimethoate were at par @ 17 DAP. The data on mealybug population pooled over the two sprays revealed that all the treatments recorded significantly lower mealybug population than untreated control but water jetting was most effective and significantly superior than chemical treatments. The population of the mealybug in the chemical treated plots was gradually increased and became at par with control But water jetting for the third time @ 35 DAP kept the population constantly lower till 45 DAP. The overall pooled data registered that water jetting is best treatment compared to chemical measures for management of papaya mealybug. The leaf yield was also significantly higher in water jetted plot than in chemical treatments.

Aleurodicus dispersus

The highest reduction in the population of spiralling whitefly was recorded in dichlorvos treated plots followed by water jetting and dimethoate @ 2 days after first treatment whereas the persistency of dimethoate was found longer than in the case of dichlorvos. The population reduction 2 days after second spray in water jetted and chemical sprayed plots were at a par except that of the plot sprayed with dichlorvos followed by dimethoate which was little lower than other treatments. However, the population reduction @ 35 DAP in the plots treated with two water jetting and two spray of

Table 1. Efficacy of water jetting and chemical measures against papaya mealybug, *Paracoccus marginatus* on mulberry

Treatment	Population of Papaya mealybug *Paracoccus marginatus* (No./10 cm twig)												Leaf yield (kg/ha)
	14DAP (PTC)	First treatment 15 DAP			Second treatment 25 DAP			Mean	Third treatment 35 DAP (Water Jetting alone)			Overall mean	
		17DAP	20DAP	25DAP	27DAP	30DAP	35DAP		37DAP	40DAP	45DAP		
T_1 Water Jetting	48.00	8.06 (83.20)	9.60 (79.94)	12.53 (74.07)	4.20 (91.76)	8.66 (83.23)	15.53 (71.16)	9.76 (80.52)	6.46 (88.53)	11.33 (79.40)	18.80 (65.05)	10.57 (79.57)	11688 (45.00)
T_2 Dichlorvos -I Dichlorvos - II	47.33	30.20 (37.08)	26.26 (45.13)	28.00 (42.06)	19.73 (61.31)	25.13 (51.35)	33.33 (38.11)	27.10 (45.91)	40.80 (27.56)	49.86 (9.34)	53.00 (1.48)	34.03 (34.25)	8798 (26.94)
T_3 Dichlorvos –I Dimethoate-II	46.66	30.66 (36.12)	27.00 (43.58)	29.33 (39.31)	21.53 (57.78)	21.00 (59.35)	28.53 (47.03)	26.34 (47.43)	37.40 (33.60)	47.60 (13.45)	50.53 (6.07)	32.62 (36.97)	9103 (29.39)
T_4 Dimethoate-I Dichlorvos -II	47.00	32.00 (33.33)	23.40 (51.10)	22.00 (54.47)	16.26 (68.11)	24.80 (52.00)	30.00 (44.30)	24.74 (50.62)	39.13 (30.53)	51.66 (6.07)	52.33 (2.73)	32.39 (37.42)	9054 (29.00)
T_5Dimethoate-I Dimethoate-II	46.53	32.40 (32.50)	22.53 (52.92)	21.86 (54.76)	15.80 (69.02)	20.60 (60.12)	26.20 (51.35)	23.23 (53.64)	33.33 (40.83)	47.40 (13.81)	50.60 (5.94)	30.08 (41.88)	9621 (33.19)
T_6 Control	47.40	48.00	47.86	48.33	51.00	51.66	53.86	50.11	56.33	55.00	53.80	51.76	6427
C.D.@5%	NS	1.08	1.12	1.78	0.98	2.11	2.11	1.16	2.12	2.51	3.05	2.16	78.67
C.V.%	9.72	9.28	9.75	8.06	9.65	8.66	8.90	7.35	8.04	9.21	9.46	8.25	11.24

PTC= Pre treatment count, DAP= Days after pruning, Figures in the parentheses are percent reduction over control

Table 2. Efficacy of water jetting and chemical measures against spiraling whitefly, *Aleurodicus dispersus* on mulberry

Treatment	Population of Spiraling Whitefly *Aleurodicus dispersus* (No./leaf)												Leaf yield (kg/ha)
	14DAP (PTC)	First treatment 15 DAP			Second treatment 25 DAP			Mean	Third treatment 35 DAP (Water Jetting alone)			Overall mean	
		17DAP	20DAP	25DAP	27DAP	30DAP	35DAP		37DAP	40DAP	45DAP		
T_1 Water Jetting	17.16	3.16 (81.41)	3.72 (78.71)	8.54 (52.55)	1.87 (89.80)	2.21 (88.71)	4.00 (80.32)	3.91 (78.80)	1.66 (91.76)	4.56 (79.80)	8.56 (63.82)	3.91 (78.80)	10210 (14.54)
T_2 Dichlorvos -I Dichlorvos -II	17.00	2.79 (83.58)	4.57 (73.85)	12.48 (30.66)	1.66 (90.94)	3.72 (81.00)	6.81 (66.50)	5.33 (71.11)	8.13 (59.67)	18.17 (19.53)	21.00 (11.24)	4.94 (73.22)	9609 (9.20)
T_3 Dichlorvos –I Dimethoate-II	16.88	2.93 (82.76)	4.79 (72.59)	12.63 (29.83)	2.14 (88.32)	2.57 (86.87)	4.53 (77.71)	4.93 (73.27)	5.33 (73.56)	12.60 (44.19)	19.53 (17.45)	4.59 (75.12)	9812 (11.07)
T_4 Dimethoate-I Dichlorvos -II	17.06	3.93 (76.88)	3.03 (82.66)	7.87 (56.27)	1.58 (91.38)	3.00 (84.67)	5.60 (72.45)	4.16 (77.45)	7.16 (64.48)	20.16 (10.71)	20.72 (12.42)	4.49 (75.66)	9798 (10.95)
T_5Dimethoate-I Dimethoate-II	17.33	4.13 (75.70)	2.93 (83.23)	8.03 (55.38)	1.77 (90.34)	2.80 (85.69)	3.93 (80.66)	3.93 (78.70)	6.00 (70.23)	13.17 (41.67)	18.33 (22.52)	3.90 (78.86)	10178 (14.27)
T_6 Control	16.50	17.00	17.48	18.00	18.33	19.58	20.33	18.45	20.16	22.58	23.66	18.45	8725
C.D.@5%	NS	0.19	0.14	0.62	0.16	0.18	0.29	0.13	0.34	0.31	0.36	0.28	66.23
C.V.%	5.39	7.48	5.68	9.62	8.34	6.37	8.37	6.24	8.12	8.34	6.24	7.42	9.59

PTC= Pre treatment count, DAP= Days after pruning, Figures in the parentheses are percent reduction over control

dimethoate @ 15 DAP and 25 DAP were at a par and superior to the rest of the treatments. The pooled data of first and second treatments and overall mean proved that the water jetting and spraying of dimethoate @ 15 and 25 DAP were equally effective but additional water jetting @ 35 DAP registered higher leaf yield than the rest of the treatments (Table 2).

Empoasca flavescens

The per cent reduction of jassid population over control at 2 days after first and second treatment did not differ significantly among the treatments but dimethoate exhibited highest persistent toxicity. The population reduction @ 35 DAP in water jetted plot was on a par with the plot treated two times with dimethoate and rest of the treatments registered comparatively lower reduction. The pooled data revealed that the water jetting was on a par with all the chemical treatments but two spray of dichlorvos exhibited little lower efficacy than others. Additional water jetting at 35 DAP recorded constant reduction in jassid population till 40 DAP which resulted in highest leaf yield (Table 3).

Pseudodendrothrips mori

The observation made on the second day of treatment showed that dimethoate was more effective in reducing the population of thrips followed by dichlorvos and water jetting. Dimethoate exhibited longest persistency and recorded highest reduction compared to dichlorvos 10 days after treatment whereas in the water jetted plot more than 50% reduction was noticed. Pooled data of first and second treatment revealed that two spray of dimethoate registered the best. The next best treatment was dimethoate followed by dichlorvos. Spray of dichlorvos followed by dimethoate and water jetting were on a par with each other, whereas two sprays of dichlorvos was the least among all the treatments. However, population of thrips was increased gradually in the chemicals treated plots but significant reduction in thrips population was extended till 45 DAP in the plots that received water jetting additionally @ 35 DAP. The overall pooled data revealed that water jetting @ 15, 25 and 35 DAP was best and on a par with two sprays of dimethoate @ 15 and 25 DAP. However the highest leaf yield was recorded in water jetting rather than chemical measures (Table 4).

Predatory coccinellids and spiders

It is evident from Tables 5 and 6 that none of the chemical treatment was found safe against the predatory coccinellids and spiders which adversely affected their population whereas water jetting exhibited very least effect and was found safer than all chemical treatments. Maximum reduction of coccinellids population was noticed in the plots sprayed with dichlorvos at 17 and 27 DAP. The adverse effect of all chemical treatments persisted till 45 DAP.

In the case of spiders, the population was affected drastically two days after second spray of insecticides and recorded >50% reductions till 15th day. However, the least reduction of spider's population in the water jetted plots recovered shortly which recorded on a par with control at 10 days after each treatment. The overall mean revealed that all chemical measures showed abrupt reduction in the population of natural enemies. The comparative observations on the natural enemies population on water jetting revealed that coccinellids was little more affected with 21.90, 20.70 and 13.97% reductions at two days after each jetting whereas in case of spiders it was 13.69, 10.36 and 6.10%, respectively.

Comparative economics

Management of major sucking pests through insecticidal treatments recorded highest expenditure of Rs. 1830.00 – 1870.00 / ha towards cost of chemical, labour to fetch water and spraying cost whereas in water jetting the expenditure was Rs.600.00 only towards labour. Further, during the process of water jetting the garden is irrigated spontaneously as the jetted water flows to the root zone of the plants and hence the cost of labour for irrigation was saved. The leaf yield net returns and benefit cost ratio recorded higher in water jetting than chemical measures, which recorded 9151-9714 kg, Rs. 16432.00 – 17568.00 and 8.78:1 – 9.44:1 respectively (Table 7).

DISCUSSION

Findings of the studies on comparative efficacy of water jetting and chemical measures practised by the farmers indicated that two treatment of water jetting at 15 and 25 DAP was more effective in controlling of papaya mealybug than all concurrent chemical measures and against spiralling whitefly and jassid exhibited the same results with two sprays of dimethoate followed by dichlorvos but superior to rest of the chemical measures. But against thrips, water jetting recorded lower efficacy than two sprays of dimethoate followed by dichlorvos, on a par with dichlorvos followed by dimethoate and better than two spray of dichlorvos. Water jetting in mulberry garden showed slight or no deleterious effect on predatory coccinellids and spiders whereas there was drastic reduction in their population on chemical measures.

After chemical measures, farmers need to wait to initiate silkworm rearing till safety period based on the persistent toxicity of the insecticide sprayed to avoid its hazardous effect to the silkworms. The safety period of dichlorvos and dimethoate was reported as 10 and 15 days respectively (Dandin *et al.*, 2003). The plant age 35-40 DAP is ideal for

Table: 3 Efficacy of water jetting and chemical measures against jassid, *Empoasca flavescens* on mulberry

Treatment	Population of Jassid *Empoasca flavescens* (No./leaf)												Leaf yield (kg/ha)
	14DAP (PTC)	First treatment 15 DAP			Second treatment 25 DAP			Mean	Third treatment 35 DAP (Water Jetting alone)			Overall mean	
		17DAP	20DAP	25DAP	27DAP	30DAP	35DAP		37DAP	40DAP	45DAP		
T_1 Water Jetting	5.73	0.60 (89.65)	1.13 (80.71)	1.86 (67.13)	0.33 (94.61)	0.46 (92.49)	2.73 (54.5)	1.18 (80.10)	0.46 (93.09)	2.33 (67.63)	6.80 (15.00)	1.85 (71.00)	9893 (21.85)
T_2 Dichlorvos -I Dichlorvos -II	5.80	0.53 (90.86)	1.00 (82.93)	3.00 (47.00)	0.26 (95.75)	0.73 (88.09)	3.33 (44.5)	1.47 (75.21)	3.93 (41.00)	6.66 (7.50)	7.80 (2.50)	3.02 (52.66)	9090 (14.95)
T_3 Dichlorvos –I Dimethoate-II	6.00	0.66 (88.62)	1.06 (81.91)	3.06 (45.93)	0.20 (96.73)	0.60 (90.21)	2.86 (52.33)	1.40 (76.39)	3.06 (54.05)	5.93 (17.64)	7.33 (7.41)	2.75 (56.89)	9300 (16.87)
T_4 Dimethoate-I Dichlorvos -II	5.93	0.53 (90.86)	0.93 (84.13)	1.66 (70.67)	0.40 (93.47)	0.66 (89.23)	3.06 (49.00)	1.20 (79.76)	3.73 (44.00)	6.53 (9.30)	7.46 (6.75)	2.77 (56.58)	9266 (16.56)
T_5Dimethoate-I Dimethoate-II	5.93	0.60 (89.65)	0.86 (85.32)	1.73 (69.43)	0.46 (92.49)	0.33 (94.61)	2.66 (55.66)	1.10 (81.45)	3.00 (54.95)	4.60 (36.11)	7.33 (8.37)	2.40 (62.38)	9443 (18.13)
T_6 Control	5.86	5.80	5.86	5.66	6.13	6.13	6.00	5.93	6.66	7.20	8.00	6.38	7731
C.D.@5%	NS	0.08	0.11	0.25	0.07	0.08	0.25	0.14	0.22	0.24	0.27	0.18	48.56
C.V.%	7.00	7.54	5.62	6.95	8.49	5.41	11.68	9.86	6.93	9.24	10.31	9.64	11.07

PTC= Pre treatment count, DAP= Days after pruning, Figures in the parentheses are percent reduction over control

Table: 4 Efficacy of water jetting and chemical measures against thrips, *Pseudodendrothrips mori* on mulberry

Treatment	Population of Thrips *Pseudodendrothrips mori* (No./leaf)												Leaf yield (kg/ha)
	14DAP (PTC)	First treatment 15 DAP			Second treatment 25 DAP			Mean	Third treatment 35 DAP (Water Jetting alone)			Overall mean	
		17DAP	20DAP	25DAP	27DAP	30DAP	35DAP		37DAP	40DAP	45DAP		
T_1 Water Jetting	50.33	14.78 (72.62)	16.03 (69.90)	22.51 (56.77)	8.73 (83.46)	11.66 (76.57)	13.10 (72.81)	14.46 (72.02)	6.63 (85.26)	9.12 (78.11)	13.00 (66.94)	12.84 (73.50)	9788 (24.77)
T_2 Dichlorvos -I Dichlorvos -II	53.56	11.63 (78.46)	19.75 (62.91)	26.75 (48.63)	8.12 (84.62)	10.34 (79.22)	13.88 (71.19)	15.07 (70.83)	18.23 (59.48)	22.87 (45.12)	32.83 (16.52)	18.26 (62.31)	9106 (19.14)
T_3 Dichlorvos –I Dimethoate-II	48.36	12.00 (77.77)	20.00 (62.44)	27.15 (47.87)	6.00 (88.63)	8.34 (83.24)	11.39 (76.36)	14.14 (72.63)	12.32 (72.62)	20.66 (50.43)	28.12 (28.50)	16.22 (66.52)	9290 (20.74)
T_4 Dimethoate-I Dichlorvos -II	49.71	10.33 (80.87)	13.30 (75.02)	17.36 (66.66)	6.56 (87.57)	9.06 (81.79)	12.57 (73.91)	11.53 (77.68)	16.40 (63.55)	23.56 (43.47)	31.00 (21.17)	15.57 (67.86)	9328 (21.06)
T_5Dimethoate-I Dimethoate-II	48.24	9.88 (81.70)	12.73 (76.09)	17.00 (67.35)	5.69 (89.22)	8.00 (83.92)	10.93 (77.31)	10.70 (79.29)	10.07 (77.62)	16.29 (60.91)	28.00 (28.80)	13.17 (72.81)	9615 (23.42)
T_6 Control	51.67	54.00	53.26	52.08	52.80	49.77	48.19	51.68	45.00	41.68	39.33	48.45	7363
C.D.@5%	NS	3.18	3.03	3.06	2.85	2.94	3.25	2.13	2.38	2.52	3.88	3.52	53.80
C.V.%	5.97	6.95	5.42	9.36	6.36	6.49	9.58	10.25	8.65	9.88	6.91	7.28	9.05

PTC= Pre treatment count, DAP= Days after pruning, Figures in the parentheses are percent reduction over control

Table: 5 Impact of water jetting and chemical measures on predatory coccinellids in mulberry garden

Treatment	Population of predatory coccinellids (No./ plant)											
	14DAP (PTC)	First treatment 15 DAP			Second treatment 25 DAP			Mean	Third treatment 35 DAP (Water Jetting alone)			Overall mean
		17DAP	20DAP	25DAP	27DAP	30DAP	35DAP		37DAP	40DAP	45DAP	
T_1 Water Jetting	8.80	7.13 (21.90)	8.13 (17.54)	9.13 (6.16)	7.66 (20.70)	8.86 (11.40)	9.85 (7.68)	8.46 (14.02)	8.80 (13.97)	9.00 (12.95)	10.66 (3.61)	8.80 (12.61)
T_2 Dichlorvos -I Dichlorvos -II	9.33	0.86 (90.58)	2.66 (73.02)	4.06 (58.27)	0.53 (94.51)	1.53 (84.70)	3.93 (63.16)	2.26 (77.03)	5.66 (44.67)	6.53 (36.84)	7.13 (35.53)	3.65 (63.75)
T_3 Dichlorvos –I Dimethoate-II	8.60	0.80 (91.23)	2.73 (72.31)	3.86 (60.32)	0.66 (93.16)	1.86 (81.4)	2.80 (73.75)	2.11 (78.55)	4.60 (55.03)	5.66 (45.26)	6.06 (45.20)	3.22 (68.02)
T_4 Dimethoate-I Dichlorvos -II	9.00	1.73 (81.05)	2.00 (79.71)	2.66 (72.66)	0.53 (94.51)	1.6 (84.00)	3.66 (65.70)	2.03 (79.37)	5.33 (47.89)	6.53 (36.84)	6.53 (40.95)	3.39 (66.33)
T_5Dimethoate-I Dimethoate-II	8.66	1.66 (81.81)	2.06 (79.10)	2.60 (73.27)	0.60 (93.78)	2.0 (80.00)	2.46 (76.94)	1.89 (80.79)	4.06 (60.31)	5.00 (51.64)	5.86 (47.01)	2.92 (71.00)
T_6 Control	9.33	9.13	9.86	9.73	9.66	10.00	10.67	9.84	10.23	10.34	11.06	10.07
C.D.@5%	NS	0.16	0.13	0.25	0.09	0.15	0.18	0.12	0.23	0.19	0.31	0.27
C.V.%	9.26	11.28	13.61	9.04	12.88	8.12	9.12	10.59	11.08	12.15	9.28	11.04

PTC= Pre treatment count, DAP= Days after pruning, Figures in the parentheses are percent reduction over control

Table: 6 Impact of water jetting and chemical measures on spiders in mulberry garden

Treatment	Population of spiders (No./ plant)											
	14DAP (PTC)	First treatment 15 DAP			Second treatment 25 DAP			Mean	Third treatment 35 DAP (Water Jetting alone)			Overall mean
		17DAP	20DAP	25DAP	27DAP	30DAP	35DAP		37DAP	40DAP	45DAP	
T_1 Water Jetting	1.46	1.26 (13.69)	1.46 (8.75)	1.80 (3.22)	1.73 (10.36)	1.86 (6.98)	1.80 (3.22)	1.65 (6.25)	2.00 (6.10)	2.33 (4.16)	2.46 (2.76)	1.85 (5.61)
T_2 Dichlorvos -I Dichlorvos -II	1.53	0.20 (86.30)	0.53 (66.87)	0.80 (56.98)	0.00 (100.0)	0.60 (67.74)	0.70 (62.36)	0.47 (73.29)	0.93 (56.33)	1.20 (50.00)	1.80 (28.85)	0.75 (61.73)
T_3 Dichlorvos –I Dimethoate-II	1.40	0.26 (82.19)	0.53 (66.87)	0.86 (53.76)	0.13 (93.26)	0.40 (78.49)	0.59 (68.27)	0.46 (73.86)	0.73 (65.72)	1.06 (55.83)	1.66 (34.38)	0.69 (64.79)
T_4 Dimethoate-I Dichlorvos -II	1.53	0.46 (68.49)	0.60 (62.50)	0.73 (60.75)	0.06 (96.89)	0.60 (67.74)	0.72 (61.29)	0.53 (69.88)	0.90 (57.74)	1.26 (47.50)	1.83 (27.66)	0.79 (60.00)
T_5Dimethoate-I Dimethoate-II	1.46	0.46 (68.49)	0.60 (62.50)	0.73 (60.75)	0.13 (93.26)	0.40 (78.49)	0.63 (66.13)	0.49 (72.16)	0.73 (65.72)	1.00 (58.33)	1.63 (35.57)	0.70 (64.28)
T_6 Control	1.53	1.46	1.60	1.86	1.93	1.86	1.86	1.76	2.13	2.40	2.53	1.96
C.D.@5%	NS	0.02	0.03	0.02	0.02	0.03	0.04	0.02	0.08	0.13	0.14	0.13
C.V.%	7.45	8.52	9.61	7.45	11.03	10.88	13.65	8.53	12.09	8.49	10.68	9.94

PTC= Pre treatment count, DAP= Days after pruning, Figures in the parentheses are percent reduction over control

Table: 7 Comparative economic benefits due to water jetting and chemical measures

Treatment	Qty. of pesticides used (ml/ha)	Cost of pesticides (Rs.)	*Cost of labour (Rs.)	**Spraying cost (Rs.)	Total cost (Rs.)	Avg. leaf yield (Kg/ha)	#Gross returns (Rs.)	Net returns (Rs.)
T_1 Water Jetting	--	--	600.00	--	600.00	10395 (27.25)	20790.00	20190.00 (25.09)
T_2 Dichlorvos -I Dichlorvos -II	1000	370.00	300.00	1200.00	1870.00	9151 (17.36)	18302.00	16432.00 (7.96)
T_3 Dichlorvos –I Dimethoate-II	1100	330.00	300.00	1200.00	1830.00	9376 (19.34)	18752.00	16922.00 (10.62)
T_4 Dimethoate-I Dichlorvos -II	1100	330.00	300.00	1200.00	1830.00	9362 (19.22)	18724.00	16894.00 (10.47)
T_5Dimethoate-I Dimethoate-II	1200	360.00	300.00	1200.00	1860.00	9714 (22.15)	19428.00	17568.00 (13.91)
T_6 Control	--	--	--	--	--	7562	15124.00	15124.00

* @ Rs. 100.00/ female labour, ** @ Rs.20.00/ tank, # @ Rs.2.00/kg, Figures in the parentheses are percent increase over control

initiation of silkworm rearing and hence chemical measure is possible only 10-15 days before initiation of rearing i.e. till 25 DAP. But the grown up plants need to be maintained up to 60-65 DAP for leaf harvest still completion of silkworm rearing. At the same time sucking pests restore their population shortly after 25 DAP because of their resistance as well as abrupt reduction in the population of their natural enemies due to application of toxic chemicals which resulted in depletion of nutritional values in mulberry leaves. Therefore feeding such leaves adversely affect the growth and development of silkworms and silk production.

In the present study, the additional treatment of water jetting a third time at 35 DAP supported to reduce the population of all sucking pests to a greater extent constantly till 45 DAP and the highest population of natural enemies in the water jetted plots also worked to keep the pest population reduced which resulted in higher leaf yield than all chemical measures. Further unlike chemical measures, water jetting could be done at any moment when the pest population crosses the ETL even after initiation of silkworm rearing. Water jetting besides controlling the sucking pests, washes out the black sooty moulds developed on the honeydew secreted by them as well as the dust sediment on the leaves which enhances the photosynthetic activity of the plant and hence the practice plays additional role in increase of mulberry leaf quality and yield whereas in chemical measures the sooty mould and dirt particles are left as such over the plants.

The efficacy of water jetting is in conformity with the suggestions of Banjo *et al.* (2004), Galanihe *et al.* (2010) and Ellis and Bradley (1996) to control the sucking pests physically through spray of a steady stream of water. Similarly, Geetha Bai *et al.*(2001) recommended use of strong jet of water to wash away the eggs and nymphs of spiralling whitefly, *Aleurodicus dispersus* Russell from mulberry plants. Water jetting involves physical force which hits on the infested plant parts to dislodge and wash out the pests so that the crop is kept free from the population of the pests. The sucking pests are soft-bodied slender insects and the force of water when jetted with a reasonably high pressure lethally injures them as well as the fallen ones will be available to ground predators and this will also make their return to the host difficult (Bissdorf, 2005). But predatory coccinellids are heavily sclerotised and resist water pressure remarkably whereas, the fast motility of spider enables if to escape from the water stream. However, the reduction in population of coccinellids recorded higher than spiders in the water jetted plots because of its little adverse effect on the grub stages.

Thus it can be concluded that the water jetting technique employed in the present study against major sucking pests of mulberry was more effective and economic than chemical measures and helps to contain the incidence of the pests even at the time of silkworm rearing. This practice is absolutely eco-friendly and also could help to avoid spray of noxious chemicals and the problem of insecticide residues which causes hazardous effects to human beings, animals, silkworms and natural enemy complex of insect pests. Unlike chemical measures, water jetting is highly compatible with bio-control measures. Hence this technique could be included as one of the component of integrated pest management programmes. Further, the efficacy of this package against the pests of agricultural and horticultural crops needs to be studied.

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