SEASONAL ABUNDANCE, VARIETAL SCREENING AND MANAGEMENT OF WHITEFLY, *Bemisia tabaci* (Gennadius) INFESTING *KHARIF* OKRA

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IN

AGRICULTURAL ENTOMOLOGY

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Dedicated

To

My Beloved Parents

For their support, prayers and hope..

Avani…

DEPARTMENT OF ENTOMOLOGY

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Bhalu Avani V.	**Dr. Y. H. Ghelani**

SEASONAL ABUNDANCE, VARIETAL SCREENING AND MANAGEMENT OF WHITEFLY, *Bemisia tabaci* (Gennadius) INFESTING *KHARIF* OKRA

ABSTRACT

Key words: *Bemisia tabaci* (Gennadius), insecticidal spray, okra, potash fertilizer, seasonal abundance, varietal screening, whitefly

Investigations on seasonal abundance, varietal screening and management of whitefly, *Bemisia tabaci* (Gennadius) infesting *kharif* okra were carried out under field condition during 2018 at Instructional Farm, College of Agriculture, Junagadh Agricultural University, Junagadh. For the management of whitefly, ten different varieties /genotypes were screened, different combinations of potash fertilizer and foliar application of insecticides were evaluated against the pest.

The incidence of whitefly, *B. tabaci* was commenced from first week of August and continued till first week of October having a single peak (7.52 whitefly /leaf) during last week of September in okra crop. Whitefly population had significant positive relation with maximum temperature (r= 0.613*) and bright sunshine hours (0.802*). While, it had significant negative correlation with minimum temperature (-0.700*), wind speed (-0.674*), morning relative humidity (-0.705*) and evening relative humidity (-0.733*). While, it had non significant negative correlation with rainfall (-0.377).

The lowest whitefly incidence was recorded in HRB-108-2 (1.65 whitefly /leaf) and JOL-11-12 (1.94) genotypes of okra and was categorized as resistant (R). While, the highest whitefly population was recorded in Pusa Sawani (5.09) variety and it was categorized as susceptible (S).

Based on both the sprays and pooled over period over sprays, whitefly can be effectively managed by application of potash fertilizer dose @ 80 kg/ha followed by spray application of acetamiprid 20 SP @ 0.006%. Interaction of potash fertilizer and insecticidal spray was found effective in treatment of potash fertilizer @ 80 kg/ha + acetamiprid 20 SP @ 0.006% followed by potash fertilizer @ 80 kg/ha + triazophos 40 EC @ 0.04% and potash fertilizer @ 80 kg/ha + diafenthiuron 50 WP @ 0.05%. Whereas, potash fertilizer @ 60 kg/ha + acetamiprid 20 SP @ 0.006%, potash fertilizer @ 60 kg/ha + triazophos 40 EC @ 0.04% and potash fertilizer @ 60 kg/ha + diafenthiuron 50 WP @ 0.05% were found mediocre in their effectiveness. Potash fertilizer @ 50 kg/ha + acetamiprid 20 SP @ 0.006%, potash fertilizer @ 50 kg/ha + triazophos 40 EC @ 0.04%, potash fertilizer @ 50 kg/ha + diafenthiuron 50 WP @ 0.05%, potash fertilizer @ 80 kg/ha + control and potash fertilizer @ 60 kg/ha + control were found less effective.

The highest fruit yield (13106 kg/ha) was harvested in the plots treated with potash fertilizer @ 80 kg/ha + acetamiprid 20 SP @ 0.006% followed by potash fertilizer @ 80 kg/ha + triazophos 40 EC @ 0.04% (12782) and potash fertilizer @ 80 kg/ha + diafenthiuron 50 WP @ 0.05% (12088). As far as the per cent increase of yield over control concerned, maximum yield was received with spray application of potash fertilizer @ 80 kg/ha + acetamiprid 20 SP @ 0.006% (67.40%) followed by potash fertilizer @ 80 kg/ha + triazophos 40 EC @ 0.04% (63.26%) and potash fertilizer @ 80 kg/ha + diafenthiuron 50 WP @ 0.05% (54.40%).

The highest Incremental Cost Benefit Ratio (ICBR) was obtained from the plots treated with potash fertilizer @ 80 kg/ha + acetamiprid 20 SP @ 0.006% (1:27.66). While, in overall effectiveness of combinations, potash fertilizer @ 80 kg/ha + acetamiprid 20 SP @ 0.006% found most effective (first rank) followed by potash fertilizer @ 80 kg/ha + triazophos 40 EC @ 0.04% > potash fertilizer @ 80 kg/ha + diafenthiuron 50 WP @ 0.05% > potash fertilizer @ 60 kg/ha + acetamiprid 20 SP @ 0.006% > potash fertilizer @ 60 kg/ha + triazophos 40 EC @ 0.04% > potash fertilizer @ 60 kg/ha + diafenthiuron 50 WP @ 0.05% > potash fertilizer @ 50 kg/ha + acetamiprid 20 SP @ 0.006% > potash fertilizer @ 50 kg/ha + triazophos 40 EC @ 0.04% > potash fertilizer @ 50 kg/ha + diafenthiuron 50 WP @ 0.05% > potash fertilizer @ 80 kg/ha + control > potash fertilizer @ 60 kg/ha + control and potash fertilizer @ 50 kg/ha + control against *B. tabaci* in okra crop.

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CERTIFICATE-I

This is to certify that the thesis work report entitled **"SEASONAL ABUNDANCE, VARIETAL SCREENING AND MANAGEMENT OF WHITEFLY, *Bemisia tabaci* (Gennadius) INFESTING *KHARIF* OKRA"** submitted by **BHALU AVANI VINODBHAI (Reg. No. 2010117016)** in partial fulfilment of the requirements for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in the subject of **AGRICULTURAL ENTOMOLOGY** to the Junagadh Agricultural University is a record of bonafide research work carried out by her under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma or other similar title. The candidate had fulfilled all prescribe requirements. The assistance and help received during the course of investigation have been fully acknowledged. She has successfully completed the comprehensive/ preliminary examination held on **March 25, 2019** as required under the regulation for post-graduate studies. She has submitted kachcha bound thesis on **May 20, 2019.**

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CERTIFICATE-II

Date: /06/2019

This is to certify that the thesis work report entitled **"SEASONAL ABUNDANCE, VARIETAL SCREENING AND MANAGEMENT OF WHITEFLY, *Bemisia tabaci* (Gennadius) INFESTING *KHARIF* OKRA"** submitted by **BHALU AVANI VINOBHAI** to Junagadh Agricultural University, Junagadh in partial fulfilment of the requirements for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in the subject of **AGRICULTURAL ENTOMOLOGY** after recommendation by the external examiners were defended by the candidate before the following members of the examination committee. The performance of the candidate in the oral examination was satisfactory. We, therefore, forward with recommendation.

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"Difficulties in your life do not come to destroy you,

But

To help you realize your hidden potential and power.

Let difficulties know that you too are difficult"

-Dr. A. P. J. Abdul Kalam

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Place: *Junagadh*

Date: /06/2019 ***(Bhalu Avani V.)***

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LIST OF ABBREVIATIONS

&	:	And
Anon.	:	Anonymous
@	:	At the rate of
a.i.	:	Active Ingredient
cm	:	Centimeter
C. V.	:	Coefficient of Variance
C. D.	:	Critical Difference
DAG	:	Days After Germination
DAS	:	Days After Sowing/ Days After Spraying
EC	:	Emulsifiable Concentrate
=	:	Equal to
et al.	:	*Et allii*; and others
ETL	:	Economic Threshold Level
Fig.	:	Figure
FS	:	Flowable concentrate for seed treatment
g	:	Gram
>	:	Greater than
<	:	Less than
ha	:	Hectare
ha^{-1}	:	Per hectare
i.e.	:	That is
Kg	:	Kilogram
Kg^{-1}	:	Per Kilogram
m	:	Meter
ml	:	Milliliter
m^{2}	:	Square metre
l	:	Litre

NPK	:	Nitrogen, Phosphorus and Potassium
NS	:	Non significant
RBD	:	Randomized Block Design
₹	:	Indian Rupees
SC	:	Soluble concentrate
S. Em. ±	:	Standard Error of mean
SP	:	Soluble Powder
SMW	:	Standard Meteorological Week
viz.,	:	Namely
/	:	Per
%	:	Per cent
WP	:	Wettable Powder

CHAPTER-I

INTRODUCTION

Vegetables constitute an important part of our balanced diet. They are also considered as "Protective food" as they contain vitamins, minerals and dietary fibres apart from protein, lipids and carbohydrates of biological value.

Among the vegetable crops grown in India, okra (*Abelmoschus esculentus* L. Moench), is also known as 'lady's finger' or 'bhendi' which is an important crop grown throughout the year. Besides India, it is grown in many tropical and subtropical parts of the world. Okra is the member of the family Malvaceae and is said to be native of Africa, possibly Ethiopia (Singh and Bhagchandani, 1967). Okra is one of the most economically important vegetable crop. It is widely cultivated as a summer season crop in North India and as a *kharif* and summer season crop in Maharashtra, Gujarat, Andhra Pradesh, Karnataka and Tamil Nadu. In India, okra is cultivated in 52.84 lakh ha with a production of 61.46 lakh tonne. While in Gujarat, total area under okra was 0.74 lakh ha with a production of 8.59 lakh tonne (Anonymous, 2017).

Okra is one of the drought tolerant vegetable species of the world and can tolerate poor soils with heavy clay and intermittent moisture. It grows well in the areas where day temperatures remain between 25 to 40 °C and that of night over 22 °C. Okra is considered as heat loving plant, hence this crop is grown in *kharif* and summer seasons. Being hardy and short duration crop, it is profitably cultivated in summer when other vegetables are not available in the market and in Gujarat; it is grown almost throughout the year. Okra is the most important vegetable crop due to its nutritional, industrial and medicinal values (Nadkarni, 1927 and Chauhan, 1972). It has its own importance, an account of its taste, flavor and nutritional values as human food. It is grown in tropical and sub-tropical parts of the world. Okra is known by many local names *viz.*, *Bhendi* in India, *lady's finger* in UK, *Gumbo* in the United States of America, *Guino-gombo* in Spanish and *Guibeiro* in Portuguese. It is quite popular in India because of easy cultivation, dependable yield and adaptability to varying climatic conditions.

Okra is mainly cultivated for its fruits. Okra fruits are harvested as immature pods and consumed as a vegetable. Okra contains proteins, carbohydrates and vitamin C (Lamont, 1999; Owolarafe and Shotonde 2004; Gopalan *et al.,* 2007; Arapistus, 2008 and Dilruba *et al.,* 2009) and plays a vital role in human diet (Kahlon *et al.,* 2007; Saifullah and Rabbani, 2009). Okra seed containing good quality edible oil and high protein are used to complement other protein. Consumption of young immature okra fruits is important as fresh fruits and it can be consumed in different forms. The ripe seed of okra are sometimes roasted, while the seed-powder is used as substitute for the aluminum salts for water purification (Vaidya and Nanoti, 1989). The immature pods are used in soups, stir fries, and stews or as a fried or boiled vegetable. Matured fruits and stems containing crude fibres are used in the paper industry. In some places, bhendi juice (mucilage extract) is used as clarificant in the manufacture of jaggery. Like soybean, the seed provides excellent vegetable protein for uses including full and fat free meals, flours, protein concentrates and isolates, cooking oils, lecithin, and nutraceuticals (Akintoye *et al.,* 2011).

Okra (per 100g) contains carbohydrates (1.5%), protein (2.0g), total fat (0.1g), dietary fiber (9%), folates (88mcg), niacin (1.000mg), pantothemic acid (0.245mg), pyridoxine (0.215mg), riboflavin (0.060mg), thiamin 0.200mg), vitamin c (21.1mg), vitamin A (375IU), vitamin E (53mcg), sodium (8mg), potassium (303mg), calcium (81mg), copper (0.094mg), iron (0.80mg), magnesium (57mg), phosphorus (63mg), selenium (0.7mcg), zinc (0.60mg), carotene (225mcg) and luteinzeaxanthin (516mcg) which are often lacking in the diet.

Its medicinal value has also been reported in curing ulcers and relief from haemorrhoids. Okra is very useful against genito-urinary disorders, spermatorrhoea and chronic dysentery (Thakur and Arora, 1986). Naturopathic medicines include okra for intestinal and irritable bowel dysfunction due to its mucilaginous properties. Okra mucilage is used for glace paper production and also a confectionary use. It has medicinal application as a plasma replacement or blood volume expander (Kumar *et al.,* 2001). Okra is also known for harnessing a superior fibre, which helps with digestion, stabilizes blood sugar and helps to control the rate at which sugar is absorbed. Okra plants are also used for treating diseases like stones in kidney, leucorrhoea, backache and goitre in human beings.

Like other crops, okra is also ravaged by various insect pests. Incidence of insect pests is one of the major limiting factors in production of okra. The crop is attacked by many species of insect and non-insect pests right from germination to harvest. Shrinivas and Rajendran (2003) recorded 72 species of insects infesting the okra. The major pests those attack okra crop include aphid, *Aphis gossypii* Glover; leafhopper, *Amrasca biguttula biguttula* Ishida; whitefly, *Bemisia tabaci* (Gennadius); red spider mite, *Tetranychus* spp. and shoot and fruit borer, *Earias vitella* Fab. which cause damage to okra plants results into yield losses.

The insect pests of minor importance are fruit borer, *Helicoverpa armigera* (Hubner) Hardwick; leaf roller, *Sylepta derogata* Fab.; leaf eating beetles, *Trachys* spp.; weevil, *Myllocerus* spp.; semilooper, *Anomis flava* Fab.; thrips, *Thrips tabaci* Linderman; mealy bug, *Ferrisia virgata* Cockrell and scale insect, *Saissetia coffeae* Walker (Butani and Jotwani, 1984). Among these pests, aphid, leafhopper, whitefly, red spider mite and shoot and fruit borer are the destructive pests of okra in Gujarat.

Nomenclature of whitefly

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Hemiptera

Sub order: Sternorrhyncha

Superfamily: Aleyrodoidea

Family: Aleyrodidae

Genus: *Bemisia*

Species: *Bemisia tabaci*

The whitefly, *Bemisia tabaci* (Gennadius) the milky white minute flies; nymphs and adults causes damage to okra by sucking the cell sap from plants and plant parts of okra. The damage is caused by desapping the plants and deposits the droplets of honeydew on leaves, which provide a suitable condition for sooty mold development; as a result it inhibits the foliar photosynthesis and reduces commercial value of the crop

(Oliveira *et al*., 2001). Whitefly besides causing as a sole direct damage, acts as a vector of more than 100 plant viruses, which cause diseases to many commercial crops in different parts of the world (Jones, 2003; Atwal and Dhaliwal, 2007). Yellow vein mosaic virus (YVMV) is one of them, which is a major constraint for okra production. This virus was systematically studied and characterized by different Indian scientists (Capoor and Verma, 1950; Kumar and Moorthy, 2000 and Verma, 1952). They concluded that yellow vein clearing mosaic virus is a member of Geminivirus group which is semi persistently transmitted by whitefly. This virus is also transmitted through grafting, but not mechanically or through seeds. YVMV is one of the most destructive diseases of the crop and causes considerable reduction in yield which could be as 92 to 94 % (Sastry and Singh, 1974). The virus seems to attack okra plants in any stage of plant growth, spreads quickly in the field and adversely affects the growth and yield contributing characters due to remarkable alternation in cellular components of the infected plants (Hossain, 1998 and Sarma *et al*., 1995). Besides quantity, fruit quality is also adversely affected due to this disease.

In the situation of global climate change, living organisms are changing their living habitat as well as style which directly affect their lifespan. An insect, have capacity to change their behavior and habitat with the changing of the environment and so, it is necessary to see the impact of changing pattern in abiotic factors on whitefly infesting okra. Use of resistant /tolerant varieties/genotypes of okra is very important consideration to minimize the damage due to whitefly and so the yield losses. Therefore, simultaneous evaluation of okra varieties/genotypes resistant or tolerant to whitefly is very much essential. In the present scenario, for ecofriendly management of insect pests in any crop application of recommended dose of fertilizer incorporated with the other good agricultural practices (GAP) is needed. Okra crop is attacked by many sucking pests. Hence, single commonly used pesticides will not provide effective control of whitefly. It is necessary to find out the effective dose of fertilizer which reduces the whitefly infestation. Combination of effective dose of fertilizer with foliar application of appropriate insecticide will give alternate management strategy for whitefly infesting okra crop.

Considering the importance of damage caused by whitefly to okra crop, the present investigations have been undertaken with the following objectives:

1. To study the seasonal abundance of *Bemisia tabaci* infesting *kharif* okra
2. To evaluate the susceptibility of okra varieties/genotypes against *B. tabaci* infesting *kharif* okra
3. Management of *B. tabaci* infesting *kharif* okra

CHAPTER II

REVIEW OF LITERATURE

Review of literature is of paramount importance to any research endeavour. This not only helps to acquire a broad general background in the given field but also provide base for theoretical framework and interpretation of the findings. The present investigation is concerned with the "Seasonal abundance, varietal screening and management of whitefly, *Bemisia tabaci* (Gennadius) infesting *kharif* okra". Hence, an earnest effort was made to review the relevant and updated literature having direct or indirect relationship with the present study.

2.1 Seasonal abundance of *Bemisia tabaci* infesting *kharif* okra

Dhamdhere *et al.* (1985) stated that whitefly remained active on okra crop throughout the *kharif* season, while in summer, it appeared at the end of April and remained active till harvest of the crop in Kerala.

Chaudhry and Dadheech (1989) reported that the incidence of whitefly occurred in *kharif* about one month old crop and gradually reached to peak (0.78 adult/leaf) at 43 days after sowing at Udaipur, Rajasthan.

Patel (1989) observed that whitefly population on okra was found highest after the 4th week of sowing in *kharif* at Sardar Krushinagar, Gujarat. There was a second peak after 7 to 8 weeks of sowing, but later on, it sharply declined and reduced to zero level. Further, he noticed significantly negative correlation of whitefly population with minimum temperature (r=0.6932), average relative humidity (r=0.7188) and evening relative humidity (r=0.5716).

Dry hot weather with little or no rainfall has been reported conducive for disease development of yellow vein mosaic and also for the multiplication of the *B. tabaci*. Whereas, cooler weather with high relative humidity and rainfall to be detrimental to whitefly multiplication and spread (Singh, 1990).

Bhagabati and Goswami (1992) reported that the whitefly populations were highest in crops sown in May and incidence of okra yellow vein mosaic virus was also highest (100%) in crops sown in May-June. Disease incidence and population of *B. tabaci* were both least in October sown crop.

Borad *et al.* (1993) studied relationship of whitefly population density in okra in Maharashtra and observed that the incidence of whitefly population started from 16^{th} days after sowing and reached at peak level during the first week of October.

Ghosh *et al.* (1999) observed the peak population of whitefly in *kharif* at the end of crop growth period in Bengal.

Kumawat *et al*. (2000) showed that the infestation of whitefly on okra started in the fourth week of July and reached at peak in the second week of September. Correlation of this pest with maximum temperature was significantly positive in Rajasthan.

Watson *et al.* (2003) revealed that low rainfall and high temperature favored significant outbreaks and dense population build-up of whitefly in summer season. Temperature above 30 °C increased the rate of egg lying but above 40 °C reduced the length of life cycle of *B. tabaci* to less than two weeks in okra crop in California.

Hegde *et al.* (2004) carried out an experiment in Siruguppa, Karnataka and reported that highest incidence of whitefly was noticed during fourth week of October with 6.43 whitefly/ 3 leaves.

Pun *et al.* (2005) revealed that there was positive correlation of whitefly population with maximum temperature, minimum temperature and sunshine hours in *kharif* season, whereas morning relative humidity, wind velocity and total rainfall had negative influence on whitefly population in Coimbatore, Tamilnadu.

Solanki (2005) found that the incidence of whitefly on okra initiated from the 4^{th} week after sowing and attained its maximum activity (10.4 whitefly/3 leaves) after the 10^{th} week of sowing in *kharif*. Whitefly population had significant positive correlation with maximum temperature and significant negative correlation with minimum temperature as well as morning relative humidity at Junagadh, Gujarat.

Whitefly incidence started from the first week of August and remains active until the third week of October and the highest population of whitefly was observed in the third week of September at Jabalpur, Madhya Pradesh (Yadav *et al.*, 2007a).

Anitha (2007) reported that activity of whitefly was noticed during the 4^{th} week of October i.e. 6.43 whitefly per 3 leaves at Dharwad, Karnataka.

Dhaka and Pareek (2008) reported that the incidence of whitefly started in the second and third week of June, which remained throughout the growth period of crop and peak was observed in the first week of October. The maximum temperature had positive significant and evening relative humidity exerted negative effect on whitefly population at Tonk, Rajasthan.

Anita and Nandihalli (2008) stated that population of whitefly on *kharif* okra crop started appearing from first week of August 2008 with peak incidence of whitefly was noticed during fourth week of October with 6.43 whiteflies/3 leaves at Dharwad, Karnataka.

Selvaraj *et al.* (2010) studied the population dynamics of important insect pests of bhendi in relation to weather parameters and reported that the peak incidence of whitefly was observed from 33rd to 36th standard week (mid August to mid October). Both maximum and minimum temperature was found to exert significant positive influence on the whitefly population.

Boopathi *et al.* (2011) showed that incidence of *B. tabaci* on okra was observed during the third week of May, with peak infestation during the third week of June during 2009-10 at Mizoram.

Das *et al.* (2011) noticed highly significant positive correlation of whitefly population with minimum & mean temperature, evening & mean relative humidity, vapour pressure, wind speed and rainfall at Gujarat.

Mohanasundaram and Sharma (2011) concluded that the highest population of whitefly was recorded between first week of August and second week of August. The whitefly population showed significant positive correlation with the minimum temperature (r=0.994), while maximum and mean temperature had non-significant positive correlation at IARI, New Delhi.

Jadhav (2013) observed that the population builds up of whitefly commenced from 3rd week after sowing i.e. 1st week of Aug. with a low level (2-3 whitefly/3 leaves/plant). The pest population gradually increased and reached a peak level (6.4 whitefly/3 leaves/plant) during 9th week after sowing. Morning relative humidity exhibited highly significant positive correlation (r=0.6722) and simultaneously maximum temperature, minimum temperature, evening relative humidity, rainfall exhibited significant positive correlation with whitefly population at Junagadh, Gujarat.

Seasonal activity of different insect pest determines the predisposing climatic factors affecting their population dynamics. In which whitefly population showed negative correlation with maximum, minimum & mean temperature and maximum & minimum relative humidity where as positive correlation with rainfall in Chitrakoot region, Madhya Pradesh (Singh *et al.*, 2013).

Harinkhere (2014) studied population dynamics of major insect pests of okra at Jabalpur, Madhya Pradesh during *kharif*, 2011. In which whitefly population started increasing from 37^{th} SW and reached at its peak during 44^{th} SW.

According to Aarwe *et al*. (2016), major activity of *Bemisia tabaci* appeared during first week of August to last week of September 2014 with two distinct peak 34^{th} and 35^{th} SW (3.83 and 3.33 whitefly/ per 30 leaves) in okra crop at Jabalpur, Madhya Pradesh.

Chouhan *et al.* (2016) revealed that in okra crop whitefly population reached to its peak period on third week (11^{th} SMW) of March with 18.07 white fly/plant in *Rabi* at Raipur, Chhattisgarh. According to him, whitefly incidence showed positive highly significant correlated with maximum temperature (r=0.748**) and positive but non significant correlation with minimum temperature (r=0.165).

Khating *et al*. (2016) observed that the seasonal incidence of sucking pests was undertaken on *kharif* crop at Khandelwal, Maharashtra in which the peak incidence of the whiteflies was recorded during the second week of September (21 whiteflies/3 leaves/ plant).

Bhatt and Karnatak (2018) carried out an experiment on population dynamics of sucking pests and their predators on okra ecosystem during *kharif* in Pantnagar, Uttarakhand. They noted that the peak density of whitefly was 12.11 whiteflies/3 leaves in 40^{th} SMW.

2.2 Evaluation of susceptibility of okra varieties/genotypes against *B. tabaci* infesting *kharif* okra

Bhagat *et al.* (2001) found that the rate of infestation of whitefly was higher in *Vaishi Vadhu* and *Pusa Sawani* as compared to *Parbhani Kranti*.

According to Patel *et al*. (2003), Gujarat Okra Hybrid-1 was tolerant than Pusa Sawani against whitefly at Anand, Gujarat.

Ali *et al.* (2005a) screened four varieties of okra and found that *Surkh Bhindi* was the least susceptible; *Subz Pari* and *Safal* were moderately susceptible and *Pahuja* was tolerant against this pest.

Solanki (2005) screened 20 varieties of okra for their susceptibility to whiteflies, the varieties Gujarat okra-1, *Arka Anamika*, Aol-02-1, Jol-1, Jol-02-9 and Aol-99-24 were found least susceptible, where as varieties Jo (2k)-20, Jo (2k)-1, Jo (2k)-15, Jo (2k)-13, Jo (2k)-10, Jo (2k)-16, Jo (2k)-19, Aol-02-4, *Pusa Sawani*, Gujarat Okra-2, Jol-02-12, Aol-99-28 and *Parbhani Kranti* were found the most susceptible under field conditions at Junagadh, Gujarat.

Raja and Kanjarla (2006) reported that among 95 genotypes screened, EC/329406 was found tolerant and IC/282280, EC/329357 & IC/282273 were found moderately tolerant against whitefly in okra at Hyderabad, Telangana.

Anitha (2007) reported that among seven okra hybrids, whitefly population recorded less in *Shagun* followed by *Suruchi* at Dharwad, Karnataka.

Among the 20 genotypes/varieties of okra screened under field condition at Junagadh, Gujarat in which the genotypes JOL-07S-9, JOL-07S-5, Gujarat Okra-2, HRB-108-2, JOL-07S-7, JOL-02-1, JOL-1 and JOL-07S-3 recorded significantly lower population of whitefly *i.e*. 6.47 to 8.65 whiteflies/three leaves/plant (Kabade, 2009).

Gonde *et al.* (2013) screened seventeen varieties of okra against *A. biguttula biguttula* and *B. tabaci* in Allahabad, Uttar Pradesh. In respect of whitely infestation, the lowest infestation was found in varieties VRO 3 and VRO 4.

Mastoi *et al.* (2013) found that among six varieties *viz.*, *Sabzpari*, *Super green*, *Noori-786*, *Sharmeeli*, *Pusa Sawani* and *Ambak* were screened against whitefly the population varied significantly ($P<0.05$) on different dates and varieties. Okra variety, Sabzpari, harboured the minimum pest (3.17 insects/ leaf) population, while Noori-786 harboured the maximum (4.46 insects/leaf) population at Bahawalpur, Pakistan.

Nataraja *et al.* (2013) evaluated twenty one okra genotypes/cultivars for their relative preference to whitefly as well as yellow vein mosaic virus disease. The genotypes *viz*., IC 331217, IC 332453 & IC 342075 and cultivars *viz.*, *Manisha-211* & *Arka*

Anamika were negligibly preferred over other genotypes/cultivars by whiteflies with tolerant reaction to Yellow Vein Mosaic Virus (YVMV) disease and also recorded higher fruit yield.

Raut *et al*. (2013) evaluated seven varieties of okra at Allahabad, Uttar Pradesh and lower infestation of whitefly was observed in two varieties *viz*., VRO 3 and VRO 4.

Pawar and Varma (2014) carried out an experiment at Sardar Krishinagar, Gujarat on 7 okra varieties, *Arka Anamika* (V1), *Phule Utkarsh* (V2), Gujarat Okra-2 (V3), *Arka Abhay* (V4), Perkins Long Green (V5), Gujarat Okra-1 (V6) and *Parbhani Kranti* (V7)and concluded that during the rainy season, significantly least population of whitefly (3.77 insects/3 leaves) with lower YVMV (%) recorded in variety Gujarat Okra-2 (V3). The superior performance with respect to cost: benefit ratio was recorded with variety Gujarat Okra-2 (V3) during dual season *i.e*. rainy and summer season.

Gadekar *et al.* (2015) screened ten varieties of okra against sucking insect pests and found that the varieties *Hissar Unnat*, *Varsha Uphar* and *Pusa Sawani* existed as less susceptible to whitefly, whereas *Aparajita* reacted as highly susceptible to whitefly population.

Among six okra varieties, overall mean density of *B. tabaci* was significantly higher on *Malay* (2.27 individuals/leaf) and lower on F1H (1.86 individuals/leaf) in Peshawar, Pakistan (Rasheed and Imtiaz, 2015).

Sewak (2016) studied the seasonal incidence of whitefly on different genotypes of okra and reported that the varieties *Arka Abhay* and VRO-5 showed minimum build-up of whitefly population at Agra, Uttar Pradesh.

Fahad *et al.* (2017) carried out an experiment on screening of different varieties of okra against sucking insect pests. The highest mean population of the whitefly was 3.25 ± 0.15 observed on *Bharat Kaiwari* and the lowered on *Rama Krishna*.

Khoso *et al.* (2017) investigated different okra varieties for their reaction against sucking pests at Pakistan and revealed that the most infested variety was *Bharat Kaiwari* followed by Silky-460 and *Rama Krishna* throughout the experimental period. The highest mean population of the whitefly was 3.25 ± 0.15 was observed on *Bharat Kaiwari* and the lowered on *Rama Krishna*. It showed the susceptible characters of *Bharat Kaiwari* variety against all sucking pests of okra.

Out of nine okra varieties screened against the sucking pests, none of the variety was found completely free from the infestation of whitefly, although they differed significantly in their degree of damage and pest numbers. The varieties IIVR-11 and IIVR-10 were found the least susceptible. *Hisar Unnat*, Pusa A-4, *Varsa Uphar*, *Pusa Sawani* & *Aparajita* as moderately susceptible and varieties *Ankur-40* & *Anika* as highly susceptible to the whitefly population (Nagar *et al*., 2017).

Rehman *et al.* (2017) screened four okra varieties against sucking pests under field conditions during 2011 at Pakistan and observed that okra variety *Sada Bahar* was less infested with whitefly (5.36/leaf) compared to other tested varieties.

Navneet and Tayde (2018) screened ten okra genotypes against whitefly, *B. tabaci* (Gennadius) *viz*., HRB-55, H14-A, JPM-20-16-32, IIVR-10, IC-14-934, IC-45862, JC-034-1124-A, VRO-6, 317-10-1, 326-10-1 at Allahabad, Uttar Pradesh. They observed that, among these ten genotypes IIVR-10 showed the lowest mean population of whitefly (1.98) and the highest mean population (7.52) was recorded in genotype 317-10-1. The YVMV was recorded lowest in the genotype IIVR-10 (3.33%) & VRO-6 (6.66%) followed by HRB-55 (20%).

2.3 Management of *B. tabaci* infesting *kharif* okra

2.3.1 Seed treatment

Elbert *et al.* (1991) reported that imidacloprid as seed treatment showed outstanding insecticidal activity against the sucking pests and has longer persistent toxicity.

Sreelatha and Divakar (1997) reported that seed treatment with imidacloprid effectively controlling pest population which resulted in increasing the plant height, leaf area and yield of okra at Hyderabad. Treatment with 7.5 g of imidacloprid/kg of okra seed was found optimal.

Application of imidacloprid as foliar spray (0.005 and 0.002 %) as well as seed treatment (3 and 5 g/kg seed) against whitefly in cotton resulted maximum reduction in pest population of whitefly at Delhi (Gupta *et al.*, 1998).

Bhargva *et al.* (2001) found that imidacloprid 600 FS at 9 ml/kg seeds and 700 WP at 10 g/kg seeds were found to be promising against whitefly.

Satpathy *et al.* (2004) reported that seed treatment of okra with imidacloprid @ 3g/ kg offered maximum protection against sucking pest at Varanasi, Uttar Pradesh.

Shivpuri *et al.* (2004) tested imidacloprid as a seed dresser on okra for the control of YVMV disease transmitted by an insect vector whitefly. They reported that all treatments were found better over untreated check with regard to reduction in YVMV and insect vector; enhanced plant growth and increase in yield. However, all imidacloprid treatments, except imidacloprid 600 FS @ 5ml/kg seed, proved most promising when tried as seed dresser along with one spray of monocrotophos followed by three sprays of Endosulfan at Durgapura, Rajasthan.

Day *et al.* (2005) evaluated imidacloprid 70 WS as seed treatment & imidacloprid 200 SL as foliar spray at 20 and 40 days after sowing at Nadia, West bengal and result revealed that all the dosages of imidacloprid 70 WS *viz*., 5, 7.5 and 10 g/kg seed provided excellent protection against whiteflies up to 45 days after sowing.

Investigations were carried out at IARI, New Delhi to evaluate four (5, 9, 18, 36 g/kg) doses of imidacloprid which afforded an effective protection of okra crop against pest population. (Lal and Sinha, 2005)

Solanki (2005) carried out an experiment to study the efficacy of insecticides as seed treatments and showed that the imidacloprid 70 WS @ 7.5 g/kg seed proved the most effective seed treatment for controlling whitefly population in okra at Junagadh, Gujarat.

Rana *et al.* (2006) revealed that the seed treatments with imidacloprid @ 2 ml/ kg seed gave the effective control of whitefly on okra in *kharif* at Raichur, Karnataka.

Sreenivas and Nagund (2006) conducted an experiment with three seed dressing chemicals to test their efficacy to manage sucking pests at initial stage of growth of okra crop. They concluded that imidacloprid 70 WS @ 5 g/kg as seed dressing chemical will protect the bhendi crop up to 50 days from sucking insect pests at Karnataka.

Sinha and Sharma (2008) reported that imidacloprid 3 g a.i./kg seed successfully managed sucking pest population on okra.

2.3.2 Potash fertilizer

Mishra and Pandey (1987) conducted an experiment on the effect of different level of nitrogen and potash on *Pusa Sawani* variety and observed that 80 kg/ha N and 40 kg/ha K significantly reduced whitefly infestation & produced higher no. of pods/plant and their by yield (154.7 q/ha).

Rote and Puri (1992) studied the effects of fertilizer application on cotton whitefly incidence at Maharashtra and found that highest population of whitefly was recorded on the plants receiving highest dose of 200:100:100 kg NPK/ha and decreased significantly as the fertilizer dose was reduced.

According to El-zahi *et al.* (2012), the combination of nitrogen fertilization with phosphorus and potashic fertilization or both at unique ratio (66:30:24) resulted in lower pest population in cotton at Giza, Egypt.

2.3.3 Insecticidal spray

Horowitz *et al.* (1998) reported that acetamiprid at 2, 7, and 14 days after application resulted in 76, 84, 96% adult mortalities of whitefly population, respectively.

Sonalkar (1999) evaluated the efficacy of acetamiprid at four doses against whitefly, *B. tabaci* on okra at Maharashtra and found that acetamiprid at 20 g a.i. /ha reduced the pest population significantly (94.42 %). However at 15 g a.i. /ha, the mortality was only 54.34 per cent.

Mustafa (2000) reported that imidacloprid and diafenthiuron gave almost 72.6 percent mortality of whitefly. He also recorded mortality of whitefly with the application of acetamiprid at Faisalabad, Pakistan.

Parrish and Assail (2001) observed that there was significant mortality of whitefly with the application of acetamiprid in cotton at America.

Ali *et al*. (2003) reported that buprofenzin, fenpropathrin, endosulfan, imidacloprid, acetamiprid and diafenthiuron reduced the whitefly nymphal population significantly in cotton. But the adult of whitefly population with the treatment plant of acetamiprid, diafenthiuron, imidacloprid and endosulfan was 56, 58.34, 61.67 and 64, respectively at Layyah, Pakistan.

Rathod (2003) conducted a field trial for evaluating the bioefficacy of acetamiprid 20 SP at different dosages against whiteflies and the results indicated that acetamiprid 20 SP @ 80 g a.i. /ha gave maximum protection to cotton against whiteflies at Parbhani, Maharashtra.

Brar and Agarwal (2005) found that acetamiprid 20 SP at 150 to 200 g/ha proved significantly better for the control of whitefly up to 7 days after spraying. Maximum reduction (50 to 77.67 %) occurred one day after spray after that its population showed an increasing trend but remained at a low level than that was observed before spray in all the treatments.

Misra (2005) stated that acetamiprid (20 g/ha) and imidacloprid (25 g/ha) proved significantly the best treatments in controlling the whitefly population on okra up to 3 weeks after application, with a population reduction of 81.02 and 82.71%, respectively over the control at Orissa.

Raghuraman and Gupta (2005) observed that acetamiprid 40 g a.i. /ha and imidacloprid 100 g a.i./ha. were the most effective treatment against *B. tabaci* (48% and 45% increase in seed cotton yield over control, respectively). Results suggested that acetamiprid and imidacloprid are good substitute for conventional insecticides in vogue, which could use in formulating a successful management strategy.

Ameta *et al.* (2006) evaluated efficacy of triazophos 20 EC @ 400, 500 and 600 g a.i./ha, triazophos 40 EC @ 500 and 600 g a.i. /ha, against whitefly, *B. tabaci* on cotton. They reported that application of triazophos 20 EC @ 600 g a.i./ha caused reduction in population of whitefly.

Reddy and Gowdar (2006) conducted the field experiments to evaluate the bioefficacy of acetamiprid 20 SP against sucking pests of okra. Acetamiprid 20 SP@ 40 and 30 g a.i. /ha followed by acetamiprid 20 SP @ 20 g a.i./ha were found to be most effective in reducing the sucking pest population with maximum okra fruit yield.

According to Gowdar *et al.* (2007), acetamiprid, imidacloprid, triazophos and monocrotophos significantly reduced mean whitefly population and YVMV incidence in okra. The spray of acetamiprid 20 SP @ 40 g a.i./ha was most effective in reducing incidence of YVMV and whitefly population at Shimoga, Karnataka.

Kanna *et al.* (2007) recorded that acetamiprid 20 SP @ 80 g a.i./ha which were 2-4 times effective than recommended dose (20 g a.i./ha) and did not cause any phytotoxicity symptoms on cotton at Coimbatore, Tamilnadu.

Reddy *et al.* (2007) showed that two sprays of acetamiprid at 40 g a.i./ha gave the maximum reduction in whitefly count, least incidence of YVMV disease and consequently increased fruit yield of okra.

Veenila *et al.* (2007) reported that acetamiprid 20 SP @ 30-40 g/ha was effective against whiteflies infesting okra crop.

Yadav *et al.* (2007b) conducted field trials to test the efficacy and economics of certain new insecticides against whitefly causing YVMV in Mesta, Greece. They revealed that acetamiprid 20 SP @100ml/ha was most effective in managing whitefly population to the tune of 74.56 and 78.33% after first and second spraying, respectively. Also the incidence of YVMV was reduced to 22.14 per cent from 59.19 per cent in untreated control.

Acharya and Bhargava (2009) found that triazophos (3 ml/lit.) proved most effective against whitefly and gave maximum yield. The highest return (Rs. 19875 /ha) was obtained from the crop treated with triazophos.

Naik *et al.* (2009) studied that all neonicotinoids, buprofezin, diafenthiuron were quite effective in managing YVMV disease indirectly by exerting direct effect on whitefly population at Bapatla, Andhra Pradesh.

According to Ghosal and Chatterjee (2013), okra whitefly population was minimum (2.67/5 plants) when diafenthiuron sprayed at 35 DAS and at 50 DAS while it was 4.33/5 plants in untreated plot at Nadia, West Bengal.

Ramu *et al.* (2011) noticed that acetamiprid @ 0.2 g/lit was found to be effective and recorded lowest whitefly population (3.33) and YVMV disease incidence (3.15%) in okra followed by imidacloprid and triazophos at Mesta, Greece.

Kannake (2014) studied different insecticides and biopesticides against whitefly on okra during summer, 2012 at Rahuri, Maharashtra. Results revealed that acetamiprid (20 SP) was the most effective treatment for the suppression of whitefly on okra and it was followed by triazophos (40 EC) & diafenthiuron (50 WP).

Gaurkhede *et al*. (2015) reported that acetamiprid 20 SP @ 0.004 percent proved to be most effective in lowering down the whitefly population (0.99 whitefly/leaf).

Kaur *et al*. (2015) evaluated the bio-efficacy of different insecticides against cotton white fly (*B. tabaci*) at Sriganganagar, Rajasthan. Maximum percent reduction was observed with trizophos 40 EC (63.22%) followed by the acetamiprid 20% SP (55.61%) and these were statistically at par and significantly superior over rest of the treatments.

Bajya *et al.* (2016) carried out an experiment on management of sucking pests of cotton and its safety to natural enemies at Gurgaon, Haryana and revealed that diafenthiuron 47.8 SC @ 286.8 g a.i. /ha was highly effective in suppressing the sucking pests *viz.*, whitefly, jassids, thrips and had no adverse effects on the natural enemies.

Kalyan *et al.* (2017) conducted an experiment to evaluate the efficacy of new molecules against jassids and whiteflies on *Bt* cotton. Among the ten insecticides tested, the maximum percent reduction in whitefly population with a mean of 81.71 and 83.27 was recorded in diafenthiuron 50 WP during both the years at Banswara, Rajasthan.

CHAPTER III

MATERIALS AND METHODS

The present investigations on seasonal abundance, varietal screening and management of whitefly of okra were carried out at the Instructional Farm, College of Agriculture, Junagadh Agricultural University, Junagadh during *kharif* season of 2018. The details of materials and methodology adopted were given here under.

3.1 Seasonal abundance of *Bemisia tabaci* infesting *kharif* okra

In order to study the seasonal abundance of okra whitefly, the crop was sown at Instructional Farm, College of Agriculture, Junagadh Agricultural University, Junagadh during the *kharif* season of 2018. The seed of okra variety GJO-3 (Gujarat Junagadh Okra-3) was sown after sufficient rain with plot size of 12m x 15m keeping the spacing of 60cm x 30cm [Plate 1]. All the other agronomical practices were followed as per the scientific recommendations. The crop under the experiment was kept free from pesticides throughout the season to allow and breed the natural infestation of various insect pests of okra. The whole plot was divided into 10 quadrates each of 2.4m x 7.5m having the plant populations of 50 plants in each quadrate. Five plants were selected randomly and tagged in each quadrate and collectively total 50 plants were observed. Observations on number of whitefly were recorded from three leaves *i.e.* upper, middle and lower portion of the plant after initiation of incidence. Mean data, thus obtained were correlated with weather parameters.

3.1.1 Methods for recording observations

During the period of the study whitefly, *Bemisia tabaci* (Gennadius) was reported as the major insect pest of okra crop at Junagadh area of Gujarat.

3.1.1.1 Whitefly population

Observations of whitefly were recorded at weekly interval by observing three leaves (upper, middle and lower) of each tagged plant. Total five plants were selected randomly from each quadrate for these studies. Observations of whitefly were recorded by counting the number of adult population by examining the leaves without disturbing them. The observations of whitefly were recorded during early morning.

3.1.2 Correlation study

In order to study the effect of different weather parameters *viz*., maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, sunshine hours, rainfall and rainy days on population of various insect pests, the simple correlation coefficients were worked out. The weekly meteorological data were obtained from Meteorological Observatory, College Farm, Junagadh Agricultural University, Junagadh.

3.2 Evaluation of susceptibility of okra varieties /genotypes against *B. tabaci* infesting *kharif* okra

To study the susceptibility of different ten varieties /genotypes *viz*., GO-2, GJO-3, GAO-5, Pusa Sawani, VRO-6, Kashi Kranti, HRB-55, HRB-108-2, JOL-11-12 and JOL-09-05 of okra, an experiment was carried out during *kharif* 2018 [Plate 2]. Two lines of each varieties /genotypes were grown in a Randomized Block Design with the spacing of 60cm x 30cm with three replications and plot size was 1.2m x 4.0m. All other agronomical practices were followed as per the scientific recommendations and varieties /genotypes under the experiment were kept free from the insecticides throughout the season. From the lines of each varieties /genotypes, five plants were randomly selected and tagged. The observations on whitefly population was recorded from three leaves from upper, middle and lower portion of each plant early in the morning at weekly interval. The data thus obtained were analyzed for assessing the least susceptible genotype against the whitefly on okra. Further, okra yield was also recorded from each genotypes/varieties.

3.2.1 Categorization of varieties /genotypes

In order to differentiate the whitefly infestation on different ten varieties /genotypes, an attempt was made to splinter the varieties /genotypes in different categories. Patel *et al.* (2002) categorized castor varieties against semi looper in to four groups *viz.*, highly resistant, resistant, susceptible and highly susceptible which was modified to fit into okra varieties for screening against whitefly. Different okra genotypes/cultivars were grouped in to six categories of resistance to whitefly *viz.*, highly resistant, resistant, moderately resistance, moderately susceptible, susceptible and highly susceptible based on no. of whitefly/three leaves. For the purpose, mean value of individual genotype ($\overline{X}_i$) was compared with mean value of all genotypes

($\overline{X}$) and standard deviation (SD). The retransformed data were used for computation of $\overline{X}$, $\overline{X}_i$ and SD in case of this parameter (Table 1).

Table 1: The scale used for categorizing different varieties /genotypes

Category of resistance	Scale for resistance
Highly resistant	$\overline{X}_i$ < ($\overline{X}$ - 2SD)
Resistant	$\overline{X}_i$ > ($\overline{X}$ - 2SD) < ($\overline{X}$ - SD)
Moderately resistant	$\overline{X}_i$ > ($\overline{X}$ - SD) < $\overline{X}$
Moderately susceptible	$\overline{X}_i$ > $\overline{X}$ < ($\overline{X}$ + SD)
Susceptible	$\overline{X}_i$ > ($\overline{X}$ + SD) < ($\overline{X}$ + 2SD)
Highly susceptible	$\overline{X}_i$ > ($\overline{X}$ + 2SD)

3.3 Management of *B. tabaci* infesting *kharif* okra

3.3.1 Details of experiment

In order to study the management of whitefly through potash fertilizer and foliar application of insecticides, the experiment was laid out in a Randomized Block Design with factorial concept having three replications with the plot size of 2.4 m X 3.0 m during *kharif*, 2018 at Instructional Farm, College of Agriculture, Junagadh Agricultural University, Junagadh. Okra variety GJO-3 was sown at a spacing of 60 cm x 30 cm in July, 2018 [Plate 3]. All agronomical practices were adopted as per the recommendation in vogue. Details of treatments are given in Table 2 & 3.

3.3.2 Application of treatments

Recommended dose of pesticide was used for the seed dressing. Seed treatment of imidacloprid 48 FS @ 4 ml/kg seed was given in to the each treatment at few hours before sowing.

Fertilizer application

The crop was raised after following standard agronomic practices. All fertilizer doses were applied in different plots according to respective treatments at the time of sowing.

Insecticide application

All the insecticides were applied in the form of foliar spray with the help of knapsack spryer (15 litre capacity). For deciding the quantity of spray fluid required per plot, the control plot was sprayed with water and determined the required spray fluid. Spray fluid was prepared by mixing measured quantity of water and insecticide. The necessary care was taken to prevent the drift of insecticide to reach the adjacent plots. Care was also taken to rinse the sprayer thoroughly before and after each spray with soap water to avoid contamination from treatment to treatment. First spray was applied at initiation of pest followed by second spray at 25 days interval.

3.3.3 Methods for recording observations

Observations of *B. tabaci* population was counted from the five randomly selected plants from the net plot area. The effectiveness of treatment was studied by recording the population of whitefly from respective treatment at weekly interval starting from the day of the crop germination to harvesting stages [Plate 4].

3.3.4 Yield, economics and incremental cost benefit ratio

With a view to evaluate the effect of different pesticides on the okra yield, crop was harvested from each net plot. The harvested yield was weighted and converted on hectare basis. Economics of all the treatments was worked out by considering the price of products, cost of insecticides and labour charges. ICBR was worked out to compare the economics of different insecticidal treatments. The per cent increase in yield over control was calculated by using following formula (Pradhan, 1969).

$$\text{Yield increased (Per cent)} = 100 \times \frac{T - C}{C}$$

Where,

T = Yield from treated plot (kg/ha)

C = Yield from untreated plot (kg/ha)

Table 2: Treatment details for management of okra whitefly, *B. tabaci*

Potash fertilizer

K_1 Potash fertilizer @ 60 kg/ha

K_2 Potash fertilizer @ 80 kg/ha

K_3 Potash fertilizer @ 50 kg/ha

Foliar application of insecticides

I_1 Triazophos 40 EC 0.04% @ 20 ml/10 lit

I_2 Acetamiprid 20 SP 0.006% @ 3 g/10 lit

I_3 Diafenthiuron 50 WP 0.05% @ 10 g/10 lit

I_4 Control

1.	**T_1**	**K_1I_1**	7.	**T_7**	**K_2I_3**
2.	**T_2**	**K_1I_2**	8.	**T_8**	**K_2I_4**
3.	**T_3**	**K_1I_3**	9.	**T_9**	**K_3I_1**
4.	**T_4**	**K_1I_4**	10.	**T_{10}**	**K_3I_2**
5.	**T_5**	**K_2I_1**	11.	**T_{11}**	**K_3I_3**
6.	**T_6**	**K_2I_2**	12.	**T_{12}**	**K_3I_4**

Table 3: Details of insecticides used in foliar applications for management of okra whitefly, *B. tabaci*

Sr. No.	**Technical name**	**Trade name**	**Formulation**	**Concentration**	**Dose /10 lit**	**Manufacture name**
I_1	Triazophos	Trizor	40 EC	0.04%	20 ml	SDS Ramcides Crop Science Pvt. Ltd.
I_2	Acetamiprid	Pound	20 SP	0.006%	3 g	Bharat insecticides Ltd.
I_3	Diafenthiuron	Pajero	50 WP	0.05%	10 g	Bharat insecticides Ltd.

CHAPTER IV

RESULTS AND DISCUSSION

The results and discussion on the present investigations carried out on "Seasonal abundance, varietal screening and management of whitefly, *Bemisia tabaci* (Gennadius) infesting *kharif* okra" are presented in this chapter. The detailed results of individual experiments have been furnished for exploration of treatment impact as per the experiment planned and put for the validation.

The purpose of the discussion is to interpret and describe the significance of the present findings in light of what was already known about the research problem being investigated, and to explain any new understanding or insights about the problem after the findings have been taken into consideration.

The results presented in the preceding chapter in the form of inferences have been discussed keeping in view the earlier findings of other workers. Wherever, the suitable literature is not available, the pertinent references on other crops have been used to support the present findings.

The experiment was carried out at Instructional Farm, College of Agriculture, Junagadh Agricultural University, Junagadh during *kharif* season, 2018. The results obtained are presented under the following main heads:

4.1 Seasonal abundance of *Bemisia tabaci* infesting *kharif* okra

4.2 Evaluation of susceptibility of okra varieties/genotypes against *B. tabaci* infesting *kharif* okra

4.3 Management of *B. tabaci* infesting *kharif* okra

4.1 Seasonal abundance of *Bemisia tabaci* infesting *kharif* okra

4.1.1 Whitefly abundance in okra crop during *kharif*, 2018

In nature, the distribution and abundance of living organisms determined by combined effect of different components of ecosystem. Abiotic factors influence the most for build-up of the population. Among the various abiotic factors temperature, humidity, rainfall, intensity of light and other physical factors play a vital role in population fluctuation of any pest species and have a direct influence on their abundance.

To know the activity of whitefly, *B. tabaci* in okra, studies were carried out during *kharif*, 2018 at Instructional Farm, College of Agriculture, Junagadh Agricultural University, Junagadh. The activity of whitefly was recorded from plants periodically at weekly interval [Plate 5].

The data (Table 4 and Figure 1) indicated that the abundance of whitefly, *B. tabaci* was commenced from first week of August *i.e.*, 31st Standard Meteorological Week (SMW) & 26 Day After Sowing (DAS) and continued till 1st week of October (40th SMW) *i.e.*, 70 DAS which ranged from 2.00 to 7.52 [whitefly /leaf]. The population of *B. tabaci* was fluctuated during the crop period. During the 3rd week of September (38th SMW) it was observed 7.14 whitefly /leaf and showed its peak 7.52 whitefly /leaf during 4th week of September (39th SMW). In subsequent weeks, the abundance was decreased and reached to 4.90 whitefly /leaf during 1st week of October (40th SMW).

Table 4: Seasonal abundance of whitefly, *B. tabaci* on okra during *kharif*, 2018

Sr. No.	Month and Year	SMW	Mean adult whitefly /leaf
1.	July, 18	30	0.00
2.	Aug., 18	31	2.30
3.		32	3.88
4.		33	3.04
5.		34	2.00
6.		35	2.36
7.	Sep., 18	36	4.08
8.		37	6.18
9.		38	**7.14**
10.		39	**7.52**
11.	Oct., 18	40	**4.90**

Note: SMW- Standard Meteorological Week

These findings are in line with the findings of Anitha and Nandihalli (2008) who reported that whitefly populations on *kharif* crop in okra started appearing from the first week of August 2006. Wajid and Ansari (2008) reported that the peak whitely population on okra was seen on the 60 days old crop, while the lowest was on the 30 days old crop during 2005 and 2006. The present findings are also in close agreement with the findings of Yadav *et al.* (2007a) who revealed that whitefly incidence started from the first week of August until the second week of October in 2005, whereas in 2006, infestation started from the first week of August to the third week of October. The highest population of whitefly was observed during in the end of September, 2005. Ghosh *et al.* (1999) observed the peak population of whitefly in *kharif at* the end of crop growth period in Bengal. Meena *et al.* (2013) showed that whiteflies (*Bemisia tabaci* Genn.) were appeared on the chilli crop soon after transplanting and it peak was found in the month of September during 2006-07 (6.7 whiteflies /3 leaves/ leaf). According to Yadav and Singh (2013) and Aarwe *et al.* (2016), in which major activity of *B. tabaci* appeared during first week of August to last week of September. These previous studies support the present findings.

4.1.2 Correlation between weather parameters and whitefly population in okra

To know the effect of various abiotic factors on the population fluctuation of whitefly of okra a correlation coefficient was worked out and presented in Table 5.

The observation on population build-up of *B. tabaci* revealed that whitefly infestation commenced when the average maximum temperature was 32.1ºC and minimum temperature was 26.1 ºC during year 2018. The peak activity of whitefly was observed when maximum and minimum temperatures were 34.7ºC and 23.1ºC, respectively during 2018, which indicate that most favorable range of temperature for fast multiplication of okra.

The correlation coefficient between whitefly and weather parameters was presented in Table 5 and Figure 1. The correlation matrix indicated that the whitefly population exhibited significant positive relation with maximum temperature (r= 0.613*) and bright sunshine hours (0.802*). Whitefly population had significant negative correlation with minimum temperature (-0.700*), wind speed (-0.674*), morning relative humidity (-0.705*) and evening relative humidity (-0.733*). While, whitefly population had non significant negative correlation with rainfall (-0.377).

The results of the present investigation are reflected in the finding of Ghosh *et al.* (2004) who reported that whitefly population was non-significantly and negatively correlated with weekly rainfall. Pun *et al.* (2005) revealed that a significant positive correlation between whitefly population and maximum temperature, minimum temperature & sunshine hours from July 1993 to 1994 at Coimbatore, Tamil Nadu. The present investigation results are also in confirmation with the findings of Threhan

(1994) who reported that, higher temperature and low rainfall were found to favor rapid multiplication of the pest. Significant positive correlation between whitefly population and maximum temperature was also reported by Yadav and Singh (2013). The findings regarding sunshine hours were in conformity with Roomi *et al.* (2016) and Mehra & Rolania (2017) who reported that whitefly population showed positive correlation with the sunshine hours.

These seasonal abundance studies varies from region to region due to the different weather parameters existing in different locations. It also varies due to the difference in sowing season and availability of alternate hosts during off season.

Table 5: Correlation of *B. tabaci* with abiotic factors in okra during *kharif*, 2018

Abiotic factors	Correlation Coefficient of whitefly
Maximum Temperature, ^{0}C (MaxT)	0.613*
Minimum Temperature, ^{0}C (MinT)	-0.700*
Morning Relative Humidity, % (RH_1)	-0.705*
Evening Relative Humidity, % (RH_2)	-0.733*
Rainfall, mm (R)	-0.377
Wind Speed, kmhr^{-1} (WS)	-0.674*
Bright Sunshine Hours, hrday^{-1} (BSS)	0.802*

* Significant at 5% level (r = 0.602)

4.2 Evaluation of susceptibility of okra varieties/genotypes against *B. tabaci* infesting *kharif* okra

To check the susceptibility okra varieties/genotypes, ten varieties/genotypes were screened for the resistance/susceptible against whitefly at Instructional Farm, College of Agriculture, Junagadh Agricultural University, Junagadh during *kharif*, 2018.

4.2.1 Evaluation of varieties /genotypes

The susceptibility of different varieties /genotypes of okra to *B. tabaci* were evaluated based on number of whitefly/leaf.

The data on different periods [Table 6 and Figure 2] revealed the order of various varieties /genotypes based on lower number of whitefly /leaf is given in bracket was: HRB-108-2 (1.65) < JOL-11-12 (1.94) < VRO-6 (2.34) < Kashi Kranti (2.53) <

GAO-5 (2.90) < GJO-3 (3.17) < GO-2 (3.47) < JOL-9-5 (3.72) < HRB-55 (4.13) < Pusa Sawani (5.09).

Table 6: Infestation of whitefly in varieties /genotypes of okra and their yield

Varieties /Genotypes	No. of whitefly /leaf	Fruit yield (kg /ha)
Pusa Sawani	2.23*f* (5.09)	4695*g*
Kashi Kranti	1.58*bc* (2.53)	8307*bc*
GAO-5	1.70*cd* (2.90)	7612*cd*
HRB-108-2	1.28*a* (1.65)	10668*a*
JOL-9-5	1.92*de* (3.72)	5529*fg*
JOL-11-12	1.38*ab* (1.94)	9557*ab*
HRB-55	2.02*ef* (4.13)	5112*fg*
GO-2	1.85*de* (3.47)	6154*ef*
VRO-6	1.52*abc* (2.34)	9001*b*
GJO-3	1.77*cde* (3.17)	6848*de*
Mean	1.73 (3.09)	7348
ANOVA		
S. Em.	0.08	424.17
C.D. at 5%	0.26	1260.21
C.V. %	8.92	10

Notes:

1. Figures in parentheses are retransformed values; those outside are √x transformed value.
2. Treatment mean with letter(s) in common are not significant at 5 % level of significance within a column.

The incidence of whitefly on okra was differed significantly among various varieties /genotypes. Variety HRB-108-2 (1.65 whitefly /leaf) recorded significantly lower infestation than rest of the varieties /genotypes which was found at par with JOL-11-12 (1.94) and VRO-6 (2.34). Further, VRO-6 (2.34) found at par with Kashi Kranti (2.53). On other side, Kashi Kranti (2.53) was found at par with GAO-5 (2.90) and GJO-3 (3.17). While, GJO-3 (3.17) was found at par with GO-2 (3.47) and JOL-9-5

(3.72). Again, JOL-9-5 (3.72) was found at par with Okra variety HRB-55 (4.13). HRB-55 (4.13) and Pusa Sawani (5.09) were found with at par with each other. Pusa Sawani (5.09) recorded significantly higher infestation than any other varieties /genotypes. Patel *et al.* 2003 reported that Pusa Sawani was more susceptible to whitefly as compared to Gujarat Okra Hybrid-1. Dabhi *et al.* (2012) recorded least population of whitefly on the genotypes VRO-5 and VRO-6. Solanki (2005) noted that GO-2 were the most susceptible to whitefly under field conditions. Kabade (2009) reported that HRB-108-2 genotype showed significantly lower population of whitefly.

In all, the infestation of *B. tabaci* was found minimum in the okra variety HRB-108-2. While, the highest infestation was found in the okra variety Pusa Sawani.

4.2.2 Categorization of okra varieties for susceptibility

The different okra varieties /genotypes were also grouped in to six categories of resistance *viz*., highly resistant (HR), resistant (R), moderately resistant (MR), moderately susceptible (MS), susceptible (S) and highly susceptible (HS) based on whitefly population and it's damage on okra by comparing the mean incidence of individual varieties /genotypes ($\overline{X_i}$) with mean incidence of all genotypes/ cultivars ($\overline{X}$) and standard deviation (SD). The categorization of different okra varieties /genotypes is summarized in Table 7.

4.2.2.1 Based on infestation of whitefly

The data revealed that none of the varieties/ genotypes was observed highly resistant (HR) to whitefly. The HRB-108-2 (1.65 whitefly/leaf) and JOL-11-12 (1.94 whitefly/leaf) were observed resistant (R) against whitefly population ranged from 0.99 to 2.04 whitefly /leaf. VRO-6 (2.34), Kashi Kranti (2.53), GAO-5 (2.90) categorized into group of moderately resistant (MR) as the infestation was recorded in the range of 2.04 to 3.09 whitefly /leaf. In case of varieties /genotype GJO-3 (3.17), GO-2 (3.47), JOL-9-5 (3.72), HRB-55 (4.13), the infestation was recorded in the range of 3.09 to 4.14 whitefly /leaf and so were categorized into moderately susceptible (MS) group. Under susceptible (S) category *i.e.*, range from 4.14 to 5.19 only one variety, Pusa Sawani (5.09) was observed. None of the varieties /genotypes was observed to have higher no. of whitefly count which comes under highly susceptible (HS) category. While spanning the information on this aspect from the published reports, Solanki (2005) noted that Pusa Sawani and GO-2 were the most susceptible to whitefly under field conditions. Kabade (2009) reported that HRB-108-2 genotype showed significantly lower population of whitefly. Navneet and Tayde (2018) investigated different okra varieties and revealed that VRO-6 (6.66%) was recorded more resistant against YVMV than HRB-55 (20%).

Table 7: Categorization of okra varieties /genotypes for their susceptibility to whitefly, *B. tabaci*

Category of resistant	Scale	Varieties /genotypes $\overline{X}_i$	
1	**2**	**3**	
Based on three leaves [upper, middle & lower] (whitefly /leaf): $\overline{X}$ = 3.09 and SD =1.05			
Highly resistant	$\overline{X}_i$ < (0.99)	-	
Resistant	$\overline{X}_i$ > (0.99) < (2.04)	HRB-108-2	(1.65)
		JOL-11-12	(1.94)
Moderately resistant	$\overline{X}_i$ > (2.04) < (3.09)	VRO-6	(2.34)
		Kashi Kranti	(2.53)
		GAO-5	(2.90)
Moderately susceptible	$\overline{X}_i$ > (3.09) < (4.14)	GJO-3	(3.17)
		GO-2	(3.47)
		JOL-9-5	(3.72)
		HRB-55	(4.13)
Susceptible	$\overline{X}_i$ > (4.14) < (5.19)	Pusa Sawani	(5.09)
Highly susceptible	$\overline{X}_i$ > (5.19)	-	

Note: Figures in parentheses are whitefly /leaf on okra

Where, $\overline{X}_i$ = Mean value of individual genotype

$\overline{X}$ = Mean value of infestation of all genotypes

SD= Standard deviation

In all, HRB-108-2 and JOL-11-12 were recorded resistant with the lowest whitefly population and Pusa Sawani was recorded susceptible with the highest whitefly population against the *B. tabaci*. No one varieties/genotypes were observed either highly resistant or highly susceptible to whitefly.

4.2.3 Yield

The data (Table 6 and Figure 2) was noted on yield from the different varieties /genotypes of okra. The chronological order of various varieties /genotypes recorded the highest yield, based on yield (kg/ha) given in bracket was HRB-108-2 (10668) < JOL-11-12 (9557) < VRO-6 (9001) < Kashi Kranti (8307) < GAO-5 (7612) < GJO-3 (6848) < GO-2 (6154) < JOL-9-5 (5529) < HRB-55 (5112) < Pusa sawani (4695). Among the different varieties /genotypes, HRB-108-2 was found the best variety and recorded significantly higher (10668 kg /ha) yield than rest of the varieties/ genotypes. However, it was found at par with JOL-11-12 (9557). On other side, JOL-11-12 (9557) found at par with VRO-6 (9001) and Kashi Kranti (8307). Further, Kashi Kranti (8307) was found at par with GAO-5 (7612) and GJO-3 (6848). While, GJO-3 (6848) was found at par with GO-2 (6154), JOL-9-5 (5529) and HRB-55 (5112). While, Pusa Sawani (4695.43) recorded lowest yield.

4.3 Management of *B. tabaci* infesting *kharif* okra

An experiment for management of whitefly through potash fertilizer and foliar application of insecticides was carried out under field condition at Instructional farm, College of Agriculture, Junagadh Agricultural University, Junagadh during *kharif*, 2018. To determine the effect of different potash fertilizer dose and foliar application of insecticides against whitefly, three potash fertilizer dose *viz.*, K_1: potash fertilizer @ 60 kg/ha, K_2: potash fertilizer @ 80 kg/ha and K_3: potash fertilizer @ 50 kg/ha application at the time of sowing and foliar application of insecticides *viz.*, I_1: triazophos 40 EC @ 20 ml/10 lit, I_2: acetamiprid 20 SP @ 3 g/10 lit, I_3: diafenthiuron 50 WP @ 10 g/10 lit and I_4: control were tested. The combination of soil application of fertilizer and foliar application of insecticides *viz.,* K_1I_1, K_2I_1, K_3I_1, K_1I_2, K_2I_2, K_3I_2, K_1I_3, K_2I_3, K_3I_3, K_1I_4, K_2I_4 and K_3I_4 were made in such manner that overall effect can be worked out. During the experiment, potash fertilizer was given at the time of sowing while foliar applications were given twice with respective insecticides. The first spray was applied at initiation of pest followed by second was carried out at twenty five day after first spray. The results on whitefly population are presented here under.

4.3.1 Effect of different interactions against whitefly, *B. tabaci* during first spray

In okra, management of whitefly population was initiated when pest crossed economic threshold level till pest reaching considerable level of control. The first spray was made when pest crossed economic threshold level. The periodical data showing effect of potash fertilizer and insecticidal spray on whitefly infestation to okra were recorded on one, three, five and seven days after spray (DAS). The effect of different interaction has been adjudged based on individual as well as pooled over period data. All the effective combinations were significantly superior to untreated control up to 10 days of spray.

4.3.1.1 Potash fertilizer

The data on mean whitefly count after first application of insecticides presented in Table 8 and depicted in Figure 3. Data revealed that among three different potash fertilizer doses, potash fertilizer @ 80 kg/ha dose showed lowest whitefly count *i.e.*, 1.93, 0.96, 2.72 and 2.99 in compare to other two treatments on first, third, fifth and seventh day after spraying. Next best treatment was potash fertilizer @ 60 kg/ha followed by potash fertilizer @ 50 kg/ha during all four days of observation.

4.3.1.2 Insecticidal spray

The data on mean whitefly population after first application of insecticides presented in Table 8 and depicted in Figure 4 revealed that among sprayed insecticides, acetamiprid 0.006% (1.88) was found most effective as lowest whitefly population was observed. However, it was found at par with triazophos 0.04% (2.07). On other side, triazophos 0.04% was found at par with diafenthiuron 0.05% (2.28) at 1DAS. At third DAS, acetamiprid 0.006% (0.74) and triazophos 0.04% (0.94) was found at par with each other followed by diafenthiuron 0.05% (1.19). Similar pattern like 1DAS was observed in fifth and seventh DAS. At 5 DAS, acetamiprid 0.006% (2.76) was found most effective as lowest whitefly population was observed. However, it was found at par with triazophos 0.04% (3.10). On other side, triazophos 0.04% was found at par with diafenthiuron 0.05% (3.35) at 5DAS. On seventh DAS, acetamiprid 0.006% (3.06) was found most effective as lowest whitefly population was observed. However, it was found at par with triazophos 0.04% (3.39). On other side, triazophos 0.04% was found at par with diafenthiuron 0.05% (3.65). All three foliar application of insecticide were found to be effective at all four days of observation.

Table 8: Effect of potash fertilizer along with foliar application of insecticides against whitefly after first spray

Treatments		No. of whitefly /leaf			
		1 DAS	**3 DAS**	**5 DAS**	**7 DAS**
Potash fertilizer (K)					
K_1	Potash fertilizer @ 60 kg/ha	1.60*b* (2.56)	1.23*b* (1.51)	1.87*b* (3.50)	1.95*b* (3.80)
K_2	Potash fertilizer @ 80 kg/ha	1.39*a* (1.93)	0.98*a* (0.96)	1.65*a* (2.72)	1.73*a* (2.99)
K_3	Potash fertilizer @ 50 kg/ha	1.77*c* (3.13)	1.48*c* (2.19)	2.03*c* (4.12)	2.10*c* (4.41)
ANOVA					
	S. Em. ±	0.03	0.03	0.03	0.03
	C. D. at 5%	0.08	0.10	0.09	0.08
Insecticidal spray(I)					
I_1	Triazophos 0.04%	1.44*ab* (2.07)	0.97*a* (0.94)	1.*76ab* (3.10)	1.*84ab* (3.39)
I_2	Acetamiprid 0.006%	1.37*a* (1.88)	0.86*a* (0.74)	1.66*a* (2.76)	1.75*a* (3.06)
I_3	Diafenthiuron 0.05%	1.51*b* (2.28)	1.09*b* (1.19)	1.83*b* (3.35)	1.91*b* (3.65)
I_4	Control	2.04*c* (4.16)	2.00*c* (4.00)	2.14*c* (4.58)	2.20*c* (4.84)
ANOVA					
	S. Em. ±	0.03	0.04	0.04	0.03
	C. D. at 5%	0.10	0.11	0.11	0.10
	C. V. %	6.28	9.31	5.86	5.18

Notes:

1. NS: Non significant and S: Significant. Figures in parentheses are retransformed values; those outside are √x transformed values.
2. Treatment mean with letter(s) in common are not significant at 5 % level of significance within a column.

4.3.1.3 Interaction effect between potash fertilizer and foliar application of insecticides on different days of observation and pooled over period

The data on interaction between potash fertilizer and foliar application of insecticides presented in Table 9 and depicted in Figure 5 revealed that twelve different interactions were found significantly different. The order of combination based on whitefly count on okra on first Day After Spraying (DAS) given in bracket was: K_2I_2 (1.25) < K_2I_1 (1.39) < K_2I_3 (1.59) < K_1I_2 (1.85) < K_1I_1 (2.13) < K_1I_3 (2.40) < K_3I_2 (2.59) < K_3I_1 (2.79) < K_3I_3 (2.92) < K_2I_4 (4.08) < K_1I_4 (4.12) < K_3I_4 (4.33). Among the different combinations, K_2I_2 (potash fertilizer @ 80 kg/ha + acetamiprid 0.006%) was found significantly superior [1.25 whitefly /leaf] to the rest of the combinations. However, it was at par with K_2I_1 (potash fertilizer @ 80 kg/ha + triazophos 0.04%) and K_2I_3 (potash fertilizer @ 80 kg/ha + diafenthiuron 0.05%). Further, K_2I_3 was found at par with K_1I_2 (potash fertilizer @ 60 kg/ha + acetamiprid 0.006%). While, K_1I_2 was found at par with K_1I_1 (potash fertilizer @ 60 kg/ha + triazophos 0.04%). on other side, K_1I_1 was found at par with K_1I_3 (potash fertilizer @ 60 kg/ha + diafenthiuron 0.05%) and K_3I_2 (potash fertilizer @ 50 kg/ha + acetamiprid 0.006%). Again, K_3I_2 was found at par with K_3I_1 (potash fertilizer @ 50 kg/ha + triazophos 0.04%) and K_3I_3 (potash fertilizer @ 50 kg/ha + diafenthiuron 0.05%). Least effective combinations were K_2I_4 (potash fertilizer @ 80 kg/ha + control) and K_1I_4 (potash fertilizer @ 60 kg/ha + control) found at par with each other.

On third DAS, the order of effective combination on based of whitefly count in okra is given in bracket was: K_2I_2 (0.31) < K_2I_1 (0.44) < K_2I_3 (0.59) < K_1I_2 (0.72) < K_1I_1 (0.92) < K_1I_3 (1.25) < K_3I_2 (1.39) < K_3I_1 (1.66) < K_3I_3 (1.93) < K_2I_4 (3.80) < K_1I_4 (4.00) < K_3I_4 (4.28). Among the different combination, K_2I_2 was found significantly superior [0.31 whitefly /leaf] to the rest of the combinations. However, it was at par with K_2I_1. While, $K_2I_1$was found at par with K_2I_3 and K_1I_2. K_1I_2 was found at par with K_1I_1. On other side, K_1I_1 was found at par with K_1I_3. Further, K_1I_3 was found at par with K_3I_2 and K_3I_1. The next best combination was K_3I_1 found at par with K_3I_3. Less effective combinations were K_2I_4 and K_1I_4 found at par with each other.

The order of effective combination on based of whitefly count on okra is given in bracket was: K_2I_2 (1.85) < K_2I_1 (2.31) < K_2I_3 (2.59) < K_1I_2 (2.89) < K_1I_1 (3.17) < K_1I_3 (3.39) < K_3I_2 (3.72) < K_3I_1 (3.92) < K_3I_3 (4.12) < K_2I_4 (4.37) < K_1I_4 (4.58) < K_3I_4 (4.71) at 5 DAS. Among the combinations, K_2I_2 was found significantly superior [1.85 whitefly /leaf] to the rest of the combinations. However, it was at par with K_2I_1.

Table 9: Interaction effect of potash fertilizer doses with different foliar application of insecticides against whitefly after first spray

Treatments	No. of whitefly /leaf									
	1 DAS		3 DAS		5 DAS		7 DAS		Pooled over periods	
K_1I_1	1.46*cd* (2.13)		0.96*cd* (0.92)		1.78*cde* (3.17)		1.88*de* (3.53)		1.52*d* (2.31)	
K_1I_2	1.36*bc* (1.85)		0.85*bc* (0.72)		1.70*bcd* (2.89)		1.77*cd* (3.13)		1.42*c* (2.02)	
K_1I_3	1.55*de* (2.40)		1.12*de* (1.25)		1.84*def* (3.39)		1.93*de* (3.72)		1.61*de* (2.59)	
K_1I_4	2.03*f* (4.12)		2.00*g* (4.00)		2.14*hi* (4.58)		2.21*gh* (4.88)		2.09*h* (4.37)	
K_2I_1	1.18*a* (1.39)		0.66*ab* (0.44)		1.52*ab* (2.31)		1.59*ab* (2.53)		1.24*b* (1.54)	
K_2I_2	1.12*a* (1.25)		0.56*a* (0.31)		1.36*a* (1.85)		1.48*a* (2.19)		1.13*a* (1.28)	
K_2I_3	1.26*ab* (1.59)		0.77*bc* (0.59)		1.61*bc* (2.59)		1.69*bc* (2.86)		1.33*bc* (1.77)	
K_2I_4	2.02*f* (4.08)		1.95*g* (3.80)		2.09*ghi* (4.37)		2.17*fgh* (4.71)		2.06*h* (4.24)	
K_3I_1	1.67*e* (2.79)		1.29*ef* (1.66)		1.98*fgh* (3.92)		2.06*fg* (4.24)		1.75*fg* (3.06)	
K_3I_2	1.61*de* (2.59)		1.18*e* (1.39)		1.93*efg* (3.72)		2.00*ef* (4.00)		1.68*ef* (2.82)	
K_3I_3	1.71*e* (2.92)		1.39*f* (1.93)		2.03*ghi* (4.12)		2.11*fgh* (4.45)		1.81*g* (3.28)	
K_3I_4	2.08*f* (4.33)		2.07*g* (4.28)		2.17*i* (4.71)		2.24*h* (5.02)		2.14*h* (4.58)	
Mean	1.59 (2.53)		1.23 (1.51)		1.85 (3.42)		1.93 (3.72)		1.65 (2.72)	
	S.Em. +	C.D. at 5 %	S.Em. +	C.D. at 5 %	S.Em. +	C.D. at 5 %	S.Em. +	C.D. at 5 %	S.Em. +	C.D. at 5 %
Potash fertilizer(K)	-	-	-	-	-	-	-	-	0.02	0.04
Insecticides(I)	-	-	-	-	-	-	-	-	0.08	0.25
Periods(P)	-	-	-	-	-	-	-	-	0.01	0.06
K x P	-	-	-	-	-	-	-	-	0.03	NS
I x P	-	-	-	-	-	-	-	-	0.04	0.10
K x I	0.06	0.17	0.07	0.19	0.06	0.18	0.06	0.17	0.03	0.09
K x I x P	-	-	-	-	-	-	-	-	0.06	NS
C.V. %	6.28		9.31		5.86		5.18		6.41	

Notes:

1. NS: Non significant and S: Significant. Figures in parentheses are retransformed values; those outside are $\sqrt{x}$ transformed values.
2. Treatment mean with letter(s) in common are not significant at 5 % level of significance within a column.
3. Potash fertilizer dose: Potash fertilizer @ 60 kg/ha (K_1), Potash fertilizer @ 80 kg/ha (K_2) & Potash fertilizer @ 50 kg/ha (K_3)
   Foliar application: Triazophos 40 EC @ 20 ml/10 lit (I_1), Acetamiprid 20 SP @ 3 g/10 lit (I_2), Diafenthuron 50 WP @ 10 g/10 lit (I_3) & Control (I_4)

While, K_2I_1 was found at par with K_2I_3 and K_1I_2. On other side, K_1I_2 was found at par with K_1I_1. Further, K_1I_1 was found at par with K_1I_3. K_1I_3 was found at par with K_3I_2. Again, K_3I_2 was found at par with K_3I_1. On other side, K_3I_1 was found at par with K_3I_3 and K_2I_4. Less effective combinations were K_2I_4 and K_1I_4 found at par with each other.

After seven days of spraying, the order of effective combination on based of whitefly count in okra is given in brackets was: K_2I_2 (2.19) < K_2I_1 (2.53) < K_2I_3 (2.86) < K_1I_2 (3.13) < K_1I_1 (3.53) < K_1I_3 (3.72) < K_3I_2 (4.00) < K_3I_1 (4.24) < K_3I_3 (4.45) < K_2I_4 (4.71) < K_1I_4 (4.88) < K_3I_4 (5.02). Among the different combinations, K_2I_2 was found superior [2.19 whitefly /leaf] than the rest of the combinations. However, it was found at par with K_2I_1. On other side, K_2I_1 was found at par with K_2I_3. While, K_2I_3 was found at par with K_1I_2. Further, K_1I_2 was found at par with K_1I_1 and K_1I_3. On other side, K_1I_3 was found at par with K_3I_2. Again, K_3I_2 was found at par with K_3I_1, K_3I_3 and K_2I_4. Least effective combinations were K_2I_4 and K_1I_4 found at par with each other.

The data on mean whitefly count of pooled over periods presented in Table 9. The order of effective combination of potash fertilizer and foliar application of insecticides based on whitefly count in okra given in bracket was: K_2I_2 (1.28) < K_2I_1 (1.54) < K_2I_3 (1.77) < K_1I_2 (2.02) < K_1I_1 (2.31) < K_1I_3 (2.59) < K_3I_2 (2.82) < K_3I_1 (3.06) < K_3I_3 (3.28) < K_2I_4 (4.24) < K_1I_4 (4.37) < K_3I_4 (4.58). The lowest whitefly population was found in the combination of K_2I_2 (potash fertilizer @ 80 kg/ha + acetamiprid 0.006%) and it was found superior [1.28 whitefly /leaf]. The next best combination was K_2I_1 (potash fertilizer @ 80 kg/ha + triazophos 0.04%) found at par with K_2I_3 (potash fertilizer @ 80 kg/ha + diafenthiuron 0.05%). While, K_2I_3 was found at par with K_1I_2 (potash fertilizer @ 60 kg/ha + acetamiprid 0.006%). Further, K_1I_1 (potash fertilizer @ 60 kg/ha + triazophos 0.04%) and K_1I_3 (potash fertilizer @ 60 kg/ha + diafenthiuron 0.05%) found at par with each other. Again, K_1I_3 was found at par with K_3I_2 (potash fertilizer @ 50 kg/ha + acetamiprid 0.006%). On other side, K_3I_2 was found at par with K_3I_1 (potash fertilizer @ 50 kg/ha + triazophos 0.04%). K_3I_1 and K_3I_3 (potash fertilizer @ 50 kg/ha + diafenthiuron 0.05%) found at par with each other. The least effective combination was K_2I_4 (potash fertilizer @ 80 kg/ha + control) and K_1I_4 (potash fertilizer @ 60 kg/ha + control) found at par with each other.

Thus, okra leaf damage due to whitefly is effectively managed by potash fertilizer dose with K_2: potash fertilizer @ 80 kg/ha followed by K_1: potash fertilizer @ 60 kg/ha and spray application of I_2: acetamiprid 0.006%, I_1: triazophos 0.04% and

I_3: diafenthiuron 0.05%. Interaction of potash fertilizer to insecticidal spray was found effective in combination K_2I_2 (potash fertilizer @ 80 kg/ha + acetamiprid 0.006%), K_2I_1 (potash fertilizer @ 80 kg/ha + triazophos 0.04%) and K_2I_3 (potash fertilizer @ 80 kg/ha + diafenthiuron 0.05%). While, other combinations performed less in giving satisfactory protection to okra crop against whitefly.

The performance of potash fertilizer to insecticidal spray beneficially worked over one, three, five and seven days after spray. The interaction K x I was found significant. Whereas, within the period, individual factors also gave significant effect.

4.3.2 Effect of different interactions against whitefly, *B. tabaci* during second spray

After twenty five days of first spray the second spray was carried out. The periodical data showing effect of potash fertilizer and insecticidal spray on whitefly infestation to okra were recorded on one, three, five and seven days after spray (DAS). The effect of different interaction has been adjudged based on individual as well as pooled over period data. All the effective combinations were significantly superior to control up to 10 days of spray.

4.3.2.1 Potash fertilizer

The data on mean whitefly count after second application of insecticides presented in Table 10 and depicted in Figure 6. Data revealed that among three different potash fertilizer doses, potash fertilizer @ 80 kg/ha dose showed lowest whitefly count (2.72 whitefly /leaf) followed by potash fertilizer @ 60 kg/ha (3.46) and potash fertilizer @ 50 kg/ha (4.12) on one Day After Spraying (DAS). Similar result was also obtained for rest three days. On three, fifth, seventh DAS potash fertilizer @ 80 kg/ha dose was found best followed by potash fertilizer @ 60 kg/ha and potash fertilizer @ 50 kg/ha.

4.3.2.2 Insecticidal spray

The data on mean whitefly count after second application of insecticides presented in Table 10 and depicted in Figure 7 revealed that among sprayed insecticides, acetamiprid 0.006% (2.76) was found with lowest whitefly count. However, it was found at par with triazophos 0.04% (3.10). On other side, triazophos 0.04% was found at par with diafenthiuron 0.05% (3.35) on first DAS. Similar pattern of insecticides was observed in rest of the three days. At 3 DAS, acetamiprid 0.006% (1.42) was found at par with triazophos 0.04% (1.64). On other side, triazophos 0.04% was found at par with diafenthiuron 0.05% (1.82). On fifth DAS, acetamiprid

Table 10: Effect of potash fertilizer along with foliar application of insecticides against whitefly after second spray

Treatments		No. of whitefly /leaf			
		1 DAS	**3 DAS**	**5 DAS**	**7 DAS**
Potash fertilizer (K)					
K_1	Potash fertilizer @ 60 kg/ha	1.86*b* (3.46)	1.45*b* (2.10)	1.77*b* (3.13)	2.25*b* (5.06)
K_2	Potash fertilizer @ 80 kg/ha	1.65*a* (2.72)	1.25*a* (1.56)	1.60*a* (2.56)	2.01*a* (4.04)
K_3	Potash fertilizer @ 50 kg/ha	2.03*c* (4.12)	1.65*c* (2.72)	1.91*c* (3.65)	2.37*c* (5.62)
ANOVA					
	S. Em. ±	0.03	0.03	0.03	0.03
	C. D. at 5%	0.09	0.09	0.08	0.09
Insecticidal spray(I)					
I_1	Triazophos 0.04%	1.*76ab* (3.10)	1.*28ab* (1.64)	1.*69ab* (2.86)	2.*14ab* (4.58)
I_2	Acetamiprid 0.006%	1.66*a* (2.76)	1.19*a* (1.42)	1.61*a* (2.59)	2.07*a* (4.28)
I_3	Diafenthiuron 0.05%	1.83*b* (3.35)	1.35*b* (1.82)	1.75*b* (3.06)	2.19*b* (4.80)
I_4	Control	2.13*c* (4.54)	1.99*c* (3.96)	2.00*c* (4.00)	2.45*c* (6.00)
ANOVA					
	S. Em. ±	0.04	0.03	0.03	0.04
	C. D. at 5%	0.11	0.10	0.09	0.10
	C. V. %	5.99	6.93	5.14	4.75

Notes:

1. NS: Non significant and S: Significant. Figures in parentheses are retransformed values; those outside are √x transformed values.
2. Treatment mean with letter(s) in common are not significant at 5 % level of significance within a column.

0.006% (2.59) was found with lowest whitefly count. However, it was found at par with triazophos 0.04% (2.86). On other side, triazophos 0.04% was found at par with diafenthiuron 0.05% (3.06). Again, acetamiprid 0.006% (4.28) was found with lowest whitefly count. However, it was found at par with triazophos 0.04% (4.58) at 7DAS. On other side, triazophos 0.04% was found at par with diafenthiuron 0.05% (4.80). All three insecticidal sprays were found to be effective at all four days of observation.

4.3.2.3 Interaction effect between potash fertilizer and foliar application of insecticides on different days of observation and pooled over period

The data on interaction between potash fertilizer and foliar application of insecticides presented in Table 11 and depicted in Figure 8 revealed that twelve different interactions were found significantly different. The order of effective combination on based of whitefly count in okra on first Day After Spraying (DAS) given in bracket was: K_2I_2 (1.85) < K_2I_1 (2.31) < K_2I_3 (2.59) < K_1I_2 (2.89) < K_1I_1 (3.17) < K_1I_3 (3.39) < K_3I_2 (3.72) < K_3I_1 (3.92) < K_3I_3 (4.12) < K_2I_4 (4.37) < K_1I_4 (4.54) < K_3I_4 (4.71). Among the combinations, K_2I_2 (potash fertilizer @ 80 kg/ha + acetamiprid 0.006%) was found significantly superior [1.85 whitefly /leaf] to the rest of the combinations. However, it was at par with K_2I_1 (potash fertilizer @ 80 kg/ha + triazophos 0.04%). On other side, K_2I_1 was found at par with K_2I_3 (potash fertilizer @ 80 kg/ha + diafenthiuron 0.05%) and K_1I_2 (potash fertilizer @ 60 kg/ha + acetamiprid 0.006%). While, K_1I_2 was found at par with K_1I_1 (potash fertilizer @ 60 kg/ha + triazophos 0.04%). Further, K_1I_1 was found at par with K_1I_3 (potash fertilizer @ 60 kg/ha + diafenthiuron 0.05%) and K_3I_2 (potash fertilizer @ 50 kg/ha + acetamiprid 0.006%). On other side, K_3I_2 was found at par with K_3I_1 (potash fertilizer @ 50 kg/ha + triazophos 0.04%) and K_3I_3 (potash fertilizer @ 50 kg/ha + diafenthiuron 0.05%). Least effective combinations were K_3I_3, K_2I_4 (potash fertilizer @ 80 kg/ha + control) and K_1I_4 (potash fertilizer @ 60 kg/ha + control) found at par with each other.

On third DAS, the order of effective combination on based of whitefly count in okra is given in bracket was: K_2I_2 (0.92) < K_2I_1 (1.00) < K_2I_3 (1.19) < K_1I_2 (1.39) < K_1I_1 (1.64) < K_1I_3 (1.80) < K_3I_2 (2.07) < K_3I_1 (2.40) < K_3I_3 (2.59) < K_2I_4 (3.80) < K_1I_4 (4.00) < K_3I_4 (4.08). Among the different combination, K_2I_2 was found significantly superior [0.92 whitefly /leaf] over the rest of the combinations. However, it was at par with K_2I_1 and K_2I_3. While, K_2I_3 was found at par with K_1I_2. On other side, K_1I_2 was found at par with K_1I_1 and K_1I_3. Again, K_1I_3 was found at par with K_3I_2. Further, K_3I_2

Table 11: Interaction effect of potash fertilizer doses with different foliar application of insecticides against whitefly after second spray

Treatments	No. of whitefly /leaf									
	1 DAS		3 DAS		5 DAS		7 DAS		Pooled over periods	
K_1I_1	1.78*cd* (3.17)		1.28*cd* (1.64)		1.71*cde* (2.92)		2.20*cd* (4.84)		1.75*d* (3.06)	
K_1I_2	1.70*bc* (2.89)		1.18*bc* (1.39)		1.63*bcd* (2.66)		2.11*bc* (4.45)		1.65*c* (2.72)	
K_1I_3	1.84*de* (3.39)		1.34*cd* (1.80)		1.75*def* (3.06)		2.25*cde* (5.06)		1.79*de* (3.20)	
K_1I_4	2.13*g* (4.54)		2.00*f* (4.00)		2.00*h* (4.00)		2.45*fg* (6.00)		2.14*h* (4.58)	
K_2I_1	1.52*ab* (2.31)		1.00*a* (1.00)		1.48*ab* (2.19)		1.88*a* (3.53)		1.47*b* (2.16)	
K_2I_2	1.36*a* (1.85)		0.96*a* (0.92)		1.39*a* (1.93)		1.81*a* (3.28)		1.38*a* (1.90)	
K_2I_3	1.61*bc* (2.59)		1.09*ab* (1.19)		1.57*bc* (2.46)		1.95*ab* (3.80)		1.55*b* (2.40)	
K_2I_4	2.09*fg* (4.37)		1.95*f* (3.80)		1.98*h* (3.92)		2.42*efg* (5.86)		2.11*h* (4.45)	
K_3I_1	1.98*efg* (3.92)		1.55*e* (2.40)		1.88*fgh* (3.53)		2.35*defg* (5.52)		1.94*fg* (3.76)	
K_3I_2	1.93*def* (3.72)		1.44*de* (2.07)		1.82*efg* (3.31)		2.29*cdef* (5.24)		1.87*ef* (3.50)	
K_3I_3	2.03*efg* (4.12)		1.61*e* (2.59)		1.93*gh* (3.72)		2.36*defg* (5.57)		1.98*g* (3.92)	
K_3I_4	2.17*g* (4.71)		2.02*f* (4.08)		2.02*h* (4.08)		2.48*g* (6.15)		2.17*h* (4.71)	
Mean	1.84 (3.39)		1.45 (2.10)		1.76 (3.10)		2.21 (4.88)		1.82 (3.31)	
	S.Em. +	C.D. at 5 %	S.Em. +	C.D. at 5 %	S.Em. +	C.D. at 5 %	S.Em. +	C.D. at 5 %	S.Em. +	C.D. at 5 %
Potash fertilizer(K)	-	-	-	-	-	-	-	-	0.01	0.04
Insecticides(I)	-	-	-	-	-	-	-	-	0.05	0.15
Periods(P)	-	-	-	-	-	-	-	-	0.01	0.06
K x P	-	-	-	-	-	-	-	-	0.03	NS
I x P	-	-	-	-	-	-	-	-	0.03	0.10
K x I	0.06	0.19	0.06	0.17	0.05	0.15	0.06	0.18	0.03	0.08
K x I x P	-	-	-	-	-	-	-	-	0.06	NS
C.V. %	5.99		6.93		5.14		4.75		5.61	

Notes:

1. NS: Non significant and S: Significant. Figures in parentheses are retransformed values; those outside are √x transformed values.
2. Treatment mean with letter(s) in common are not significant at 5 % level of significance within a column.
3. Potash fertilizer dose: Potash fertilizer @ 60 kg/ha (K_1), Potash fertilizer @ 80 kg/ha (K_2) & Potash fertilizer @ 50 kg/ha (K_3)
   Foliar application: Triazophos 40 EC @ 20 ml/10 lit (I_1), Acetamiprid 20 SP @ 3 g/10 lit (I_2), Diafenthuron 50 WP @ 10 g/10 lit (I_3) & Control (I_4)

was found at par with K_3I_1 and K_3I_3. Least effective combinations were K_2I_4 and K_1I_4 found at par with each other.

The order of effective combination on based of whitefly count in okra is given in bracket was: K_2I_2 (1.93) < K_2I_1 (2.19) < K_2I_3 (2.46) < K_1I_2 (2.66) < K_1I_1 (2.92) < K_1I_3 (3.06) < K_3I_2 (3.31) < K_3I_1 (3.53) < K_3I_3 (3.72) < K_2I_4 (3.92) < K_1I_4 (4.00) < K_3I_4 (4.08) at 5 DAS. Among the combinations given, K_2I_2 was found significantly superior [1.93 whitefly /leaf] to the rest of the combinations. However, it was at par with K_2I_1. On other side, K_2I_1 was found at par with K_2I_3 and K_1I_2. Again, K_1I_2 was found at par with K_1I_1. While, K_1I_1 was found at par with K_1I_3. Further, K_1I_3 was found at par with. K_3I_2. Again, K_3I_2 was found at par with K_3I_1 and K_3I_3. Least effective combinations were K_3I_3, K_2I_4 and K_1I_4 found at par with each other.

After seven days of spraying, the order of effective combination on based of whitefly count in okra is given in brackets was: K_2I_2 (3.28) < K_2I_1 (3.53) < K_2I_3 (3.80) < K_1I_2 (4.45) < K_1I_1 (4.84) < K_1I_3 (5.06) < K_3I_2 (5.24) < K_3I_1 (5.52) < K_3I_3 (5.57) < K_2I_4 (5.86) < K_1I_4 (6.00) < K_3I_4 (6.15). Among the different combinations, K_2I_2 was found superior [3.28 whitefly /leaf] than the rest of the combinations. However, it was at par with K_2I_1 and K_2I_3. On other side, K_2I_3 was found at par with K_1I_2. While, K_1I_2 was found at par with K_1I_1, K_1I_3 and K_3I_2. While, K_3I_2 was found at par with K_3I_1 and K_3I_3. Least effective combinations were K_3I_3, K_2I_4 and K_1I_4 found at par with each other.

The data on mean whitefly count of pooled over periods presented in Table 11. The order of effective combination of potash fertilizer and foliar application of insecticides based on whitefly count on okra given in bracket was: K_2I_2 (1.90) < K_2I_1 (2.16) < K_2I_3 (2.40) < K_1I_2 (2.72) < K_1I_1 (3.06) < K_1I_3 (3.20) < K_3I_2 (3.50) < K_3I_1 (3.76) < K_3I_3 (3.92) < K_2I_4 (4.45) < K_1I_4 (4.58) < K_3I_4 (4.71). The lowest whitefly population was found in the combination of K_2I_2 (potash fertilizer @ 80 kg/ha + acetamiprid 0.006%) and it was found superior [1.90 whitefly /leaf]. The next best combination was K_2I_1 (potash fertilizer @ 80 kg/ha + triazophos 0.04%) found at par with K_2I_3 (potash fertilizer @ 80 kg/ha + diafenthiuron 0.05%) followed by K_1I_2 (potash fertilizer @ 60 kg/ha + acetamiprid 0.006%). The next best combination was K_1I_1 (potash fertilizer @ 60 kg/ha + triazophos 0.04%) found at par with K_1I_3 (potash fertilizer @ 60 kg/ha + diafenthiuron 0.05%). While, K_1I_3 was found at par with K_3I_2 (potash fertilizer @ 50 kg/ha + acetamiprid 0.006%). On other side, K_3I_2 was found at par with K_3I_1 (potash fertilizer @ 50 kg/ha + triazophos 0.04%) and K_3I_3 (potash fertilizer @ 50 kg/ha + diafenthiuron 0.05%). Least effective combinations were K_2I_4 (potash fertilizer @ 80 kg/ha + control) and K_1I_4 (potash fertilizer @ 60 kg/ha + control) found at par with each other.

As like first spray data, okra leaf damage due to whitefly incidence was effectively managed by potash fertilizer dose with K_2: potash fertilizer @ 80 kg/ha followed by K_1: potash fertilizer @ 60 kg/ha and spray application of I_2: acetamiprid 0.006%, I_1: triazophos 0.04% and I_3: diafenthiuron 0.05%. Interaction of potash fertilizer to insecticidal spray was found effective in combination K_2I_2 (potash fertilizer @ 80 kg/ha + acetamiprid 0.006%), K_2I_1 (potash fertilizer @ 80 kg/ha + triazophos 0.04%) and K_2I_3 (potash fertilizer @ 80 kg/ha + diafenthiuron 0.05%). While, other combinations performed less in giving satisfactory protection to okra crop against whitefly.

Thus, the performance of potash fertilizer to insecticidal spray beneficially worked over one, three, five and seven days after spray. The interaction K x I was found significant. Whereas, within the period, individual factors K and I also gave significant effect.

4.3.3 Effect of different interactions against whitefly, *B. tabaci* pooled over sprays

The periodical data showing effect of potash fertilizer and foliar application of insecticides on infestation to okra due to whitefly were recorded on one, three, five and seven days after spray (DAS). The effect of different interaction has been adjudged based on pooled over spray.

4.3.3.1 Potash fertilizer

The data on mean whitefly count of pooled over spray presented in Table 12 and depicted in Figure 9. Data revealed that among three potash fertilizer doses, potash fertilizer @ 80 kg/ha dose showed lowest whitefly count (2.31 whitefly /leaf). Next best treatment was potash fertilizer @ 60 kg/ha (2.99) followed by potash fertilizer @ 50 kg/ha (3.61) at one day after spray (DAS). Similar result was obtained from rest three day's data. On three, fifth, seventh DAS, potash fertilizer @ 80 kg/ha dose was found best followed by potash fertilizer @ 60 kg/ha and potash fertilizer @ 50 kg/ha.

4.3.3.2 Insecticidal spray

The data on mean whitefly count of pooled over spray presented in Table 12 and depicted in Figure 10 revealed that among sprayed insecticides, acetamiprid 0.006% (2.28) was found with lowest whitefly also found at par with triazophos

Table 12: Effect of potash fertilizer along with foliar application of insecticides against whitefly (pooled over sprays)

Treatments		No. of whitefly /leaf			
		1 DAS	**3 DAS**	**5 DAS**	**7 DAS**
Potash fertilizer (K)					
K_1	Potash fertilizer @ 60 kg/ha	1.73*b* (2.99)	1.34*b* (1.80)	1.82*b* (3.31)	2.10*b* (4.41)
K_2	Potash fertilizer @ 80 kg/ha	1.52*a* (2.31)	1.12*a* (1.25)	1.62*a* (2.62)	1.87*a* (3.50)
K_3	Potash fertilizer @ 50 kg/ha	1.90*c* (3.61)	1.57*c* (2.46)	1.97*c* (3.88)	2.24*c* (5.02)
ANOVA					
	S. Em. ±	0.02	0.02	0.02	0.02
	C. D. at 5%	0.06	0.06	0.06	0.06
Insecticidal spray(I)					
I_1	Triazophos 0.04%	1.60*a* (2.56)	1.12*a* (1.25)	1.*72b* (2.96)	1.*99b* (3.96)
I_2	Acetamiprid 0.006%	1.51*a* (2.28)	1.03*a* (1.06)	1.64*a* (2.69)	1.91*a* (3.65)
I_3	Diafenthiuron 0.05%	1.67*a* (2.79)	1.22*a* (1.49)	1.79*b*(3.20)	2.05*b* (4.20)
I_4	Control	2.09*b* (4.37)	2.00*b* (4.00)	2.07*c* (4.28)	2.33*c* (5.43)
ANOVA					
	S. Em. ±	0.06	0.08	0.02	0.02
	C. D. at 5%	0.26	0.36	0.07	0.07
	C. V. %	6.13	8.04	5.53	4.95

Notes:

1. NS: Non significant and S: Significant. Figures in parentheses are retransformed values; those outside are √x transformed values.
2. Treatment mean with letter(s) in common are not significant at 5 % level of significance within a column.

0.04% (2.56) and diafenthiuron 0.05% (2.79) on first DAS. While, on third DAS acetamiprid 0.006% (1.06) was found with minimum whitefly population found at par with triazophos 0.04% (1.25) and diafenthiuron 0.05% (1.49). On fifth DAS, acetamiprid 0.006% (2.69) gave good result with minimum whitefly population found at par with triazophos 0.04% (2.96). On other side, triazophos 0.04% was found at par with diafenthiuron 0.05% (3.20). As like 5DAS, acetamiprid 0.006% (3.65) gave good result with minimum whitefly population found at par with triazophos 0.04% (3.96). On other side, triazophos 0.04% was found at par with diafenthiuron 0.05% (4.20) at 7DAS.

4.3.3.3 Interaction effect between potash fertilizer and foliar application of insecticides on different days of observation (pooled over sprays & pooled over periods over sprays)

The data presented in Table 13 and depicted in Figure 11 showing interaction between potash fertilizer and foliar application of insecticides revealed that the interaction was found significant on first, third, fifth & seventh DAS.

The order of effective combination based on whitefly count in okra on first Day After Spraying (DAS) is given in bracket was: K_2I_2 (1.54) < K_2I_1 (1.82) < K_2I_3 (2.07) < K_1I_2 (2.34) < K_1I_1 (2.62) < K_1I_3 (2.86) < K_3I_2 (3.13) < K_3I_1 (3.35) < K_3I_3 (3.50) < K_2I_4 (4.24) < K_1I_4 (4.33) < K_3I_4 (4.54). Among the combinations, K_2I_2 (potash fertilizer @ 80 kg/ha + acetamiprid 0.006%) was found significantly superior [1.54 whitefly /leaf] to the rest of the combinations. However, it was at par with K_2I_1 (potash fertilizer @ 80 kg/ha + triazophos 0.04%). On other side, K_2I_1 was found at par with K_2I_3 (potash fertilizer @ 80 kg/ha + diafenthiuron 0.05%). While, K_2I_3 was found at par with K_1I_2 (potash fertilizer @ 60 kg/ha + acetamiprid 0.006%). Again, K_1I_2 was found at par with K_1I_1 (potash fertilizer @ 60 kg/ha + triazophos 0.04%). K_1I_1 was found at par with K_1I_3 (potash fertilizer @ 60 kg/ha + diafenthiuron 0.05%). Further, K_1I_3 was found at par with K_3I_2 (potash fertilizer @ 50 kg/ha + acetamiprid 0.006%). Again, K_3I_2 was found at par with K_3I_1 (potash fertilizer @ 50 kg/ha + triazophos 0.04%) and K_3I_3 (potash fertilizer @ 50 kg/ha + diafenthiuron 0.05%). Least effective combinations were K_2I_4 (potash fertilizer @ 80 kg/ha + control) and K_1I_4 (potash fertilizer @ 60 kg/ha + control) found at par with each other.

On third DAS, the order of effective combination based on whitefly count in okra is given in bracket was: K_2I_2 (0.58) < K_2I_1 (0.69) < K_2I_3 (0.86) < K_1I_2 (1.04) < K_1I_1 (1.25) < K_1I_3 (1.51) < K_3I_2 (1.72) < K_3I_1 (2.02) < K_3I_3 (2.25) < K_2I_4 (3.80) < K_1I_4

Table 13: Interaction effect of potash fertilizer doses with different foliar application of insecticides against whitefly after pooled over sprays

Treatments	**No. of whitefly /leaf**									
	1 DAS		**3 DAS**		**5 DAS**		**7 DAS**		**Pooled over periods**	
K_1I_1	1.62*de* (2.62)		1.12*de* (1.25)		1.75*de* (3.06)		2.04*de* (4.16)		1.63*e* (2.66)	
K_1I_2	1.53*cd* (2.34)		1.02*cd* (1.04)		1.66*cd* (2.76)		1.94*cd* (3.76)		1.54*d* (2.37)	
K_1I_3	1.69*ef* (2.86)		1.23*ef* (1.51)		1.79*ef* (3.20)		2.09*ef* (4.37)		1.70*f* (2.89)	
K_1I_4	2.08*h* (4.33)		2.00*i* (4.00)		2.07*i* (4.28)		2.33*hi* (5.43)		2.12*ij* (4.49)	
K_2I_1	1.35*ab* (1.82)		0.83*ab* (0.69)		1.50*b* (2.25)		1.73*ab* (2.99)		1.35*b* (1.82)	
K_2I_2	1.24*a* (1.54)		0.76*a* (0.58)		1.37*a* (1.88)		1.64*a* (2.69)		1.25*a* (1.56)	
K_2I_3	1.44*bc* (2.07)		0.93*bc* (0.86)		1.59*bc* (2.53)		1.82*bc* (3.31)		1.44*c* (2.07)	
K_2I_4	2.06*h* (4.24)		1.95*i* (3.80)		2.04*hi* (4.16)		2.30*hi* (5.29)		2.08*i* (4.33)	
K_3I_1	1.83*g* (3.35)		1.42*gh* (2.02)		1.93*gh* (3.72)		2.21*fgh* (4.88)		1.85*h* (3.42)	
K_3I_2	1.77*fg* (3.13)		1.31*fg* (1.72)		1.88*fg* (3.53)		2.15*efg* (4.62)		1.78*g* (3.17)	
K_3I_3	1.87*g* (3.50)		1.50*h* (2.25)		1.98*ghi* (3.92)		2.24*ghi* (5.02)		1.90*h* (3.61)	
K_3I_4	2.13*h* (4.54)		2.04*i* (4.16)		2.09*i* (4.37)		2.36*i* (5.57)		2.15*j* (4.62)	
Mean	1.72 (2.96)		1.34 (1.80)		1.80 (3.24)		2.07 (4.28)		1.73 (2.99)	
	S.Em. +	C.D. at 5 %	S.Em. +	C.D. at 5 %	S.Em. +	C.D. at 5 %	S.Em. +	C.D. at 5 %	S.Em. +	C.D. at 5 %
Periods (P)	-	-	-	-	-	-	-	-	0.02	0.07
Spray(Sp)	-	-	-	-	-	-	-	-	0.02	0.05
K x I	0.04	0.12	0.04	0.13	0.04	0.12	0.04	0.12	0.02	0.06
Sp x P	-	-	-	-	-	-	-	-	0.03	0.10
Sp x K x I	-	-	-	-	-	-	-	-	0.03	0.08
P x K x I	-	-	-	-	-	-	-	-	0.04	0.12
Sp x P x K x I	-	-	-	-	-	-	-	-	0.06	NS
C.V. %	6.13		8.04		5.53		4.95		11.33	

Notes:

1. NS: Non significant and S: Significant. Figures in parentheses are retransformed values; those outside are √X transformed values.
2. Treatment mean with letter(s) in common are not significant at 5 % level of significance within a column.
3. Potash fertilizer dose: Potash fertilizer @ 60 kg/ha (K_1), Potash fertilizer @ 80 kg/ha (K_2) & Potash fertilizer @ 50 kg/ha (K_3)
   Foliar application: Triazophos 40 EC @ 20 ml/10 lit (I_1), Acetamiprid 20 SP @ 3 g/10 lit (I_2), Diafenthuron 50 WP @ 10 g/10 lit (I_3) & Control (I_4)

(4.00) < K_3I_4 (4.16). Among the different combinations, K_2I_2 was found significantly superior [0.58 whitefly /leaf] to the rest of the combinations. However, it was at par with K_2I_1. On other side, K_2I_1 was found at par with K_2I_3. While, K_2I_3 was found at par with K_1I_2. Again, K_1I_2 was found at par with K_1I_1. K_1I_1 was found at par with K_1I_3. Further, K_1I_3 was found at par with K_3I_2. Again, K_3I_2 was found at par with K_3I_1. and K_3I_1 was found at par with K_3I_3. Least effective combinations were K_2I_4 and K_1I_4 found at par with each other.

The order of effective combination after five days of spraying based on whitefly count in okra is given in bracket was: K_2I_2 (1.88) < K_2I_1 (2.25) < K_2I_3 (2.53) < K_1I_2 (2.76) < K_1I_1 (3.06) < K_1I_3 (3.20) < K_3I_2 (3.53) < K_3I_1 (3.72) < K_3I_3 (3.92) < K_2I_4 (4.16) < K_1I_4 (4.28) < K_3I_4 (4.37). Among the combinations, K_2I_2 was found significantly superior [1.88 whitefly /leaf] to the rest of the combination followed by K_2I_1. K_2I_1 was found at par with K_2I_3. While, K_2I_3 was found at par with K_1I_2. Again, K_1I_2 was found at par with K_1I_1. K_1I_1 was found at par with K_1I_3. Further, K_1I_3 was found at par with K_3I_2. Again, K_3I_2 was found at par with K_3I_1 and K_3I_3. Least effective combinations were K_3I_3, K_2I_4 and K_1I_4 found at par with each other.

After seven days of spraying, the order of effective combination based on whitefly count in okra is given in brackets was: K_2I_2 (2.69) < K_2I_1 (2.99) < K_2I_3 (3.31) < K_1I_2 (3.76) < K_1I_1 (4.16) < K_1I_3 (4.37) < K_3I_2 (4.62) < K_3I_1 (4.88) < K_3I_3 (5.02) < K_2I_4 (5.29) < K_1I_4 (5.43) < K_3I_4 (5.57). Among the different combinations, K_2I_2 was found superior [2.69 whitefly /leaf] than the rest of the combinations. However, it was at par with K_2I_1. On other side, K_2I_1 was found at par with K_2I_3. While, K_2I_3 was found at par with K_1I_2. Again, K_1I_2 was found at par with K_1I_1. K_1I_1 was found at par with K_1I_3 and K_3I_2. Again, K_3I_2 was found at par with K_3I_1. K_3I_1 was found at par with K_3I_3. Least effective combinations were K_3I_3, K_2I_4 and K_1I_4 found at par with each other.

The data on mean whitefly count of pooled over spray and periods presented in Table 13. The order of effective combination of potash fertilizer and foliar application of insecticides based on whitefly count on okra given in bracket was: K_2I_2 (1.56) < K_2I_1 (1.82) < K_2I_3 (2.07) < K_1I_2 (2.37) < K_1I_1 (2.66) < K_1I_3 (2.89) < K_3I_2 (3.17) < K_3I_1 (3.42) < K_3I_3 (3.61) < K_2I_4 (4.33) < K_1I_4 (4.49) < K_3I_4 (4.62). The lowest whitefly population was found in the combination of K_2I_2 (potash fertilizer @ 80 kg/ha + acetamiprid 0.006%) and it was found superior [1.56 whitefly /leaf]. The next best combination was K_2I_1 (potash fertilizer @ 80 kg/ha + triazophos 0.04%) followed by K_2I_3 (potash fertilizer @ 80 kg/ha + diafenthiuron 0.05%), K_1I_2 (potash fertilizer @ 60 kg/ha +

acetamiprid 0.006%), K_1I_1 (potash fertilizer @ 60 kg/ha + triazophos 0.04%), K_1I_3 (potash fertilizer @ 60 kg/ha + diafenthiuron 0.05%), K_3I_2 (potash fertilizer @ 50 kg/ha + acetamiprid 0.006%) and K_3I_1 (potash fertilizer @ 50 kg/ha + triazophos 0.04%). While, K_3I_1 was found at par with K_3I_3 (potash fertilizer @ 50 kg/ha + diafenthiuron 0.05%). Least effective combinations were K_2I_4 (potash fertilizer @ 80 kg/ha + control) and K_1I_4 (potash fertilizer @ 60 kg/ha + control) found at par with each other.

The obtained results are in close conformity with the earlier workers as El-zahi *et al.* (2012) proved that the inorganic fertilization of cotton field plants found effective to sucking pests' management. The combination of nitrogen fertilization with phosphorus and potashic fertilization results lower pest population. Raghuraman and Gupta (2005) reported that acetamiprid 20SP provided better control of *B. tabaci*. Rana *et al.* (2006) also reported similar results. Yadav *et al*. (2007b) indicated that acetamiprid 20SP @ 100 g/ha was effective in reducing the incidence of whitefly as well as YVMV. Ramu *et al.* (2011) reported that acetamiprid found to be effective with recording lowest disease incidence (3.15%) and whitefly population (3.33%). The next best treatment was triazophos was in agreement with findings of Ali *et al.* (2005b). Kannake (2014) revealed that acetamiprid (20 SP) was the most effective treatment for the suppression of whitefly in okra and it was followed by triazophos (40 EC) and diafenthiuron (50 WP). Hence, all these reports are in close agreement with the present findings.

4.3.4. Impact of Potash fertilizer with insecticides on okra yield, yield loss and economics

4.3.4.1 Yield

The data on yield harvested during 9 pickings from the different combinations are summarized in Table 14 and depicted in Figure 12 revealed that all doses of potash fertilizer with insecticidal sprays recorded significantly higher yield than control. The chronological order of effective combination in relation to yield kg/ha in comparison to control is given in bracket was: K_2I_2 (13106) > K_2I_1 (12782) > K_2I_3 (12088) > K_1I_2 (11532) > K_1I_1 (10930) > K_1I_3 (9773) > K_3I_2 (9403) > K_3I_1 (9125) > K_3I_3 (8708) > K_2I_4 (8384) > K_1I_4 (8106) > K_3I_4 (7829). The significantly highest (13106 kg/ha) yield

Table 14: Effectiveness of various combinations of potash fertilizer and foliar application of insecticides on okra yield due to whitefly

Treatments	Yield (kg/ha)	Yield increase over control (kg/ha)	Percentage yield increase over control
K_1I_1	10930*bc*	3101	39.61
K_1I_2	11532*ab*	3703	47.30
K_1I_3	9773*cd*	1944	24.83
K_1I_4	8106*de*	277	3.54
K_2I_1	12782*a*	4953	63.26
K_2I_2	13106*a*	5277	67.40
K_2I_3	12088*ab*	4259	54.40
K_2I_4	8384*de*	555	7.09
K_3I_1	9125*de*	1296	16.55
K_3I_2	9403*cde*	1574	20.17
K_3I_3	8708*de*	879	11.23
K_3I_4	7829*e*	-	-
Mean	10147	-	-
ANOVA			
S. Em. +	585.83	-	-
C. D. at 5%	1718.33	-	-
C. V.%	10	-	-

Notes:

1. Yield increased over control = Yield of treatment – Yield of control
2. Percentage yield increase over control = $100 \times \frac{T-C}{C}$

   Where,

   T = Yield from treated plot (kg/ha)

   C = Yield from untreated plot (kg/ha)
3. Treatment mean with letter(s) in common are not significant at 5 % level of significance within a column.
4. Potash fertilizer dose: Potash fertilizer @ 60 kg/ha (K_1), Potash fertilizer @ 80 kg/ha (K_2) & Potash fertilizer @ 50 kg/ha (K_3)
   Foliar application: Triazophos 40 EC @ 20 ml/10 lit (I_1), Acetamiprid 20 SP @ 3 g/10 lit (I_2), Diafenthuron 50 WP @ 10 g/10 lit (I_3) & Control (I_4)

harvested in the plots treated with K_2I_2 (potash fertilizer @ 80 kg/ha + acetamiprid 0.006%). However, it was found at par with K_2I_1 (potash fertilizer @ 80 kg/ha + triazophos 0.04%) [12782], K_2I_3 (potash fertilizer @ 80 kg/ha + diafenthiuron 0.05%), [12088] and K_1I_2 (potash fertilizer @ 60 kg/ha + acetamiprid 0.006%) [11532]. Further, K_1I_2 (potash fertilizer @ 60 kg/ha + acetamiprid 0.006%) [11532] was found at par with K_1I_1 (potash fertilizer @ 60 kg/ha + triazophos 0.04%) [10930]. while, K_1I_1 (potash fertilizer @ 60 kg/ha + triazophos 0.04%) [10930] was found at par with K_1I_3 (potash fertilizer @ 60 kg/ha + diafenthiuron 0.05%) [9773] and K_3I_2 (potash fertilizer @ 50 kg/ha + acetamiprid 0.006%) [9403]. Again, K_3I_2 (potash fertilizer @ 50 kg/ha +

acetamiprid 0.006%) [9403] was found at par with K_3I_1 (potash fertilizer @ 50 kg/ha + triazophos 0.04%) [9125], K_3I_3 (8708), K_2I_4 (8384) and K_1I_4 (8106).

4.3.4.2 Yield increase over control

The yield increased over control was also worked out and presented in Table 14 and depicted in Figure 12. The chronological order of various combinations based on increase in yield over control given in bracket was: K_2I_2 (5277) > K_2I_1 (4953) > K_2I_3 (4259) > K_1I_2 (3703) > K_1I_1 (3101) > K_1I_3 (1944) > K_3I_2 (1574) > K_3I_1 (1296) > K_3I_3 (879) > K_2I_4 (555) > K_1I_4 (277). Maximum yield was increased in combination of K_2I_2 (potash fertilizer @ 80 kg/ha + acetamiprid 0.006%) [5277] followed by K_2I_1 (4953), K_2I_3 (4259) and K_1I_2 (3703). While, K_1I_1 (3101), K_1I_3 (1944) and K_3I_2 (1574) found medium yield increase over control. Very less yield increase over control was recorded in the combinations of K_3I_1 (1296), K_3I_3 (879), K_2I_4 (555) and K_1I_4 (277) as compare to the best combinations.

4.3.4.3 Per cent increase in yield over control

The per cent increase over control in yield was also worked out and presented in Table 14. The chronological order of various combinations based on the per cent increase in yield over control given in bracket was: K_2I_2 (67.40) > K_2I_1 (63.26) > K_2I_3 (54.40) > K_1I_2 (47.30) > K_1I_1 (39.61) > K_1I_3 (24.83) > K_3I_2 (20.17) > K_3I_1 (16.55) > K_3I_3 (11.23) > K_2I_4 (7.09) > K_1I_4 (3.54). Maximum yield loss could be avoided with application of K_2I_2 (potash fertilizer @ 80 kg/ha + acetamiprid 0.006%) (67.40) followed by K_2I_1 (63.26), K_2I_3 (54.40) and K_1I_2 (47.30). Even though the yield and yield increase over control was very low in the combinations *i.e.*, K_1I_1, K_1I_3, K_3I_2, K_3I_1, K_3I_3, K_2I_4 and K_1I_4 they increased the yield in range of 3.54 to 39.61 per cent.

4.3.4.4 Economics

The economics of various combinations (Table 15) revealed that the highest (79155 ₹ /ha) net realization was obtained in the combination of K_2I_2 (potash fertilizer @ 80 kg/ha + acetamiprid 0.006%) followed by K_2I_1 (74295 ₹ /ha), K_2I_3 (63885 ₹ /ha), K_1I_2 (55545 ₹ /ha), K_1I_1 (46515 ₹ /ha), K_1I_3 (29160 ₹ /ha), K_3I_2 (23610 ₹ /ha), K_3I_1 (19440 ₹ /ha), K_3I_3 (13185 ₹ /ha), K_2I_4 (8325 ₹ /ha) and K_1I_4 (4155 ₹ /ha). The highest incremental cost benefit ratio (ICBR) was obtained from the combination of K_2I_2 (1:27.66) followed by K_2I_1 (1:23.26), K_1I_2 (1:22.09), K_1I_1 (1:16.36) and K_2I_3 (1:11.59). The other combinations *viz.*, K_1I_3, K_3I_2, K_3I_1, K_3I_3, K_2I_4 and K_1I_4 recorded lower (1:2.64 to 1:10.09) ICBR and were found poor in respect to their economics. Kannake (2014)

Table 15: Yield and economics of different combinations applied for the control of whitefly in okra crop during *kharif*, 2018

Treatments	Quantity of potash fertilizer (kg /ha)	Quantity of insecticides for two sprays (l or kg /ha)	Cost of potash fertilizer (kg)	Cost of insecticide (l or kg)	Cost of labour (potash fertilizer + Spraying) (ha)	Total cost of plant protection for two sprays (ha)	Yield (kg /ha)	Gross realization (₹ /ha)	Net realization over control (₹ /ha)	ICBR
K_1I_1	60	2	1044	900	900	2844	10930	163950	46515	1:16.36
K_1I_2	60	0.30	1044	570	900	2514	11532	172980	55545	1:22.09
K_1I_3	60	1	1044	3220	900	5164	9773	146595	29160	1:5.65
K_1I_4	60	-	1044	-	300	1344	8106	121590	4155	1:3.09
K_2I_1	80	2	1392	900	900	3192	12782	191730	74295	1:23.26
K_2I_2	80	0.30	1392	570	900	2862	13106	196590	79155	1:27.66
K_2I_3	80	1	1392	3220	900	5512	12088	181320	63888	1:11.59
K_2I_4	80	-	1392	-	300	1692	8384	125760	8325	1:4.92
K_3I_1	50	2	870	900	900	2670	9125	136875	19440	1:7.28
K_3I_2	50	0.30	870	570	900	2340	9403	141045	23610	1:10.09
K_3I_3	50	1	870	3220	900	4990	8708	130620	13185	1:2.64
K_3I_4	50	-	870	-	300	1170	7829	117435	-	-

Notes:

1. Potash fertilizer- Rs. 17.4/kg.
2. Triazophos - Rs. 450/lit., Acetamiprid - Rs. 1900/kg., Diafenthiuron - Rs. 3220/kg.
3. Labour charges - Rs.300/day, Market price of Okra - Rs. 15 per kg.
4. Potash fertilizer dose: Potash fertilizer @ 60 kg/ha (K_1), Potash fertilizer @ 80 kg/ha (K_2) & Potash fertilizer @ 50 kg/ha (K_3)
   Foliar application: Triazophos 0.04% (I_1), Acetamiprid 0.006% (I_2), Diafenthiuron 0.05% (I_3) & Control (I_4)

revealed that net profit obtained from acetamiprid treated plot (61890.00 ₹ /ha) was higher than triazophos treated plot (57880.00 ₹ /ha).

4.3.4.5 Overall effectiveness of various combinations on the basis of ranking

The effectiveness of various insecticidal combinations was also evaluated by utilizing overall rank method. For this purpose, all combinations were given their individual rank in descending order of their effectiveness for different characters studied. These ranks of individual characters under study were summed up and re-ranked (Table 16). From the Table 16, it can be seen that K_2I_2 (potash fertilizer @ 80 kg/ha + acetamiprid 0.006%) found most effective over rest of the combinations as it occupied first rank. The next best combinations in rank were K_2I_1, K_2I_3, K_1I_2, K_1I_1, K_1I_3, K_3I_2, K_3I_1, K_3I_3, K_2I_4, K_1I_4 and K_3I_4, respectively.

Table 16: Overall effectiveness of various combinations based on ranking

Treatments	Rank for control of whitefly			Yield	ICBR	Total of ranks	Overall Ranking
	1st Spray	2nd Spray	Pooled over sprays over periods				
K_1I_1	5	5	5	5	4	24	5
K_1I_2	4	4	4	4	3	19	4
K_1I_3	6	6	6	6	8	32	6
K_1I_4	11	11	11	11	10	54	11
K_2I_1	2	2	2	2	2	10	2
K_2I_2	1	1	1	1	1	5	1
K_2I_3	3	3	3	3	5	17	3
K_2I_4	10	10	10	10	9	49	10
K_3I_1	8	8	8	8	7	39	8
K_3I_2	7	7	7	7	6	34	7
K_3I_3	9	9	9	9	11	47	9
K_3I_4	12	12	12	12	12	60	12

Notes:

Potash fertilizer dose: Potash fertilizer @ 60 kg/ha (K_1), Potash fertilizer @ 80 kg/ha (K_2) & Potash fertilizer @ 50 kg/ha (K_3)
Foliar application: Triazophos 0.04% (I_1), Acetamiprid 0.006% (I_2), Diafenthiuron 0.05% (I_3) & Control (I_4)

CHAPTER V

SUMMARY AND CONCLUSION

Present investigations on different aspects on whitefly, *Bemisia tabaci* (Gennadius) infesting okra were carried out under field condition during *kharif*, 2018 at Instructional Farm, College of Agriculture, Junagadh Agricultural University, Junagadh. The important findings under different aspects of these studies are summarized in this chapter under following heads.

5.1 Seasonal abundance of *Bemisia tabaci* infesting *kharif* okra.

5.2 Evaluation of susceptibility of okra varieties/genotypes against *B. tabaci* infesting *kharif* okra.

5.3 Management of *B. tabaci* infesting *kharif* okra.

5.1 Seasonal abundance of *Bemisia tabaci* infesting *kharif* okra

The investigations of abundance of okra whitefly revealed that whitefly population was commenced from first week of August *i.e.*, 31st Standard Meteorological Week (SMW) & 26 Day After Sowing (DAS) and continued till 1st week of October (40th SMW) *i.e.*,70 DAS which ranged from 2.00 to 7.52 [whitefly /plant]. The population of *B. tabaci* was fluctuated during the crop period. During the 3rd week of September (38th SMW) it was observed 7.14 whitefly /plant and showed its peak 7.52 whitefly /plant during 4th week of September (39th SMW). In subsequent week, the abundance was decreased and reached to 4.90 whitefly /plant during 1st week of October (40th SMW).

During the present study it was found that the initial population was found comparatively low in August but as the temperature increased, the whitefly population also multiplied very fast and attained its peak level during September when temperature was comparatively high. After that population decreased with crop attaining maturity.

The observation on population build-up of *B. tabaci* revealed that whitefly infestation commenced when the average maximum temperature was 32.1 ºC and minimum temperature was 26.1 ºC during year 2018. The peak activity of whitefly was observed when maximum and minimum temperatures were 34.7 ºC and 23.1 ºC, respectively during 2018, which indicate that most favorable range of temperature for fast multiplication of okra.

The correlation co-efficient values indicated that population of whitefly exhibited significant positive relation with maximum temperature (r= 0.613*) and bright sunshine hours (0.802*). Whitefly population had significant negative correlation with minimum temperature (-0.700*), wind speed (-0.674*), morning relative humidity (-0.705*) and evening relative humidity (-0.733*). While, whitefly population had non significant negative correlation with rainfall (-0.377).

5.2 Evaluation of susceptibility of okra varieties/genotypes against *B. tabaci* infesting *kharif* okra

Among the different varieties /genotypes, significantly lower infestation of whitefly was recorded in HRB-108-2 (1.65 whitefly /leaf) than rest of the varieties /genotypes which was found at par with JOL-11-12 (1.94) and VRO-6 (2.34). Further, VRO-6 (2.34) found at par with Kashi Kranti (2.53). On other side, Kashi Kranti (2.53) found at par with GAO-5 (2.90) and GJO-3 (3.17). While, GJO-3 (3.17) was found at par with GO-2 (3.47) and JOL-9-5 (3.72). Again, JOL-9-5 (3.72) was found at par with Okra variety HRB-55 (4.13). HRB-55 (4.13) and Pusa Sawani (5.09) were found with at par with each other. Pusa Sawani (5.09) recorded significantly higher infestation than any other varieties /genotypes.

None of the varieties /genotypes found highly resistant (HR). In resistant (R) category *i.e.*, whitefly population ranged from 0.99 to 2.04 of varieties /genotypes: HRB-108-2 (1.65 whitefly/leaf) and JOL-11-12 (1.94) were recorded. VRO-6 (2.34), Kashi Kranti (2.53), GAO-5 (2.90) categorized into group of moderately resistant (MR) as the infestation was recorded in the ranged of 2.04 to 3.09 whitefly /leaf. In case of varieties /genotype GJO-3 (3.17), GO-2 (3.47), JOL-9-5 (3.72), HRB-55 (4.13), the infestation was recorded in the range of 3.09 to 4.14 whitefly /leaf and so were categorized into moderately susceptible (MS) group. Under susceptible (S) category *i.e.*, ranged from 4.14 to 5.19 only one variety, Pusa Sawani (5.09) was observed. None of the varieties /genotypes was observed to have higher no. of whitefly count which comes under highly susceptible (HS) category.

As far as the yield of the varieties /genotypes is concerned, HRB-108-2 was found the best variety and recorded significantly higher (10668 kg /ha) yield than rest of the varieties/ genotypes. However, it was found at par with JOL-11-12 (9557). On other side, JOL-11-12 (9557) found at par with VRO-6 (9001) and Kashi Kranti (8306.54). Further, Kashi Kranti (8307) was found at par with GAO-5 (7612) and GJO-3 (6848). While, GJO-3 (6848) was found at par with GO-2 (6154), JOL-9-5 (5529) and HRB-55 (5112). While, Pusa Sawani (4695) recorded the lowest yield under the investigation.

5.3 Management of *B. tabaci* infesting *kharif* okra

Among the different potash fertilizer doses under study, potash fertilizer @ 80 kg/ha dose was found superior to rest of the treatment. Next best treatment was potash fertilizer @ 60 kg/ha dose followed by potash fertilizer @ 50 kg/ha dose during all one, three, five and seven days of observation after spray. Among foliar application of insecticides, acetamiprid 0.006% was found best insecticide than rest of the treatments *i.e.*, triazophos 0.04% and diafenthiuron 0.05%. Superior two potash fertilizer doses and foliar application of three insecticides were found to be effective as compared to control during both the sprays.

From the different twelve combination of potash fertilizer to foliar application of insecticides in first spray, K_2I_2 (potash fertilizer @ 80 kg/ha + acetamiprid 0.006%) was found superior [1.28 whitefly /leaf]. The next best combination was K_2I_1 (potash fertilizer @ 80 kg/ha + triazophos 0.04%) [1.54] found at par with K_2I_3 (potash fertilizer @ 80 kg/ha + diafenthiuron 0.05%) [1.77]. While, K_2I_3 was found at par with K_1I_2 (potash fertilizer @ 60 kg/ha + acetamiprid 0.006%) [2.02]. Further, K_1I_1 (potash fertilizer @ 60 kg/ha + triazophos 0.04%) [2.31] and K_1I_3 (potash fertilizer @ 60 kg/ha + diafenthiuron 0.05%) [2.59] found at par with each other. Again, K_1I_3 was found at par with K_3I_2 (potash fertilizer @ 50 kg/ha + acetamiprid 0.006%) [2.82]. On other side, K_3I_2 was found at par with K_3I_1 (potash fertilizer @ 50 kg/ha + triazophos 0.04%) [3.06]. K_3I_1 and K_3I_3 (potash fertilizer @ 50 kg/ha + diafenthiuron 0.05%) [3.28] found at par with each other. The least effective combination was K_2I_4 (potash fertilizer @ 80 kg/ha + control) [4.24] and K_1I_4 (potash fertilizer @ 60 kg/ha + control) [4.37] found at par with each other. The performance of potash fertilizer to insecticidal spray beneficially worked over one, three, five and seven days after spray. The interaction K x I was found significant. Whereas, within the period, individual factors also gave significant effect.

In second spray, K_2I_2 (potash fertilizer @ 80 kg/ha + acetamiprid 0.006%) was found superior [1.90 whitefly /leaf]. The next best combination was K_2I_1 (potash fertilizer @ 80 kg/ha + triazophos 0.04%) [2.16] found at par with K_2I_3 (potash fertilizer @ 80 kg/ha + diafenthiuron 0.05%) [2.40] followed by K_1I_2 (potash fertilizer @ 60 kg/ha + acetamiprid 0.006%) [2.72]. The next best combination was K_1I_1 (potash fertilizer @ 60 kg/ha + triazophos 0.04%) [3.06] found at par with K_1I_3 (potash fertilizer @ 60 kg/ha + diafenthiuron 0.05%) [3.20]. While, K_1I_3 was found at par with K_3I_2 (potash fertilizer @ 50 kg/ha + acetamiprid 0.006%) [3.50]. On other side, K_3I_2 was found at par with K_3I_1 (potash fertilizer @ 50 kg/ha + triazophos 0.04%) [3.76] and K_3I_3 (potash fertilizer @ 50 kg/ha + diafenthiuron 0.05%) [3.92]. Least effective combinations were K_2I_4 (potash fertilizer @ 80 kg/ha + control) [4.45] and K_1I_4 (potash fertilizer @ 60 kg/ha + control) [4.58] found at par with each other. The performance of potash fertilizer to insecticidal spray beneficially worked over one, three, five and seven days after spray. The interaction K x I was found significant. Whereas, within the period, individual factors also gave significant effect.

While, pertaining to the data on pooled over periods and sprays, it was found that K_2I_2 (potash fertilizer @ 80 kg/ha + acetamiprid 0.006%) was found superior [1.56 whitefly /leaf]. The next best combination was K_2I_1 (potash fertilizer @ 80 kg/ha + triazophos 0.04%) [1.82] followed by K_2I_3 (potash fertilizer @ 80 kg/ha + diafenthiuron 0.05%) [2.07], K_1I_2 (potash fertilizer @ 60 kg/ha + acetamiprid 0.006%) [2.37], K_1I_1 (potash fertilizer @ 60 kg/ha + triazophos 0.04%) [2.66], K_1I_3 (potash fertilizer @ 60 kg/ha + diafenthiuron 0.05%) [2.89], K_3I_2 (potash fertilizer @ 50 kg/ha + acetamiprid 0.006%) [3.17] and K_3I_1 (potash fertilizer @ 50 kg/ha + triazophos 0.04%) [3.42]. While, K_3I_1 was found at par with K_3I_3 (potash fertilizer @ 50 kg/ha + diafenthiuron 0.05%) [3.61]. Least effective combinations were K_2I_4 (potash fertilizer @ 80 kg/ha + control) [4.33] and K_1I_4 (potash fertilizer @ 60 kg/ha + control) [4.49] found at par with each other.

Based on both the sprays, whitefly, *B. tabaci* can be effectively managed by potash fertilizer dose with K_2: potash fertilizer @ 80 kg/ha and foliar application of I_2: acetamiprid 0.006%. Among the different combinations of potash fertilizer and insecticidal spray, combination K_2I_2 (potash fertilizer @ 80 kg/ha + acetamiprid 0.006%) was most effective which was followed by K_2I_1 (potash fertilizer @ 80 kg/ha + triazophos 0.04%) and K_2I_3 (potash fertilizer @ 80 kg/ha + diafenthiuron 0.05%). While, K_2I_4 (potash fertilizer @ 80 kg/ha + control) and K_1I_4 (potash fertilizer @ 60 kg/ha + control) combination perform less in giving satisfactory protection to okra crop against whitefly.

5.4 Yield and Economics

All combinations of potash fertilizer and foliar application of insecticides recorded significantly higher yield than control. Significantly highest (13106 kg /ha) yield harvested in the plots treated with K_2I_2 (potash fertilizer @ 80 kg/ha + acetamiprid 0.006%). However, it was found at par with K_2I_1 (potash fertilizer @ 80 kg/ha + triazophos 0.04%) [12782.29], K_2I_3 (potash fertilizer @ 80 kg/ha + diafenthiuron 0.05%), [12088] and K_1I_2 (potash fertilizer @ 60 kg/ha + acetamiprid 0.006%) [11532]. Further, K_1I_2 (potash fertilizer @ 60 kg/ha + acetamiprid 0.006%) [11532] was found at par with K_1I_1 (potash fertilizer @ 60 kg/ha + triazophos 0.04%) [10930]. While, K_1I_1 (potash fertilizer @ 60 kg/ha + triazophos 0.04%) [10930] was found at par with K_1I_3 (potash fertilizer @ 60 kg/ha + diafenthiuron 0.05%) [9773] and K_3I_2 (potash fertilizer @ 50 kg/ha + acetamiprid 0.006%) [9403]. Again, K_3I_2 (potash fertilizer @ 50 kg/ha + acetamiprid 0.006%) [9403] was found at par with K_3I_1 (potash fertilizer @ 50 kg/ha + triazophos 0.04%) [9125], K_3I_3 (8708), K_2I_4 (8384) and K_1I_4 (8106).

As far as the per cent increase of yield over control concern, maximum yield loss can be avoided in combination of K_2I_2 (potash fertilizer @ 80 kg/ha + acetamiprid 0.006%) [67.40] followed by K_2I_1 (potash fertilizer @ 80 kg/ha + triazophos 0.04%) [63.26], K_2I_3 (potash fertilizer @ 80 kg/ha + diafenthiuron 0.05%) [54.40] and K_1I_2 (potash fertilizer @ 60 kg/ha + acetamiprid 0.006%) [47.30]. Even though the yield and yield increase over control was very low in the treatments *i.e.*, K_1I_1 (potash fertilizer @ 60 kg/ha + triazophos 0.04%), K_1I_3 (potash fertilizer @ 60 kg/ha + diafenthiuron 0.05%), K_3I_2 (potash fertilizer @ 50 kg/ha + acetamiprid 0.006%), K_3I_1 (potash fertilizer @ 50 kg/ha + triazophos 0.04%), K_3I_3 (potash fertilizer @ 50 kg/ha + diafenthiuron 0.05%), K_2I_4 (potash fertilizer @ 80 kg/ha + control) and K_1I_4 (potash fertilizer @ 60 kg/ha + control) they increased the yield in range of 3.54 to 39.61 per cent.

The highest (79155 ₹ /ha) net realization was obtained in the treatment K_2I_2 (potash fertilizer @ 80 kg/ha + acetamiprid 0.006%) followed by K_2I_1 (74295 ₹ /ha), K_2I_3 (63888 ₹ /ha), K_1I_2 (55545 ₹ /ha), K_1I_1 (46515 ₹ /ha), K_1I_3 (29160 ₹ /ha), K_3I_2 (23610 ₹ /ha), K_3I_1 (19440 ₹ /ha), K_3I_3 (13185 ₹ /ha) K_2I_4, (8325 ₹ /ha) and K_1I_4 (4155 ₹ /ha). The highest incremental cost benefit ratio (ICBR) was obtained from the plots treated with K_2I_2 (1:27.66) followed by K_2I_1 (1:23.26), K_1I_2 (1:22.09), K_1I_1 (1:16.36) and K_2I_3 (1:11.59). The other combinations *viz.*, K_1I_3, K_3I_2, K_3I_1, K_3I_3, K_2I_4

and K_1I_4 recorded lower (1:2.64 to 1:10.09) ICBR and were found poor in respect to their economics.

Considering the effectiveness of various combinations, K_2I_2 (potash fertilizer @ 80 kg/ha + acetamiprid 0.006%) was found most effective over rest of the combinations as it occupied first rank. The next best combinations in rank were K_2I_1, K_2I_3, K_1I_2, K_1I_1, K_1I_3, K_3I_2, K_3I_1, K_3I_3, K_2I_4, K_1I_4 and K_3I_4, respectively.

From the present investigation, it can be concluded that whitefly, *B. tabaci* was active more during second to fourth week of September *i.e.* 37th to 39th SMW in *kharif* okra. Okra genotype HRB-108-2 was found resistant against whitefly which could be further used for breeding programme. While, Pusa Sawani was found susceptible. Among the potash fertilizer and spray application, potash fertilizer @ 80 kg/ha + spray of acetamiprid 0.006% found most effective in controlling whitefly population.

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Appendix I: Weekly meteorological data recorded at observatory of Instructional Farm, Junagadh Agricultural University, Junagadh (2018)

Sr. No.	Month	Date of observation	SMW	Mean adult whitefly /plant	Temp.(^{0}C)		RH (%)		Rainfall (mm)	Wind (km/h)	BSS (hrs/day)
					Max.	Min.	Morning	Evening			
1.	July, 18	25/07/2018	30	0.00	30.2	26.1	90	76	1.8	12.0	0.1
2.	Aug., 18	01/08/2018	31	2.30	32.1	26.1	88	63	4.5	13.0	0.2
3.		08/08/2018	32	3.88	31.5	25.4	87	72	8.8	12.3	0.2
4.		15/08/2018	33	3.04	30.1	25.1	91	76	10.0	7.8	0.1
5.		22/08/2018	34	2.00	29.0	24.2	94	84	50.3	7.4	3.0
6.		29/08/2018	35	2.36	29.5	24.0	92	78	31.3	5.9	0.1
7.	Sep., 18	05/09/2018	36	4.08	30.1	24.0	89	66	27.4	6.4	3.3
8.		12/09/2018	37	6.18	31.3	23.6	87	59	2.1	5.9	5.2
9.		19/09/2018	38	**7.14**	33.5	23.9	84	54	6.2	4.1	8.6
10.		26/09/2018	39	**7.52**	34.7	23.1	76	38	0.0	4.1	8.7
11.	Oct., 18	03/10/2018	40	**4.90**	37.4	22.9	76	32	0.0	2.5	9.9

Appendix II: Population of whitefly on different varieties/ genotypes of okra

Varieties /genotypes	Whitefly infestation (No. of whiteflies /leaf) at indicated weeks after sowing									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Pusa Sawani	1.55 (2.40)	1.91 (3.66)	2.53 (6.38)	2.23 (4.99)	2.16 (4.66)	2.38 (5.65)	2.47 (6.12)	2.53 (6.38)	2.59 (6.70)	2.00 (3.99)
Kashi Kranti	1.17 (1.38)	1.39 (1.92)	1.70 (2.90)	1.61 (2.59)	1.52 (2.31)	1.65 (2.72)	1.71 (2.93)	1.73 (2.98)	1.76 (3.11)	1.57 (2.46)
GAO-5	1.36 (1.85)	1.52 (2.32)	1.78 (3.18)	1.71 (2.94)	1.65(2.73)	1.73 (2.99)	1.84 (3.38)	1.82 (3.31)	1.89 (3.58)	1.65 (2.73)
HRB-108-2	1.00 (1.00)	1.09 (1.19)	1.40 (1.95)	1.34 (1.79)	1.15 (1.31)	1.26 (1.58)	1.36 (1.86)	1.46 (2.12)	1.47 (2.17)	1.23 (1.52)
JOL-9-5	1.41 (2.00)	1.76 (3.11)	2.06 (4.25)	2.03 (4.12)	1.93 (3.71)	1.94 (3.77)	2.03 (4.12)	2.06 (4.25)	2.13 (4.52)	1.84 (3.39)
JOL-11-12	1.03 (1.06)	1.18 (1.39)	1.52 (2.31)	1.46 (2.14)	1.36 (1.85)	1.38 (1.91)	1.50 (2.25)	1.55 (2.42)	1.58 (2.49)	1.26 (1.58)
HRB-55	1.49 (2.22)	1.84 (3.39)	2.23 (4.96)	2.07 (4.30)	2.03 (4.13)	2.06 (4.25)	2.10 (4.39)	2.19 (4.78)	2.28 (5.18)	1.93 (3.71)
GO-2	1.40 (1.97)	1.70 (2.89)	1.98 (3.92)	1.96 (3.86)	1.84 (3.39)	1.91 (3.65)	1.96 (3.85)	1.98 (3.92)	2.00 (3.98)	1.80 (3.25)
VRO-6	1.15 (1.31)	1.36 (1.86)	1.63 (2.65)	1.52 (2.32)	1.40 (1.97)	1.82 (3.32)	1.58 (2.50)	1.60 (2.57)	1.69 (2.84)	1.44 (2.06)
GJO-3	1.36 (1.85)	1.58 (2.48)	1.94 (3.76)	1.84 (3.40)	1.75 (3.06)	1.77 (3.14)	1.89 (3.56)	1.94 (3.75)	1.95 (3.81)	1.70 (2.90)
Mean	1.29 (1.70)	1.53 (2.42)	1.88 (3.63)	1.78 (3.25)	1.68 (2.91)	1.79 (3.30)	1.84 (3.50)	1.88 (3.65)	1.93 (3.84)	1.64 (2.76)
ANOVA										
S. Em. +	0.07	0.07	0.09	0.08	0.08	0.09	0.09	0.09	0.10	0.08
C. D. @ 5%	0.21	0.22	0.28	0.24	0.24	0.29	0.28	0.29	0.30	0.24
C.V.%	9.68	8.46	8.97	8.14	8.47	9.49	9.00	9.00	9.26	8.69

Notes: Figures in parentheses are retransformed values; those outside are $\sqrt{x}$ transformed values.

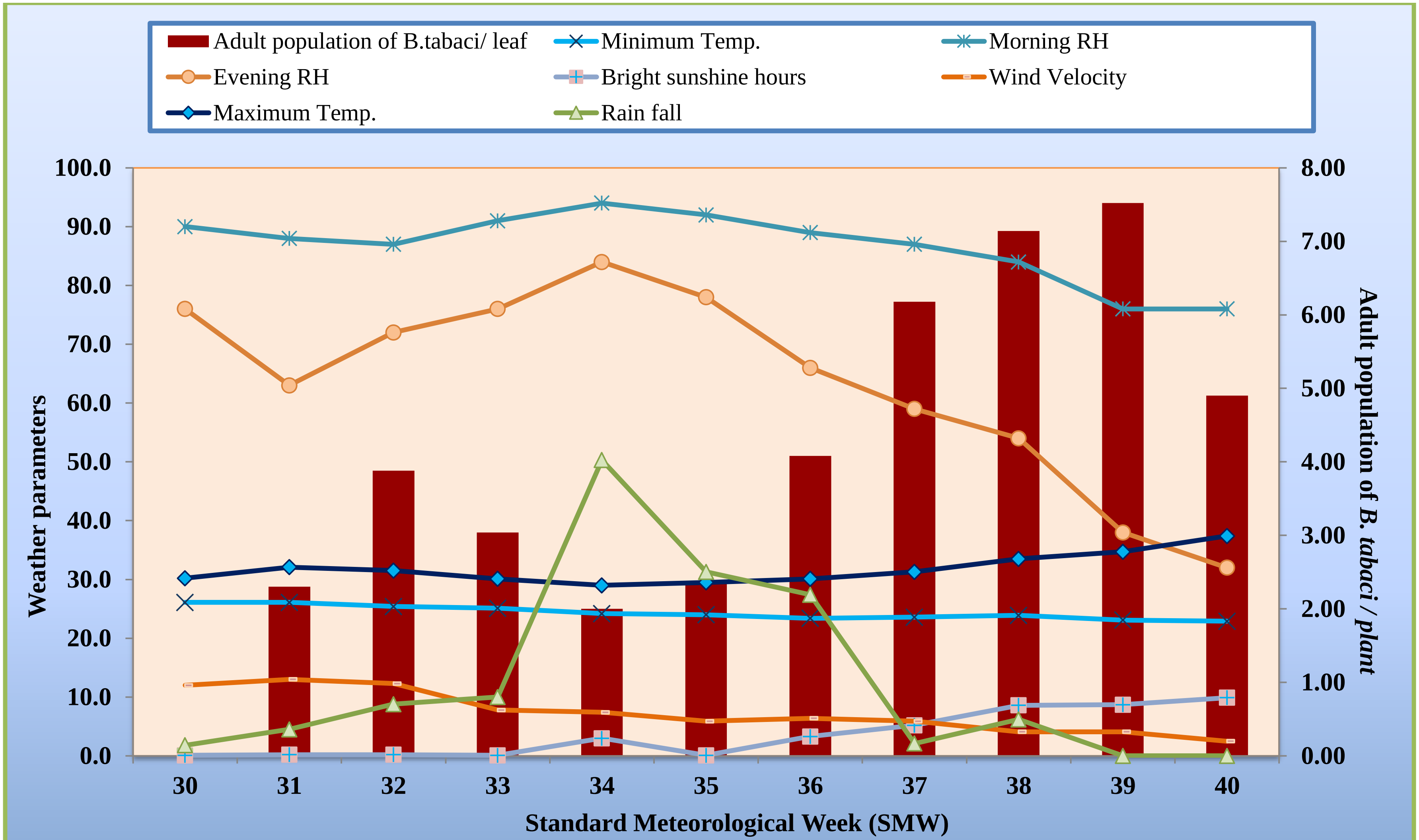


Figure 1: Influence of abiotic factors on whitefly, *B. tabaci* infesting okra

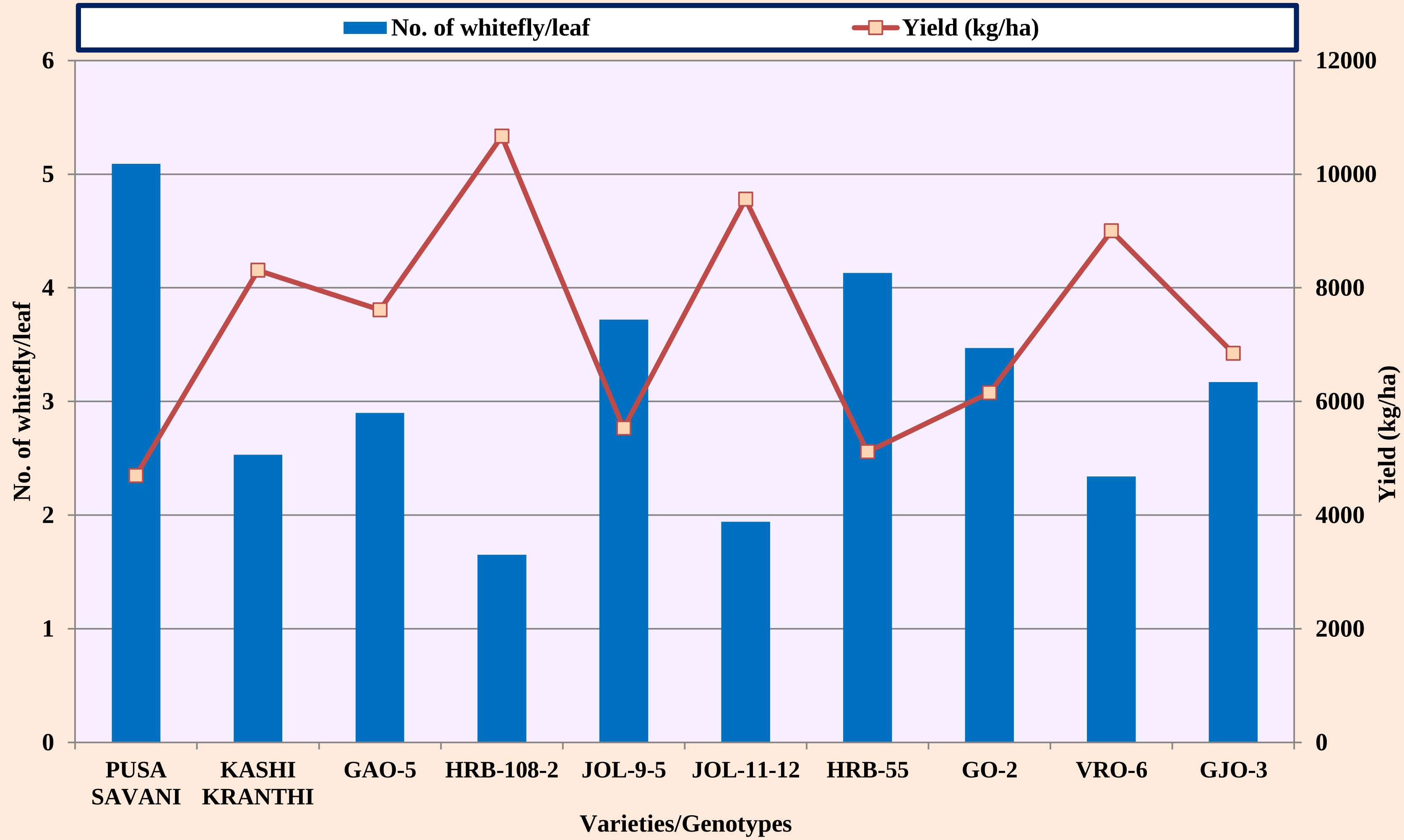


Figure 2: Infestation of whitefly, *Bemisia tabaci* in different varieties/genotypes of okra and their yield

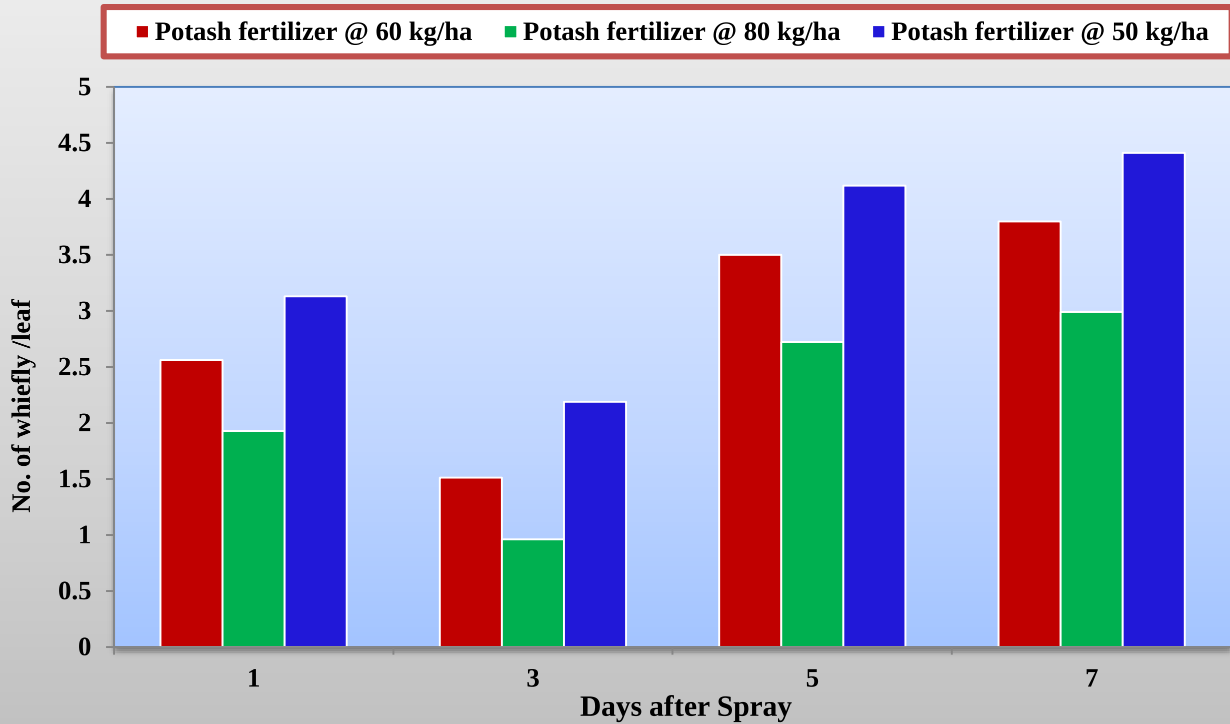


Figure 3: Effect of different doses of potash fertilizer on okra whitefly after first spray

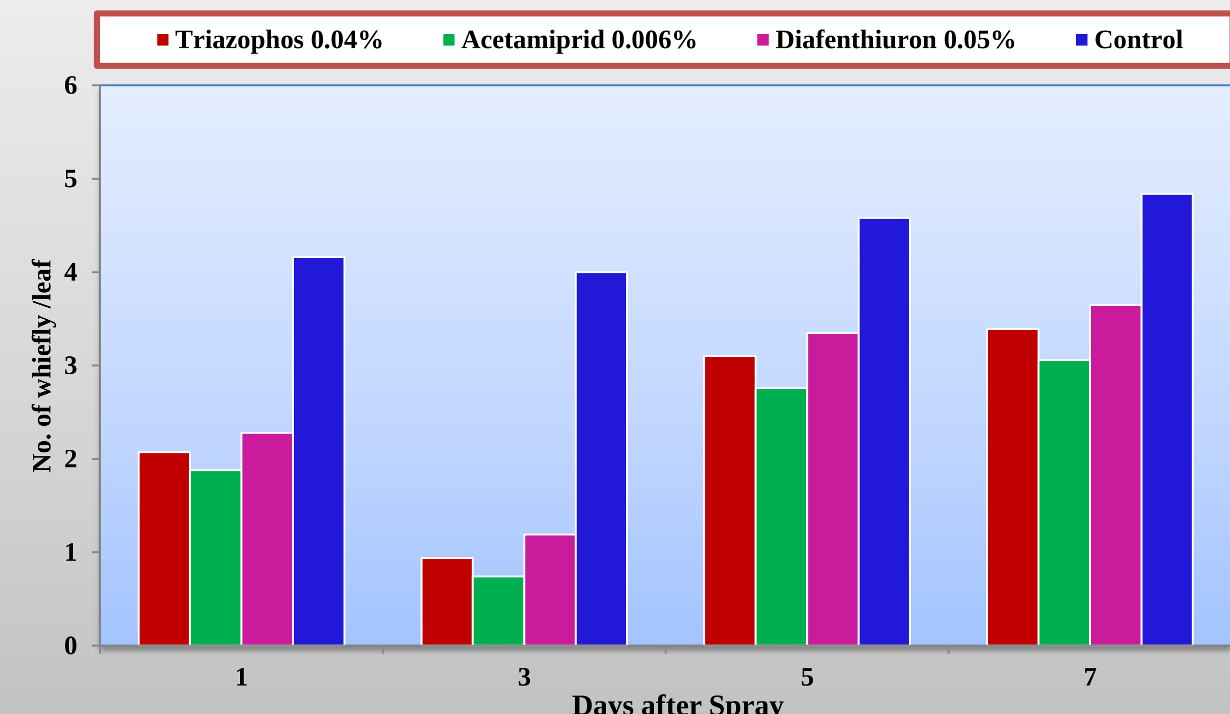


Figure 4: Effect of different insecticidal spray on okra whitefly after first spray

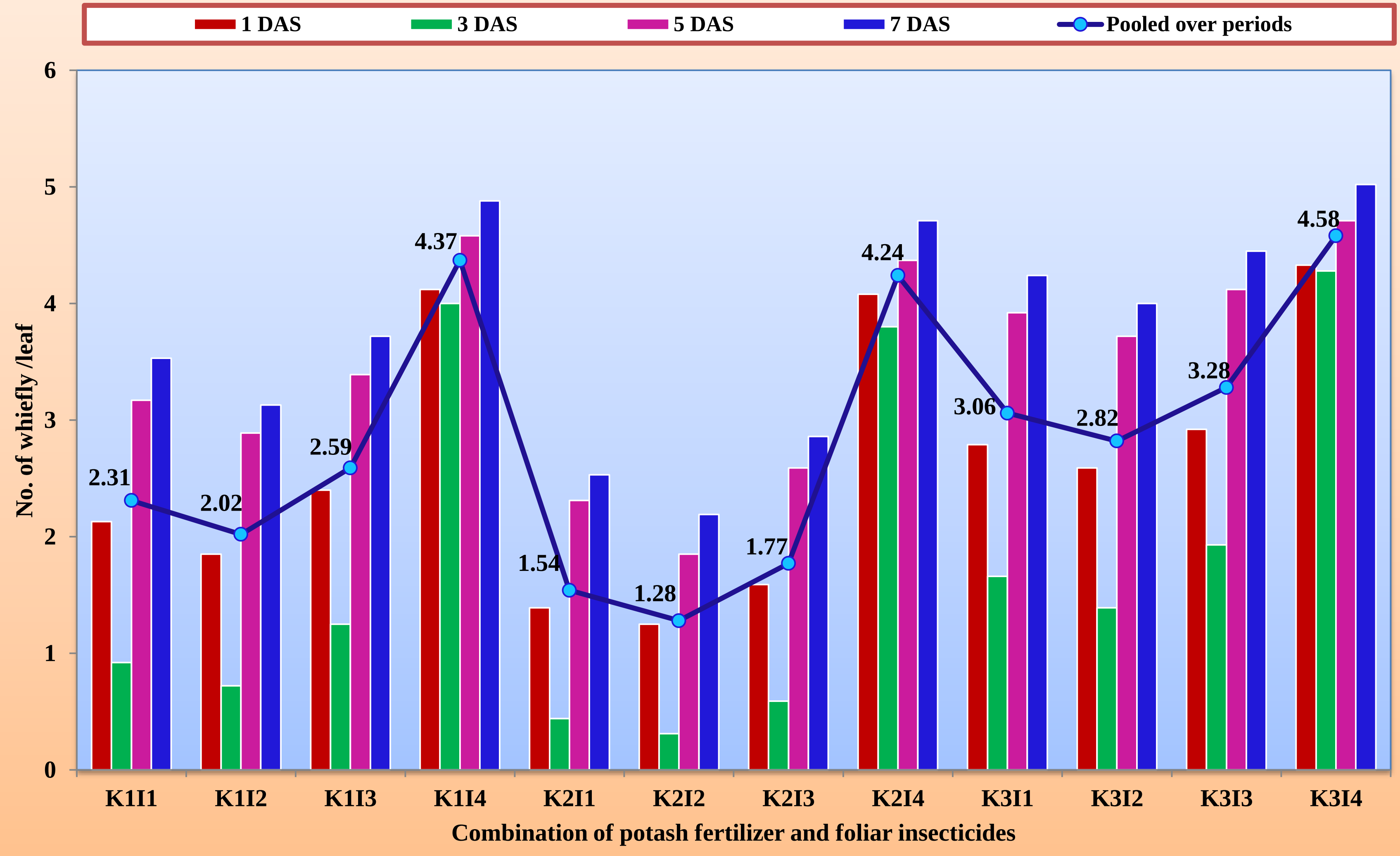


Figure 5: Interaction effect of potash fertilizer (K) and foliar application of insecticides (I) on okra whitefly after first spray

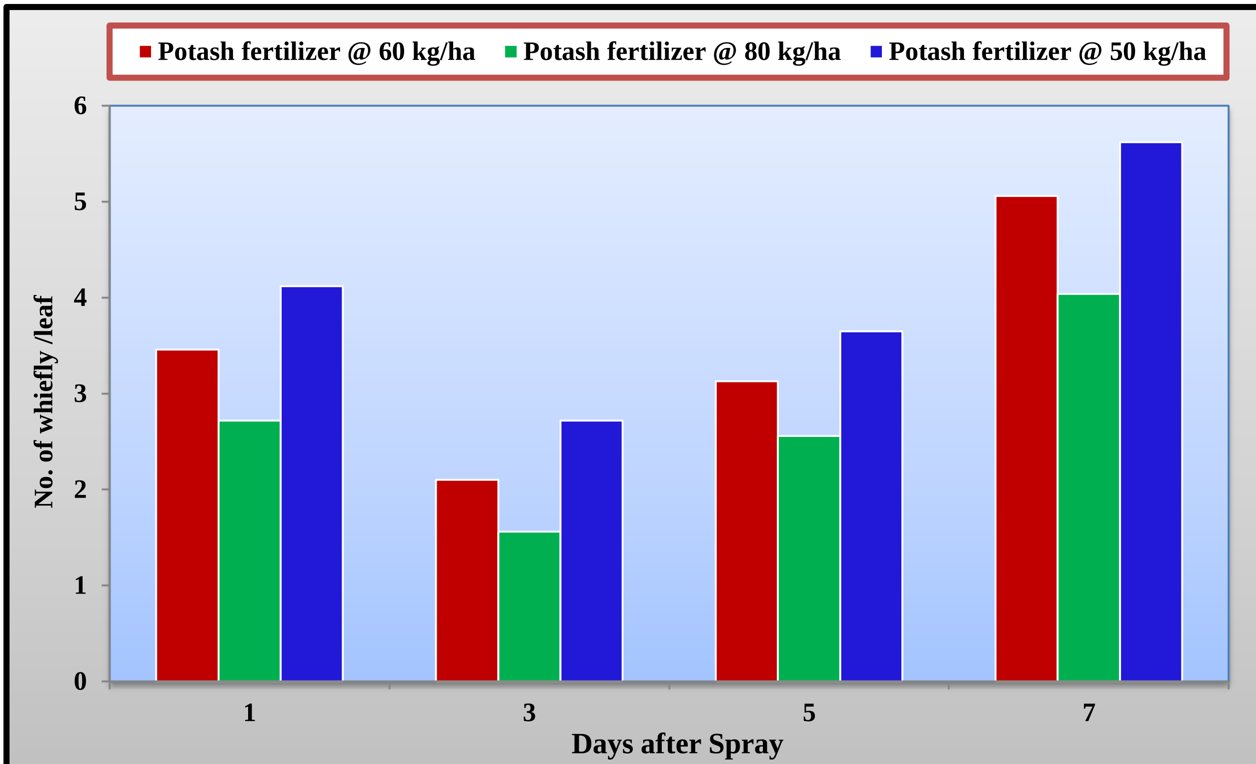


Figure 6: Effect of different doses of potash fertilizer on okra whitefly after second spray

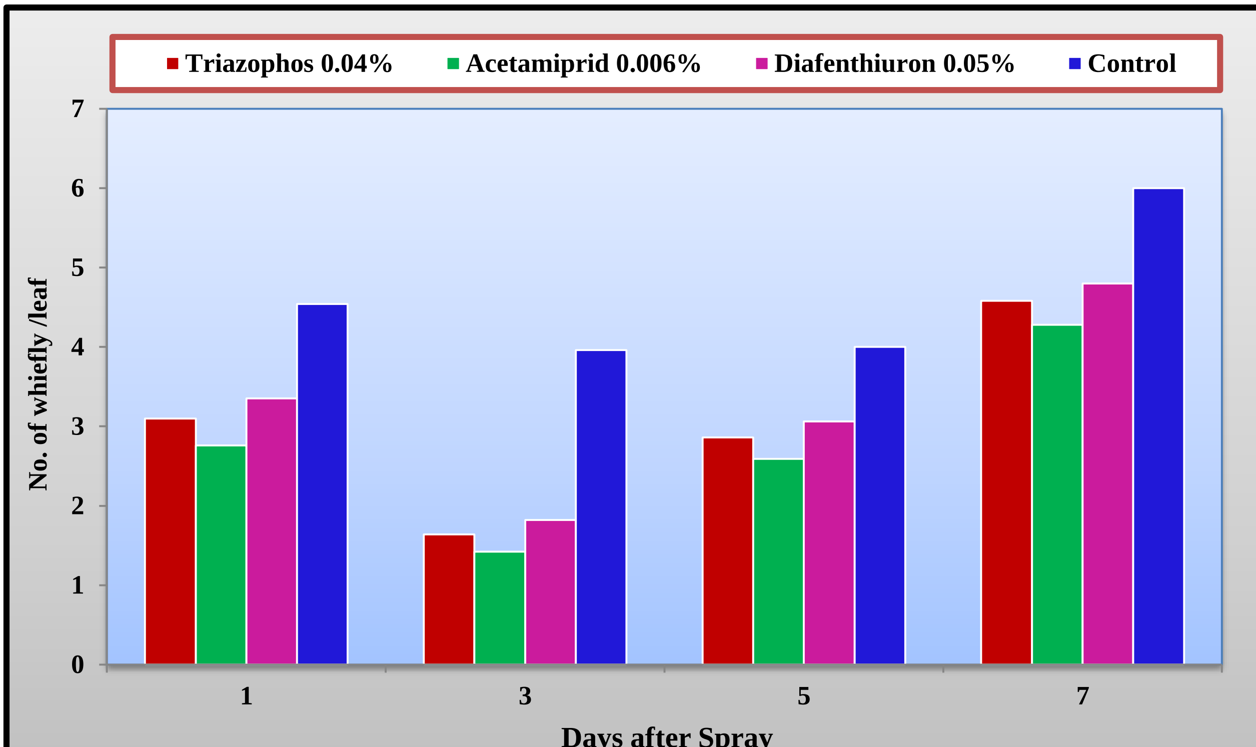


Figure 7: Effect of different insecticidal spray on okra whitefly after second spray

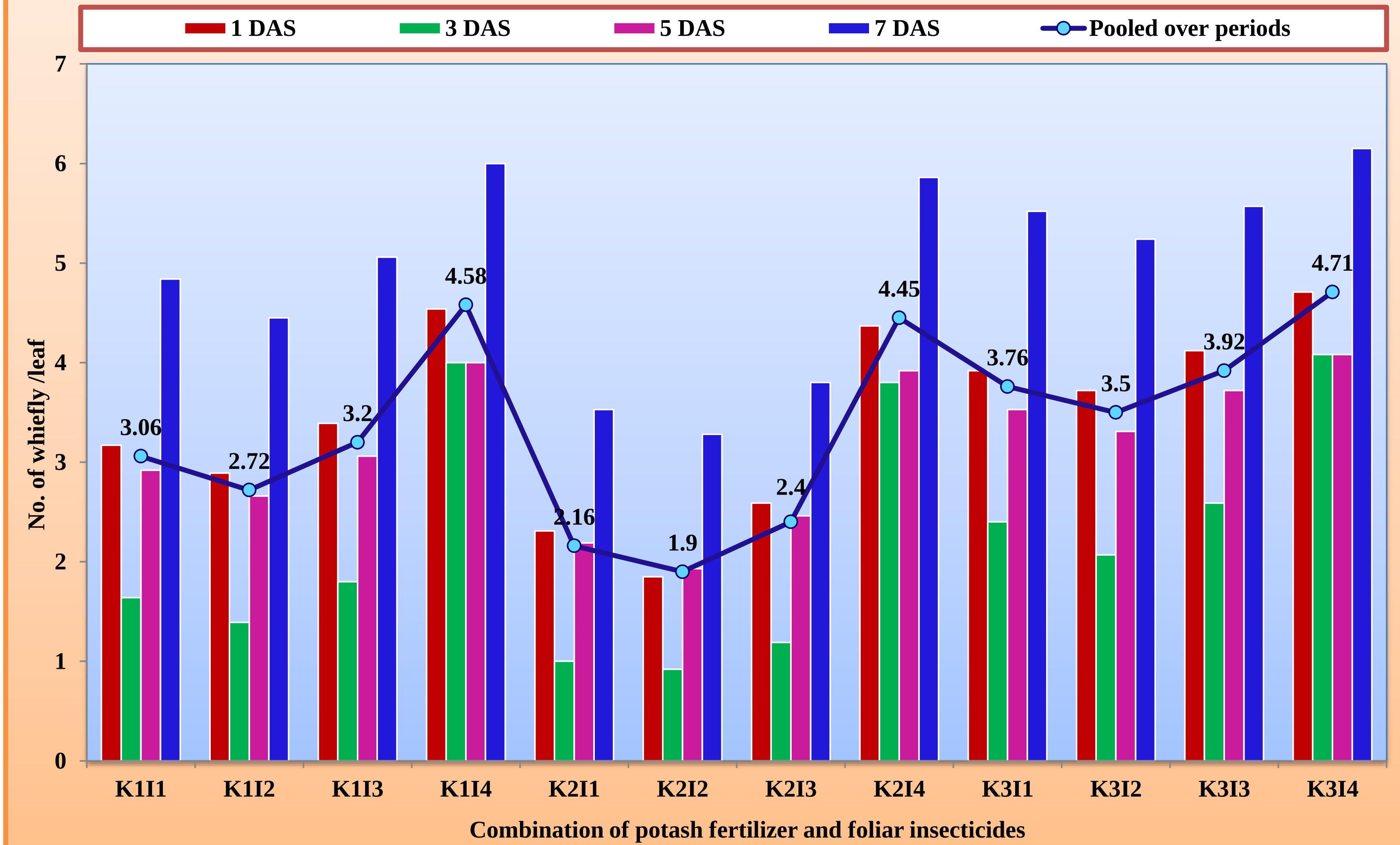


Figure 8: Interaction effect of potash fertilizer (K) and foliar application of insecticides (I) on okra whitefly after second spray

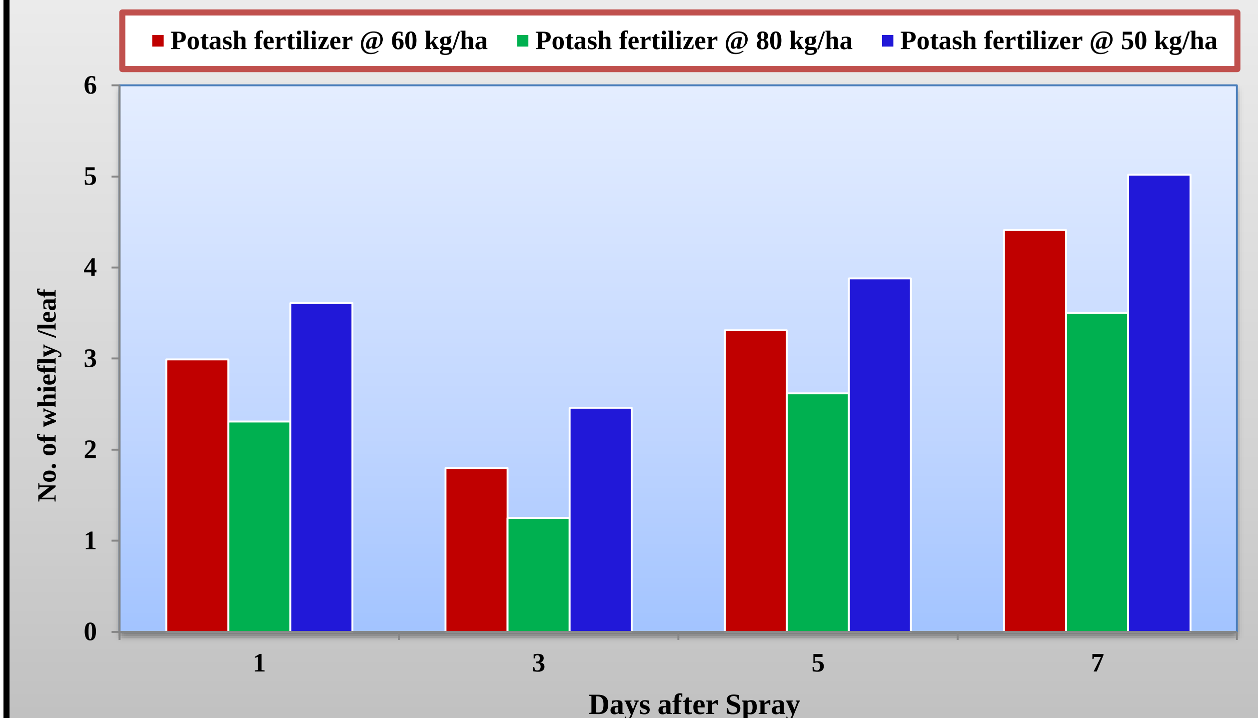


Figure 9: Effect of different doses of potash fertilizer on okra whitefly (Pooled over sprays)

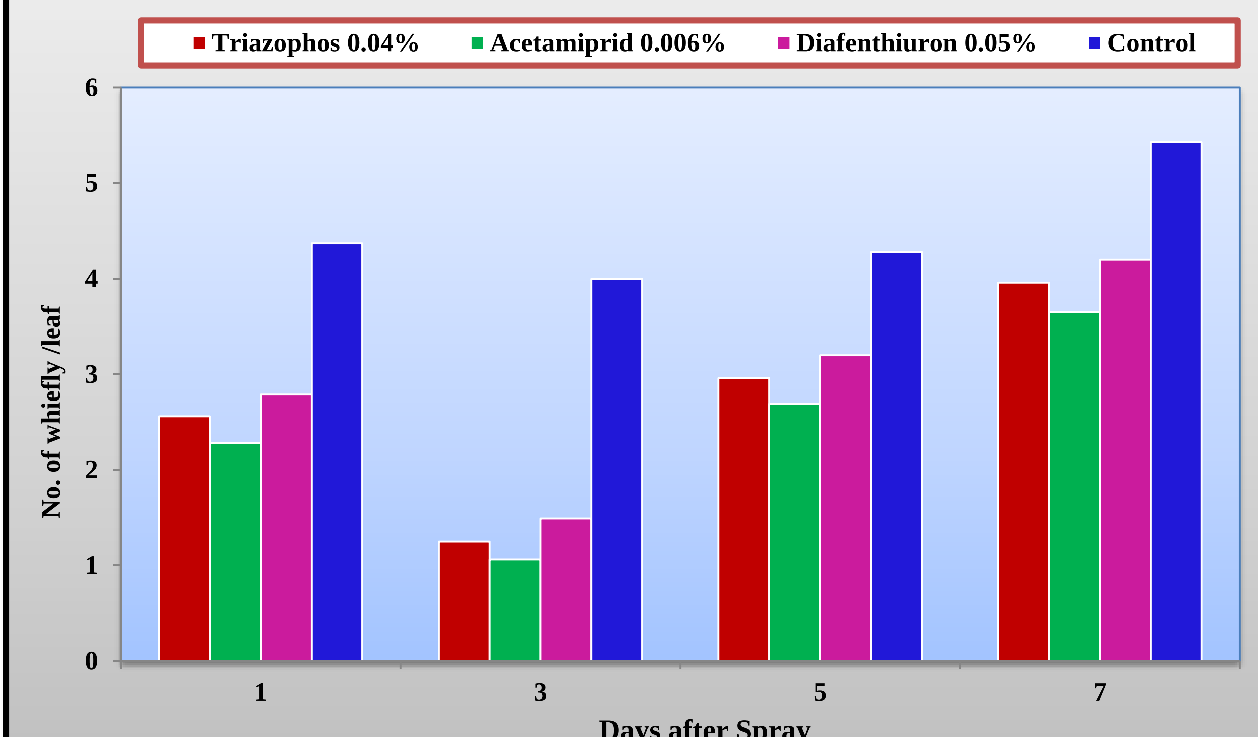


Figure 10: Effect of different insecticidal spray on okra whitefly (Pooled over sprays)

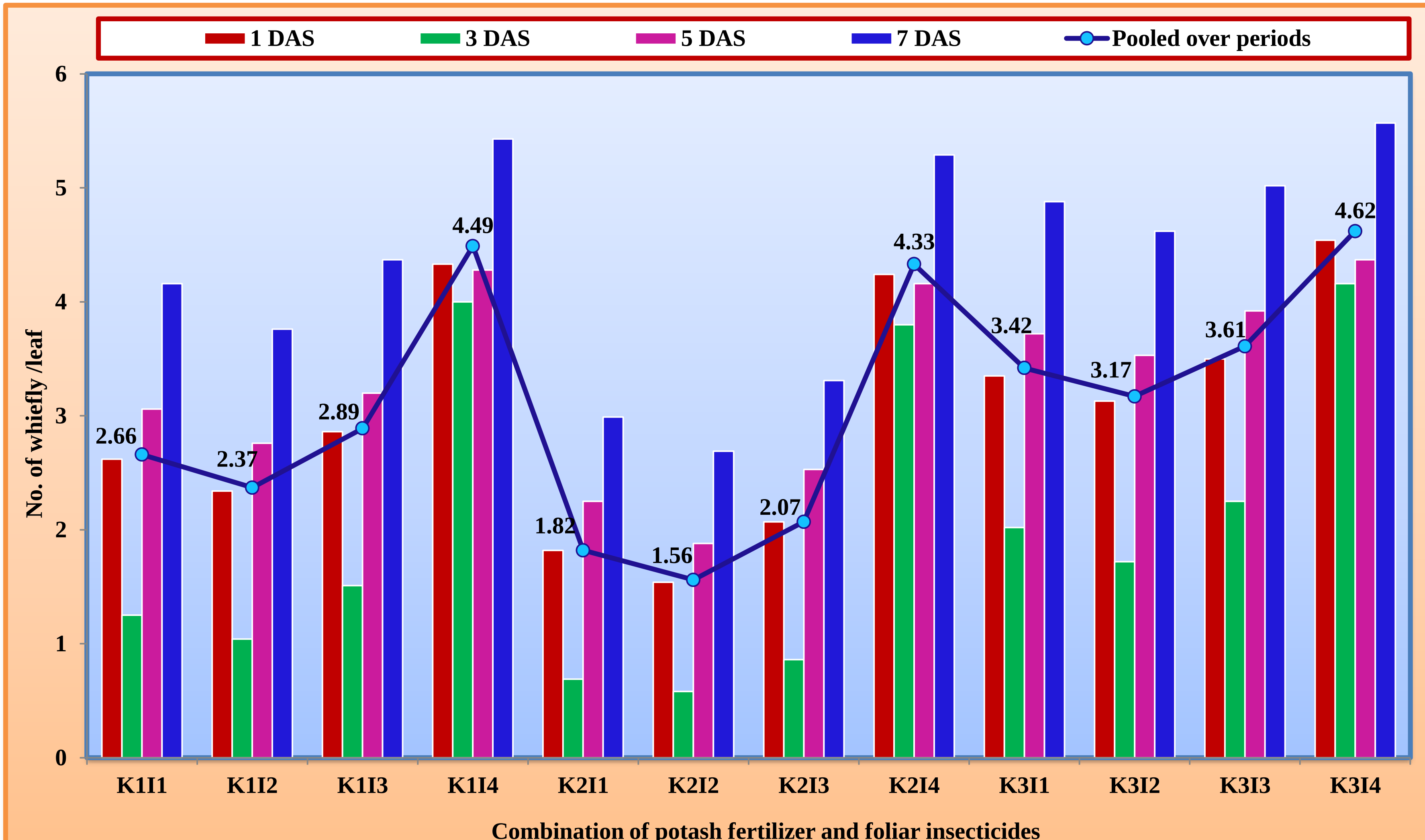


Figure 11: Interaction effect of potash fertilizer (K) and foliar application of insecticides (I) on okra whitefly (Pooled over sprays)

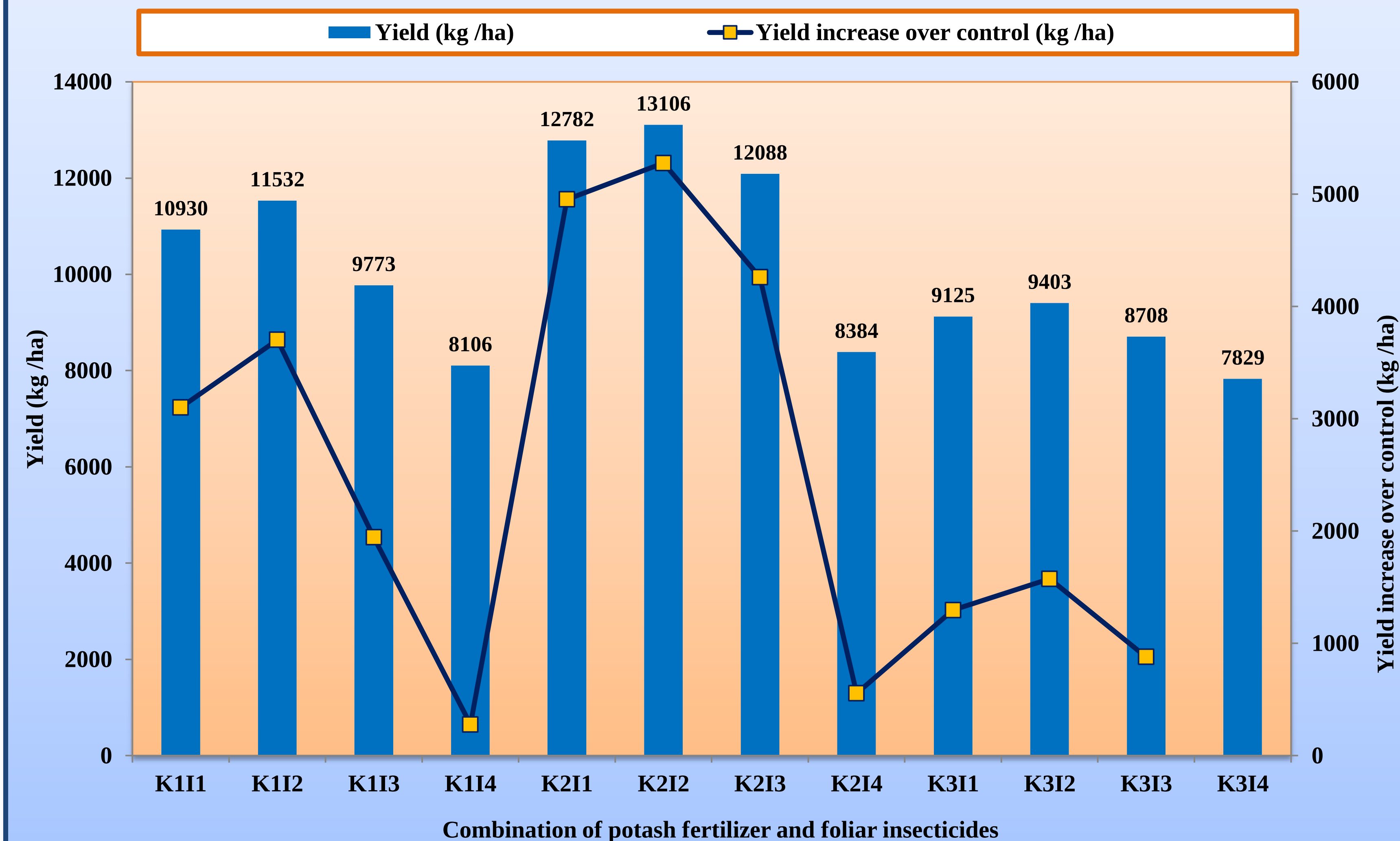
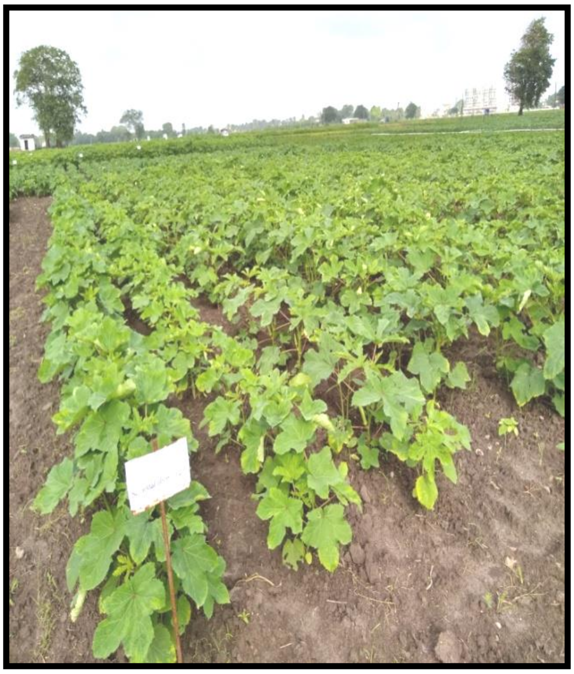


Figure 12: Effectiveness of various combinations on okra yield and yield loss due to *B. tabaci*



(a) Close view **(b) Overview of whole plot**

(c) Overview of whole plot

Plate 1: Experimental plot for seasonal abundance study

(a) Pusa Sawani

(b) HRB-108-2

(c) JOL-9-5

(d) Kashi Kranti

Plate 2: Experimental plot for varietal screening study

(a) Close view

(b) Overview of whole plot

Plate 3: Experimental plot for management of whitefly infesting okra

(a) Germination

(b) Vegetative

(c) Flowering

(d) Fruiting

(e) Maturity/ Harvesting

Plate 4: Different stages of okra in field

(a) Close view

(b) Normal view

Plate 5: Population of whitefly on okra leaves