Indian Journal of Entomology 86(1): 93-97 (2024) DoI. No.: 10.55446/IJE.2023.853

ASSESSMENT OF ELECTROSTATIC SPRAYER AGAINST CITRUS PSYLLA *DIAPHORINA CITRI* KUWAYAMA IN KINNOW MANDARIN

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ABSTRACT

Field experiments were conducted to evaluate and standardize the efficiency of electrostatic sprayer for checking citrus psylla *Diaphorina citri* population in kinnow mandarin orchards using the recommended insecticide imidacloprid @ 0.0071% and compared to standard knapsack sprayer and tractor mounted power sprayer. The results revealed that the use of electrostatic sprayer was significantly efficient in reducing >30% spray volume, covered significant more area (4.8-5.6 ha/ day), is labour saving (1 labour per operation) and much effective in reducing *D. citri* population by >80% after 14 days of spray in kinnow mandarin orchards.

Key words: Citrus, kinnow mandarin, *Diaphorina citri*, seasonal incidence, spray technology, electrostatic sprayer, management, imidacloprid, knapsack sprayer, spray volume, labour

In Punjab, Kinnow mandarin occupies a prominent place in terms of acreage and production although other citrus cultivars viz. mandarin, sweet orange, grapefruit, lime and lemons are also gaining importance in the region. Many of the biotic stresses (diseases and insect-pests) contribute to the qualitative and quantitative losses in citrus fruit crop. Among the major insect-pests attacking this crop citrus psylla, *Diaphorina citri* Kuwayama is the most serious as it inflicts damage in multifarious ways i.e. it devitalizes the plant by sucking cell sap, secretes honeydew that captivate sooty mould fungus growth and impairs photosynthesis. Moreover, it vectors the fastidious bacterium, responsible for citrus greening disease that ultimately contributes to citrus decline. To avoid these undue pest losses, various spray operations are done. Traditionally, the high volume knapsack sprayers and tractor mounted power sprayers are been used in kinnow orchards which are simple, cost-effective and exhibit easy operability (Bateman and Jessop 2008 and Roten et al., 2013) but lacks in terms of their targeted delivery, distribution and penetration to the target host in tree crops which contributed in over application of pesticides and reduced pest control (high does, frequent applications etc). Moreover, their energy use efficiency in terms of manpower and spray coverage is also less. These are labour-intensive, time consuming and exhibit high application costs. Significant revolution in spray technology is marked with the application of electrostatic sprayers the use of which overall increases the bio-efficacy and deposition efficiency of pesticides (Hoffmann et al., 2007; Patel et al., 2015; Ukran et al., 2016 and Patel 2016). These electrostatic sprayers are effective in controlling the pest with impending reduction of over usage of insecticides (Kabashima et al., 1995 and Gossen et al., 2008). Under Punjab field conditions, the comparative evaluation of electrostatic sprayer over the traditional sprayers demonstrated that the electrostatic sprayer was significant in terms of bio-efficacy in cotton crop which resulted due to improved droplet density, spray deposition, and higher area coverage (Patel et al., 2016 and Patel et al., 2017). The application of electrostatic spray technology has already been demonstrated in many crops showing significant enhanced efficiency as discussed above. In citrus orchards, the introduction/procurement of these electrostatic sprayers for application of pesticides has been undertaken in recent years by different farmers in Punjab. However, their efficiency and delivery parameters are not quantified and standardized. Hence, this study was undertaken to compare the efficiency of electrostatic sprayer with the conventionally used sprayers in delivering the spray solutions and managing the in kinnow mandarin.

MATERIALS AND METHODS

The experiments were carried out at the experimental farm of the Punjab Agricultural University Regional Research Station, Abohar, India (30°08'N; 74°12'E and 185.78 amsl). The area is semi-arid, characterized by hot and dry weather and receives 75-300 mm of annual rainfall most of which befalling between July to September months. The study was conducted on

a 15 year old Kinnow mandarin orchard planted at a spacing of 20 x 20 feet maintained as per recommended practices of Punjab Agricultural University, Ludhiana (Annonymous 2016). To study the population dynamics of *D. citri*, weekly observations were recorded from fifteen marked kinnow mandarin plants. No hard insecticide spray was given for any of the insect-pest during the season. The number of *D. citri* adults was counted from 10 leaves from each direction of the plant, while *D. citri* nymphal count was taken from 10 cm apical twig from all the directions.

For the management of *D. citri* there were a total four experiments conducted during March and August months, respectively in randomized block design with three replications/ treatment. The plot size taken was 400 m^2. Three different sprayers viz. manually operated knapsack sprayer, tractor mounted power sprayer and tractor mounted electrostatic sprayer was compared to find out the best effective spray technology for pest management in citrus orchards. The treatment with manually operated knapsack sprayer was kept as check (general practice of spraying in orchards) to compare of efficiency of modern spray technology. Commercial formulation of imidacloprid (Confidor 17.8% SL, Bayer Crop Science) procured from local market was used to find out the efficacy of the insecticide with the three different sprayers against citrus psylla in kinnow mandarin orchards. Sampling was carried out one day before and 3, 7, 10 and 14 days after the spray application. From each replication five kinnow mandarin plants was randomly selected for taking *D. citri* nymphal counts. Five twigs of 10 cm length covering all the directions of tree were randomly picked and number of *D. citri* live nymphs counted. The corrected efficacy percentage was calculated as per Henderson and Tilton's (1955). The (%) data were subjected to arc sine transformation for statistical analyses. The data generated was pooled and subjected to ANOVA to evaluate the treatment effects and the means separated (LSD p=0.05).

RESULTS AND DISCUSSION

The detailed specifications of the different sprayers used during the experiment are depicted in Table 1. The seasonal incidence of *D. citri* nymphs and adults on kinnow mandarin plants during the experiment is presented in Fig. 1. During the study period the population of *D. citri* was ranged from 0.0 - 58.70 nymphs/ 10 cm apical twig and 5.33 - 51.55 adults/ 10 leaves from SMW 1 to SMW 52 (Table 1). The incidence of *D. citri* was found to be severe between SMW 7-16 and 6-15 for nymphs and adults, respectively, during this period it inflicts maximum damage to kinnow plants. However, the population of *D. citri* peaked during 9th and 11th SMW for the adults and nymphs, respectively (Fig. 1). Two peaks of *D. citri* population were observed annually, first between SMW 7-15 and the second between SMW 31-35. The damage of *D. citri* on kinnow mandarin plants was at peak in between mid-February to first week of April in comparison to the second peak (August-September). In south western Punjab *D. citri* became a major threat to citrus cultivation causing huge economic loses to farmers every year. The adults of *D. citri* remain active in unmanaged citrus orchards as well as on other alternate host throughout the year and shift immediately to the citrus as the new flush start emerging. While plotting the peak activity period of *D. citri* to major abiotic factors, a temperature ranged between 21.02 – 37.73 °C (Tmax), 10.17 – 20.49 °C (Tmin) along with 47.16 - 77.5% RH was found favourable for the population buildup and further spread of this insect.

The comparison of electrostatic sprayer with the standard operating sprayers was quantified in terms of efficacy in reducing *D. citri* population in kinnow mandarin, volume of water used per acre and area covered per day. In terms of insecticide efficacy as revealed from the experiment data, both electrostatic sprayer and tractor mounted power sprayer were at par in reducing the population of *D. citri* nymphs in kinnow mandarin by more than 80% after 14 days of spray application. The major differences observed were water use efficiency, area covered/day and manpower used (number of persons involved). The electrostatic sprayer was proved to be more efficient as compared to power operated gun sprayer as it reduces more than 30% of spray solution, covers more area per day and is labour saving (Table 1). The tractor mounted electrostatic sprayer in kinnow orchards utilizes around 1125 ℓ of spray volume to cover 1 ha of orchard in comparison to power sprayer (Average: 1500l/ ha) thus it will significantly able to reduce the insecticide usage in orchards. Also the manpower involved in spray application was reduced with electrostatic sprayer (1 labour used for handling and spraying) whereas the tractor mounted power sprayer engaged 3 individuals (1 tractor driver and 2 labrourers for handling spray guns). Because of ease in handling the electrostatic sprayer covers about 4.8 - 5.6 ha/ day for spray application of chemicals in orchards. It has substantial potential on application of different spray formulations in

Table 1. Sprayers used their performance assessment against *D. citri* in kinnow mandarin

Detailed specifications of the sprayers				
Particulars		Details of sprayers		
		KS	TMPS	TMES
Prime mover	Type	Manual operated	Tractor PTO	Tractor PTO
	Power, kW	0.075-0.100	20-30	20-30
Pump	Type	Diaphragm	Hydraulic	Hydraulic triple action piston
	Horse power, kW	0.075-0.100	5.0	5.0
	Pump, rpm	-	600	900-1200
	Discharge l/ min	1.0	60-80	50
	Pressure developed, kPa	4.0	35.00	35.0
Fan	Diameter of blade, mm	-	-	612
Nozzle	Type	Hollow cone	Gun hollow	Hollow cone (Electrostatic)
	Type of energy used to atomize the liquid	Hydraulic	Hydraulic	Gaseous
	Pressure at nozzle tip, kPa	3.00	7.00	3.00
	Flow rate of nozzle, l/min	0.80-1.00	20.00	20
	Number of nozzle	one	one	
	Nozzle spacing	-	-	
Tank	Materials	PVC	PVC	PVC
	Main Capacity lit	16	500	600
	Hand wash capacity, lit			10.0
Hose pipe	Material	HDVC	HDVC	-
	Length, m	1.5	60	-

Evaluation of efficiency (pooled data)

S. No.	Treatments	Insecticide used	Dosage ml/ l	Area covered/ day (ha)	Spray volume used ℓ/ ha	Pre-treatment count of *D. citri* nymphs/ 10 cm twig	% reduction in *D. citri* nymphs population				No. of persons involved
							3 DAT	7 DAT	10 DAT	14 DAT	
1	KS	Imidacloprid	0.4	0.3 – 0.4	1375	39.60	72.25 (56.12)	78.94 (62.55)	83.87 (64.78)	74.59 (56.29)	1
2	TMPS	Imidacloprid	0.4	4.0 – 4.8	1500	41.40	75.63 (58.47)	84.78 (66.74)	90.02 (70.58)	82.25 (62.33)	3
3	TMES	Imidacloprid	0.4	4.8 – 5.6	1125	40.90	78.31 (59.52)	86.89 (67.56)	91.54 (72.71)	83.11 (62.27)	1
	CD (p=0.05)						(3.37)	(4.43)	(5.03)	(4.64)	

*DAT: days after treatment; KS: Knapsack Sprayer; TMPS: Tractor Mounted Power Sprayer; TMES: Tractor Mounted Electrostatic Sprayer

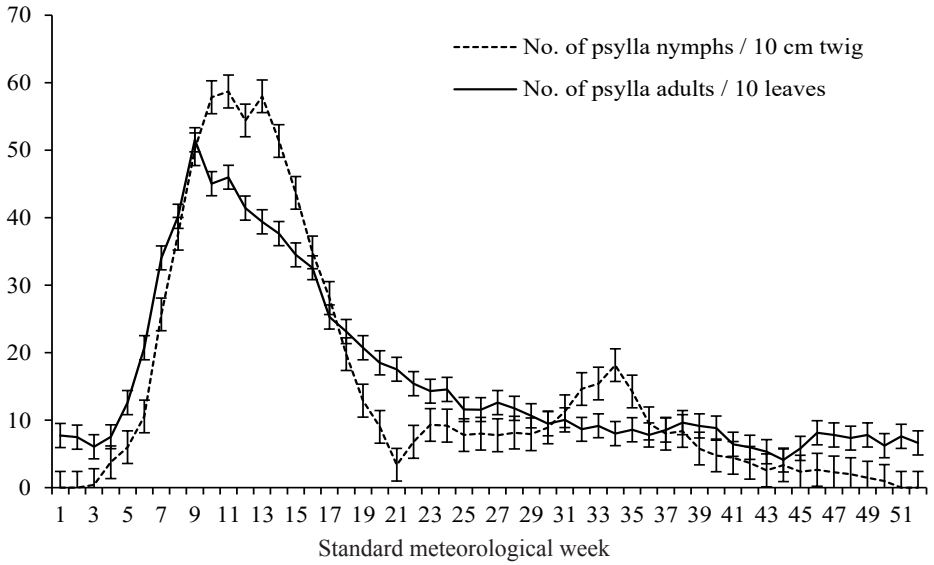

Fig. 1. Seasonal dynamics of *Diaphorina citri* nymphs and adults in kinnow mandarin orchards (pooled)

agricultural crops as the charged particles can execute uniform coverage of spray on the crop canopy with noticeably less quantity and better efficacy. Derksen et al. (1991) also supported that electrostatic sprayers have a better application efficiency of roughly 80% with 50% less spray volume used which corroborates our findings. Comparison of air-assisted electrostatic pesticide application techniques with conventional sprayer revealed that these sprayers showed improved performance against green peach and melon aphids as electrostatic application provided significant control over the conventional sprayers while using 40 times less water in an equivalent area (Derksen et al., 1991). Electrostatic spray technology resulted in significant gain in spray deposition in the order of 1.6 to 2.5 times, and reduced application rates, ultimately contributing to higher application efficiency has been reported (Kabashima et al., 1995). Another study revealed that the use of electrostatic sprayers for the management of insect-pests in fruit crops (Patel et al., 2016) and cotton (Kumar et al., 2016) enhance the deposition efficiency of insecticide thereby reducing the usage of chemicals to about 30 to 40% compared to air-assisted sprayer. According to a study conducted by Aneesha et al. (2020), the energy use efficiency of electrostatic sprayer was 1.5 and 2 times higher than that of mist blower and air compression sprayers, respectively, alongwith reduced chemical usage as compared to knapsack sprayer.

It can be concluded from the study that the lower spray volume witnessed through the electrostatic sprayer resulted in corresponding lower volume of active ingredient, while accounting the significant higher efficacy against increasing population of *D. citri* in kinnow mandarin orchards over the knapsack sprayer. Better deposition, more area coverage equipped with single manpower highlighted the significance of this sprayer over the conventional sprayers and in long run this type of sprayers can play a pivotal role in improvising the spray technology in orchards. Advancement in pesticide application has been made by the commercialization of electrostatic sprayers and by making these sprayers available to farmers on custom hiring basis will improve the overall efficiency of spray in orchards**.** It is also emphasized that there is a need to standardize the technology for reduced dosage of active ingredient of insecticide implying to decrease input cost of insecticide to achieve significant control of insect-pests in orchards.

ACKNOWLEDGEMENTS

The authors thank the Director, Punjab Agricultural University Regional Research Station, Abohar for providing necessary facilities to execute the present study.

FINANCIAL SUPPORT

The financial support for conducting this study provided by Punjab Agricultural University, Ludhiana is duly acknowledged.

AUTHOR CONTRIBUTION STATEMENT

PKA conceived and designed research. MP and PKA conducted experiments. MP and PKA analyzed data. MP and US wrote the manuscript. All authors read and approved the manuscript.

CONFLICT OF INTEREST

No conflict of interest.

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(Manuscript Received: October, 2022; Revised: May, 2023;
Accepted: May, 2023; Online Published: May, 2023)
Online First in www.entosocindia.org and indianentomology.org Ref. No. e23853