Ecofriendly management and screening of mungbean (*Vigna radiata* L.) genotypes against whitefly, *Bemisia tabaci* (Gennadius)

BY
KHIN THANDA MIN
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CERTIFICATE-I

This is to certify that this thesis entitled: **"Ecofriendly management and screening of mungbean (*Vigna radiata* L.) genotypes against whitefly (*Bemisia tabaci* Gennadius)"** submitted for the degree of **Master of Science** in the subject of **Entomology** of the Chaudhary Charan Singh Haryana Agricultural University, Hisar, is a bonafide research work carried out by **Mrs. Khin Thanda Min, Admission No. 2017A34M** under my supervision and that no part of the thesis has been submitted by her for any other degree.

All the assistance and help received during the course of investigation have been duly acknowledged.

DR. TARUN VERMA
(Major Advisor)
District Extension Specialist (Entomology)
Agricultural Technology Information Center,
CCS Haryana Agricultural University,
Hisar, Haryana.

CERTIFICATE-II

This is to certify that this entitled: "Ecofriendly management and screening of mungbean (*Vigna radiata* L.) genotypes against whitefly (*Bemisia tabaci* Gennadius)" submitted by **Mrs. Khin Thanda Min 2017A34M** to the Chaudhary Charan Singh Haryana Agricultural University, Hisar in partial fulfillment of the requirements for the degree of **Master of Science** in the subject of **Entomology**, has been approved by the Student's Advisory Committee after an oral examination on the same.

MAJOR ADVISOR **EXTERNAL EXAMINER**

HEAD OF DEPARTMENT

DEAN, POST-GRADUATE STUDIES

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CHAPTER–I

INTRODUCTION

Mungbean, *Vigna radiata* (L.) Wilczek is one of the most important pulse crop grown throughout the world. It is excellent source of high quality protein, mainly consumed as human food in form of dhal, sprouts etc., also used as green manuring crop. Worldwide mungbean is widely grown in Bangladesh, Bhutan, China, India, Myanmar, Nepal, Sri Lanka, Thailand and Pakistan. It belongs to Family; Fabaceae and inclusion of this crop to the cereal cropping system has the potential to increase farm income, improve human health and soil productivity, save irrigation water and promote long term sustainability of agriculture (Swaminathan *et al*., 2012). India, is the world's largest mungbean producer covering 65% of world's acreage and 54% global production, (Jayappa *et al.*, 2017). In India, it occupies an area 4.26 million hectares with annual production of 2.01 million tons and average productivity 472 kg/ha (Anon., 2018). Ten states *viz*. Rajasthan, Maharashtra, Madhya Pradesh, Karnataka, Andhra Pradesh, Odisha, Gujarat, Tamil Nadu, Bihar and Telangana are the major pulse growing states contributing more than 80 per cent share of the total mungbean production in the country. Though India has distinction of being the world's largest producer of pulse crops, even then the average productivity is very low.

Several factors are responsible for the low productivity of mungbean crop, of these insect-pests are the major factor. About 64 species of insect-pests attack this crop at different stages of its growth (Lal, 1985). Among which whitefly, *Bemisia tabaci*, leafhopper, *Empoasca kerri*, black aphid, *Aphis craccivora*, spotted pod borer, *Maruca vitrata*, pod bug, *Riptortus pedestris*, spiny pod borer, *Etiella zinckenella* and gram pod borer, *Helicoverpa armigera* are important pest attacking this crop. On an average, 2.5 to 3.0 million tonnes of pulses are lost annually due to pest damage. The annual yield loss due to the insect pests has been estimated at about 30 per cent in urdbean and mungbean (Patidar, 2015). Economic loss of 20-25 per cent and yield loss of 2-84 per cent have also been reported due to *M. vitrata*. Floral damage i.e., 17.53 per cent has also been reported due to *M. pustulata* in mungbean (Durairaj, 2001). The avoidable yield losses on different varieties due to pest complex were 32.97 per cent (Duraimurugan and Tyagi, 2014).

Whitefly, *Bemisia tabaci* (Sub order : Homoptera, Family : Aleyrodidae) poses the most serious threat in northern states of India, sucks cell sap from leaves, secretes honeydew on which sooty mould develops, hinders photosynthesis. Besides this it also acts as a vector of yellow mosaic virus. Narasimhan *et al.* (2010) reported yield penalty of cent per cent under severe condition in *Vigna* species due to whitefly.

Different control measures have been adopted by various workers for the management of whitefly, which includes seed treatment with dimethoate 30 EC @ 5ml/kg of seed (Saini, 2014), application of insecticides like imidacloprid 70WS (Iqbal *et al*., 2013), acetamiprid (Zeeshan *et al.*, 2017); ready mixture i.e., Thiamethoxam + Chlorantraneliprole (Hossain, 2015), biopesticides *viz.,* NSKE 5% (Saini, 2014) for the management of whitefly in mungbean. But the main reliance was given on the use of insecticides that resulted into pesticide load in crop ecosystem which culminated in many undesirable effects such as insecticide resistance, resurgence, pesticide residue, environmental pollution etc. Bio pesticides being a part of ecological component and for their non-hazardous nature are now considered as the pivotal part of Integrated Pest Management (IPM). Neem, *Azadirachta indica* have been well studied for pest control all over the world. Studies on screening of different genotypes, correlation between weather parameters may provide a clue to develop strategy for pest management. Similarly population dynamics of insect pest and natural enemies will help in initiating control measure timely.

Keeping in view the importance of the crop, the present studies were undertaken to have an idea regarding an ecofriendly management and to screen the different genotypes against whitefly with the following objectives.

Objectives

1. To screen mungbean genotypes against whitefly, *Bemisia tabaci*
2. To evaluate different ecofriendly management practices against whitefly, *B. tabaci*
3. To study the population dynamics of major insect pests of mungbean

CHAPTER–II

REVIEW OF LITERATURE

In this chapter, an attempt has been made to review the recorded information regarding screening of mungbean genotypes against whitefly, ecological management of whitefly, population dynamics of major insect-pests, weather parameters correlation with whitefly population. Work done on these aspects on mungbean and some other related crops have also been collected and summarized in this chapter under different subheads.

2.1. Screening of mungbean genotypes against whitefly

Patel and Srivastava (1990) screened 28 genotypes of mungbean and reported that the number of whitefly ranged between 1.35 to 3.00 per 20 leaves. Yadav and Dahiya (2000) reported different genotypes *viz.* ML 5, ML 803, ML 839, PDM 91-249 and PMB 5 as resistant to whitefly. Khattak *et al.* (2004) observed low whitefly population on genotypes NM-92 and NM-98 as compared to other. Yadav and Dahiya (2004) evaluated thirty six mungbean genotypes for resistance to whitefly and reported high population of whitefly on Pusa 97-71, BDYR, BM-4, HUM-8 and OUM 11-5. Panghal (2006) evaluated eighteen mungbean genotypes against whitefly and reported that genotypes, MH 412 and MH 435 harboured the minimum population of whitefly adults, eggs, nymphs and pupae. MH 401 was found highly susceptible and K-851 were the most preferred hosts for whitefly. Kooner (2006) screened fifty seven genotypes of mungbean against *B. tabaci* and found two genotypes ML 1265 and ML 1229 as promising. Similarly studies conducted at Varanasi by Lakshminarayan *et al.* (2007) showed that mungbean genotypes, PDM 76, ML 325, ML 326 were least susceptible to whitefly, while Pusa Baisakhi, T 44 and PS 10 were found as highly susceptible.

Panduranga, *et al*. (2011) recorded less whitefly population on mungbean resistant checks ML 267 (1.33 adults/5 plants) and KM 200 (1.55 adults/5 plants) as compared to maximum population on susceptible check, WGG 2 (9.11 adults/5 plants) followed by MGG 350 (7.66 adults/5 plants) and UPM 99 (6.77 adults/5 plants). Nadeem *et al*. (2014) reported the comparison among ten tested genotypes of mungbean against whitefly. Genotype MH 3153 harboured minimum number of whiteflies while maximum number were recorded on MH 34113. Singh and Singh (2014) expressed the minimum population of whitefly on mungbean genotypes was occurred in TMB-36, RMG-1004 and maximum in BM-2003-2 and HUM-12.

Varietal screening of mungbean varieties against whitefly conducted by Rahad (2016). Among the varieties, BARI Mung-6 showed the least whitefly population and highest resistance against whitefly infestations at different stages. The highest seed yield was

recorded from BARI Mung-6 (1.82 t ha-1) and the lowest (1.30 t ha-1) was recorded from BARI Mung-4.

Further, Sekar and Nalini (2017) screened 52 genotypes of mungbean against whitefly and reported that whitefly population was less than 3.0 per three leaves on VBN 2, CO 8, VBN-3 as compared to maximum on RM 612 (7.7 no. /3 leaves). Khan, *et al*. (2018) evaluated 12 lines of mungbean and found four lines, NM-92, NM-2006, Azri 2006, and NM-121 as promising against whitefly.

2.2 Correlation of weather parameters with whitefly population

The weather factors *viz.* temperature, relative humidity, rainfall and sunshine hours play a important role in the population build up of insects. Temperature has a profound effect on distribution and prevalence of whitefly (James *et al*. 2002, Hoffman *et al*., 2003).

Ghosh *et al.* (2004) correlated weather parameter with whitefly population in brinjal. The association of whitefly was found negative and significant with average temperature and non-significantly and negative with average humidity and weekly rainfall. Phanghal (2006) correlated weather parameter (temperature, pan evaporation, sunshine, relative humidity, rainfall) with whitefly population. The population of whitefly showed positive and non-significant correlation with temperature, pan evaporation and sunshine, however, it was negative and non significant with relative humidity and rainfall. Cui *et al.* (2008) reported that whitefly survival was upto 41^{o}C and they show dying symptoms and got killed beyond this temperature indicating the effect of maximum temperature on survival of whitefly. Further, Singh and Kumar (2011) observed that minimum temperature and relative humidity have positive and non-significant correlation that whitefly, whereas maximum temperature and rainfall showed non-significant negative correlation with whitefly. Similarly Yadav and Singh (2013) reported significant and negative correlation of whitefly adults with maximum temperature, sunshine and evaporation. Contrary to this Jain (2014) reported positive correlation of whitefly with temperature and negative correlation with rainfall. Similar finding was also observed by Bairwa and Singh (2017) who reported positive and significant correlation of whitefly with maximum temperature. Whereas minimum temperature, wind speed and evaporation found positively and non-significantly correlated with whitefly population.

Tamang *et al*. (2017) studied the correlation between whitefly and abiotic factors in mungbean crop and reported that whitefly exhibited highly significant and positive correlation with maximum temperature and highly significant and negative correlation with evening relative humidity and rainfall. Mehra and Rolania (2017) reported that maximum and minimum temperatures, rainfall, wind speed and evening relative humidity had negative and non-significant correlation with whitefly population.

Patil (2018) reported that maximum temperature, minimum temperature and relative humidity at 7 hrs showed positive non-significant effect (r = 0.505, r = 0.150 and r = 0.273, respectively), whereas relative humidity at 14 hrs and rainfall (mm) showed negative non-significant effect (r = - 0.080 and r = - 0.050, respectively) with whitefly population. Bhowmik *et al.* (2018) reported that wind velocity, rainfall, number of rainy days, morning vapour pressure and evening vapour pressure have significant and positive correlation with whitefly population.

Fluctuation in whitefly population in relation to abiotic factors was studied by Jha and Kumar (2018) showed that whitefly population was positively correlated with mean temperature and negatively with relative humidity. The negative association between whitefly population and relative humidity was occurred because of heavy rain. In Andhra Pradesh, the weather parameters such as maximum, minimum temperature and morning relative humidity have shown positive correlation whereas evening humidity has shown negative correlation with whitefly population.

2.3. Eco-friendly management of whitefly

Different group of insecticides are used under field conditions to manage whitefly and their indiscriminate use has led to many problems *viz*., development of resistance to most of available insecticides, insecticide induced resurgence and disruption of the population of predators and parasitoids. The present review related to ecofriendly management of whitefly also includes management of whitefly in other crop in addition to mungbean.

The efficacy of seed treatments and spray against whitefly in mungbean reported by Phanghal (2006) revealed that seed treatment with imidacloprid 200SL @ 3ml and dimethoate 30EC @ 5ml/kg seed followed by spray of NSKE 5% proved most effective treatments in controlling whitefly. Saini (2014) reported maximum cost benefit ratio in seed treatment with dimethoate 30EC @ 5ml/kg seed. However, spray of NSKE 5% with ethion was found the most effective against whitefly on mungbean.

Gupta and Pathak (2009) observed that admixture treatments, neen seed kernel extract (NSKE 3%) (in cow urine) + dimethoate, 0.03% and neem oil 0.5% + dimethoate 0.03% not only reduced the incidence of whitefly and yellow mosaic but also reduced attack of pod borer in Black gram. Studies conducted by Hossain (2010) revealed that lowest population of whitefly (6.58/plant) was found in Marshal 20 EC (Carbosulfan) treated plot, which showed maximum per cent reduction of sucking insects. Iqbal *et al*. (2013) evaluated combination of seed treatment with imidacloprid (Confidor 70 WS) and spray with detergent and four insecticide sprays: imidacloprid (Confidor 20SL), acetamiprid (Acelan 20SL), thiomethoxam (Actara 25WG) and acephate (Commando 75SP), against sucking insect pests on mungbean during 2012. However, Imidacloprid resulted in a maximum mortality of the whitefly followed by acetamiprid.

Kabir *et al*. (2014) conducted the experiment at the research field of Sher-e-Bangla to manage the sucking insects of mungbean. Lowest population of whitefly at vegetative stage of the crop (4.90/ plant) and at reproductive stage (3.80/plant) was found in plot sprayed with Marshal 20 EC. Neem oil showed the intermediate results considering all the parameters.

Saini (2014) reported NSKE 5% alternated with novaluron and NSKE 5% alternated with ethion as most effective against whitefly adult population in urdbean, but maximum yield was obtained in plot sprayed twice with nimbecidine (5ml/l). Maximum cost benefit ratio was obtained in plot treated with dimethoate (5ml/kg) followed by seed treatment with dimethoate alternated with one spray of dimethoate and NSKE 5% alternated with spray of ethion. Similarly Lal and Jat (2015) reported the lowest whitefly population (1.6 and 6.4 adults/ cage/ plant) in NSKE 5% at 3 days after spray (DAS) on mungbean genotypes. At 7 DAS, NSKE 5% and triazophos 0.04% was the most effective in keeping the lower whitefly incidence. Spraying of triazophos 0.04% resulted in higher grain yield as well as net profit.

Bioefficacy studies of different novel insecticides against whitefly in okra was conducted by Ahmad *et al*. (2015). The most significantly effective treatment were imidacloprid @ 5 g/kg seed + neemazal @ 5000 ppm spray + indoxacarb 75 g a.i/ha spray + *Bacillus thuringiensis* (Biolep) @ 1 kg/ha spray, which reduced whitefly count by 63.01-52.13 and 52.45 -42.34% at one and seven days after first and second spraying, respectively.

Khaliq *et al*. (2017) evaluated certain selective insecticidal molecules, *viz.* imidacloprid, dimethoate + triazophos, thiamethoxam, neem oil, dimethoate, oxy- demeton methyl, triazophos and NSKE against the field populations of *B. tabaci*, during *Zaid* and *Kharif* season, 2014. The results indicated that imidacloprid showed higher efficacy against *B. tabaci* in reducing pest population followed by dimethoate + triazophos.

Zeeshan *et al*. (2017) evaluated different insecticides against whitefly in mungbean. Acetamiprid was found the most effective insecticide followed by methomyl, methamidophos, fenpropathrin and buprofezin causing 69.69, 62.69, 58.89, 54.76 and 40.28% mortality of whitefly. respectively. Mehra *et al*. (2018) observed that four sprays of nimbecidine 300 ppm @ 5ml/l at 10 days interval gave highest benefit cost ratio (0.86). The most effective spray was nimbecidine 300 ppm @ 5ml/l followed by dimethoate 30EC @ 1.5 ml/l, triazophos 40EC @ 3 ml/l, novaluron 10EC @ 1ml/l.

Patil (2018) described the effectiveness of the foliar spray of synthetic insecticides and plant products. Imidacloprid 17.8 SL @ 0.005% and thiamethoxam 25WG @ 0.025% when applied thrice at fortnightly interval initiating after one month of sowing, provided maximum protection to mungbean crop in minimizing whitefly population 1.9, 1.2 and 0.5 whitefly/trifoliate leaf and 2.0, 1.5 and 0.9 whitefly/trifoliate leaf, respectively compared with untreated control 4.1, 6.6 and 4.8 whitefly/trifoliate leaf after first, second and third spraying, respectively.

Asawalam and Constance (2018) conducted the experiment to determine the efficacy of plant extracts from seven plant species against insect pests of mungbean. The results indicated that all the treatments were effective against whitefly, *Bemisia tabaci*. There was a significant reduction in the population of insects on the plots treated with plant extracts and karate in 2015 and 2016 cropping seasons. *Azadirachta indica* and *Curcuma longa* extracts recorded the highest seed yield of 50.00 kg/ha and 42.33 kg/ha in 2015 and 2016, respectively. No significant differences were observed between the plant extracts and karate, which recorded significantly higher yields when compared with the control (23.30 kg/ha).

2.4. Population dynamics of major insect pests of mungbean

Taggar *et al*., (2012) reported that the damage by flower chafer beetles, *Oxycetonia versicolor* damage mostly occurred during August and September, coinciding with the peak flowering period of pigeonpea and mungbean in north India,

Yadav and Singh (2013) recorded the maximum incidence of spotted pod borer (2.4 larvae/plant) during 36th standard weeks. Similarly, Duraimurugan and Tyagi (2014) carried out field experiments to search the change in pest spectra, their status, and yield loss in mungbean and urd bean under changing climatic scenario. The pests spectra of 35 species on mungbean and 25 species on urd bean were found during *kharif* season and 17 species were recorded during summer season in both crops. Blister beetle (*Mylabris pustulata*), bean flower thrips (*Megalurothrip susitatus*) and spotted pod borer (*Maruca vitrata*) were found as major pests during *kharif* season. Jyothi (2014) observed the maximum population of whitefly (2.20/leaf) and thrips (3.86/leaf) during second fortnight of July, while their lowest incidence was noticed in first fortnight of July (1.07/leaf) and October (0.45/leaf) in black gram. Accordingly, Jain (2014) recorded the population dynamics of insect-pests in green gram. Aphid, jassid and whitefly commenced in the last week of July, while blister beetle and pod borer commenced in 4th and 3rd week of August, respectively. The peak population of aphid, whitefly and jassid was during second week of August, third week of August and first week of September, respectively. Blister beetle and pod borer attained their peak during first and third week of September, respectively.

Yadav and Singh (2015) reported peak activity of pod sucking bug during 38th standard week. The biology of spotted pod borer studied by Sravani (2015) in Guntur concluded the peak population of *M. vitrata* larvae in mungbean during first week of December coinciding with peak flowering and pod development stage, then the larval population declined gradually. Similar studies were also reported by Khamoriya (2017) who reported the peak population of *C. gibbosa* during 9th (2015-16 : 6.0 adults/plant) and 10th (2016-17 : 5.5 adults/plant) standard week.

Tamang *et al*. (2017) studied the population of insect-pests and natural enemies of mungbean for two seasons. Highest population of aphids, whitefly and thrips were recorded

during 2nd week of April during 2nd season. The highest coccinellid predators were observed during 2nd week of Feb. and 1st week of April, respectively during first and second seasons.

Ahir (2017) reported the incidence of tobacco caterpillar in 2nd week of September (37th SMW : 0.20 caterpillar/plant), populations slowly increased and reached to its peak in the 2nd week of October (41st SMW) with a mean of 1.40 caterpillar/ plant.

Studies conducted by Patil (2018) revealed that the activity of whitefly on mungbean gradually increased from 16th SMW. Maximum whitefly population (10.4/trifoliate leaf) was recorded during 20th SMW. Makwana *et al.* (2018) reported the maximum aphid population (74.6 aphids/3 leaves/ plant) during 22nd week and the maximum (16.4 jassids/3 leaves/plant) activity of jassid was observed during 16th week after sowing in cotton. The highest population of whitefly (58.8 whiteflies /3 leaves/plant) during 44th standard week.

2.5 Correlation of weather parameter with major insect-pests of mungbean

Kumar *et al*. (2004) reported that whitefly had a positive correlation with both minimum and maximum temperature and sunshine hours and negative correlation with relative humidity on mungbean crop in both *zaid* and *kharif* seasons. Yadav and Singh (2006) reported positive and significant correlation of maximum temperature with thrips population, while it was negative with rainfall during rainy season in mungbean. Jassid population was affected adversely by high humidity and rainfall, while marked increase was observed with maximum and minimum temperature.

Ali and Rahman (2009) studied macro and microclimatic temperature, relative humidity and rainfall; and these were found negatively correlated with the incidence of whitefly on mungbean. The incidence of whitefly and MYMV infection were the maximum in Barisal and minimum in Jessore and intermediate in Gazipur. Thus yield performance was higher in Jessore (1160.6 kg/ha) followed by Barisal (866.7 kg/ha) and Gazipur (414.7 kg/ha). Yadav and Singh (2013) reported significant and positive correlation of sunshine and evaporation with population of leafhopper and spotted pod borer. However, whitefly population showed significant and negative correlation with maximum temperature, sunshine and evaporation.

Pawar (2014) correlated blister population with weather parameter. Blister beetle population was found negatively and significantly correlated with minimum temperature and bright sunshine hours, whereas, relative humidity, rainfall showed positive influence on their abundance on green gram. Yadav and Singh (2015) reported that the tobacco caterpillar on mungbean had significantly negative correlation with minimum temperature. Tamang *et al*. (2017) reported that the sucking pest *viz.*, aphid, thrips, whitefly and its predatory coccinellid populations exhibited highly significant positive correlation with maximum temperature (r= 0.78,0.78,0.79,0.78) and significant negative correlation with evening relative humidity (r= -0.51,-0.51,-0.57, -0.53) and rainfall (-0.41,-0.41,-0.45,-0.45), respectively. Spotted pod borer

population exhibited highly significant positive correlation with minimum temperature (r= 0.79) and significant and negative correlation with maximum temperature (r= -0.46).

Reddy (2016) reported highly significant and positive correlation of maximum and minimum temperature with thrips population, while it showed significant and negative correlation with relative humidity and rainfall. Khamoriya (2017) found the significant positive and negative correlation of *C. gibbosa* with maximum temperature and average relative humidity, respectively. Studies conducted by Tamang *et al.* (2017) at West Bengal revealed that whitefly exhibited highly significant positive correlation with maximum temperature and significant and negative with evening relative humidity and rainfall. However, spotted pod borer population exhibited highly significant positive and negative correlation with minimum temperature and maximum temperature, respectively.

Bairwa and Singh (2017) reported that whitefly population exhibited positive and significant correlation with maximum temperature. However, *Empoasca kerri*, *Aphis craccivora*, *Caliothrips indicus* and *Maruca vitrata* showed non-significant positive correlation. Whereas, minimum temperature, wind speed and evaporation showed positive and non-significant correlation against *B. tabaci*, *E. kerri*, *A. craccivora*, *C. indicus* and *M. vitrata*. Rainfall showed negative and non significant correlation with *B. tabaci*, *A. craccivora*, *C. indicus and M. vitrata* while positive and non-significant with *E. kerri*. Sunshine hours were found negatively and non significantly correlated with *E. kerri* but positively and non significantly correlated with all other insect. Makwana *et al*. (2018) studied the correlation of weather parameter and insect-pests of cotton. The aphid and jassid population exhibited highly significant positive correlation with minimum temperature, morning relative humidity, afternoon relative humidity while the population of thrips was positively correlated with maximum temperature and minimum temperature. The incidence of whitefly was highly positive correlated with maximum temperature.

CHAPTER–III

MATERIALS AND METHODS

The present studies entitled "Ecofriendly management and screening of mungbean genotypes against whitefly (*Bemisia tabaci*) were conducted during *Kharif*, 2018 at the Research farm of Pulses Section, Chaudhary Charan Singh Agricultural University, Hisar (Haryana). Hisar is situated in the sub-tropical region at an elevation of 215.2 m above mean sea level with a longitude of 75º46'E and latitude of 29º10'N. The soil condition of this geographical region are reported to be flat, well drained and moderately fertile being less in available nitrogen, phosphorous and potash. The mean annual rainfall of this area is around 400 mm. Extreme temperature fluctuation may occur within a very short time interval. Summers are very hot and maximum temperature generally reaching 45ºC and winters are fairy cool, minimum temperature around 1º± 1ºC. The materials and methods adopted during the course of investigations are described as under.

3.1. Materials

3.1.1. Plant Materials

Twenty seven genotypes obtained from Pulse Section, Department of Genetics and Plant Breeding, CCS HAU, were screened against whitefly.

Table 1. List of mungbean genotypes screened against whitefly, *B. tabaci* during *Kharif*, 2018

S. No.	Genotype	S. No.	Genotype	S. No.	Genotype
1	MH 1129	10	MH 1346	19	MH 1467
2	MH 1142	11	MH 1429	20	MH 1468
3	MH 1303	12	MH 1431	21	MH 1489
4	MH 1305	13	MH 1432	22	MH 1703
5	MH 1314	14	MH 1436	23	MH 1704
6	MH 1315	15	MH 1451	24	Sattya*
7	MH 1320	16	MH 1452	25	Basanti*
8	MH 1323	17	MH 1457	26	MH 421*
9	MH 1344	18	MH 1465	27	MH 318*

*Recommended check

3.1.1.1 Raising the crop

The crop was sown under field conditions at the Research Farm of Pulse Section, CCS HAU, Hisar. Hand weeding was done starting from 25 days after sowing to minimize the crop competition with weed. All the recommended package of practices except insecticidal spray were adopted from time to time during the studies to ensure a healthy crop stand.

Date of sowing : 7 July, 2018

Spacing : 30 x 10cm

Plot size	:	2 rows of 4 m length
Design	:	Randomized block design (RBD)
Replications	:	Three
Test Insect	:	*Bemisia tabaci* (Gennadius)

3.2 Methods:

3.2.1. Recording the incidence of whitefly, *Bemisia tabaci*

Regular field inspections were made from the germination for the appearance of whitefly (adults and nymphs). The genotypes were kept completely under unsprayed conditions and the pest population was recorded at ten days intervals, initiating 15 days after sowing and was continued up to the crop maturity.

Whitefly adult population per plant was recorded with the help of split cage (60 cm height and 45 cm diameter) from five randomly selected plants per plot as suggested by Nath (1994). The cage was made up from wooden frame or cubical iron-frame trap and covered with black cloth from all sides except one side provided with a glass pane. The glass pane side was kept facing to Sun, while taking observations so that whitefly being photo tactic can migrate on the glass pane.

3.2.2. Observation of Immature stages of whitefly, *B. tabaci*

The observations on the immature stages i.e., nymphs were recorded at ten days intervals. For this purpose, three plants from each genotype were selected at random and three leaves from each plant (one from upper, middle and lower canopy) were examined under magnifying hand lens. The observations were started 15 days after sowing (DAS) and continued to 45 DAS.

3.2.3. Correlation of weather parameters with incidence of whitefly

Various weather parameters *viz.*, temperature (maximum and minimum), relative humidity (evening and morning), rainfall, pan evaporation and sunshine were collected from Meteorological Observatory, Department of Meteorology, CCS HAU, Hisar. These parameters were computed and correlated with whitefly incidence.

3.2.4. Seed Yield

The seed yield of all the genotypes were recorded after harvesting of the crop and weighed as kg/plot, then calculated as kg/ha. The data obtained was subjected to ANOVA after using proper transformations statistical analysis.

3.2.5. Eco-friendly management of whitefly

The crop was raised at the Research Farm of Pulse Section, CCS HAU, Hisar by following the recommended package of practices. The mungbean crop was sprayed with different biopesticides at 30 DAS and second spray was repeated at 15 days after first spray.

Details of different treatments

1	NSKE 5% (Methanolic extract)
2	NSKE 5% (Aqueous extract)
3	Neem oil 1% (Crude)
4	Neem oil 2% (Crude)
5	Foliar spray of *Beauveria bassiana* @ 1250 g/ha
6	*Beauveria bassiana* @1250 g/ha alternated with NSKE 5% (Methanolic extract)
7.	*Beauveria bassiana* @1250 g/ha alternated with Neem oil 2%
8.	Neemastra @ 25 l /ha
9.	Untreated (Control)

Genotype	:	MH 421
Sowing Time	:	7, July 2018
Plot size	:	3m x 3m
Design	:	RBD
Replications	:	Three
Test insect	:	*Bemisia tabaci*
No. of spray	:	Need based spraying

3.2.5.1. Preparation of Neem seed kernel extract (NSKE 5%): Methanolic extract

Neem seeds were collected during the summer season. The seeds were shade dried for 1 month and crushed into pieces using a mallet. NSKE 5% (Methanolic extract) was prepared in the insecticide residue laboratory of Department of Entomology, CCS HAU, Hisar. One kg powdered neem seed kernel was placed in a round bottomed flask (5 litre) and the solvent methanol was added to immerse the pieces. The flask was fitted with a water condenser and the methanol was boiled for 12 h using a heating mantle in the laboratory. The extract was concentrated by repeating the boiling of the given seeds for another 12h in laboratory. The methanol distilled off to obtain the extract. After that, the extract solution was transferred to the conical flask and evaporated by using slightly heat treatment or natural evaporation in shade.

3.2.5.1.1. Preparation of stock solutions for NSKE 5% (Methanolic extract)

Neem extract (10g) was weighed in a 100 ml flask and methanol was added to it. The volume was made up to 100ml. This constituted 10% methanol-diluted extract which was designated as the stock solution of neem. Different concentrations required for different experiments were obtained by diluting the standard stock solutions serially with methanol or water as desired.

3.2.5.2. Preparation of stock solutions for NSKE 5% (Aqueous extract)

Collected the Neem kernels during bearing season and air-dried them under shade. Only the freshly collected seeds were used as old seeds of over eight months of age lose their

activity and are not good in quality for NSKE preparation. Required quantity of neem seed kernel 1 kg as ground gently to powder and soaked in 10 liter of water overnight. Stir with wooden plank in the morning till the solution becomes milky white and filter through the layer of muslin cloth and make the volume to 100 liter. Add 1% detergent paste into it and mix well. Different concentrations required for different were obtained by building the standard stock solutions serially with water as necessary (Anon., 2018a)

3.2.5.3 Preparation of Neemastra

Two kg cow dung and ten litre cow urine was added in 100 litre of water and then freshly collected five kg neem leaves were added in this solution, stirred and kept for 48 hours (Anon. 2018b).

3.2.6. Recording the incidence of *Bemisia tabaci*

Whitefly adult population were recorded with split cage from five randomly selected plants in each replication of each genotype, one day before spraying of insecticide and 1, 3 and 7 days after spraying. Spraying was done at the appearance of whitefly in the experimental area. The first spray was done 30 days after sowing and the second spray was done at 15 days interval.

3.2.6.1. Recording of yield data

At harvest, yield was recorded from each plot and calculated as kg/ha. These data were subjected to statistical analysis to draw inferences.

3.2.7. Population dynamics of major insect pests in mungbean

Genotypes	:	MH 421, MH 318
No. of replication	:	4
Plot size	:	10m x 10m

3.2.7.1. Incidence of major insect-pests in mungbean

Major insect-pests namely, whitefly adults and leafhopper nymphs (from 3 leaves/plant), blister beetle, pod bug, tobacco caterpillar, spotted pod borer, pod borer (number per plant) in mungbean were recorded from 10 randomly selected plants per replication at weekly interval starting from 15 DAS and the populations were correlated with meteorological parameters i.e., temperature, relative humidity, sunshine hours, rainfall etc.

Population of leafhopper (nymphs & adults) and whitefly adults was estimated by the visual count technique during early hours of the day from 10 plants (3 leaves/plants) in each replication. The top, middle and bottom leaf of the tagged plants were chosen for recording population.

3.2.8. Statistical analysis

The final data was statistically analyzed with analysis of variance (ANOVA) and means were separated by using least significant difference (LSD) test at 5% level of significance.

CHAPTER–IV

RESULTS

The present study entitled "Ecofriendly management and screening of mungbean (*Vigna radiata* L.) genotypes against whitefly (*Bemisia tabaci* Gennadius)", was conducted with a view to find out the least susceptible genotypes to whitefly, to correlate weather parameters with whitefly incidence, ecofriendly management of whitefly and population dynamics of major insect-pests of mungbean. The results obtained are presented in the following sections.

4.1 Screening of mungbean genotypes against whitefly

Twenty seven genotypes of mungbean were evaluated under field conditions to find out the least susceptible genotypes against whitefly. Whitefly adult population were recorded from five randomly selected plants in each replication with the help of split cage as described by Nath (1994). However, nymphal population was recorded from three plants per replication selected randomly from three leaves of each plant in each genotype. The data recorded on the whitefly nymph population is presented in Table 2. Whitefly nymph population at 15 DAS varied from 0.6 to 2.07 whitefly nymph/3 leaves/plant. The minimum whitefly nymph population was occurred in MH 1467 (0.60 whitefly nymph/three leaves/plant) and the maximum populations was recorded in genotype, MH 1315 (2.07 whitefly nymph/three leaves/plant). The whitefly nymph population varied from 0.60 to 2.13 per three leaves per plant at 25 DAS. The minimum numbers were occurred in MH 1432, MH 1457 and MH 1346 of (0.60 whitefly nymph/3 leaves/plant). Maximum number of whitefly nymph population was recorded on genotype MH 421 (2.13 whitefly nymph/3leaves/plant). The whitefly nymph population showed non- significant differences during non-significant at 15 and 25 days after sowing.

Whitefly nymph population showed significant differences during 35 and 45 DAS. Peak population of whitefly nymphs were observed during 35 DAS. The number of whitefly nymphs varied from 4.00 to 38.6 per 3 leaves per plant at 35 DAS. Minimum whitefly nymphs was recorded in MH 1344 (4.0 whitefly nymph/3 leaves/ plant) which was at par with genotypes, MH 1436 (6.00 whitefly nymph/3 leaves/ plant), MH 1457 (6.33 whitefly nymph/3 leaves/ plant), MH 1465 (5.4 whitefly nymph/3 leaves/ plant), MH 1468 (4.47 whitefly nymph/ 3 leaves/ plant), MH 1489 (5.53 whitefly nymph/3 leaves/ plant), MH 1314 (9.07 whitefly nymph/3 leaves/ plant), MH 1320 (5.20 whitefly nymph/3 leaves/ plant), MH 1323 (8.13 whitefly nymph/3 leaves/ plant), MH 1703 (8.33 whitefly nymph/3 leaves/ plant),

MH 1704 (8.80 whitefly nymph/3 leaves/ plant), MH 421 (5.20 whitefly nymph/3 leaves/ plant) and MH 318 (4.07 whitefly nymph/3 leaves/ plant). The maximum number of whitefly nymphs were occurred in genotype, MH 1315 (38.60 nymph/3 leaves/plant) which was found at par with genotype, MH 1431(35.40 whitefly nymph/3 leaves/plant), MH 1432 (28.13 whitefly nymph/3 leaves/plant), MH 1452 (34.47 whitefly nymph/3 leaves/plant) and MH 1142 (27.87 whitefly nymph/3 leaves/plant) respectively.

Table 2: Evaluation of mungbean genotypes against whitefly nymph under natural field conditions during 2018

Genotypes	Whitefly nymph/3 leaves/plant				Mean
	15 DAS	25 DAS	35 DAS	45 DAS	
MH 1129	1.93 (1.70)	1.33 (1.51)	11.8 (3.56)	2.07 (1.75)	4.28(2.30)
MH 1142	0.93 (1.37)	0.67 (1.29)	19.33 (2.53)	6.80 (2.77)	6.93 (2.82)
MH 1303	0.93 (1.39)	1.67 (1.63)	11.63 (3.52)	1.40 (1.55)	3.91(2.21)
MH 1305	0.80 (1.34)	1.47 (1.56)	11.20 (3.47)	5.60 (2.57)	4.77(2.40)
MH 1314	1.20 (1.46)	1.40 (1.54)	9.07 (3.15)	5.60 (2.56)	4.32(2.30)
MH 1315	2.07 (1.70)	1.50 (1.56)	38.60 (6.29)	4.53 (2.33)	11.68(3.56)
MH 1320	1.00 (1.41)	1.33 (1.53)	5.20 (2.48)	2.67 (1.91)	2.55(1.88)
MH 1323	1.80 (1.67)	0.80 (1.33)	8.13 (3.01)	2.07 (1.74)	3.20(2.05)
MH 1344	0.80 (1.34)	0.80 (1.33)	4.00 (2.22)	5.80 (2.58)	2.85 (1.96)
MH 1346	1.73 (1.65)	0.60 (1.26)	22.80 (4.87)	5.40 (2.53)	7.63(2.93)
MH 1429	0.73 (1.31)	1.53 (1.58)	20.40 (4.56)	3.07 (2.00)	6.43(2.71)
MH 1431	1.40 (1.53)	0.67 (1.29)	35.40 (6.01)	2.60 (1.83)	10.02(3.32)
MH 1432	1.07 (1.42)	0.60 (1.26)	28.13 (5.40)	4.07 (2.19)	8.47(3.07)
MH 1436	1.20 (1.48)	1.60 (1.56)	6.00 (2.62)	1.40 (1.54)	2.55(1.87)
MH 1451	1.20 (1.48)	0.67 (1.28)	22.00 (4.54)	2.00 (1.72)	6.47(2.64)
MH 1452	1.20 (1.45)	0.80 (1.33)	34.47 (5.94)	1.60 (1.58)	9.52(3.23)
MH 1457	1.20 (1.48)	0.60 (1.24)	6.33 (2.71)	3.33 (2.07)	2.87(1.97)
MH 1465	1.20 (1.47)	1.07 (1.41)	5.40 (2.46)	1.60 (1.58)	2.32(1.81)
MH 1467	0.60 (1.26)	0.80 (1.31)	9.80 (3.27)	0.73 (1.32)	2.98(1.99)
MH 1468	0.73 (1.31)	0.70 (1.30)	4.47 (2.31)	3.87 (2.17)	2.44(1.85)
MH 1489	1.13 (1.45)	1.20 (1.46)	5.53 (2.53)	3.80 (2.18)	2.92 (1.97)
MH 1703	0.87 (1.35)	1.07 (1.43)	8.33 (3.02)	2.20 (1.77)	3.12(2.02)
MH 1704	1.60 (1.59)	1.13 (1.44)	8.80 (3.11)	1.13 (1.46)	3.17(2.04)
Sattya*	1.13 (1.46)	0.93(1.39)	16.53 (4.19)	0.73 (1.31)	4.83(2.41)
Basanti*	1.00 (1.41)	1.80 (1.66)	15.53 (4.06)	1.33 (1.50)	4.92(2.43)
MH 421*	1.07 (1.43)	2.13 (1.76)	5.20 (2.46)	0.87 (1.36)	2.32 (1.81)
MH 318*	1.13 (1.46)	2.00 (1.73)	4.07 (2.24)	1.60 (1.61)	2.20 (1.79)
Range	0.60 -2.07	0.60 - 2.1	4.00 - 38.6	0.73 - 6.80	2.20 - 11.68
C.D	(N.S.)	(N.S.)	(0.93)	(0.54)	(0.40)
SE (m)	(0.12)	(0.13)	(0.33)	(0.19)	(0.14)

Values in parenthesis are square root transformation values ($\sqrt{n+1}$)
DAS: Days after sowing

Whitefly nymph population at 45 DAS varied from 0.73 to 6.80 whitefly nymphs/3 leaves/plant and the minimum population occurred on Sattya and MH 1467 (0.73 nymph/3 leaves/plant) which was at par with genotypes MH 1431(2.60 whitefly nymph/3 leaves/plant), MH 1436 (1.4 whitefly nymph/3 leaves/plant), MH 1451 (2.00 whitefly nymph/3 leaves/plant), MH 1452 (1.60 whitefly nymph/3 leaves/plant), MH 1465 (1.60 whitefly nymph/3 leaves/plant), MH 1323 (2.07 whitefly nymph/3 leaves/plant), MH 1129 (2.07 whitefly nymph/3 leaves/plant), MH 1303 (1.40 whitefly nymph/3 leaves/plant), MH 1703 (2.20 whitefly nymph/3 leaves/plant), MH 1704 (1.13 whitefly nymph/3 leaves/plant), Basanti (1.33 whitefly nymph/3 leaves/plant), MH 421 (0.87 whitefly nymph/3 leaves/plant) and MH 318 (1.60 whitefly nymph/3 leaves/plant) respectively. Maximum whitefly nymphs were observed on genotype, MH 1142 (6.80 whitefly nymph/3 leaves/plant) which was statistically at par with MH 1344 (5.80 whitefly nymph/3 leaves/plant), MH1346 (5.40 whitefly nymph/3 leaves/plant), MH1305 (5.60 whitefly nymph/3 leaves/plant), MH 1314 (5.60 whitefly nymph/3 leaves/plant) and MH 1315 (4.53 whitefly nymph/3 leaves/plant).

Mean population of whitefly nymphs showed significant differences among the genotypes, ranging from 2.20 to 11.68 whitefly nymph/3 leaves/plant. Minimum population of whitefly nymph observed in MH 318 (2.20 whitefly nymph/3 leaves/plant) which was at par with MH 1436 (2.55 whitefly nymph/3 leaves/plant), MH 1457 (2.87 whitefly nymph/3 leaves/plant), MH 1465 (2.32 whitefly nymph/3 leaves/plant), MH 1467 (2.98 whitefly nymph/3 leaves/plant), MH 1468 (2.44 whitefly nymph/3 leaves/plant), MH 1489 (2.92 whitefly nymph/3 leaves/plant), MH1344 (2.85 whitefly nymph/3 leaves/plant), MH1320 (2.55 whitefly nymph/3 leaves/plant), MH1323 (3.20 whitefly nymph/3 leaves/plant), MH 1303 (3.91 whitefly nymph/3 leaves/plant), MH 1703 (3.12 whitefly nymph/3 leaves/plant), MH 1704 (3.17 whitefly nymph/3 leaves/plant) and MH 421 (2.32 whitefly nymph/3 leaves/plant). Maximum population of whitefly nymph was occurred in the genotype MH1315 (11.68 whitefly/3 leaves/plant) which was at par with MH 1431 (10.02 whitefly nymph/3 leaves/plant), MH1452 (9.52 whitefly nymph/3 leaves/plant), MH 1142 (9.07 whitefly nymph/3 leaves/plant) respectively.

The whitefly adult populations ranged from 3.8 to 6.7 adults/ plant, 3.0 to 7.4 adults/ plant, 16.8 to 99.0 adults/plant and 11.7 to 28.0 adults/ plant at 15, 25, 35 and 45 DAS, respectively (Table 3). The minimum number of whitefly adults were recorded on variety MH 1429 (3.86 adults/ plant), MH 1457 (3.0 adults/plant) and MH 1429 (11.7 adults/plant) at 15, 25 and 45 DAS, respectively. Similarly, genotype, MH 1323 (6.7 adults/plant), MH 1303 (7.4 adults/plant) and MH 1452 (28.0 whitefly adults/plant) harboured maximum whitefly adult population at 15, 25 and 45 DAS, respectively. However, the numbers of whitefly adults were not significantly differed among genotypes at 15, 25 and 45 DAS.

Table 3: Evaluation of mungbean genotypes against whitefly adults and yield parameter under natural field conditions during 2018

S. No.	Genotypes	Whitefly adults/plant				Mean	Mean Yield (Kg/ha)
		15 DAS	25 DAS	35 DAS	45 DAS		
	1	2	3	4	5	6	7
1	MH 1129	5.1 (2.46)	3.8 (2.15)	81.3 (9.01)	24.7 (5.06)	28.73 (5.43)	316.67
2	MH 1142	4.7 (2.37)	4.0 (2.23)	40.9 (6.41)	23.9 (4.95)	18.38 (4.40)	222.22
3	MH 1303	5.7 (2.58)	7.4 (2.87)	66.0 (8.18)	17.9 (4.18)	24.25 (5.01)	252.78
4	MH 1305	5.1 (2.47)	7.2 (2.82)	52.7 (7.32)	18.2 (4.34)	20.82 (4.65)	311.11
5	MH 1314	5.7 (2.59)	7.2 (2.84)	49.0 (7.06)	21.4 (4.73)	20.83 (4.67)	319.44
6	MH 1315	5.3 (2.48)	4.0 (2.20)	26.1 (5.18)	21.8 (4.77)	14.29 (3.91)	261.11
7	MH 1320	5.4 (2.52)	4.5 (2.35)	42.0 (6.40)	18.1 (4.15)	17.52 (4.30)	236.11
8	MH 1323	6.7 (2.78)	5.7 (2.58)	67.0 (8.21)	15.4 (3.92)	23.71 (4.97)	302.78
9	MH 1344	5.0 (2.44)	5.4 (2.48)	60.7 (7.82)	19.2 (4.38)	22.57 (4.83)	213.89
10	MH 1346	6.3 (2.71)	3.5 (2.09)	49.1 (6.97)	12.3 (3.59)	17.78 (4.29)	216.67
11	MH 1429	3.8 (2.19)	5.9 (2.51)	37.7 (5.95)	11.7 (3.40)	14.77 (3.86)	363.89
12	MH 1431	4.2 (2.25)	4.5 (2.34)	99.0 (9.97)	24.2 (4.87)	32.98 (5.83)	408.33
13	MH 1432	5.6 (2.55)	3.1 (2.00)	86.3 (9.34)	16.5 (4.14)	27.88 (5.37)	302.78
14	MH 1436	4.4 (2.30)	5.6 (2.49)	72.3 (8.36)	19.5 (4.37)	25.47 (5.11)	422.22
15	MH 1451	4.9 (2.41)	3.8 (2.10)	76.3 (8.79)	27.8 (5.36)	28.20 (5.40)	241.67
16	MH 1452	4.7 (2.35)	3.7 (2.13)	44.0 (6.49)	28.0 (5.38)	20.08 (4.53)	294.44
17	MH 1457	4.9 (2.40)	3.0 (1.91)	35.3 (5.13)	22.9 (4.72)	16.53 (3.99)	450
18	MH 1465	5.3 (2.50)	4.1 (2.24)	55.7 (7.26)	17.6 (4.22)	20.70(4.55)	286.11
19	MH 1467	4.5 (2.33)	4.1 (2.14)	32.9 (5.62)	13.7 (3.82)	13.82 (3.78)	575
20	MH 1468	5.5 (2.55)	3.4 (2.09)	42.9 (6.54)	16.1 (4.06)	16.98 (4.20)	330.56
21	MH 1489	6.3 (2.71)	4.6 (2.37)	56.8 (7.41)	16.1 (4.10)	20.96 (4.64)	255.56
22	MH 1703	5.2 (2.48)	4.8 (2.39)	88.7 (9.46)	22.5 (4.74)	30.30 (5.59)	336.11
23	MH 1704	5.3 (2.52)	5.1 (2.44)	76.0 (8.66)	19.1 (4.25)	26.38 (5.19)	241.67
24	Sattya	6.5 (2.73)	5.5 (2.53)	82.7 (9.13)	22.0 (4.62)	29.15 (5.48)	191.67
25	Basanti	5.4 (2.53)	7.3 (2.87)	77.3 (8.84)	20.3 (4.47)	27.58 (5.34)	152.78
26	MH 421	6.0 (2.62)	5.7 (2.58)	59.3 (7.76)	25.0 (5.09)	24.00 (5.00)	222.22
27	MH 318	5.9 (2.62)	6.2 (2.65)	16.8 (4.18)	25.7 (5.02)	13.65 (3.79)	344.44
	Range	3.8 - 6.7	3.0 - 7.4	16.8 - 99.0	11.7 - 28.0	13.65 - 32.98	152.8-575.0
	C.D	(N.S.)	(N.S.)	(2.42)	(N.S.)	(1.03)	192.99
	SE (m)	(0.16)	(0.27)	(0.85)	(0.65)	(0.36)	67.81

DAS: Days after sowing

Values in parenthesis are square root transformation values ($\sqrt{n+1}$)

Whitefly adult population was found at its peak during 35 DAS and significant differences among the different genotypes were observed. Minimum population of whitefly adults were occurred on MH 318 (16.8 adults/ plant) which was at par with MH 1315 (26.1 adults/plant), MH 1467 (32.9 adults/plant), MH 1457 (35.3 adults/plant), MH 1429 (37.7 adults/ plant), MH 1142 (40.9 adults/plant), MH 1320 (42.0 adults/plant), MH1468 (42.9 adults/plant) and MH 1452 (44.0 adults/plant). Maximum population of whitefly adults were found on the genotype, MH 1431 (99.0 adults/plant) and it was found at par with statistically differ from other varieties which was at par with MH 1432 (86.3 adults/plant), MH 1436

(72.3 adults/plant), MH 1451 (76.3 adults/plant), MH 1344 (60.7 adults/plant), MH 1323 (67.0 adults/plant), MH 1129 (81.3 adults/plant), MH 1303 (66.0 adults/plant), MH 1703 (88.7 adults/plant), MH 1704 (76.0 adults/plant), Sattya (82.7 adults/plant), Basanti (77.3 adults/plant) and MH 421 (59.3 adults/plant).

On the basis of overall mean, whitefly adults population showed significant differences among the different genotypes. The minimum population of whitefly adults were observed on MH 318 (13.65 whitefly adults/plant) and it was found at par with MH 1467 (13.82 whitefly adults/plant), MH 1315 (14.29 whitefly adults/plant), MH 1429 (14.77 whitefly adults/plant), MH 1457 (16.53 whitefly adults/plant), MH 1468 (16.98 whitefly adults/plant), MH 1320 (17.52 whitefly adults/plant), MH 1346 (17.78 whitefly adults/plant), MH 1142 (18.38 whitefly adults/plant), MH 1452 (20.08 whitefly adults/plant), , MH 1465 (20.70 whitefly adults/plant), MH 1305 (20.82 whitefly adults/plant), MH 1314 (20.83 whitefly adults/plant) and MH 1489 (20.96 whitefly adults/plant). However, maximum number of whitefly adult were recorded on genotype, MH 1431 (32.98 whitefly adults/plant), which was at par with MH 1432 (27.88 whitefly adults/plant), MH 1436 (25.47 whitefly adults/plant), MH 1451 (28.20 whitefly adults/plant), MH 1344 (22.57 whitefly adults/plant), MH 1323 (23.71 whitefly adults/plant), MH 1129 (28.73 whitefly adults/plant), MH 1303 (24.25 whitefly adults/plant), MH 1703 (30.30 whitefly adults/plant), MH 1704 (26.3857 whitefly adults/plant), Sattya (29.15 whitefly adults/plant), Basanti (27.58 whitefly adults/plant) and MH 421(24.00 whitefly adults/plant).

Grain yield performance of mungbean were significant each other among the genotypes. The highest yield was shown in genotype MH 1467 (575 kg/ha) which was at par with three genotypes MH1431(408.33 kg/ha), MH1436 (422.22 kg/ha), MH1457 (450.00 kg/ha) respectively and lowest yield was observed in genotype Basanti (152.78 kg/ha) which was at par with MH 1432(302.78 kg/ha), MH 1451(241.67 kg/ha), MH 1452 (294.44 kg/ha), MH1465(286.11kg/ha), MH 1468(330.56 kg/ha), MH 1489 (255.56 kg/ha), MH 1142 (222.22 kg/ha), MH 1344 (213.89 kg/ha), MH 1346 (216.67 kg/ha), MH1305(311.11 kg/ha), MH 1314 (319.44 kg/ha), MH 1315 (261.11 kg/ha), MH 1320 (236.11 kg/ha), MH1323 (302.78kg/ha), MH1129(316.67kg/ha), MH 1303 (252.78 kg/ha), MH 1703 (336.11kg/ha), MH 1704 (241.67 kg/ha), Sattya (191.67 kg/ha), MH 421 (222.22 kg/ha) and MH 318(344.44 kg/ha).

4.1.1 Brief account of meteorological parameters during course of investigations

Weather data (temperature, relative humidity and rainfall) was also recorded at weekly intervals initiating with the sowing of mungbean (July, 2018) and continued till the harvesting of the crop (Table-4). The average rainfall data indicated that maximum rainfall was received during the month of August (146.9mm) followed by of July (140.7 mm) (Fig. 1).

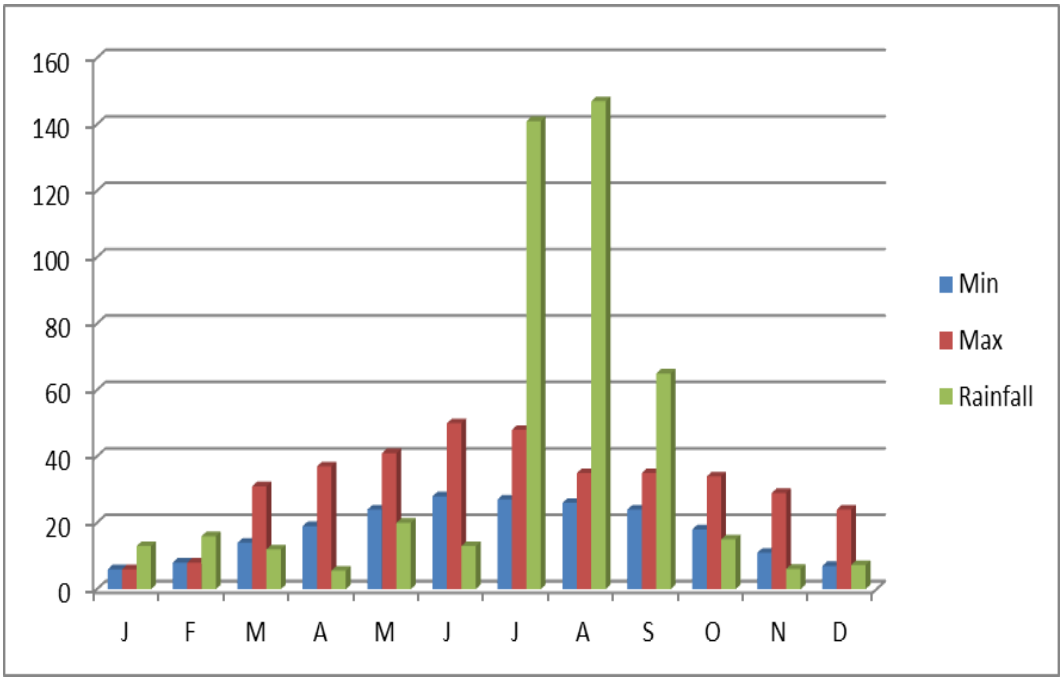


Fig 1: Mean weekly meteorological data during crop season *kharif*, 2018.

Table 4: Data on abiotic factors (Temp., R.H. and Rainfall) during *Kharif*, 2018

Standard metrological week (SMW)	Temp. (^{0}C)			Relative humidity (%)			Rainfall (mm) /week	Wind Speed (Km/h)	Bright Sun Shine Hours (h)
	Max.	Min.	Av.	Mor.	Eve.	Av.			
29	34	26.9	30.5	92.6	86.9	89.8	5.0	4.9	3.9
30	33.3	26.5	29.9	95.3	78.1	86.7	13.4	4.4	2.9
31	36.1	26.5	31.3	80.0	54.9	67.5	0.0	6.7	6.1
32	32.8	26.3	29.6	91.1	75	83.1	3.2	6.4	2.7
33	35.5	27	31.3	87.6	63.1	75.4	5.3	6.6	6.3
34	36.1	27.2	31.7	91.1	64.2	77.7	0.2	6.6	4.5
35	35.6	26.5	31.1	86.9	61.8	77.5	0.0	6.1	5.3
36	33.9	25.6	29.8	89.9	72.9	81.4	1.2	5.3	3.3
37	33.9	23.9	28.9	90.1	64.6	77.4	6.2	7.5	6.5

4.1.3. Correlation between whitefly population and weather parameter

Whitefly adults population in all the genotypes were recorded at 15, 25, 35 and 45 days after sowing and correlated with weather parameters (Table 5). Data presented in Table 6 and Fig.2, revealed that maximum temperature (r=0.773) and morning relative humidity (r=0.076) exhibited non-significant and positive correlation with whitefly adult population, whereas the minimum temperature (r= 0.962*) and bright sun shine hours (r=0.957*) showed significant and positive correlation with whitefly adult population. However, whitefly adult population was showed non-significant and negative correlation with evening relative humidity (r= -0.839), wind speed (r= -0.016) and rainfall (r= -0.571).

Table 5: Weather parameters and mean whitefly adult population on different genotypes

Days after sowing	Mean population of Whitefly adults/plant	Temp. (^{0}C)		Relative humidity (%)		Rainfall (mm) /week	Wind Speed (Km/h)	Bright Sun Shine Hours (h)
		Max.	Min.	Mor.	Eve.			
15	5.3	22.5	3.8	94.1	45.6	0.0	2.3	6.8
25	4.9	19.4	7.2	97.6	71.7	1.1	2.4	4.5
35	58.3	22.4	4.7	89.4	65.5	0.0	1.7	7.3
45	20.1	23.8	8.1	90.9	49.9	0.1	3.0	6.2

Table 6: Correlation of weather parameters with whitefly population in different genotypes

Meteorological parameter	Correlation Coefficient
Max. Temperature ($^{\circ}$C)	0.773
Min. Temperature (^{o}C)	0.962*
Relative Humidity Morning (%)	0.076
Relative Humidity Evening (%)	-0.839
Wind speed (Km/hour)	-0.016
Bright sunshine hours	0.957*
Rainfall (mm)	-0.571

* Significant at 5% level

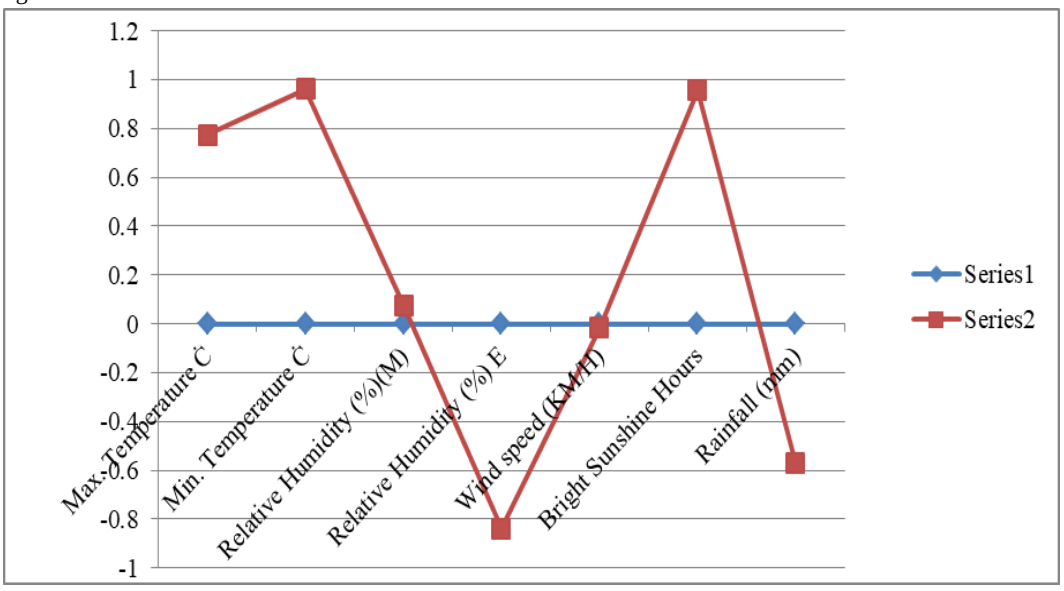


Fig. 2: Correlation between whitefly population and weather parameter

Series1- Weather parameter, series2 – whitefly adults

4.3 Eco-friendly management practices for the management of whitefly on mung bean genotype MH-421

Nine different spray sequences along with untreated control were evaluated to determine their efficacy against whitefly *B. tabaci* on mungbean genotype MH- 421. The results were presented in the Table (7) and the observations were recorded one day before spray, three days, five days and seven days after each spray in different treatments.

4.3.1 Whitefly adults population after first and second spray.

Different bio rationals were evaluated against whitefly in mungbean crop variety MH 421. The crop was sprayed two times i.e. 5.8.2018 (First spray) and 20.8.2018 (second spray). Whitefly adults was recorded before spray (BS) in each treatment and the recorded at 1, 3 and 7 days after spray (DAS). The results showed that a day before imposition of treatments the whitefly adult populations did not differ significantly indicating a uniform distribution of whitefly in the experimental plot (Table-7). The populations of whitefly adults reduced in all the treatments at one day after first spray but differences among treatments were found non-significant.

Minimum whitefly adults (13.60 adults/plant) were recorded in treatment T_2 i.e., NSKE 5% aqueous extract sprayed plot after 3 days of first spray and it was found at par with which was at par with T_1 (NSKE 5% (methanolic extract) : 20.10 whitefly/plant), T_3 (Neem oil 1% (crude) : 13.73 whitefly/plant), T_4 (Neem oil 2% (crude) : 18.40 whitefly/plant), T_5, T_7 and T_6 (Foliar spray of *Beauveria bassiana* @1250 g/ha : 17.33, 18.93 and 20.47 whitefly adults/plant, respectively).

At 7 days after spray, minimum whitefly adults (10.13 adults/plant) were recorded in T_1 i.e. NSKE 5% (methanolic extract) sprayed plot and it was found at par with T_2 (NSKE 5% aqueous extract: 14.93 whitefly/plant) and T_3 (Neem oil 1% (crude): 15.33 whitefly/plant). There was increase in whitefly adults population in all the treatments except T_1 (NSKE 5% methanolic extract) at 7 days after spray. Foliar spray of *Beauvaria bassiana* (T_5, T_6 and T_7) and Neemastra (T_8) were not able to keep the population of whitefly under check.

The populations of whitefly adults were observed lesser in the second spray than the first, although the differences among the treatments before spray were not significant. Minimum whitefly adults (4.33 whitefly/plant) population was recorded in T_4 i.e. Neem oil 2% (crude) sprayed plot which was at par with T_1 (NSKE 5%: methanolic extract) and T_2 (NSKE 5% : aqueous extract). However, at three day after second spray, it was lowest in T_2 (NSKE 5% aqueous extract : 4.13 whitefly/plant) which was at par with T_1 (NSKE 5% methanolic extract : 5.53 whitefly/plant), T_3 (Neem oil 1% crude : 5.8 whitefly/plant), T_4 (Neem oil 2% crude : 5.27 whitefly/plant), T_5 (spray of *Beauveria bassiana* @1250g/ha : 6.07 whitefly/plant) and T_6 (NSKE 5% methanolic extract : 7.53 whitefly/plant). Similarly minimum whitefly adult populations (4.00 adults/plant) was recorded in T_2 (NSKE 5% aqueous extract) at seven days after second spray and it was at par with T_1 (NSKE 5% methanolic extract: 5.8 whitefly/plant), T_3 (Neem oil 1% crude : 5.6 whitefly/plant), T_4 (Neem oil 2% crude : 5.73 whitefly/plant and T_5 (spray of *Beauveria bassiana* @1250 g/ha : 8.20 whitefly/plant). The maximum whitefly populations (20.0 whitefly/plant) were observed in T_9 untreated control.

4.3.2 Whitefly adult population during first and second sprays and grain yield

The mean whitefly adult populations showed significant differences among all the treatments after first and second spray (Table 8). The lowest whitefly adults populations were observed in T_4 i.e. Neem oil 2% (crude): 17.68 whitefly adults/plant in first spray which was at par with the T_1 (NSKE 5% methanolic extract : 21.87 whitefly adults/plant), T_2 (NSKE 5% aqueous extract : 19.13 whitefly adults/plant), T_3 (Neem oil 1% crude : 20.70 whitefly adults/plant and T_5 (spray of *Beauveria bassiana* @ 1250 g/ha : 23.88 whitefly adults /plant). The maximum population of whitefly were occurred on T_9 (untreated control : 35.58 whitefly adults /plant).

During the second spray, the lowest populations of whitefly adult were recorded in T_2 (NSKE 5% aqueous extract : 7.00 whitefly adults/plant) which was found at par with T_1 (NSKE 5% methanolic extract : 8.18 whitefly adults/plant), T_4 i.e. Neem oil 2% (crude) : 7.08 whitefly adults/plant) T_3 (Neem oil 1% crude : 7.60 whitefly adults/plant) and T_5 (spray of *Beauveria bassiana* @1250g/ha : 8.27 whitefly adults/plant). The maximum population of whitefly were occurred on the untreated control (29.70 whitefly adults/plant).

On the basis of overall mean of first and second spray, the populations of whitefly adult were lowest in T_4 i.e. Neem oil 2% (crude) (12.38 whitefly adults/plant) which was found at par with T_1 (NSKE 5% methanolic extract : 15.03 whitefly adults/plant), T_2 (NSKE 5% aqueous extract : 13.07 whitefly adults/plant), T_3 (Neem oil 1% crude : 14.15 whitefly adults/plant) and T_5 (spray of *Beauveria bassiana* @1250g/ha : 16.08 whitefly adults/plant). The maximum population of whitefly were occurred on the untreated control (29.70 whitefly adults/plant) which was at par with Neemastra i.e. 22.78 whitefly adults/plant (Table 8). However, the maximum grain yield was obtained in T_1 NSKE 5% (methanolic extract): (259.26 kg/ha) which was at par with T_2 NSKE 5% (aqueous extract): (217.41) and T_4 Neem oil 2% (crude): (221.11 kg/ha). The lowest yield was recorded in the untreated control T_9 : (152.22 kg/ha) which was found at par with T_6 *Beauveria bassiana* @1250 g/ha alternated with NSKE 5% (methanolic extract) : (192.59 kg/ha), T_7 *Beauveria bassiana* @1250 g/ha alternated with Neem oil 2% : (187.41 kg/ha) and T_8 Neemastra : (168.52 kg/ha), respectively.

Table 7: Evaluation of different bio-rationals against whitefly on mungbean variety, MH – 421 (First and second spray)

Tr. No.	Treatments	Whitefly adults/plant								
		Before Spray	First spray				Before Spray	Second spray		
			1 DAS	3 DAS	7 DAS	Av.		1 DAS	3 DAS	7 DAS	Av.
T_1	NSKE 5% (Methanolic extract)	34.87 (5.97)	22.33 (4.70)	20.10 (4.59)	10.13 (3.32)	21.87 (4.77)	15.80 (4.08)	5.60 (2.55)	5.53 (2.55)	5.80 (2.61)	8.18 (3.03)
T_2	NSKE 5% (Aqueous extract)	34.07 (5.91)	13.93 (3.80)	13.60 (3.81)	14.93 (3.99)	19.13 (4.48)	13.53 (3.78)	6.33 (2.71)	4.13 (2.27)	4.00 (2.22)	7.00 (2.83)
T_3	Neem oil 1% (Crude)	29.27 (5.47)	17.33 (4.15)	18.40 (4.34)	17.80 (4.28)	20.70 (4.62)	12.97 (3.71)	6.00 (2.64)	5.80 (2.59)	5.60 (2.56)	7.60 (2.91)
T_4	Neem oil 2% (Crude)	28.00 (5.29)	13.67 (3.83)	13.73 (3.81)	15.33 (4.02)	17.68 (4.31)	12.97 (3.73)	4.33 (2.30)	5.27 (2.50)	5.73 (2.57)	7.08 (2.86)
T_5	Foliar spray of *Beauveria bassiana* @ 1250 g/ha	30.60 (5.61)	20.00 (4.53)	17.33 (4.27)	27.60 (5.33)	23.88 (4.98)	12.47 (3.64)	6.33 (2.71)	6.07 (2.62)	8.20 (3.02)	8.27 (3.01)
T_6	Foliar spray of *Beauveria bassiana* @1250 g/ha alternated with NSKE 5% (Methanolic extract)	37.33 (6.17)	37.00 (5.91)	20.47 (4.62)	25.60 (5.13)	30.10 (5.53)	14.53 (3.82)	10.6 (3.40)	7.53 (2.92)	10.00 (3.24)	10.67 (3.41)
T_7	Foliar spray of *Beauveria bassiana* @1250 g/ha alternated with Neem oil 2%	39.53 (6.30)	38.00 (6.05)	18.93 (4.39)	22.67 (4.84)	29.78 (5.51)	22.33 (4.77)	10.07 (3.32)	13.40 (3.69)	12.67 (3.67)	14.62 (3.93)
T_8	Neemastra @ 25 l/ha	35.67 (5.97)	35.33 (5.93)	23.13 (4.85)	23.67 (4.95)	29.45 (5.46)	23.00 (4.86)	9.67 (3.26)	19.27 (4.49)	12.47 (3.67)	16.10 (4.13)
T_9	Untreated (Control)	29.93 (5.56)	29.00 (5.47)	44.10 (6.66)	39.27 (6.33)	35.58 (6.03)	27.33 (5.26)	24.27 (5.02)	23.67 (4.94)	20.0 (4.57)	23.82 (4.98)
C.D.(P=0.05)		(N.S.)	(N.S.)	(0.97)	(0.91)	(1.01)	(N.S.)	(0.45)	(0.65)	(0.77)	(0.46)
S.E.(m)±		(0.40)	(0.59)	(0.32)	(0.30)	(0.34)	(0.45)	(0.15)	(0.22)	(0.26)	(0.15)

BS : Before spray, DAS : Days after spray

Values in parenthesis are square root transformation values

Table 8: Whitefly adult population on mungbean variety, MH 421 after spray and grain yield (Kg/ha) during *Kharif*, 2018

Tr. No.	Treatments	Whitefly adults/plant after			Grain yield (Kg/ha)
		First spray	Second spray	Mean	
T_1	NSKE 5% (Methanolic extract)	21.87 (4.77)	8.18 (3.03)	15.03 (3.99)	259.26
T_2	NSKE 5% (Aqueous extract)	19.13 (4.48)	7.00 (2.83)	13.07 (3.75)	217.41
T_3	Neem oil 1% (Crude)	20.70 (4.62)	7.60 (2.91)	14.15 (3.87)	197.04
T_4	Neem oil 2% (Crude)	17.68 (4.31)	7.08 (2.86)	12.38 (3.66)	221.11
T_5	Foliar spray of *Beauveria bassiana* @ 1250 g/ha	23.88 (4.98)	8.27 (3.01)	16.08 (4.13)	198.89
T_6	Foliar spray of *Beauveria bassiana* @1250 g/ha alternated with NSKE 5% (Methanolic extract)	30.10 (5.53)	10.67 (3.41)	20.38 (4.60)	192.59
T_7	Foliar spray of *Beauveria bassiana* @1250 g/ha alternated with Neem oil 2%	29.78 (5.51)	14.62 (3.93)	22.20 (4.79)	187.41
T_8	Neemastra @ 25l/ha	29.45 (5.46)	16.10 (4.13)	22.78 (4.86)	168.52
T_9	Untreated (Control)	35.58 (6.03)	23.82 (4.98)	29.70 (5.53)	152.22
C.D.(P=0.05)		(1.01)	(0.46)	(0.68)	(42.07)
S.E.(m)±		(0.34)	(0.15)	(0.22)	(13.91)

BS : Before spray, DAS : Days after spray, Values in parenthesis are square root transformation values

4.4 Population dynamics of major insect pests of mungbean

Major insect-pests and natural enemies of mungbean crop on variety MH 318 were recorded during different standard meteorological weeks (SMW) initiating with 29th SMW i.e. 22 July 2018. The data presented in Table revealed that on variety MH 318, whitefly adults; *Bemisia tabaci*, leafhopper; *Empoasca kerri* nymphs, pod bug; *Riptortus pedestris* reached at their peaks during 31st (9.6 whitefly/3 leaves/plant), 32nd (6.0 nymphs/3leaves/plant) and 34th (1 adult/plant) SMW, respectively. However, spotted pod borer; *Maruca vitrata*, tobacco caterpillar; *Spodoptera litura*, Blister beetle; *Mylarbris pustulata* reached its peak during 33rd (3.3 larvae/plant), 31st (5.25 larvae/plant), 30th, 32nd and 33rd (1 adult/plant), respectively. Blue butterfly *Polyommatus icarus* reached its peak 30th, 36th and 37th (1 adult/plant) respectively. Among natural enemies, yellow wasp; *Ropalidia marginata* start appearing from 29th SMW (0.7/plant) and attained its peak during 36th SMW (1 wasp/plant).

Table9: Insect-pests populations on mungbean var., MH 318 during the different standard meteorological week (SMW)

SMW	Number of insect-pests and natural enemies /plant								
	B. tabaci/ 3 leaves	*E. kerri*/ 3 leaves	*R. pedestris*	*M. vitrata*	*S. litura*	*P. icarus*	*M. pustulata*	*R. marginata*	*O. versicolor*
29	4.2	0.2	0.7	0.6	2.75	0.8	0.3	0.70	0.50
30	4.5	0.1	0.1	1.7	4.50	1.0	1.0	0.65	0.50
31	9.6	1.0	0.2	2.1	5.25	0.2	0.5	0.55	0.50
32	4.6	6.0	0.0	1.2	3.00	0.2	1.0	0.40	0.50
33	8.3	0.0	0.2	3.3	0.75	0.3	1.0	0.40	0.75
34	5.5	0.0	1.0	2.2	0.80	0.3	0.0	0.50	1.10
35	4.4	0.0	0.1	2.0	1.50	0.2	0.6	0.45	0.20
36	3.6	0.0	0.6	3.2	2.60	1.0	0.7	1.00	0.60
37	2.0	0.4	0.0	1.1	3.00	1.0	0.5	0.00	0.85

Table 10: Insect-pests populations on mungbean var., MH 421 during the different standard meteorological week (SMW)

SMW	Number of insect-pests and natural enemies /plant								
	B. tabaci/ 3leaves	*E. kerri*/ 3 leaves	*R. pedestris*	*M. vitrata*	*S. litura*	*P. icarus*	*M. pustulata*	*R. marginata*	*O. versicolor*
29	5.1	0	1.4	3.2	2.5	1.2	0.6	0.8	1.25
30	3.6	0.5	0.2	1	3.25	1	0.02	0.8	1.25
31	9.8	0.06	0.4	1.3	3.75	0.42	0.28	0.8	0.5
32	5.3	0.6	0	1.1	2.5	0.4	0.24	0.8	1
33	7.1	0.6	0.2	1.3	3.3	0.46	0.2	0.8	0.75
34	8.5	0.4	0.2	1	3.3	0.6	0.4	0.6	0.78
35	7.2	0.2	0.2	2.3	2.2	0.44	1	0.6	1.2
36	6	0.4	1.2	0	2	1	0.8	0.4	1
37	3	0.4	1	2.1	1.1	0.4	0.6	0.4	1.1

The data presented in Table 10 revealed that on variety MH 421, whitefly adults; *B. tabaci*, leafhopper; *E. kerri* nymphs, pod bug; *R. pedestris* reached at its peaks during 31st (9.8 whitefly/3 leaves/plant), 32nd and 33th (0.6 nymph/3leaves/plant) and 29th (1.4adult/plant) SMW, respectively. Spotted pod borer; *M. vitrata*, tobacco caterpillar; *S.litura*, Blue butterfly; *P.icarus* reached its peak during 29th (3.2 larvae/plant), 31st (3.75 larvae/plant) and 29th (1.2 adult/plant) SMW, respectively. Blister beetle; *M. pustulata* reached its peaks during 35th (1 adult/plant). Among natural enemies, yellow wasp; *R. marginata* was found distributed uniformly throughout the crop season. Flower chafer beetle; *O. versicolor* reached at its peak on 29th and 30th (1.25/plant) and the lowest population occurred in 31th (0.5/plant).

Whitefly population exhibited significant and positive (r=0.843*) correlation with maximum temperature, whereas association was found negative and significant with relative humidity (r=-743*) and rainfall (r=-747*) in variety MH 421 (Table 11). Negative and significant association of whitefly was observed with relative humidity (eve. r=-0.646*) in MH 318. Sunshine hours exhibited positive and non significant correlation with whitefly.

Table 11: Correlation of weather parameters with insect-pests of mungbean crop on varieties MH 318 and MH 421

Weather parameter	Correlation co-efficient																	
	Whitefly		Leafhopper		Pod bug		Spotted pod borer		Tobacco caterpillar		Blue butterfly		Blister beetle		Flower Chafer beetle		Yellow wasp	
	MH 421	MH 318	MH 421	MH 318	MH 421	MH 318	MH 421	MH 318	MH 421	MH 318	MH 421	MH 318	MH 421	MH 318	MH 421	MH 318	MH 421	MH 318
Max. Temp. (°C)	0.843*	0.635	-0.359	-0.492	-0.240	0.329	0.059	0.445	0.467	-0.327	-0.378	-0.573	0.157	-0.504	-0.639	0.205	0.019	-0.073
Min. Temp. (°C)	0.579	0.595	-0.115	-0.023	-0.423	0.426	0.007	0.207	0.810*	-0.250	0.193	-0.556	-0.294	-0.073	-0.232	-0.107	0.706*	0.432
R. H. (Mor.) (%)	-0.743*	-0.686*	0.394	0.034	0.149	0.190	0.027	-0.336	-0.275	-0.174	0.578	0.565	-0.142	0.105	0.742*	0.181	-0.053	0.117
R. H. (Eve.) (%)	-0.627	- 0.516	0.002	0.156	0.430	0.216	0.213	-0.471	-0.199	0.088	0.800*	0.537	-0.066	0.125	0.708*	-0.166	0.195	0.408
Rainfall	-0.747*	-0.259	0.359	-0.081	0.001	-0.347	0.064	-0.269	-0.007	0.318	0.383	0.597	-0.551	0.490	0.503	-0.011	0.266	-0.097
Winds	0.279	0.179	0.142	-0.186	-0.225	-0.227	0.034	0.071	-0.186	-0.241	-0.88*	-0.448	0.068	-0.208	-0.551	0.429	-0.286	-0.764*
Sunshine	0.167	0.502	0.408	-0.179	-0.236	-0.135	-0.06	0.560	0.285	-0.471	-0.255	-0.261	-0.297	0.392	-0.350	0.207	0.276	-0.185

Leafhopper nymphs population showed negative and positive non -significant correlation with temperature (max. and min.) and relative humidity (morning and evening), respectively in both the varieties. However, pod bug population showed negative and non - significant correlation with wind and sunshine hours in both the varieties. Similarly the correlation was negative and non- significant with temperature (maximum and minimum) in MH 421, while positive and significant in MH 318, respectively. Spotted pod borer population showed positive and non- significant association with temperature (max. and min.) and winds. However, relative humidity and rainfall showed non-significant positive and negative association in MH 421 and MH 318, respectively. The populations of tobacco caterpillar and blue butterfly showed significant positively correlation with the minimum temperature (r=0.810*) and evening relative humidity (r=0.800*), respectively in MH 421. Wind (r= -0.88*) was found significantly and negatively correlated with blue butterfly population. However, other remaining factors showed positive and negative, non-significant correlation with population of tobacco caterpillar. Blister beetle population showed non - significant positive and negative correlation with all the weather parameters. Flower chafer beetle population was found significantly positively correlated with relative humidity (r=0.742* and 0.708*) in MH 421. Yellow wasps showed significant and positive correlation with temperature (r=0.706*) and negative correlation with winds speed (r=-0.764*).

CHAPTER–V

DISCUSSION

The results of the experiment entitled "Ecofriendly management and screening of mungbean (*Vigna radiata* L.) genotypes against whitefly (*Bemisia tabaci* Gennadius)" carried out during *Kharif* , 2018 are briefly discussed under the following sub heads.

5.1 Screening of mungbean genotypes against whitefly

Studies on screening of different mungbean genotypes against whitefly were conducted by various worker earlier. Present studies on screening were conducted on 27 genotypes including recommended varieties; Sattya, Basanti, MH 421 and MH 318.

5.1.1 Response of mungbean genotypes against whitefly

Whitefly nymph and adult population was found at its peak at 35 days after sowing (32nd SMW) and then decreased gradually at 45 DAS. Minimum number of whitefly nymphs and adults was recorded in MH 1344 (4.0 whitefly nymph/3 leaves and 16.8 adults/plant), and maximum whitefly nymphs and adults occurred on genotype, MH 1315 (38.60 nymph/3 leaves) and MH 1431 (99.0 adults/plant), respectively at 35 DAS. On the basis of overall mean whitefly nymphs ranged from 2.20 to 11.68 nymphs/three leaves, with minimum (2.20 whitefly nymph/three leaves) population on MH 318 and maximum (11.68 whitefly/three leaf) on MH 1315, respectively. However, minimum and maximum whitefly adults were recorded on MH 318 (13.65 whitefly adults/plant) and MH 1431 (32.98 whitefly adults/plant), respectively. Maximum and minimum grain yield was obtained in genotype MH 1467(575.0 kg/ha) and Basanti (152.78 kg/ha), respectively. Minimum and maximum population of whitefly on different genotypes have also been reported by different worker on different genotypes *viz*.. SM 9-117 (8.3/cage/plant) and MH 732 (2.68 per cage per plant) by Narasimhudu. (2011); resistant checks, ML 267 (1.33 adults/5 plants) and KM 200 (1.55 adults/5 plants) and susceptible check, WGG 2 (9.11 adults/5 plants) by Panduranga, *et al*. (2011). Promising genotypes against whitefly viz. MH 412 and MH 435 (Panghal, 2006), ML 5, ML 803, ML 839, PDM 91-249 and PMB 5 (Yadav and Dahiya, 2000), ML 1265 and ML 1229 (Kooner, 2006), PDM 76, ML 325, ML 326 (Lakshminarayan *et al.,* 2007) have also reported by various workers from different locations.

5.1.2 Correlation between whitefly population and weather parameter

Correlation of whitefly with the maximum (r = 0.773), minimum (r = 0.962*) temperature and bright sunshine hours (r=0.957*) was positive and significant. The present findings are in accordance with the results of Kumar *et al*. (2004) who reported positive correlation of temperature and sunshine hours with whitefly in mungbean crop. Contrary to

this, Yadav and Singh (2013) reported significant and negative correlation of whitefly adults with maximum temperature, sunshine and evaporation.

Rainfall (mm), wind speed (Km/h) and relative humidity (evening) were negatively correlated (r = -0.571, r = -0.016, r= -0.839) with the whitefly adult populations, respectively in all genotypes. These results are in confirmation with the finding of Ghosh *et al*. (2004), Panghal (2006) and Patil (2018) who reported negative and non-significant correlation with average humidity and rainfall.

5.2 Eco friendly management practices for the management of whitefly in mungbean

Different bio-rationals were evaluated against whitefly in mungbean crop variety, MH 421. Whitefly adults population was recorded before spray (BS) in each treatment and then recorded at 1, 3 and 7 days after first and second spray. Before imposition of spray the whitefly adult populations did not differ significantly indicating a uniform distribution of whitefly in the experimental plot. After 7 days of first spray, minimum populations of whitefly were recorded in the treatment T_1 (NSKE 5% Methanolic extract: 10.13 whitefly /plant). The present findings are in confirmation with Panghal (2006) who reported a drastic decrease in the adults population after spray of NSKE 5%.

On mean basis the lowest whitefly adults populations were observed in T_4 i.e. neem oil 2% (crude) : 17.68 whitefly adults/plant in first spray. The studies are in accordance with Mehra *et. al*. (2018) who reported spray of nimbecidine 300 ppm @ 5ml/l as most effective at 5 days interval.

However, during second spray minimum whitefly adult were recorded in T_2 (NSKE 5% aqueous extract : 7.00 whitefly adults/plant). On the basis of overall mean of first and second spray, T_4 i.e. neem oil 2% (crude) was found most effective (12.38 whitefly adults/plant) treatment. Maximum grain yield was obtained in T_1 (NSKE 5% Methanolic extract: 259.26 kg/ha) After the spray of two times, the mean populations of whitefly adult were lowest in the treatment T_4 Neem oil 2% (crude) : 12.38 whitefly/cage/plant and at par with T_1 NSKE 5% Methanolic extract: 15.03 whitefly adults/cage/plant, T_2 (NSKE 5% Aqueous extract:13.07 whitefly adults/cage/plant,T_3 Neem oil 1% crude: 14.15 whitefly adults/cage/plant. Significantly reduced whitefly adult populations was observed in NSKE and Neem oil based insecticides.

5.3 Population dynamics of major insect pests of mungbean

Major insect-pests and natural enemies of mungbean crop (varieties MH 318 and MH 421) were recorded during different standard meteorological weeks (SMW). On variety MH 318, peak population of different pests *viz*., whitefly adults, leafhopper nymphs, pod bug, spotted pod borer and tobacco caterpillar were observed during 31st (9.6 whitefly/3 leaves), 32nd (6.0 nymphs/3leaves), 34th (1.0 adult/plant), 33rd (3.3 larvae/plant), 31st (5.25 larvae/plant), SMW, respectively. However, blister beetle attained its peak during 30th, 32nd

and 33rd (1 adult/plant) SMW and blue butterfly (*Polyommatus icarus*) reached its peak at 30th, 36th and 37th (1 adult/plant). Among natural enemies, yellow wasp; *R. marginata* was found distributed uniformly throughout the crop season on both the varieties. However, on variety MH 421, whitefly adults; *B. tabaci*, leafhopper; *E. kerri* nymphs, pod bug; *R. pedestris*, spotted pod borer, tobacco caterpillar, blue butterfly and blister beetle reached at their peaks during 31st (9.8 whitefly/3 leaves/plant), 32nd and 33th (0.6 nymph/3leaves/plant), 29th (1.4adult/plant), 29th (3.2 larvae/plant), 31st (3.75 larvae/plant), 29th (1.2 adult/plant) and 35th (1 adult/plant) SMW, respectively.

Various workers conducted studies at different locations and reported peaks as detailed. Jain (2014) found the peak population of whitefly, leafhopper, blister beetle and pod borer during third week of August, first week of September, first and third week of September, respectively in mungbean.

Yadav and Singh (2015) reported peak activity of pod bug reached in 38th standard week. Spotted pod borer larvae in mungbean attained its peak activity during first week of December (Sravani, 2015) coinciding with peak flowering and pod development stage, then the larval population declined gradually. Patil (2018) reported peak of whitefly in mungbean during 20th SMW. Khamoriya *et al*. (2017) reported peaks of pod bug reached during 9th and 10th standard weeks. Makwana *et al.* (2018) reported that the maximum number of leafhopper (16.4 leafhopper/3 leaves/plant) was observed during 16th week after sowing in cotton.

5.3.1 Correlation of major insect-pests with weather parameter

Whitefly population exhibited significant and positive (r=0.843*) correlation with maximum temperature, whereas association was found negative and significant with relative humidity (r=-743*) and rainfall (r=-747*) in variety MH 421. The present findings are in accordance of Marabi *et al.* (2017) who reported positive and significant correlation of whitefly with maximum temperature and highly significant and negative correlation with rainfall. Singh and Butter (1985), Rote and Puri (1991) also reported positive and negative association of whitefly with temperature and relative humidity, respectively. Contrary to this Yadav and Singh (2013) reported negative correlation of whitefly with maximum temperature. Sunshine hours exhibited positive and non significant correlation with whitefly, the findings are in accordance with those conducted by Kumar *et al.* (2004) in mungbean. As the temperature and sunshine hours decreased, the whitefly population also decreased. Heavy rainfall and relative humidity adversely affected the population of whitefly and sharply decline in the population was observed. In variety MH 318, negative and significant association of whitefly was observed with relative humidity (eve. r=-0.646*). The present findings are in accordance with Mehra and Rolania (2017) who reported negative correlation of whitefly with evening relative humidity in cotton crop.

Leafhopper nymphs population showed negative and positive non significant correlation with temperature (max. and min.) and relative humidity (morning and evening), respectively in both the varieties. The findings are in confirmation with those conducted by Yadav and Singh (2015) and reported positive correlation of leafhopper population with average relative humidity.

However, pod bug population showed negative and non significant correlation with wind and sunshine hours in both the varieties. Similarly the correlation was negative and non significant with temperature (maximum and minimum) in MH 421, while positive and significant in MH 318, respectively. The results are in confirmation with those reported by Yadav and Singh (2015) and Khamoriya *et al*. (2017).

Spotted pod borer population showed positive and non significant association with temperature (max. and min.) and winds. However, relative humidity and rainfall showed non-significant positive and negative association in MH 421 and MH 318, respectively.

The populations of tobacco caterpillar and blue butterfly showed significant positively correlation with the minimum temperature (r=0.810*) and evening relative humidity (r=0.800*). The present findings are in confirmation with Khan and Talukder (2017) who also reported positive correlation between population of *Spodoptera litura* and temperature. Contrary to this, Yadav and Singh (2015) reported negative association of tobacco caterpillar and spotted pod borer with minimum temperature on mungbean.

Chafer beetle population was found significantly positively correlated with relative humidity (r=0.742* and 0.708*) in MH 421. Yellow wasps showed significant and positive correlation with temperature (r=0.706*) and negative correlation with winds speed (r=-0.764*). Blister beetle population showed non-significant positive and negative correlation with all the weather parameters

CHAPTER–VI

SUMMARY AND CONCLUSION

The present investigation on "Ecofriendly management and screening of mungbean genotypes against whitefly (*Bemisia tabaci* (G))" were carried out during *Kharif* season of 2018 at the Pulses Section Research Farm, College of Agriculture, Chaudhary Charan Singh Haryana Agricultural University, Hisar. Screening of twenty seven mungbean genotypes was carried out and results revealed that none of the genotype was completely free from whitefly incidence.

Whitefly nymph and adult population was found at its peak at 35 days after sowing. Genotype MH 1344 harboured minimum number of whitefly nymphs and adults (4.0 whitefly nymph/3 leaves and 16.8 adults/plant), while MH 1315 and MH 1431 harboured maximum whitefly nymphs (38.60 nymphs/3plants) and adults (99.0 adults/plant), respectively at 35 DAS. Overall mean whitefly nymphs ranged from 2.20 to 11.68 nymphs/three leaves, with minimum (2.20 whitefly nymph/three leaves) population on MH 318 and maximum (11.68 whitefly/three leaf) on MH 1315, respectively. Similarly minimum and maximum whitefly adults were recorded on MH 318 (13.65 whitefly adults/plant) and MH 1431 (32.98 whitefly adults/plant), respectively. Maximum and minimum grain yield was obtained in genotype, MH 1467 (575.0 kg/ha) and Basanti (152.78 kg/ha), respectively.

Studies conducted on correlation of whitefly with weather parameter revealed the positive and significant correlation of maximum (r = 0.773), minimum (r = 0.962*) temperature and bright sunshine hours (r=0.957*) with whitefly population. However, whitefly population was found negatively correlated with rainfall (r = -0.571), wind speed (r = -0.016) and evening relative humidity (r= -0.839) in all genotypes.

Evaluation of different bio-rationals against whitefly on variety MH 421 was carried out and results demonstrated that before spray whitefly adult populations did not differ significantly indicating a uniform distribution of whitefly. Minimum whitefly adult population (10.13 whitefly /plant) was observed in NSKE 5% (methanolic extract) sprayed plot (T_1) after 7 days of first spray. On mean basis the lowest whitefly adults populations (17.68 whitefly adults/plant) was observed in Neem oil 2% (crude) (T_4) in first spray. However, during second spray minimum whitefly adult (7.00 whitefly adults/plant) were recorded in (T_2) (NSKE 5% aqueous extract). Neem oil 2% (crude) (T_4) was found most effective (12.38 whitefly adults/plant) treatment on the basis of overall mean of first and second spray. Whereas maximum grain yield (259.26 kg/ha) was obtained in (T_1) (NSKE 5% methanolic extract). Minimum yield was recorded in the untreated control (T_9) (152.22 kg/ha).

Studies on population dynamics of major insect-pests and natural enemies of mungbean crop (MH 318 and MH 421) was also conducted. Peak population of whitefly

adults, leafhopper nymphs, pod bug, spotted pod borer and tobacco caterpillar were observed during 31st (9.6 whitefly/3 leaves), 32nd (6.0 nymphs/3leaves), 34th (1.0 adult/plant), 33rd (3.3 larvae/plant), 31st (5.25 larvae/plant), SMW, respectively on MH 318. However, blister beetle attained its peak during 30th, 32nd and 33rd (1 adult/plant) SMW and blue butterfly reached its peak at 30th, 36th and 37th (1 adult/plant). Yellow wasp was found distributed uniformly throughout the crop season on both the varieties. However, on variety MH 421, whitefly adults, leafhopper; nymphs, pod bug, spotted pod borer, tobacco caterpillar, blue butterfly and blister beetle reached at their peaks during 31st (9.8 whitefly/3 leaves/plant), 32nd and 33th (0.6 nymph/3leaves/plant), 29th (1.4adult/plant), 29th (3.2 larvae/plant), 31st (3.75 larvae/plant), 29th (1.2 adult/plant) and 35th (1 adult/plant) SMW, respectively.

Studies conducted on correlation of weather parameter and insect pest and natural enemies of mungbean crop revealed that whitefly exhibited significant and positive (r=0.843*) correlation with maximum temperature and negative and significant with relative humidity (r=-743*) and rainfall (r=-747*) in MH 421. Sunshine hours exhibited positive and non significant correlation with whitefly. However, in MH 318, negative and significant association of whitefly was observed with relative humidity (eve. r=-0.646*). Leafhopper nymphs population showed negative and positive non significant correlation with temperature (max. and min.) and relative humidity (morning and evening), respectively in both the varieties. Pod bug population showed negative and non significant correlation with wind and sunshine hours in both the varieties. Similarly the correlation was negative and non significant with temperature (maximum and minimum) in MH 421, while positive and significant in MH 318, respectively. Spotted pod borer population found positively and non significantly correlated with temperature (max. and min.) and winds. However, relative humidity and rainfall showed non-significant positive and negative association in MH 421 and MH 318, respectively. The populations of tobacco caterpillar and blue butterfly showed significant positively correlation with the minimum temperature (r=0.810*) and evening relative humidity (r=0.800*). Chafer beetle population was found significantly positively correlated with relative humidity (r=0.742* and 0.708*) in MH 421. Yellow wasps showed significant and positive correlation with temperature (r=0.706*) and negative correlation with winds speed (r=-0.764*).

Genotypes, MH 318 was found least susceptible harbouring minimum whitefly nymphs and adult populations i.e., 2.20 whitefly nymph and 13.65 whitefly adults, respectively. Neem oil 2% (crude) was found most effective against whitefly.

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ABSTRACT

Title of thesis	:	Ecofriendly management and screening of mungbean (*Vigna radiata* L.) genotypes against whitefly (*Bemisia tabaci* Gennadius)
Name of the degree holder	:	KHIN THANDA MIN
Admission No.	:	2017A 34 M
Title of degree	:	MASTER OF SCIENCE
Name and address of Major Advisor	:	Dr. TARUN VERMA, D.E.S (Entomology) O/O Agricultural Technology Information Centre CCS Haryana Agricultural University, Hisar 125004, Haryana.
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Field studies on "**Ecofriendly management and screening of mungbean, *Vigna radiata* L. genotypes against whitefly *Bemisia tabaci* Gennadius**" was carried out during the *Kharif*, 2018. The minimum and maximum population of whitefly nymph observed in MH 318 and MH 1315 (2.20, 11.68 whitefly nymph /3 leaves/plant) respectively. The minimum and maximum populations of whitefly adults were observed on genotype MH 318 and MH 1413 (13.65, 32.98 whitefly/plant), respectively. The activity of whitefly nymphs and adults reached its peaks at 35DAS (32^{th} SMW means 2^{nd} week of August). Maximum grain yield was obtained in genotype MH 1467 (575.0 kg/ha) and lowest yield was observed in genotype Basanti (152.78 kg/ha). Correlation of whitefly with the maximum, minimum temperature and sunshine hours was positive and significant, while negative and non-significant with evening relative humidity in different genotypes screened. Biorational spray on variety MH 421 was done which indicated minimum whitefly adult population in Neem oil 2% (crude) (T_4) in first spray. However, during second spray minimum whitefly adult (7.00 whitefly adults/plant) were recorded in T_2 (NSKE 5% aqueous extract). Neem oil 2% (crude) (T_4) was found most effective (12.38 whitefly adults/plant) treatment on the basis of overall mean of first and second spray. Maximum grain yield (259.26 kg/ha) was obtained in T_1 (NSKE 5% Methanolic extract) which was at par with T_2 NSKE 5% (Aqueous extract): (217.41kg/ha) andT_4 Neem oil 2% (crude): (221.11 kg/ha). Correlation between whitefly and weather factors was exhibited significantly positive with maximum temperature (r=0.843), negative correlated with relative humidity (r =-743) and rainfall (r=-747). The populations of tobacco caterpillar were significantly positive correlated with the minimum temperature (r=0.810) and negatively correlated with the relative humidity(r=-0.275). Correlation between maximum temperature, minimum temperature with spotted pod borer was found positive (r= 0.445, 0.207), while it was negative with the relative humidity and rainfall (r= -0.336, -0.471) (r= - 0.269) respectively.

MAJOR ADVISOR **SIGNATURE OF STUDENT**

HEAD OF DEPARTMENT

CURRICULUM VITAE



(a) Name : Khin Thanda Min

(b) Date of Birth : 26.6.1976

(c) Place of Birth : Aungban City, Kalaw Township

(d) Father' Name : U Khin

(e) Mother' Name : Daw Than Kyi

(f) Permanent Address : No.49, Ba Htoo Road, N0.3 Quarter, Aungban, Southern Shan State, Myanmar

(g) Mobile : +919466086726, +95 440223822

(h) E- mail : khinthandamin76@gmail.com

(i) Academic Qualification :

Degree	University / Board	Year of Passing	Percentage of marks	Subjects
M.Sc.	CCS HAU, Hisar, India	2019	72.4%	Major : Entomology Minor : Plant Pathology
B.Sc.	Yezin Agricultural University, Myanmar (YAU)	2000	82.4%	Agriculture (Entomology)
Matriculation	No.1, High School,Kalaw Township, Myanmar	1993	76%	Myanmar, English, Mathematics, Physics, Chemistry, Biology

(j) Co-Curricular Activities : Activity participated in all debates, International symposium, Hisar, India and previous postgraduate training, JICA

(k) Medals/ Honours received : -

(l) List of Publications : -

Khin Thanda Min

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