The Pharma Innovation Journal 2022; SP-11(2): 579-581

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(2): 579-581

www.thepharmajournal.com
Received: 11-12-2021
Accepted: 15-01-2022

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Efficacy of different insecticides against whitefly (*Bemisia tabaci*) on tomato (*Lycopersicon esculentum* Mill.)

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DOI: https://doi.org/10.22271/tpi.2022.v11.i2Sh.10709

Abstract
Investigations were carried out on management of whitefly on tomato, which was conducted at Agricultural Research Farm of Raja Balwant Singh College, Bichpuri, Agra, during Rabi season of 2019-2020. The treatment of Imidacloprid 17.8 SL (0.22 ml/lit.) and Acetamiprid 20 SP (0.20 ml/lit.) were found to be more effective for the control of whitefly (*Bemisia tabaci*) on tomato followed by mint oil (3 ml/lit) and Neem oil (3ml/lit). The fruit yield of tomato was significantly highest in Imidacloprid 17.8 SL @ 0.22 ml/lit. (91.67 q ha^{-1}).

Keywords: Tomato crop, *whitefly (Bemisia tabaci*), insecticides

Introduction
Tomato (*Lycopersicon esculentum* Mill.) is one of the most important vegetable crops of the globe due to its immense commercial and nutritive value and wide range of climatic adaptability. It is a good source of vitamins *viz*. A and reported to possess anti cancerous properties. Per 100g ripe tomato fruits contains Vitamin C (31.0 mg), Vitamin A (320 IU) and Riboflavin (0.001 mg), Nicotinic acid (0.4 mg) and minerals *viz*., Potassium (114.0 mg), Sulphur (24.0 mg), Chlorine (38.0), Sodium (45.8 mg), Calcium (20.0 mg), phosphorus (36.0 mg), Iron (1.8 mg), Magnesium (15.0 mg), Copper (0.19 mg) (Aykroyd, 1963) [1].
India ranks second in the production of tomato after China having an area of 786 thousand hectare with production of 19377 metric tons during 2017-18. Among the states Maharashtra is leading in tomato cultivation, cultivated on 50 thousand hectares with production of 1200 thousands metric ton and productivity 24 metric tons per hectare. (Annual Report, IIVR, 2018). In Uttar Pradesh, average area under tomato for last 5 years is 10.6 thousand hectares with average annual production of 540.67 thousand metric tonnes (NHB, 2019) [5].
In India, productivity of tomato is very low as compare to its production potential of the developed countries. There are many factors for low production potential, these include abiotic factors like weather parameters such as temperature, humidity, nutrient deficiency, water deficiency etc. Biotic factors include insect pests, pathogens and weed which limit the productivity of tomato crop. Among them insect-pests infestation is one of the major factors that is responsible for reduction in productivity. The production and quality of tomato fruits are considerably affected by array of insect pests infesting at different stages of crop growth. The sucking pests *viz*., aphid, whiteflies and thrips cause severe damage to crop by transmitting virus disease rather than direct feeding. Among the various insect pest, whitefly (*Bemisia tabaci*) is major insect pest causing considerable damage to the crop by attacking the different plant parts of tomato Yield losses due to direct and indirect damage caused by whiteflies were reported to the extent of 20 to 100% (Papisarta and Garzia, 2002) [6].
Management of sucking pests with only pesticides frequently is difficult due to the pest fast reproduction and short lifecycle of the pest. Therefore, to overcome these problems the use of plant derived oils and new generation synthetic chemical insecticides is an ultimate tool for an effective pest management programme in an integrated manner.

Materials and Methods
To study the efficacy of some newer insecticides and botanicals, a field experiment was carried out at Agricultural Farm of Raja Balwant Singh College, Bichpuri, Agra, during Rabi season of 2020-21. The tomato variety Pusa hybrid-1 was sown in a Randomized Block Design with a spacing of 50 cm × 50 cm.

All the recommended agronomical practices were adopted for good growth of the crop. Details of treatments are given in Table 1. Seven treatments including control with three replications were evaluated against leaf miner whitefly (*Bemisia tabaci*) on tomato.

Two sprays were applied with a spray fluid volume of 500 lit. ha^{-1} with the selected insecticides. The pre-treatment count and post - treatment observations on whitefly population at l, 3, 7 and 10 days after spraying were recorded from 6 leaves per plant, 2 from top, 2 middle and 2 bottom and then mean was calculated to find out the population per leaf. Five plants per plot were selected at random leaving border rows during pre-treatment observation and subsequent data were recorded from these selected plants.

Results and Discussion

Pre-treatment count

One day before first spray the mean population varied from (4.44 to 5.16) *whiteflies* / leaf / plant, in all the treatments showed non-significant variation indicate that the mean adult whitefly population was homogeneous or statistically similar amongst all the experimental plots before spraying.

One day after first spray

The mean adult whitefly population at 24 hours after application of different insecticides (Table 2) revealed that the that lowest population was observed in the treatments T_6 and T_7 which were statistically at par and recorded 1.4 and 1.56 whiteflies /leaf/ plant, respectively. Treatments T_5, T_4, T_3 and T_1 were found comparatively less effective with higher population ranged within 2.2 to 2.6 whiteflies/ leaf/ plant.

Three days after first spray

The mean adult whitefly population after three days of application of insecticides indicated that treatments T_6 and T_7 did not differ among themselves but found the most effective treatments, gave 0.72 and 0.8 whiteflies / leaf / plant, respectively followed by T_5, T_1, T_4, T_3, T_2 having 1.23, 1.7, 2.03, 2.38 and 2.80 whiteflies/ leaf/ plant, respectively. Significantly higher population of whiteflies /leaf /plant i.e. 4.66 was noted with untreated check(T_8).

Seven days after first spray

Perusal of data on mean adult population of whitefly (Table 2) revealed that Imidacloprid 17.8 SL(T_7) and Acetamiprid 20 SP(T_6) were found to be the most toxic and gave 0.63 and 0.68 mean adult population, respectively, of whitefly at seventh day after first spray. The treatments T_4, T_1, T_5 and T_3 were found less effective and recorded 1.43-1.83 whiteflies/ leaf/ plant. However, significantly higher population was recorded with the treatment T_2 (Fenazaquin 10EC+Bifenthrin 4 EC) but it was significantly lower than that of the untreated check (T_8).

Ten days after first spray

The data obtained at 10 days after 1st spray indicate that lowest number (0.29 and 0.32 whiteflies/ leaf/ plant) were again recorded from the treatments T_7 and T_6 respectively. Treatments T_4, T_3, T_1, T_2 and T_5 were found to be less effective having whiteflies population in a range of 1.34-2.20 / leaf/plant. However, all the treatments were found effective, recorded with significantly lower population than untreated check (5.23 whiteflies/ leaf/ plant).

Before second spray

The results enumerated in Table 2 reveal that all the experimental plots showed non-significant variation with respect to the mean adult whitefly population indicate that the mean adult whitefly population was homogeneous or statistically similar before second spraying.

One day after second spray

The mean adult whitefly population one day after application of different insecticides and botanicals (Table 2) revealed that Acetamiprid 20 SP(T_6) and Imidacloprid 17.8 SL(T_7) were at par and proved to be the most effective treatments with 1.21 and 1.30 mean adult whitefly population per leaf / plant, respectively. Whereas, treatments T_1, T_4, T_3, T_5 and T_2 were found less effective, recorded mean whiteflies population in the range of 1.95-2.68 leaf/ plant. However, the population recorded in all the treatments were significantly lower from untreated check with 4.8 whiteflies / leaf /plant.

Three days after second spray

The mean adult whitefly population after three days of application of insecticides (Table 2) indicated that Imidacloprid 17.8 SL and Acetamiprid 20 SP were found to be the most effective treatments, reported 0.79 and 0.84 mean adult whiteflies /leaf / plant, respectively. Treatments Mint Oil (1.36), Neem oil (1.56), Fenazaquin 10EC+Bifenthrin 4 EC 1.75ml/lit (1.80) and Fenazaquin 10EC+Bifenthrin 4 EC 1.50ml/lit (1.90) were next effective treatments which were at par among themselves. Application of Fenazaquin 10EC+Bifenthrin 4 EC 1.25ml/lit (2.46) was found least effective against whitefly however it was noted significantly lower population of whiteflies /leaf / plant than that of untreated control (5.00).

Seven days after second spray

Although after seven days of second spray treatments T_6 and T_7 did not differ much but recorded lowest population i.e. 0.52 and 0.65 whiteflies / leaf / plant, respectively. Relatively higher population was recorded from the treatments T_1, T_5, T_4 and T_3 with a range of population (1.03-1.51 whiteflies / leaf / plant). However, significantly higher population than above mentioned treatments was recorded from treatment T_2 (2.1 whiteflies/plant) which was significantly lower than untreated check (4.96 whiteflies /plant).

Ten days after second spray

The data obtained after 10 days of second spray, revealed that treatments T_6 and T_7 were at par and recorded the lowest population (0.40 and 0.57 whiteflies / leaf / plant, respectively) whereas, treatments T_4 T_3, T_1 and T_2 recorded with mean population of whiteflies ranging (1.33-1.91 whiteflies / leaf / plant). However, all the treatments were recorded with significantly lower population of whiteflies than that of the untreated check (4.54 whiteflies/ leaf / plant).

Yield of tomato fruit

The data on yield of tomato fruits obtained in various insecticidal treatments are summarized in Table 3. The yield of tomato fruits in different treatments varied from 64.33 to 91.67 q/ha. The highest yield of tomato fruits (91.67 q/ha) was recorded with the application of the Imidacloprid 17.8 SL @ 0.22 ml/lit followed by Acetamiprid 20 SP @ 0.20/lit. (88.33 q/ha), Mint oil @ 3 ml/lit. (86.67 q/ha), neem oil @ 3 ml/lit (81.67 q/ha). The moderate yield of tomato fruit was

obtained from different concentration of Fenazaquin 10EC + Bifenthrin 4 EC @ 1.75ml/ lit, 1.50 ml/lit and 1.25 ml/lit gave tomato yield of 76.67, 70.00 and 66.67 q/ha, respectively. Whereas, the lowest yield i.e. 64.33 q/ha was recorded from the untreated control plot.

Looking to the per cent increase in yield over control, it was varied from 3.64 to 42.50 per cent (Table 3). The maximum increase in yield of tomato fruit (42.50 per cent) over control was recorded in the treatment of Imidacloprid 17.8 SL @ 0.22 ml/lit followed by Acetamiprid 20 SP @ 0.20 ml/lit. (37.31%). The treatments found next in order with respect to per cent increase in yield of tomato fruits over control were Mint oil @ 3 ml/lit., Neem oil @ 3 ml/lit, Fenazaquin 10EC+Bifenthrin 4 EC @ 1.75ml/lit as they registered 34.73, 26.95 and 19.18 per cent increase in yield of tomato fruit over control, respectively. According to Ghosal and Chatterjee (2013) imidacloprid 17.8 SL @ 50 g a.i./ha was superior against whiteflies among other treatments as well as highest marketable fruit yield of tomato. Thus, the present findings are more or less in agreement with the results reported by earlier workers.

Table 1: Treatment Details

Treatments		Dose
T_1	Neem Oil	3 ml/lit
T_2	Fenazaquin10EC+Bifenthrin 4EC	1.25ml/lit
T_3	Fenazaquin10EC+Bifenthrin4EC	1.5ml/lit
T_4	Fenazaquin10EC+Bifenthrin4EC	1.75ml/lit
T_5	Mentha Oil	3 ml/lit
T_6	Acetamiprid 20 SP	0.2g/lit
T_7	Imidacloprid 17.8 SL	0.22 ml/lit
T_8	Untreated control	-

Table 2: Effect of various treatments on the population of whitefly in tomato

Treatments		Average number of white flies / leaf / plant									
		Days after first application					Days after second application				
		PTC	1 DAT	3 DAT	7DAT	10 DAT	PTC	1 DAT	3 DAT	7 DAT	10 DAT
T_1	Neem oil	4.7 (2.25)	2.6 (1.74)	1.7 (1.32)	1.56 (1.24)	1.73 (1.09)	4.36 (2.20)	1.95 (1.56)	1.56 (1.43)	1.03 (1.23)	1.63 (1.45)
T_2	Fenazaquin 10EC+Bifenthrin 4 EC	5 (2.33)	3.03 (1.87)	2.80 (1.81)	2.35 (1.68)	2.20 (1.64)	4.0 (2.10)	2.68 (1.78)	2.46 (1.71)	2.10 (1.61)	1.91 (1.55)
T_3	Fenazaquin 10EC+Bifenthrin 4 EC	4.44 (2.21)	2.51 (1.73)	2.38 (1.69)	1.83 (1.52)	1.60 (1.45)	3.76 (2.06)	2.06 (1.60)	1.90 (1.54)	1.51 (1.41)	1.38 (1.37)
T_4	Fenazaquin 10EC+Bifenthrin 4 EC	4.53 (2.22)	2.2 (1.64)	2.03 (2.58)	1.43 (1.38)	1.34 (1.35)	3.70 (2.04)	1.98 (1.57)	1.80 (1.51)	1.40 (1.38)	1.33 (1.35)
T_5	Mint Oil	4.8 (2.29)	2.08 (1.60)	1.23 (1.31)	1.72 (1.00)	2.66 (1.30)	4.60 (2.25)	2.63 (1.76)	1.36 (1.36)	1.06 (1.24)	2.10 (1.61)
T_6	Acetamiprid 20 SP	4.6 (2.25)	1.40 (1.37)	0.72 (1.10)	0.68 (1.08)	0.32 (0.90)	3.55 (2.01)	1.21 (1.38)	0.79 (1.13)	0.52 (1.01)	0.40 (0.99)
T_7	Imidacloprid 17.8 SL	5.16 (2.36)	1.56 (1.43)	0.80 (1.14)	0.63 (1.07)	0.29 (0.90)	3.53 (2.00)	1.30 (1.37)	0.84 (1.15)	0.65 (1.05)	0.57 (1.03)
T_8	Untreated control	4.46 (2.22)	4.55 (2.24)	4.66 (2.26)	5.22 (2.23)	5.23 (2.39)	4.57 (2.25)	4.80 (2.25)	5.00 (2.12)	4.96 (2.35)	4.54 (2.38)
SE(m)±		0.063	0.062	0.06	0.047	0.043	0.067	0.049	0.05	0.053	0.029
CD @ 5%		NS	0.188	0.183	0.142	0.13	0.202	0.15	0.152	0.16	0.087

(PTC- Pre-treatment count; DAT- days after treatment; values in parentheses are √b+0.5 transformed values

Table 3: Impact of insecticides on yield and economic returns in tomato

Treatments		Dose	Yield (q ha^{-1})	% increase over control
T_1	Neem oil	3ml/lit	81.67	26.95
T_2	Fenazaquin 10EC+Bifenthrin 4 EC	1.25 ml/lit	66.67	3.64
T_3	Fenazaquin 10EC+Bifenthrin 4 EC	1.5 ml/lit	70.00	8.81
T_4	Fenazaquin 10EC+Bifenthrin 4 EC	1.75 ml/lit	76.67	19.18
T_5	Mint Oil	3 ml/lit	86.67	34.73
T_6	Acetamiprid 20 SP	0.2 /lit	88.33	37.31
T_7	Imidacloprid 17.8 SL	0.22ml/lit	91.67	42.50
T_8	Untreated control		64.33	0.00

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