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Efficacy and economics of some newer and conventional insecticides against mustard whitefly (*Bemisia tabaci* (Gennadius))

RF Chaudhary, JR Patel and Mahesh Chaudhary

Abstract

Field experiment was conducted during *Rabi* season of 2015-16, 2016-17 and 2018-19 at Maize Research Station, Sardarkrushinagar Dantiwada Agricultural University, Khedbrahma to study the effect of newer insecticides against mustard whitefly, *Bemisia tabaci* on mustard. Experiment was laid out in Randomized Block Design with nine treatments. The least population of whitefly after first and second sprays during the three years was registered in plots treated with seed treatment with imidacloprid 600 FS @ 5 ml/kg seed + spray of flonicamid 50 WG @ 2.0 g/10 lit. Water (0.01%). It was followed by seed treatment with thiamethoxam 35 FS @ 6 ml/kg seed + spray of flonicamid 50 WG @ 2.0 g/10 lit. Water (0.01%). It also explicated that the highest seed yield of mustard with maximum profit was recorded in plots treated with seed treatment with imidacloprid 600 FS @ 5 ml/kg seed + spray of flonicamid 50 WG @ 2.0 g/10lit. Water (0.01%). It was followed by seed treatment with thiamethoxam 35 FS @ 6 ml/kg seed + spray of flonicamid 50 WG @ 2.0 g/10 lit. Water (0.01%).

Keywords: Mustard, whitefly, insecticide

Introduction

Mustard crop belong to the *Brassicaceae* family. Members of this genus are informally known as cruciferous plants. Most common species of this crop are *B. campestris*, *B. napus* and *B. juncea*. This crop is grown in *Rabi* growing season in both irrigated and rain fed areas of India (Ahmed *et al.*, 2018) ^[1]. Mustard occupies a supreme position as a source of edible oil for human. The production of mustard is low in India as compared to other countries mainly due to damage caused by insect pest and diseases including other factors. More than 43 species of insect pests infest mustard crop in India, out of which about a dozen of species are considered as major pest (Mandal *et al.*, 2012) ^[6]. Mustard crop is highly vulnerable to insect pests at different stages of growth, of which mustard aphid (*Lipaphis erysimi* kalt) is the key pest followed by whitefly, mustard saw fly, painted bug and pea leaf miner (Sahito *et al.*, 2016) ^[8]. These are responsible for reducing yield. These pests could be controlled to some extent by chemical pesticides. New molecules for seed treatment and for spraying are available in market but information on these molecules is scanty. Considering yield losses due to this pest, chemical control measures are suggested and in many cases seed yield loss have been minimized. The present investigation was carried out with the objective to find out the effective and economical insecticides against whitefly of mustard.

Material and Methods

The experiment was conducted at Maize Research Station, Sardarkrushinagar Dantiwada Agricultural University, Khedbrahma, Gujarat (India), during *rabi* season of 2015-16, 2016-17 and 2018-19. GDM 4; a cultivar extensively sown in the field area was used as test crop. The experiment was laid out in Randomized Block Design with three replications. Individual size of the plot was 5.0 m x 2.7 m along with spacing of 45 cm X 15 cm and fertilizer was used at ratio of 50:50:00 NPK (kg/ha). Respective seed treatment of insecticides was given to the seed at the time of sowing. Spray of insecticides were given on initiation of whitefly, second spray was given at 15 days after first spray. While, during 2017-18 only aphid infestation was there but no whitefly population was observed, so these year was not considered in experimental calculation. Five plants were selected randomly from each plot and white fly populations from 3 leaves per plant were recorded. Observation of mustard whitefly was recorded before spray and 1, 3 and 7 days after spray.

Agronomic practices for growing of the crop were followed as per recommendations of the region. Yield data were calculated as a kg/ha.

| Experimental details | |
|----------------------|---|
| Treatments: | |
| T1 | Seed treatment with imidacloprid 600 FS @ 5 ml/kg seed |
| T2 | Seed treatment with thiamethoxam 35 FS @ 6 ml/kg seed |
| T3 | T ₁ + spray of flonicamid 50 WG @ 2.0 g/10 lit. water (0.01%) |
| T4 | T ₁ + spray of dimethoate 30 EC @ 10 ml /10 lit. water (0.03%) |
| T5 | T ₂ + spray of flonicamid 50 WG @ 2.0 g/10 lit. water (0.01%) |
| T6 | Spray of imidacloprid 17.8 SL @ 20 g a.i./ha |
| T7 | Spray of thiamethoxam 25 WG @ 25 g a.i/ha |
| T8 | Spray of fipronil 5 SC @ 50 g a.i/ha |
| T9 | Control (untreated water spray) |

Results and Conclusion

First spray:

There was no any significant difference on whitefly

population observed in all the treatments before spray and one day after first spray (Table 1 & 2).

Table 1: Efficacy of newer insecticides against mustard whitefly (*Bemisia tabaci*) on mustard

| Treat. No. | Treatments | Average no. of whitefly per plant | | | |
|------------|---|-----------------------------------|-----------------------------|-----------------------------|----------------------------|
| | | Before First spray | | | |
| | | 2015-16 | 2016-17 | 2018-19 | Pooled |
| 1 | Seed treatment with Imidacloprid 600 FS @ 5 ml/kg seed | 3.69 * ^{ab} (13.59) | 3.85 * ^a (14.82) | 3.67 * ^a (13.51) | 3.73* ^b (13.95) |
| 2 | Seed treatment with Thiamethoxam 35 FS @ 6 ml/kg seed | 3.68 ^b (13.56) | 3.91 ^a (15.29) | 4.10 ^a (16.76) | 3.89 ^{ab} (15.17) |
| 3 | T ₁ + spray of Flonicamid 50 WG @2.0 g/10 lit. water (0.01%) | 3.67 ^b (13.49) | 3.86 ^a (14.90) | 4.37 ^a (19.09) | 3.97 ^{ab} (15.75) |
| 4 | T ₁ + spray of Dimethoate 30 EC @ 10 ml /10 lit. water (0.03%) | 3.72 ^{ab} (13.88) | 3.97 ^a (15.76) | 4.39 ^a (19.27) | 4.03 ^{ab} (16.22) |
| 5 | T ₂ + spray of Flonicamid 50 WG @2.0 g/10 lit. water (0.01%) | 3.66 ^b (13.41) | 3.83 ^a (14.67) | 4.389 ^a (19.20) | 3.96 ^{ab} (15.67) |
| 6 | Spray of Imidacloprid 17.8 SL @ 20 g a.i./ha | 3.85 ^{ab} (14.82) | 3.98 ^a (15.84) | 4.18 ^a (17.44) | 4.00 ^{ab} (16.02) |
| 7 | Spray of Thiamethoxam 25 WG @ 25 g a.i/ha | 4.19 ^a (17.62) | 4.05 ^a (16.40) | 4.32 ^a (18.65) | 4.19 ^a (17.55) |
| 8 | Spray of Fipronil 5 SC @ 50 g a.i/ha | 3.98 ^{ab} (15.87) | 4.06 ^a (16.48) | 4.18 ^a (17.46) | 4.08 ^a (16.61) |
| 9 | Control (untreated water spray) | 3.96 ^{ab} (15.68) | 3.95 ^a (15.60) | 4.00 ^a (16.03) | 3.97 ^{ab} (15.78) |
| | S.Em.± | 0.14 | 0.16 | 0.23 ^a | 0.100 |
| | C.D. at 5 % | NS | NS | NS | NS |
| | C.V. % | 6.14 | 6.93 | 9.49 | 7.77 |
| | Y x T | | | | NS |

Notes: 1.*Figures are $\sqrt{x+0.5}$ transformed values, whereas figures in parentheses are retransformed values.

2. Treatment means with the letter/letters in common are not significant by DNMRT at 5% level of significance within a column.

Table 2: Efficacy of newer insecticides against mustard whitefly (*Bemisia tabaci*) on mustard

| Treat. No. | Treatments | Average no. of whitefly per plant | | | |
|------------|---|-----------------------------------|-----------------------------|-----------------------------|----------------------------|
| | | 1 days after First spray | | | |
| | | 2015-16 | 2016-17 | 2018-19 | Pooled |
| 1 | Seed treatment with Imidacloprid 600 FS @ 5 ml/kg seed | 3.71 * ^{abc} (13.80) | 3.88 * ^a (15.05) | 3.78* ^{ab} (14.33) | 3.79* ^a (14.39) |
| 2 | Seed treatment with Thiamethoxam 35 FS @ 6 ml/kg seed | 3.66 ^{abcd} (13.43) | 3.92 ^a (15.37) | 4.28 ^a (18.36) | 3.96 ^a (15.65) |
| 3 | T ₁ + spray of Flonicamid 50 WG @2.0 g/10 lit. water (0.01%) | 3.26 ^d (10.61) | 3.35 ^c (11.22) | 3.53 ^b (12.49) | 3.38 ^a (11.42) |
| 4 | T ₁ + spray of Dimethoate 30 EC @ 10 ml /10 lit. water (0.03%) | 3.43 ^{bcd} (11.80) | 3.77 ^{ab} (13.84) | 4.01 ^{ab} (16.09) | 3.74 ^a (13.98) |
| 5 | T ₂ + spray of Flonicamid 50 WG @2.0 g/10 lit. water (0.01%) | 3.33 ^{cd} (11.15) | 3.47 ^{bc} (12.04) | 3.78 ^{ab} (14.30) | 3.53 ^a (12.46) |
| 6 | Spray of Imidacloprid 17.8 SL @ 20 g a.i./ha | 3.52 ^{bcd} (12.43) | 3.73 ^{ab} (13.91) | 3.80 ^{ab} (14.46) | 3.65 ^a (13.57) |
| 7 | Spray of Thiamethoxam 25 WG @ 25 g a.i/ha | 3.80 ^{ab} (14.46) | 3.78 ^{ab} (14.29) | 4.09 ^a (16.73) | 3.89 ^a (15.15) |
| 8 | Spray of Fipronil 5 SC @ 50 g a.i/ha | 3.73 ^{abc} (13.97) | 3.85 ^{ab} (14.82) | 3.99 ^{ab} (15.35) | 3.83 ^a (14.70) |
| 9 | Control (untreated water spray) | 3.96 ^a (15.72) | 4.03 ^a (16.24) | 4.32 ^a (18.70) | 4.11 ^a (16.85) |
| | S.Em.± | 0.13 | 0.12 | 0.16 | 0.76 |
| | C.D. at 5 % | 0.38 | 0.37 | NS | 0.21 |
| | C.V. % | 6.02 | 5.69 | 7.16 | 6.36 |
| | Y x T | | | | NS |

Notes: 1.*Figures are $\sqrt{x+0.5}$ transformed values, whereas figures in parentheses are retransformed values.

2. Treatment means with the letter/letters in common are not significant by DNMRT at 5% level of significance within a column

Perusal of the pooled result revealed that the whitefly population was differed significantly at 3 days after first spray. It can be revealed from the table 3 that the plots treated with seed treatment with imidacloprid 600 FS @ 5 ml/kg seed + spray of flonicamid 50 WG @ 2.0 g/10 lit. water (0.01%)

had registered the least whitefly population (6.32 whitefly per plant) at 3 days after first spray which was statistically at par with seed treatment with thiamethoxam 35 FS @ 6 ml/kg seed + spray of flonicamid 50 WG @ 2.0 g/10 lit. water (0.01%) and spray of imidacloprid 17.8 SL @ 20 g a.i./ha.

Table 3: Efficacy of newer insecticides against mustard whitefly (*Bemisia tabaci*) on mustard

| Treat. No. | Treatments | Average no. of whitefly per plant | | | |
|------------|---|-----------------------------------|----------------------------|------------------------------|-----------------------------|
| | | 3 days after First spray | | | |
| | | 2015-16 | 2016-17 | 2018-19 | Pooled |
| 1 | Seed treatment with Imidacloprid 600 FS @ 5 ml/kg seed | 3.78 * ^a (14.33) | 3.94* ^a (15.52) | 3.78 * ^{bc} (14.33) | 3.84* ^{ab} (14.72) |
| 2 | Seed treatment with Thiamethoxam 35 FS @ 6 ml/kg seed | 3.74 ^a (14.03) | 3.96 ^a (15.68) | 4.28 ^{ab} (18.36) | 3.99 ^a (15.97) |
| 3 | T ₁ + spray of Flonicamid 50 WG @2.0 g/10 lit. water (0.01%) | 1.88 ^d (3.55) | 2.65 ^c (7.02) | 3.01 ^e (9.03) | 2.51 ^c (6.32) |
| 4 | T ₁ + spray of Dimethoate 30 EC @ 10 ml /10 lit. water (0.03%) | 2.36 ^{bc} (5.61) | 3.13 ^b (9.80) | 3.66 ^{cd} (13.43) | 3.06 ^b (9.34) |
| 5 | T ₂ + spray of Flonicamid 50 WG @2.0 g/10 lit. water (0.01%) | 1.96 ^d (3.40) | 2.90 ^{bc} (8.41) | 3.23 ^{de} (10.41) | 2.70 ^{bc} (7.27) |
| 6 | Spray of Imidacloprid 17.8 SL @ 20 g a.i./ha | 2.12 ^{cd} (4.00) | 3.10 ^b (9.61) | 3.40 ^{cd} (11.58) | 2.87 ^{bc} (8.27) |
| 7 | Spray of Thiamethoxam 25 WG @ 25 g a.i./ha | 2.37 ^{bc} (5.62) | 3.21 ^b (10.30) | 3.62 ^{bc} (13.14) | 3.07 ^b (9.41) |
| 8 | Spray of Fipronil 5 SC @ 50 g a.i./ha | 2.49 ^b (6.21) | 3.32 ^b (11.02) | 3.58 ^{bc} (12.82) | 3.13 ^b (9.80) |
| 9 | Control (untreated water spray) | 4.03 ^a (16.25) | 4.05 ^a (16.40) | 4.41 ^a (19.42) | 4.16 ^a (17.34) |
| | S.Em.± | 0.11 | 0.14 | 0.16 | 0.15 |
| | C.D. at 5 % | 0.32 | 0.41 | 0.48 | 0.45 |
| | C.V. % | 6.96 | 7.02 | 7.57 | 7.18 |
| | Y x T | | | | 0.38 |

Notes: 1.*Figures are $\sqrt{x+0.5}$ transformed values, whereas figures in parentheses are retransformed values.

2. Treatment means with the letter/letters in common are not significant by DNMRT at 5% level of significance within a column.

The result on seven days after first spray (table 4) revealed that significantly minimum whitefly population was registered in the treatment of seed treatment with imidacloprid 600 FS @ 5 ml/kg seed + spray of flonicamid 50 WG @ 2.0 g/10 lit.

Water (0.01%) as compared to rest of all treatments during all the three years. It was at par with seed treatment with thiamethoxam 35 FS @ 6 ml/kg seed + spray of flonicamid 50 WG @ 2.0 g/10 lit. Water (0.01%).

Table 4: Efficacy of newer insecticides against mustard whitefly (*Bemisia tabaci*) on mustard

| Trt. No. | Treatments | Average no. of whitefly per plant | | | |
|----------|---|-----------------------------------|-----------------------------|-----------------------------|----------------------------|
| | | 7 days after First spray | | | |
| | | 2015-16 | 2016-17 | 2018-19 | Pooled |
| 1 | Seed treatment with Imidacloprid 600 FS @ 5 ml/kg seed | 3.84 * ^a (14.74) | 4.03 * ^a (16.24) | 4.05 * ^b (16.43) | 3.97* ^a (15.80) |
| 2 | Seed treatment with Thiamethoxam 35 FS @ 6 ml/kg seed | 3.83 ^a (14.70) | 4.07 ^a (16.56) | 4.56 ^a (20.83) | 4.15 ^a (17.26) |
| 3 | T ₁ + spray of Flonicamid 50 WG @2.0 g/10 lit. water (0.01%) | 1.35 ^d (1.82) | 1.93 ^d (3.72) | 2.53 ^e (6.42) | 1.94 ^d (3.76) |
| 4 | T ₁ + spray of Dimethoate 30 EC @ 10 ml /10 lit. water (0.03%) | 1.95 ^c (3.83) | 2.41 ^{bc} (5.81) | 3.27 ^c (10.69) | 2.54 ^{bc} (6.48) |
| 5 | T ₂ + spray of Flonicamid 50 WG @2.0 g/10 lit. water (0.01%) | 1.50 ^{cd} (2.28) | 2.15 ^{cd} (4.62) | 2.69 ^{de} (7.23) | 2.16 ^{cd} (4.48) |
| 6 | Spray of Imidacloprid 17.8 SL @ 20 g a.i./ha | 1.71 ^c (2.94) | 2.47 ^{bc} (6.10) | 3.01 ^{cd} (9.07) | 2.40 ^{bcd} (5.75) |
| 7 | Spray of Thiamethoxam 25 WG @ 25 g a.i./ha | 1.91 ^{bc} (3.66) | 2.41 ^{bc} (5.81) | 3.27 ^c (10.71) | 2.53 ^{bc} (6.42) |
| 8 | Spray of Fipronil 5 SC @ 50 g a.i./ha | 2.11 ^b (4.47) | 2.62 ^b (6.86) | 3.31 ^c (10.95) | 2.68 ^b (7.19) |
| 9 | Control (untreated water spray) | 4.13 ^a (17.07) | 4.17 ^a (17.39) | 4.72 ^a (22.24) | 4.34 ^a (18.84) |
| | S.Em.± | 0.11 | 0.12 | 0.12 | 0.12 |
| | C.D. at 5 % | 0.33 | 0.35 | 0.35 | 0.37 |
| | C.V. % | 7.64 | 6.95 | 5.72 | 6.66 |
| | Y x T | | | | 0.32 |

Notes: 1.*Figures are $\sqrt{x+0.5}$ transformed values, whereas figures in parentheses are retransformed values.

2. Treatment means with the letter/letters in common are not significant by DNMRT at 5% level of significance within a column.

Second spray

The results presented in table 5 revealed that significantly minimum whitefly population recorded in seed treatment with imidacloprid 600 FS @ 5 ml/kg seed + spray of flonicamid 50 WG @ 2.0 g/10 lit. water (0.01%) as compared to rest of all treatments during all the three years as well as in pooled and it

was at par with seed treatment with thiamethoxam 35 FS @ 6 ml/kg seed + spray of flonicamid 50 WG @ 2.0 g/10 lit. water (0.01%), spray of imidacloprid 17.8 SL @ 20 g a.i./ha and seed treatment with imidacloprid 600 FS @ 5 ml/kg seed + spray of dimethoate 30 EC @ 10 ml /10 lit. water (0.03%) at one day after second spray.

Table 5: Efficacy of newer insecticides against mustard whitefly (*Bemisia tabaci*) on mustard

| Treat. No. | Treatments | Average no. of whitefly per plant | | | |
|------------|---|-----------------------------------|-------------------------------|-----------------------------|----------------------------|
| | | 1 days after Second spray | | | |
| | | 2015-16 | 2016-17 | 2018-19 | Pooled |
| 1 | Seed treatment with Imidacloprid 600 FS @ 5 ml/kg seed | 4.26* ^{ab} (18.22) | 4.38 * ^{abc} (19.18) | 4.43* ^{ab} (19.66) | 4.40* ^a (19.00) |
| 2 | Seed treatment with Thiamethoxam 35 FS @ 6 ml/kg seed | 4.04 ^{abc} (16.39) | 4.43 ^{ab} (19.62) | 4.62 ^a (21.35) | 4.36 ^a (19.05) |
| 3 | T ₁ + spray of Flonicamid 50 WG @2.0 g/10 lit. water (0.01%) | 3.41 ^{de} (11.69) | 3.54 ^d (12.53) | 3.32 ^d (11.05) | 3.43 ^c (10.75) |
| 4 | T ₁ + spray of Dimethoate 30 EC @ 10 ml /10 lit. water (0.03%) | 3.79 ^{bcd} (14.39) | 3.83 ^{bcd} (14.67) | 3.77 ^{cd} (14.20) | 3.80 ^{bc} (14.42) |
| 5 | T ₂ + spray of Flonicamid 50 WG @2.0 g/10 lit. water (0.01%) | 3.34 ^e (11.16) | 3.58 ^d (12.82) | 3.44 ^{cd} (11.82) | 3.45 ^c (11.92) |
| 6 | Spray of Imidacloprid 17.8 SL @ 20 g a.i./ha | 3.62 ^{cde} (13.16) | 3.77 ^{cd} (14.21) | 3.74 ^{cd} (13.97) | 3.71 ^{bc} (13.78) |
| 7 | Spray of Thiamethoxam 25 WG @ 25 g a.i./ha | 3.91 ^{bcd} (15.29) | 3.86 ^{bcd} (14.90) | 3.94 ^{bc} (15.54) | 3.90 ^b (15.23) |
| 8 | Spray of Fipronil 5 SC @ 50 g a.i./ha | 3.70 ^{cde} (13.75) | 4.11 ^{abcd} (16.89) | 3.97 ^{bc} (15.79) | 3.93 ^b (15.46) |
| 9 | Control (untreated water spray) | 4.44 ^a (19.73) | 4.58 ^a (20.98) | 4.82 ^a (23.19) | 4.61 ^a (21.29) |
| | S.Em.± | 0.15 | 0.19 | 0.18 | 0.094 |

| | | | | | |
|--|-------------|------|------|------|------|
| | C.D. at 5 % | 0.45 | 0.58 | 0.53 | 0.27 |
| | C.V. % | 6.78 | 8.32 | 7.68 | 7.64 |
| | Y x T | | | | NS |

Notes: 1.*Figures are $\sqrt{x+0.5}$ transformed values, whereas figures in parentheses are retransformed values.

2. Treatment means with the letter/letters in common are not significant by DNMRT at 5% level of significance within a column.

The results presented in table 6 revealed that significantly minimum whitefly population recorded in the seed treatment with imidacloprid 600 FS @ 5 ml/kg seed + spray of flonicamid 50 WG @ 2.0 g/10 lit. water (0.01%) as compared to rest of all treatments during during 2015-16 and 2016-17 and it was at par with seed treatment with thiamethoxam 35

FS @ 6 ml/kg seed + spray of flonicamid 50 WG @ 2.0 g/10 lit. water (0.01%) and spray of imidacloprid 17.8 SL @ 20 g a.i./ha Where as it was only at par with the seed treatment with thiamethoxam 35 FS @ 6 ml/kg seed + spray of flonicamid 50 WG @ 2.0 g/10 lit. water (0.01%) during 2018-19 and in pooled result at three days after second spray.

Table 6: Efficacy of newer insecticides against mustard whitefly (*Bemisia tabaci*) on mustard

| Treat. No. | Treatments | Average no. of whitefly per plant | | | |
|------------|---|-----------------------------------|-----------------|------------------|---------------------------|
| | | 3 days after Second spray | | | |
| | | 2015-16 | 2016-17 | 2018-19 | Pooled |
| 1 | Seed treatment with Imidacloprid 600 FS @ 5 ml/kg seed | 4.36 * a (19.06) | 4.42* a (19.54) | 4.45 * a (19.83) | 4.41* a (19.46) |
| 2 | Seed treatment with Thiamethoxam 35 FS @ 6 ml/kg seed | 4.40 a (19.39) | 4.46 a (19.89) | 4.65 a(21.62) | 4.50a (20.27) |
| 3 | T1 + spray of Flonicamid 50 WG @2.0 g/10 lit. water (0.01%) | 2.03 c (4.15) | 2.59 d (6.71) | 2.58 d (6.65) | 2.40 ^c (5.77) |
| 4 | T1 + spray of Dimethoate 30 EC @ 10 ml /10 lit. water (0.03%) | 2.69 b (7.27) | 3.16 bc (9.99) | 3.37 b (10.71) | 3.04 ^{bc} (9.25) |
| 5 | T2 + spray of Flonicamid 50 WG @2.0 g/10 lit. water (0.01%) | 2.03 c (4.15) | 2.67 cd (7.13) | 2.77 cd (7.68) | 2.49 ^{de} (6.22) |
| 6 | Spray of Imidacloprid 17.8 SL @ 20 g a.i./ha | 2.37 bc (5.65) | 3.03 cd (9.18) | 3.11 bc (9.66) | 2.84 ^{cd} (8.05) |
| 7 | Spray of Thiamethoxam 25 WG @ 25 g a.i./ha | 2.63 b (6.96) | 3.16 bc (9.99) | 3.51 b (12.35) | 3.10 ^{bc} (9.63) |
| 8 | Spray of Fipronil 5 SC @ 50 g a.i./ha | 2.59 b (6.75) | 3.61 b (13.03) | 3.53 b (12.45) | 3.25 ^b (10.53) |
| 9 | Control (untreated water spray) | 4.61 a (21.29) | 4.67 a (21.81) | 4.82 a (23.19) | 4.70 ^a (22.10) |
| | S.Em.± | 0.13 | 0.17 | 0.14 | 0.094 |
| | C.D. at 5 % | 0.40 | 0.52 | 0.43 | 0.26 |
| | C.V. % | 7.99 | 8.53 | 6.91 | 7.69 |
| | Y x T | | | | NS |

Notes: 1.*Figures are $\sqrt{x+0.5}$ transformed values, whereas figures in parentheses are retransformed values.

2. Treatment means with the letter/letters in common are not significant by DNMRT at 5% level of significance within a column.

At seven days after second spray, results are presented in table 7. It can be revealed from the data that the seed treatment with imidacloprid 600 FS @ 5 ml/kg seed + spray of flonicamid 50 WG @ 2.0 g/10 lit. water (0.01%) found minimum whitefly population (3.10 whitefly per plant) during pooled and all the three years but it was at par with seed treatment with thiamethoxam 35 FS @ 6 ml/kg seed + spray of flonicamid 50 WG @ 2.0 g/10 lit. water (0.01%). So, seed

treatment with imidacloprid 600 FS @ 5 ml/kg seed + spray of flonicamid 50 WG @ 2.0 g/10 lit. water (0.01%) and seed treatment with thiamethoxam 35 FS @ 6 ml/kg seed + spray of flonicamid 50 WG @ 2.0 g/10 lit. water (0.01) exhibited significantly superior as compared to the rest of treatments at seven days after second spray in all three years and pooled result.

Table 7: Efficacy of newer insecticides against mustard whitefly (*Bemisia tabaci*) on mustard

| Treat. No. | Treatments | Average no. of whitefly per plant | | | |
|------------|---|-----------------------------------|------------------|------------------|---------------------------|
| | | 7 days after Second spray | | | |
| | | 2015-16 | 2016-17 | 2018-19 | Pooled |
| 1 | Seed treatment with Imidacloprid 600 FS @ 5 ml/kg seed | 4.54** a (20.69) | 4.62 * a (21.34) | 4.51 * a (20.35) | 4.56* a (20.79) |
| 2 | Seed treatment with Thiamethoxam 35 FS @ 6 ml/kg seed | 4.62 a (21.42) | 4.66 a (21.72) | 4.74 a (22.48) | 4.68a (21.87) |
| 3 | T1 + spray of Flonicamid 50 WG @2.0 g/10 lit. water (0.01%) | 1.56 c (2.45) | 1.75 c (3.06) | 1.97 d (3.87) | 1.76 ^d (3.10) |
| 4 | T1 + spray of Dimethoate 30 EC @ 10 ml /10 lit. water (0.03%) | 2.27 b (5.16) | 2.58 b (6.66) | 2.88 bc (8.29) | 2.68 ^b (6.64) |
| 5 | T2 + spray of Flonicamid 50 WG @2.0 g/10 lit. water (0.01%) | 1.60 c (2.57) | 2.42 b (5.86) | 2.15 d (4.61) | 2.05 ^{cd} (4.22) |
| 6 | Spray of Imidacloprid 17.8 SL @ 20 g a.i./ha | 2.09 b (4.35) | 2.50 b (6.25) | 2.65 c (7.01) | 2.41 ^{bc} (5.81) |
| 7 | Spray of Thiamethoxam 25 WG @ 25 g a.i./ha | 2.21 b (4.90) | 2.50 b (6.25) | 3.28 b (10.79) | 2.66 ^b (7.10) |
| 8 | Spray of Fipronil 5 SC @ 50 g a.i./ha | 2.24 b (5.04) | 2.87 b (8.24) | 3.37 b (11.39) | 2.83 ^b (8.00) |
| 9 | Control (untreated water spray) | 4.71 a (22.18) | 4.80 a (23.04) | 4.90 a (24.04) | 4.80 ^a (23.07) |
| | S.Em.± | 0.13 | 0.17 | 0.15 | 0.135 |
| | C.D. at 5 % | 0.38 | 0.50 | 0.44 | 0.41 |
| | C.V. % | 7.68 | 9.05 | 7.59 | 7.16 |
| | Y x T | | | | 0.42 |

Notes: 1.*Figures are $\sqrt{x+0.5}$ transformed values, whereas figures in parentheses are retransformed values.

2. Treatment means with the letter/letters in common are not significant by DNMRT at 5% level of significance within a column.

Yield

During the year 2015-16 (Table 8), significantly highest seed yield (1811.11Kg/ha) was recorded in the treatment of seed treatment with imidacloprid 600 FS @ 5 ml/kg seed + spray

of flonicamid 50 WG @2.0 g/10lit.water (0.01%) and during 2016-17 the highest yield (2690.74 kg/ha.) was obtained from the same treatment and was at par with seed treatment with thiamethoxam 35 FS @ 6 ml/kg seed + spray of flonicamid 50

WG @ 2.0 g/10 lit. water (0.01%) (2347.22) and spray of imidacloprid 17.8 SL @ 20 g a.i./ha (2217.13 kg/ha.) during both years. While during 2018-19 the maximum yield (2947.69 kg/ha) was obtained from the same treatment and was at par with seed treatment with thiamethoxam 35 FS @ 6 ml/kg seed + spray of flonicamid 50 WG @ 2.0 g/10 lit. water (0.01%) (2676.39 kg/ha) and seed treatment with imidacloprid 600 FS @ 5 ml/kg seed + spray of dimethoate 30

EC @ 10 ml /10 lit. water (0.03%) (2500.46 kg/ha). In pooled data also significantly highest yield (2483.18 kg/ha) was recorded in plot treated with seed treatment with imidacloprid 600 FS @ 5 ml/kg seed + spray of flonicamid 50 WG @ 2.0 g/10lit.water (0.01%) and it was at par with the seed treatment with thiamethoxam 35 FS @ 6 ml/kg seed + spray of flonicamid 50 WG @ 2.0 g/10 lit. water (0.01%) (2271.76 kg/ha).

Table 8: Seed yield of mustard in different treatments

| Treat. No. | Treatments | Seed yield (Kg/ha) | | | |
|------------|---|-----------------------|------------------------|------------------------|-----------------------|
| | | 2015-16 | 2016-17 | 2018-19 | Pooled |
| 1 | Seed treatment with Imidacloprid 600 FS @ 5 ml/kg seed | 1343.98 ^{ab} | 1529.17 ^{cd} | 1531.94 ^{de} | 1468.36 ^e |
| 2 | Seed treatment with Thiamethoxam 35 FS @ 6 ml/kg seed | 1377.78 ^{ab} | 1516.67 ^{cd} | 1844.91 ^{cde} | 1579.78 ^{de} |
| 3 | T1 + spray of Flonicamid 50 WG @2.0 g/10 lit. water (0.01%) | 1811.11 ^a | 2690.74 ^a | 2947.69 ^a | 2483.18 ^a |
| 4 | T1 + spray of Dimethoate 30 EC @ 10 ml /10 lit. water (0.03%) | 1435.19 ^{ab} | 1851.85 ^{bcd} | 2500.46 ^{ab} | 1929.19 ^{bc} |
| 5 | T2 + spray of Flonicamid 50 WG @2.0 g/10 lit. water (0.01%) | 1791.67 ^a | 2347.22 ^{ab} | 2676.39 ^{ab} | 2271.76 ^{ab} |
| 6 | Spray of Imidacloprid 17.8 SL @ 20 g a.i./ha | 1707.87 ^a | 2217.13 ^{ab} | 2236.11 ^{bc} | 2053.70 ^{bc} |
| 7 | Spray of Thiamethoxam 25 WG @ 25 g a.i/ha | 1510.19 ^{ab} | 1950.00 ^{bc} | 2196.76 ^{bc} | 1885.65 ^{cd} |
| 8 | Spray of Fipronil 5 SC @ 50 g a.i/ha | 1487.04 ^{ab} | 1807.41 ^{bcd} | 2095.37 ^{bcd} | 1796.60 ^{cd} |
| 9 | Control (untreated water spray) | 1193.05 ^a | 1285.19 ^d | 1258.80 ^a | 1245.68 ^e |
| | S.Em.± | 144.76 | 195.23 | 186.78 | 105.56 |
| | C.D. at 5 % | NS | 585.32 | 559.98 | 298.28 |
| | C.V. % | 16.52 | 17.70 | 15.10 | 16.51 |
| | Y x T | | | | NS |

Notes: 1. Treatment means with the letter/letters in common are not significant by DNMR at 5% level of significance within a column.

Economics

Economics of different treatments against mustard whitefly were worked out considering prevailing market price of mustard seed and cost of different treatments including labour

charges (Table 9). The gross realization, net realization and Protection Cost Benefit Ratio (PCBR) were also worked out for different treatments.

Table 9: Economics of different newer insecticides evaluated against mustard whitefly (*Bemisia tabaci*)

| Sr. No. | Treatments | Qty. required (L/kg/ha) | Price of insecticides (Rs./ha) | Labour cost (Rs.) | Total cost of treatment (Rs./ha) | Yield (Kg/ha) | Gross realization (Rs./ha) | Net realization over control (Rs./ha) | Net gain (Rs. /ha) | PCBR |
|---------|---|-------------------------|--------------------------------|-------------------|----------------------------------|---------------|----------------------------|---------------------------------------|--------------------|----------|
| 1 | Seed treatment with Imidacloprid 600 FS @ 5 ml/kg seed | 0.0175 | 73.50 | - | 73.50 | 1468.36 | 51392.6 | 7793.8 | 7720.3 | 1:105.04 |
| 2 | Seed treatment with Thiamethoxam 35 FS @ 6 ml/kg seed | 0.0210 | 60.00 | - | 60.00 | 1579.78 | 55292.3 | 11693.5 | 11633.5 | 1:193.89 |
| 3 | T1 + spray of Flonicamid 50 WG @2.0 g/10 lit. water (0.01%) | 0.0175 + 0.300 | 73.50 + 3000 | 954.00 | 4027.50 | 2483.18 | 86911.3 | 43312.5 | 39285 | 1:9.75 |
| 4 | T1 + spray of Dimethoate 30 EC @ 10 ml /10 lit. water (0.03%) | 0.0175 + 3.0 | 73.50 + 1350 | 954.00 | 2377.50 | 1929.19 | 67521.65 | 23922.85 | 21545.35 | 1:9.06 |
| 5 | T2 + spray of Flonicamid 50 WG @2.0 g/10 lit. water (0.01%) | 0.0210+ 0.300 | 60.00 + 3000 | 954.00 | 4014 | 2271.76 | 79511.6 | 35912.8 | 31898.8 | 1:7.95 |
| 6 | Spray of Imidacloprid 17.8 SL @ 20 g a.i./ha | 0.375 | 645.00 | 954.00 | 1599 | 2053.70 | 71879.5 | 28280.7 | 26681.7 | 1:16.69 |
| 7 | Spray of Thiamethoxam 25 WG @ 25 g a.i/ha | 0.600 | 1080.00 | 954.00 | 2034 | 1885.65 | 65997.75 | 22398.95 | 20364.95 | 1:10.01 |
| 8 | Spray of Fipronil 5 SC @ 50 g a.i/ha | 3.0 | 3720.00 | 954.00 | 4674 | 1796.60 | 62881 | 19282.2 | 14608.2 | 1:3.13 |
| 9 | Control (untreated water spray) | --- | -- | 954.00 | 954 | 1245.68 | 43598.8 | -- | --- | --- |

The data showed that maximum net realization and net gain was obtained in the treatment of seed treatment with imidacloprid 600 FS @ 5 ml/kg seed + spray of flonicamid 50 WG @2.0 g/10lit.water (0.01%) followed by seed treatment with thiamethoxam 35 FS @ 6 ml/kg seed + spray of

flonicamid 50 WG @2.0 g/10 lit. water (0.01%). Where as Highest PCBR was obtained in the plot treated with seed treatment with thiamethoxam 35 FS @ 6 ml/kg seed.

The results finding are in agreement with those of Jha and Kumar (2017) [4], achieved significantly superior over control

in reducing whitefly population with the application of imidacloprid @ 20 g a.i./ha followed by profenophos 40% + cypermethrin 4%. Bambhaniya *et al.* (2018) ^[2] revealed that imidacloprid 0.005 per cent, difenthiuron 0.05 per cent, acetamiprid 0.008 per cent and thiacloprid 0.024 per cent were found to be the most effective insecticides against whitefly. Das and Islam (2014) ^[3] reported that imidacloprid, fipronil and buprofezin proved to be the superior against whitefly. Singh and Verma (2008) ^[9] reported that imidacloprid 70 WS @ 5 g and 10 g a.i./kg seed controlled the sucking pest population on mustard when used as seed treatment. Khedkar *et al.* (2012) ^[5] reported that the imidacloprid 17.8 SL (0.008%), acetamiprid 20 SP (0.01%) and thiamethoxam 25 WG (0.0125%) proved to be more effective against sucking pest followed by acephate (0.075%), dimethoate (0.03%) and thiacloprid (0.024%). Maurya *et al.* (2018) ^[7] revealed that thiamethoxam 25% WG @100 g/ha was found most effective treatment in reducing the sucking pest population followed by acephate 75 SP @ 500g/ha. Among conventional insecticides imidacloprid 17.8 SL @ 150 ml/ha was found more effective than dimethoate 30% EC @ 1000 ml/ha and fipronil 5 SC @ 1000 ml/ha.

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