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MANAGEMENT OF *BEMISIA TABACI* VECTOR OF BIPARTITE *BEGOMOVIRUS* WITH BOTANICALS AND INSECTICIDES

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ABSTRACT

Begomovirus is one of the most prevailing threats to mungbean crop in Pakistan. Mungbean yellow mosaic virus spread in a persistent manner through *Bemisia tabaci*. Mungbean crop was sown in natural field condition with randomized complete block design. Influence of whitefly population on disease incidence was studied through correlation and regression analysis. Botanicals (onion, garlic) at the rate 3% and insecticides (acetamiprid, imidacloprid) were tested against whitefly population. Among botanicals and insecticides onion and imidacloprid gave 73% and 82% control respectively, over whitefly population and virus progression, as compared to other treatments. Results of current study indicated that the tolerant germplasm could be recommended for cultivation with appropriate management for whitefly population until genotypes with highly resistant characters were not developed through efficient breeding program.

Keywords: Mungbean, MYMV, Vector, Management

INTRODUCTION

Mungbean [*Vigna radiata* (L.)Wilczek] is an important pulse crop grown throughout the world. In Pakistan, it covers an area of 136.1 thousand hectares, with a total production of 89.3 thousand tonnes of grains (Economic Survey of Pakistan, 2015). The susceptible mungbean germplasm and favorable environmental conditions contribute towards the outbreak of viral diseases. Mungbean yellow mosaic virus is an important disease of this crop in Pakistan, causing huge losses in its production (Bashir *et al.*, 2006). The crop is susceptible to mungbean yellow mosaic virus that caused heavy yield losses every year (Habib *et al.*, 2007; Binyamin *et al.*, 2015; Binyamin *et al.*, 2016). The virus was reported to be first in India in 1955 with its vector *Bemisia tabaci* Gen. MYMV also infects others legume crops including urdbean, soybean and cowpea (Dhingra and Chenulu, 1985; Qazi *et al.*, 2007). Whitefly is the only vector reported by several scientists for the natural transmission of virus in different plants. Whitefly nymphs obtain the virus from diseased leaves (Honda and Ikegami, 1986). Influence of whitefly population on mungbean yellow mosaic virus had already been reported by Nadeem *et al.*, 2006). Correlation of whitefly population with the disease development was also reported by a number of researchers (Akhtar *et al.*, 2011; Khan *et al.*, 2006; Srivastava and Prajapati, 2012). Neem leaf extract, garlic clove extract, allamanda leaf extract were evaluated for the management of whitefly population (Binyamin *et al.*, 2011; Hossain *et al.*, 2010). Plant extracts (Onion, Ginger and Garlic) were effective in reducing disease incidence of PVX and PVY (Ahmad *et al.*, 2011). Acetamaprid reduced the whitefly population and mungbean yellow mosaic virus disease incidence (Panduranga *et al.*, 2011).

In spite of good agronomic practices, farmers often rely heavily on pesticides. The environmental pollution caused by excessive use and misuse of pesticides has led to considerable changes in people's attitudes towards the use of pesticides in agriculture. Consequently, disease management research focused their efforts on developing alternative inputs to synthetic chemicals for controlling pests. Among these alternatives is use of plant extracts and their derivatives. Increased resistance to insecticides in whitefly population due to excessive use of same group of insecticides has increased the incidence of mungbean yellow mosaic virus disease

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(Ahmad *et al.*, 2002; Ahmad *et al.*, 2010). Therefore, there is a great demand not only for introducing new groups of insecticides that should be environment friendly, but also commercially available various bio pesticides against sucking insects that are the main cause of many plant viruses.

The reasonable method of controlling viral diseases is regarded as the use of resistant crop varieties. In the absence of resistant varieties/lines tolerant varieties can be exploited through application of extracts and insecticides for yield maximization. Integration of different management options including, plant extracts and insecticides will help to compare their effectiveness against whitefly population. Frequent spraying is neither economical nor beneficial for the environment (Faria and Wraight, 2001). Therefore, the main objective of the study was to identify the plant extracts and insecticides that can reduce the incidence of virus and its vector as the plant extracts management options are economical and environment friendly.

MATERIALS AND METHODS

Experiment layout

Four tolerant varieties/lines were selected on previous year's data and grown in field with randomized complete block design for two years repeated trail. Each test entry was planted in a row of 3 meter in length with 30 cm row-to- row distance. One row of a most susceptible check (Kabuli mung) was sown after each test entries, in addition to these two rows of susceptible check were also sown all around the experiment. The pathogencity of virus was confirmed through grafting method (Akhtar and Haq, 2003). Symptomatic plants were collected from the field for grafting on to healthy plants in the pots. A slanting was made on the stem of infected plant. The grafted portion was wrapped tightly with parafilm and covered by polyethylene bags.

Whitefly data recording

Whitefly data was recorded from upper, middle and lower leaves of the diseased plants and average was calculated on weekly basis.

Management through botanicals and insecticides

Two botanicals (plant extracts), two insecticides were used to control the vector (whitefly) and disease development. For this purpose 3% plant extracts of onion and garlic were used. The spray was conducted after seven days interval. Progression of mungbean yellow mosaic virus based on disease severity was recorded at weekly interval. Whitefly population was calculated (Rehman *et al.*, 2015) after 24 hrs when plant extracts and insecticides were applied. Three plants from each variety were selected for whitefly population. Whiteflies numbers from upper, middle and lower leaf of selected plants were counted and calculated on weekly basis (Parveen *et al.*, 2010). In case of management of disease and whitefly population data were subjected to analysis of variance using "Statistix" statistical software and treatment means were compared with the Least Significance Difference (LSD) Test at 5% level of probability (Steel and Torrie, 1997). Plants showing such symptoms were counted and percent infection was calculated based on 0-5 arbitrary scale as suggested by (Bashir *et al.*, 2005) (Table 1). The number of genotypes infected per week was recorded.

Correlation of whitefly population with MYMV and regression analysis

The influence of whitefly population on disease incidence was studied through correlation and regression analysis. Quantitative independent variable is used in regression analyses to explain variation in quantitative dependent variable. In simple linear regression models, the dependent variable (Y) is a direct function of an independent variable (X). The following is the general equation for simple linear regressions:

$$Y = \beta_0 + \beta_1 X$$

Where β_0 is the intercept and β_1 is the slope.

RESULTS

Correlation and regression analysis of whitefly population with MYMV

Data of disease incidence and whitefly was recorded during both growing years for correlation studies. The overall correlation of whitefly population with disease incidence was highly significant. When data were split by genotypes, whitefly population showed strong positive correlation, as twenty two genotypes showed highly significant correlation, seven showed significant and only one genotype showed non-significant correlation with disease incidence during 1st year (Table 2). Whitefly population again showed a strong positive correlation, as twenty genotypes showed highly significant correlation, nine showed significant and only one genotype showed non-significant correlation with disease incidence during 2nd year (Table 3). The regression analysis of whitefly population showed linear relationship with mungbean yellow mosaic virus disease during both years (Fig. 1 & Fig. 2). The regression analysis of four lines showed strong relationship due to its high values of regression coefficient (r) which ranges from 0.60 to 0.99.

Effect of botanicals and insecticides on whitefly population

Effects of botanicals and insecticides for the management of whitefly showed that there was a positive significant result given by the treatments i.e; insecticides & botanicals, number of sprays and varieties. For the first growing season analysis of variance showed that the number of sprays, different treatments, varieties, interaction of spray*treatment, spray*varieties, treatment*varieties had significant effects on the management of whitefly population. Whereas, spray*treatment*varieties interaction results were non-significant (Table 4). Whitefly population observed with the application of imidacloprid was 1.25, followed by acetamiprid (1.68). Onion extract gave more control (2.52) over whitefly as compared to garlic (2.77). Whitefly population (6.95) was observed on untreated check (Fig. 3). Whitefly population (3.88) was observed after first spray, followed by second spray (3.05), and third (2.68), least whitefly population (2.60) was observed in the case of forth spray (Fig. 4). In varieties/lines studies maximum whitefly population (3.75) was observed on line 98001, followed by line 7007 (2.96) and NM-121-25 (2.80), minimum whitefly population (2.63) was observed for variety NM-92 (Fig. 5).

For the second growing season analysis of variance results again showed that the number of sprays, different treatments, varieties, interaction of spray*treatment, spray*varieties, treatment*varieties had significant effects on the management of whitefly population. Whereas, spray*treatment*varieties interaction results were non-significant (Table 5). Whitefly population observed after application of imidacloprid was 1.08, followed by acetamiprid (1.42). Onions extract gave more control (2.07) over whitefly population as compared to garlic extract (2.31). Whitefly population (6.50) was observed on untreated check (control), (Fig. 6). Whitefly population (3.42) was observed after first spray followed by second spray (2.67) and third (2.34), while least whitefly population (2.27) was observed in case of forth sprays (Fig. 7). In varieties/lines studies maximum whitefly population (3.34) was observed on line 98001, followed by line 7007 (2.61) and NM-121-25 (2.43), minimum whitefly population (2.32) was observed on variety NM-92 (Fig. 8).

Interaction of botanicals and insecticides with number of sprays

In 1st growing season, interaction of treatments with number of sprays (at weekly intervals) showed significant results. After first week spray of onions extract whitefly population (3.58) was observed, compared to control (7). Followed by garlic extract (3.50) and acetamiprid (2.75), and whitefly population (2.58) was observed after spray of imidacloprid. Data of whitefly population obtained after sprays of second week showed that, whitefly population (2.7) was observed after spray of garlic extract compared to control (6.75). Followed by onion extract (2.58), acetamiprid (1.91), and whitefly population (1.25) were observed after spray of imidacloprid. After third week spray of garlic extract (2.08) whitefly population was observed compared to control (7.08). Followed by onion extract (2.00), acetamiprid (1.16), and (0.75) was observed after spray of imidacloprid. After forth week spray of garlic extract, whitefly population (2.75) was observed as compared to control (7.00). Followed by onion extract (1.91), acetamiprid (0.91), and minimum whitefly was observed after the spray of imidacloprid (0.41), (Table 6).

In 2nd growing season, interaction of treatments with number of sprays (at weekly intervals) showed significant results. After first week spray of garlic extract whitefly population (3.08) were observed compared to control (6.54). Followed by onion extract (3.00), acetamiprid (2.32), and whitefly population (2.18) were observed after spray of imidacloprid. Data of whitefly population obtained after sprays of second week showed that, whitefly population (2.29) was observed after spray of garlic extract compared to control (6.29). Followed by onion extract (2.08), acetamiprid (1.61), and (1.07) was observed after spray of imidacloprid. After third week spray of garlic extract whitefly population (2.25) was observed compared to control (6.66). Followed by onion extract (1.66), acetamiprid (0.99), and (0.66) was observed after spray of imidacloprid. Whitefly population after forth week spray of garlic extract was (1.70) compared to control (6.50). Followed by onion extract (1.45), acetamiprid (0.75) and minimum whitefly (0.41) was observed after spray of imidacloprid (Table 7).

Interaction of varieties/lines with number of sprays

In 1st growing season, interaction of varieties/lines with number of sprays (at weekly intervals) showed significant results. Whitefly population (5.06) was observed on line 98001, followed by line 7007 (4.20). Whitefly population (3.13) was observed on both variety NM-92, and line NM-121-25 after first week spray of all the treatments (Insecticides, Nutrients, Plant extracts). Whitefly population after second week sprays were (4.13) on line 98001, followed by line NM-121-25 (3.06), variety NM-92 (2.53), and 2.46 on line 7007. Data of whitefly population after third week sprays were (3.00) on line 98001, followed by line NM-121-25 (2.60), line 7007 (2.46), and 2.40 on variety NM-92. After forth week sprays, whitefly population (2.80) were observed on line 98001, followed by line 7007 (2.73), and variety NM-92 and line NM-121-25 showed 2.40 whitefly population (Table 8).

In 2nd growing season, interaction of varieties with number of sprays (at weekly intervals) showed significant results. Whitefly population (4.56) was observed on line 98001, followed by lines 7007 (3.71), NM-121-25 (2.74), and (2.68) on variety NM-92 after first week spray of all treatments (Insecticides, Nutrients, Plant extracts). Whitefly population after second week sprays were (3.63) on line 98001, followed by line NM-121-25 (2.68), line 7007 (2.60), and (2.31) on variety NM-92. Data of whitefly population after third week sprays were (2.70) on line 98001, followed by line 7007 (2.40), line NM-121-25 (2.24) and (2.14) on variety NM-92. After forth week sprays, whitefly population (2.48) on line 98001, followed by lines 7007 (2.20), NM-121-25 (2.14) and variety NM-92 showed 2.08 whitefly population (Table 9).

Interaction of botanicals and insecticides with varieties/lines

In 1st growing season, interaction of treatments with varieties/lines showed significant results. After the application of garlic extract on line 98001, whitefly population (3.58) was observed compared to control (7.08). Followed by onion extract (3.00), acetamiprid (2.83), and (2.25) after spray of imidacloprid. On line 7007, whitefly population (2.83) was observed after spray of garlic extract compared to control (6.75). Followed by onion extract (2.50), acetamiprid (1.50) and (1.25) after spray of imidacloprid. On variety NM-92, whitefly population (2.33) was observed after spray of onion extract compared to control (6.75). Followed by garlic extract (2.25), acetamiprid (1.08), and (0.75) after spray of imidacloprid. On line NM-121-25, whitefly population (2.41) was observed after spray of garlic compared to control (7.25). Followed by onion extract (2.25), acetamiprid (1.33), and (0.75) after spray of imidacloprid (Table 10).

In 2nd growing season, interaction of treatments with varieties/lines again showed significant results. After the garlic extracts on line 98001, whitefly population (3.12) was observed compared to control (6.75). Followed by onion extract (2.58), acetamiprid (2.43), and (1.95) after spray of imidacloprid. On line 7007, whitefly population (2.14) was observed after spray of garlic extract compared to control (6.62). Followed by onion extract (2.04), acetamiprid (1.24), and (1.05) after spray of imidacloprid. On variety NM-92, whitefly population (1.87) was observed after spray of garlic extract compared to control (6.29). Followed by onion extract (1.79), acetamiprid (0.94), and (0.65) after spray of imidacloprid. On line NM-121-25, whitefly population (1.91) was observed after spray of garlic extract compared to control (6.33). Followed by onion extract (1.79), acetamiprid (1.07), and (0.66) after spray of imidacloprid (Table 11).

DISCUSSION

As mungbean yellow mosaic virus belongs to *Geminiviridae* and genus *Begomovirus* and is transmitted only by whitefly, so the only way in which virus reaches the mungbean from alternate hosts is via whitefly. Mungbean yellow mosaic virus transmitted in a persistant manner which increases the chance of genetic recombination within the virus as already reported in cotton leaf curl virus, tomato leaf curl virus, and mungbean yellow mosaic virus. In order to manage mungbean yellow mosaic virus its vector should be controlled so that disease could be managed, consequently. Mungbean yellow mosaic virus did not spread through seed, soil or contact and was transmitted through vector whitefly, in a persistent manner (Malathi and John, 2008). In present study whitefly population showed significantly positive correlation with the disease development. Whitefly acted as a vector of mungbean yellow mosaic virus and different scientists studied the relationship of whitefly with the disease development. Significantly positive correlation of whitefly population with disease development was observed by (Khan *et al.*, 2012). Disease development increased rapidly with the increase in whitefly population. Disease development was directly proportional to the whitefly population as reported by number of different scientists, including Srivastava and Prajapati, 2012; Akhtar *et al.*, 2011; Khan *et al.*, 2006. As the pressure of whitefly population increased the increment in disease development was also took place. Whitefly population and its frequency have been increased now a day due to excessive use of insecticides that have developed resistance in whitefly (Ahmad *et al.*, 2002; Ahmad *et al.*, 2010).

In the present study imidacloprid reduced the whitefly population to the highest level followed by acetamiprid, onion and garlic extracts, while maximum whitefly population was observed on control (untreated check). Different insecticides, botanicals, and cultural practices were used for the management of mungbean yellow mosaic virus disease, and it was found imidacloprid treated plants of mungbean showed the minimum disease as compared to all other treatments (Hossain *et al.*, 2010). Imidacloprid, thiomethoxam, and acetamaprid were used for the management of whitefly population and found imidacloprid to be the best for the control of the whitefly population (Abbas *et al.*, 2012). Garlic extracts showed good efficacy against mungbean yellow mosaic virus (Hossain *et al.*, 2010; Islam *et al.*, 2006) and results of present study supported their findings that both garlic and onion have antimicrobial activity due to compound allicin (Gurjar *et al.*, 2012).Garlic extract showed suppression efficiency against legume viral diseases (Thirumalaisamy *et al.*, 2003). Significant effect of imidacloprid in reducing the vector population was reported by (Dandale *et al.*, 2001; Kotreshe 2002; Hossain *et al.*, 2010; Abbas *et al.*, 2012), which is directly related with the disease transmission. Imidacloprid proved best for the management of mungbean yellow mosaic virus (Khan *et al.*, 2012).Previous literature has also stated the occurrence of virus is due to whitefly that transmits the virus in a persistent manner. Present study results showed that disease and whitefly population started to reduce after the first spray. As the number of sprays increased on weekly basis whitefly and disease were at their minimum level after forth spray. These results also showed that virus was strongly linked with the vector population. Variation within the varieties was also observed in relation to the disease severity and vector population, which showed that they have different response for the virus. Maximum whitefly population was observed on line 98001, and minimum whitefly population was observed on variety NM-92 during the both growing seasons. Maximum disease was observed on line 98001, and minimum disease was observed on variety NM-92 during both growing seasons. Thus, the mungbean yellow mosaic virus disease can be managed by proper selection of insecticides, botanicalsand proper timing of the spray.

Increased resistance in whitefly population due to excessive use of same group insecticides has increased the incidence of mungbean yellow mosaic virus (Ahmad *et al.*, 2002; Ahmad *et al.*, 2010). There is a great demand not only for introducing new groups of insecticides that should be environmentally friendly but also commercial availability of various bio pesticides against sucking insect pests that are the vectors of several plant viruses. In addition to chemicals, botanicals were also evaluated as they were environmentally friendly and had no residual effect. Chemicals were significantly more effective as compared to botanicals in both controlling the whitefly population and the virus. Botanicals efficacy against vector and disease could be improved by increasing its concentration and identifying the actual active components involved in disease inhibition and understanding their mechanism of action and interaction with the pathogen. The results of present studies showed that botanicals had great potential for the management of mungbean yellow mosaic virus. As stated above there is a great need not only to identify the active compounds involved and their proper purification and formulation is required so that they could be easily commercially available for the farmers.

CONCLUSION

Whitefly (*Bemisia tabaci*) population showed strong correlation with mungbean yellow mosaic virus. Botanicals in combination with insecticides should be used for the management of virus vector. This option will be environment friendly and ultimately reduce the input cost as well.

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Table 1
Disease rating scale (0-5) for MYMV disease

Severity	% Infection	Visual Symptoms	Infection Category
0	All plant free of virus symptoms	Complete absence of symptoms	Highly resistant
1	1-10% infection	Small yellowish spots scattered on some leaves	Resistant
2	11-20% infection	Yellowish bright spots common on leaves, easy to observe	Moderately resistant
3	21-30% infection	Yellowish bright specks common on leaves, easy to observe with larger patches of symptoms	Moderately susceptible
4	30-50% infection	Bright yellow specks or spots on all leaves, minor stunting of plants and less number of pods	Susceptible
5	More than 50% infection	Yellowing or chlorosis of all leaves on whole plant, shortening of internode, severe stunting of plants with no yield or few flowers and deformed pods produced with small, immature and shriveled seeds	Highly susceptible

Table 2
Correlation of disease incidence with whitefly population on different lines during 1st year.

Sr. no.	Varieties/lines	Whiteflypopulation	Sr. no.	Varieties/lines	Whiteflypopulation
1	013954	0.722** 0.000	16	014293	0.663** 0.001
2	013955	0.831** 0.000	17	014295	0.463* 0.034
3	013956	0.735** 0.000	18	014296	0.424* 0.055
4	013957	0.572* 0.007	19	014311	0.424* 0.055
5	014227	0.640** 0.002	20	014315	0.627** 0.002
6	014228	0.633** 0.002	21	014316	0.657** 0.001
7	014232	0.561** 0.008	22	014343	0.689** 0.001
8	014234	0.645** 0.002	23	014358	0.531* 0.013
9	014261	0.741** 0.000	24	014359	0.453* 0.039
10	014275	0.712** 0.000	25	014364	0.481* 0.027
11	014276	0.679** 0.001	26	014380	0.588** 0.005
12	014285	0.693** 0.000	27	014488	0.742** 0.000
13	014286	0.702** 0.000	28	014532	0.599** 0.004
14	014289	0.588** 0.005	29	014559	0.694** 0.000
15	014292	0.574** 0.006	30	07005	0.209 0.364

Upper values in a column indicate pearson's correlation cofficients **= Highly significant
Lower values in column indicate significance level at P=0.05*=Significant

Table 3
Correlation of disease incidence with whitefly population on different lines during 2nd year.

Sr. no.	Varieties/lines	Whitefly population	Sr. no.	Varieties/lines	Whitefly population
1	013954	0.692** 0.000	16	014293	0.685** 0.001
2	013955	0.801** 0.000	17	014295	0.442* 0.042
3	013956	0.695** 0.000	18	014296	0.412* 0.065
4	013957	0.525* 0.009	19	014311	0.404* 0.070
5	014227	0.610** 0.003	20	014315	0.688** 0.003
6	014228	0.480* 0.009	21	014316	0.597** 0.003
7	014232	0.541** 0.008	22	014343	0.689** 0.001
8	014234	0.605** 0.004	23	014358	0.499* 0.015
9	014261	0.881** 0.000	24	014359	0.491* 0.030
10	014275	0.828** 0.000	25	014364	0.478* 0.025
11	014276	0.576** 0.005	26	014380	0.575** 0.006
12	014285	0.689** 0.001	27	014488	0.698* 0.001
13	014286	0.692** 0.001	28	014532	0.599** 0.004
14	014289	0.550** 0.007	29	014559	0.658** 0.002
15	014292	0.551** 0.007	30	07005	0.365 0.115

Upper values in a column indicate pearson's correlation cofficients **= Highly significant
Lower values in column indicate significance level at P=0.05*=Significant

Table 4
Analysis of variance table for different treatments applied against whitefly population (1st year).

Source	Degree of freedom	Sum of squares	Mean square	F Value	Prob>F
Replication	2	1.23	0.613		
Spray	3	65.05	21.682	38.59**	0.0000
Treatment	4	994.97	248.744	442.71**	0.0000
Varieties	3	43.95	14.649	26.07**	0.0000
Spray*Treatment	12	26.22	2.185	3.89*	0.0000
Spray*Varieties	9	27.14	3.015	5.37*	0.0000
Treatment*Varieties	12	15.16	1.263	2.25*	0.0119
Spray*Treatment*Varieties	36	14.17	0.394	0.70 NS	0.8946
Error	158	88.77	0.562		
Total	239	1276.66			

**= Highly significant, *=Significant, NS= Non significant, Significant level at P=0.05

Table 5
Analysis of variance table for different treatments applied against whitefly population (2nd year)

Source	Degree of freedom	Sum of squares	Mean square	F Value	Prob>F
Replication	2	1.03	0.516		
Spray	3	50.15	16.717	35.32	0.0000
Treatment	4	922.51	230.627	487.24	0.0000
Varieties	3	38.04	12.678	26.79	0.0000
Spray*Treatment	12	19.28	1.607	3.39	0.0002
Spray*Varieties	9	23.52	2.613	5.52	0.0000
Treatment*Varieties	12	11.82	0.985	2.08	0.0209
Spray*Treatment*Varieties	36	12.82	0.356	0.75	0.8407
Error	158	74.79	0.473		
Total	239	1153.96			

**= Highly significant, *=Significant, NS= Non significant, Significance level at P=0.05

Table 6
Interaction of treatments with sprays for the management of whitefly population (1st year).

No. of Sprays	Acetamiprid	Imidacloprid	Onion	Garlic	Control
1st	2.75 C	2.58 CD	3.58 B	3.50 B	7.00 A
2nd	1.91 E	1.25 F	2.58 CD	2.75 C	6.75 A
3rd	1.16 F	0.75 FG	2.00 DE	2.08 DE	7.08 A
4th	0.91 FG	0.41 G	1.91 E	2.75 C	7.00 A

Mean sharing similar letters in a row or in a column are statically non-significant (P>0.05) LSD = 0.6044

Table 7
Interaction of treatments with sprays for the management of whitefly population (2nd year).

No. of Sprays	Acetamiprid	Imidacloprid	Onion	Garlic	Control
1st	2.32 C	2.18 CDE	3.00 B	3.08 B	6.54 A
2nd	1.61 FGH	1.07 HIJ	2.08 CDEF	2.29 C	6.29 A
3rd	0.99 IJ	0.66 JK	1.66 EFG	1.70 DEFG	6.66 A
4th	0.75 JK	0.41 K	1.45 GHI	2.25 CD	6.50 A

Mean sharing similar letters in a row or in a column are statically non-significant (P>0.05) LSD = 0.5547

Table 8
Interaction of varieties with sprays for the management of whitefly population (1st year).

No. of Sprays	98001	7007	NM-92	NM-121-25
1st	5.06 A	4.20 B	3.13 C	3.13 C
2nd	4.13 B	2.46 EF	2.53 DEF	3.06 CD
3rd	3.00 CDE	2.46 EF	2.46 EF	2.60 CDEF
4th	2.80 CDEF	2.73 CDEF	2.40 F	2.40 F

Mean sharing similar letters in a row or in a column are statically non-significant (P>0.05) LSD = 0.5406

Table 9
Interaction of varieties with sprays for the management of whitefly population (2nd year)

No. of Sprays	98001	7007	NM-92	NM-121-25
1st	4.56 A	3.71 B	2.68 CDE	2.74 C
2nd	3.63 B	2.60 CDE	2.31 CDEF	2.68 CDE
3rd	2.70 CD	2.40 CDEF	2.14 F	2.24 DEF
4th	2.48 CDEF	2.20 DEF	2.08 F	2.14 F

Mean sharing similar letters in a row or in a column are statically non-significant (P>0.05) LSD = 0.4962

Table 10

Table 10
Interaction of treatments with varieties for the management of whitefly population (1st year).

Varieties/Lines	98001	7007	NM-92	NM-121-25
Acetamiprid	2.83 CD	1.50 E	1.08 EF	1.33 EF
Imidacloprid	2.25 D	1.25 EF	0.75 F	0.75 F
Onion	3.00 BC	2.50 CD	2.33 D	2.25 D
Garlic	3.58 B	2.83 CD	2.25 D	2.41 CD
Control	7.08 A	6.75 A	6.75 A	7.25 A

Mean sharing similar letters in a row or in a column are statically non-significant (P>0.05) LSD = 0.6044

Table 11
Interaction of treatments with varieties for the management of whitefly population (2nd year).

Varieties/Lines	98001	7007	NM-92	NM-121-25
Acetamiprid	2.43 CD	1.24 GH	0.94 HI	1.07 HI
Imidacloprid	1.95 DEF	1.05 HI	0.65 I	0.66 I
Onion	2.58 BC	2.04 CDEF	1.79 FG	1.79 FG
Garlic	3.12 B	2.41 CDE	1.87 EF	1.91 DEF
Control	6.75 A	6.62 A	6.29 A	6.33 A

Mean sharing similar letters in a row or in a column are statically non-significant (P>0.05) LSD = 0.5547

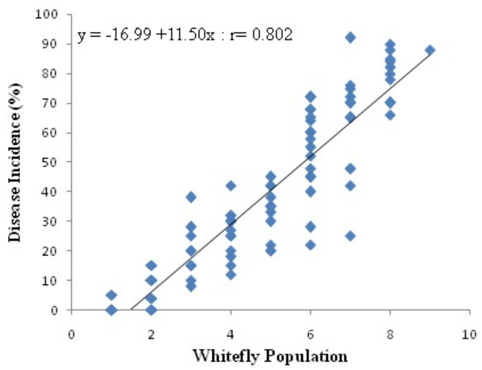

Fig. 1
Relationship of whitefly population with MYMV disease incidence recorded during 1st year.

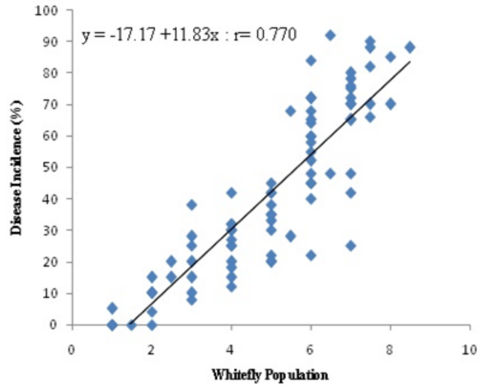

Fig. 2
Relationship of whitefly population with MYMV disease incidence recorded during 2nd year.

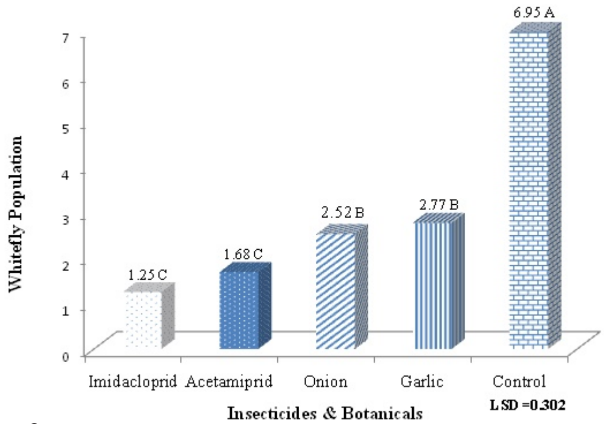

Fig. 3
Evaluation of insecticides and botanicals against whitefly population 1st year.

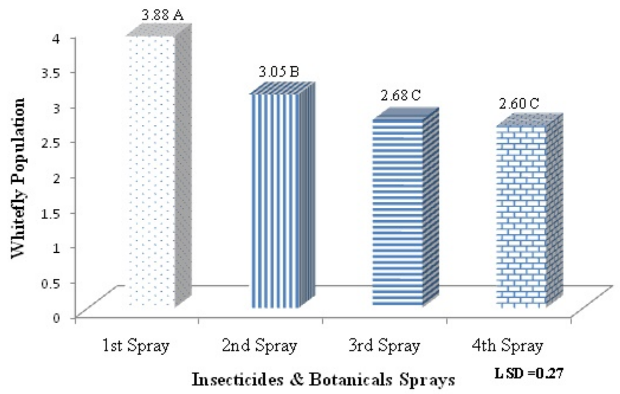

Fig. 4
Effect of different no. of sprays against whitefly population 2nd year.

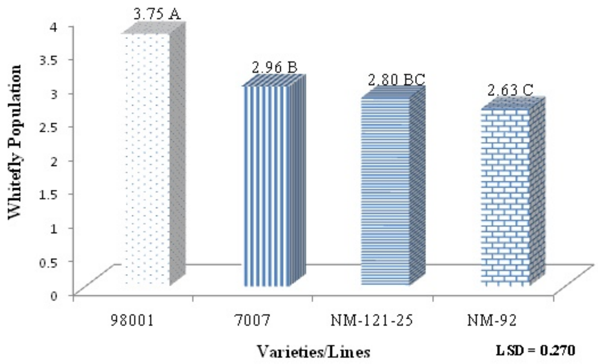

Fig. 5
Response of varieties/lines against whitefly population 1st year

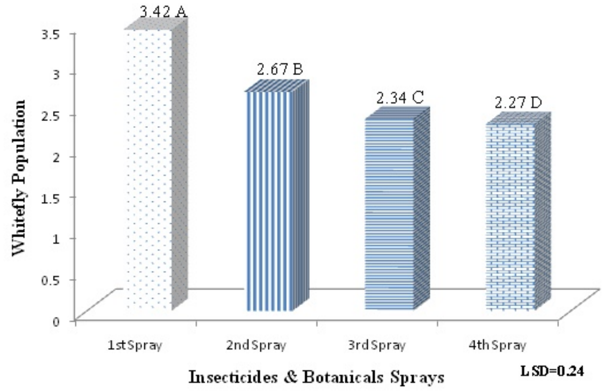

Fig. 6
Evaluation of insecticides and botanicals against whitefly population 2nd year.

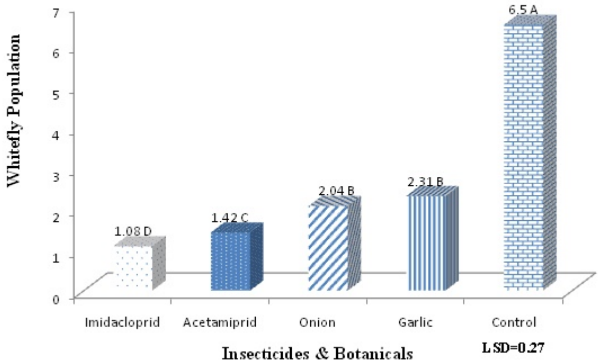

Fig. 7
Effect of different no. of sprays against whitefly population 2nd year.

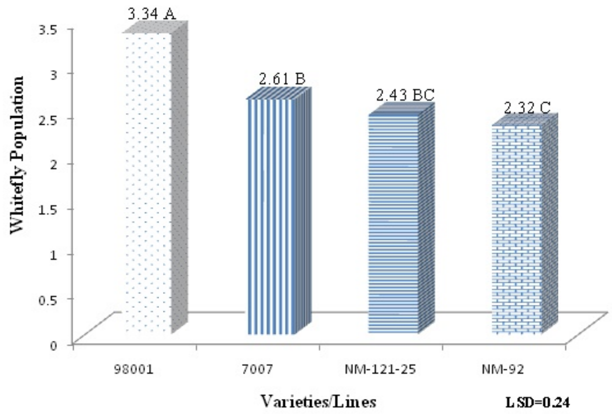

Fig. 8
Response of varieties/lines against whitefly population 2nd year.

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