

**Studies on the Incidence and Management of Thrips on
Gladiolus, *Gladiolus grandiflorus* L.”**

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(MSA-2019-1272)



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**Faculty of Agriculture, Wadura
Sher-e-Kashmir University of Agricultural Sciences and
Technology of Kashmir**

2021

**Studies on the Incidence and Management of Thrips on
Gladiolus, *Gladiolus grandiflorus* L.”**

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Thesis

Submitted to

The Faculty of Agriculture

Sher-e-Kashmir University of Agricultural Sciences &

Technology of Kashmir

In partial fulfilment of requirement for the award of the degree of

Master of Science in Agriculture

(Entomology)

2021

TO...

**My Beloved Parents and
Family**

***For their love, endless support,
encouragement & sacrifices***

Sher-e-Kashmir
University of Agricultural Sciences and Technology of Kashmir
Division of Entomology, Faculty of Agriculture, Wadura
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Certificate – I

This is to certify that the thesis entitled “**Studies on the Incidence and Management of Thrips on Gladiolus, *Gladiolus grandiflorus* L.**” submitted in partial fulfilment of the requirements for the award of the degree of **Master of Science in Agriculture (Entomology)**, to the **Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir** is a record of bonafide research work carried out by **Ms. Sheikh Salma Irshad (Regd. No. MSA-2019-1272)** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

It is further certified that information received during the course of investigation has duly been acknowledged.

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ABSTRACT

Gladiolus is a beautiful and glamorous bulbous flowering plant known for its beautiful and versatile flowers, hence, called “Queen of Bulb”. It is perennial cormous flowering plant that belongs to family Iridaceae. Gladiolus flower is one of the most important cut flowers, however, its quality and productivity is being affected by several factors *viz.*, climate, cultivar, nutrient management, diseases and pests. Among the insect pests, the sucking type are the most important ones with greater damage caused by thrips. Therefore, the present investigations entitled, “*Studies on the Incidence and Management of Thrips on Gladiolus, Gladiolus grandiflorus* L.” were carried out to study the incidence of *Scirtothrips dorsalis* (Hood) on gladiolus and its management at Faculty of Agriculture, Wadura. The studies witnessed commencement of gladiolus thrips from 24th standard meteorological week (SMW) on gladiolus (0.2 ± 0.05 thrips/plant) under field conditions. The population of *Scirtothrips dorsalis* (Hood) reached to its peak (26.96 ± 0.78 thrips/plant) in 31st standard meteorological week after which it started to decline. The incidence of gladiolus thrips revealed positive correlation with maximum ($r = 0.69$) and minimum temperature ($r = 0.70$), morning ($r = 0.29$) and evening relative humidity ($r = 0.54$) and negative correlation with rainfall ($r =$

- 0.07). For management of thrips on gladiolus, *Scirtothrips dorsalis* (Hood) different insecticides viz. fipronil 5SC (0.005 %), imidacloprid 17.8SL (0.003%), Neem oil (0.005 %) and NSKE 0.15 EC (0.0006 %) were evaluated under field conditions. The data recorded up to 7 days after spray revealed fipronil 5 SC (0.005 %) most effective in reducing gladiolus thrips. Imidacloprid 17.8 SL (0.003 %) was at par with fipronil 5 SC (0.005 %) with mean population of 6.96 and 7.49, respectively and mortality percentage 74.34 and 72.24, respectively. Neem oil (0.005 %) and NSKE 0.15EC (0.0006 %) recorded 14.56 and 15.50 thrips per plant, respectively. The mortality percentage recorded was highest in fipronil 5 SC (0.005 %) followed by imidacloprid (0.003 %), neem oil (0.005 %) and NSKE 0.15EC (0.0006 %). All the treatments were significantly superior over control (water) in reducing *S. dorsalis* (Hood) on gladiolus. Fipronil 5SC (0.005 %) however, shall be preferred considering the population of the natural enemies. Three different coloured sticky traps viz., yellow, blue and white were installed at four heights (25cm, 50cm, 75cm and 100cm) under field conditions in 25th standard week. The blue sticky traps attracted maximum number of thrips (29.98) followed by yellow (27.27) and white traps (18.71). The traps installed at 75cm were more effective in attracting *S. dorsalis* (Hood) followed by 100cm, 50cm and 25cm with mean number of thrips per plant as 37.37, 34.60, 26.50 and 19.40, respectively. Blue coloured sticky trap installed at 75 cm above ground can, therefore, be used for efficient and eco-friendly management of *S. dorsalis* (Hood).

Key words: Gladiolus, Insecticides, Management, *Scirtothrips*, Sticky traps.

Signature of Student

Signature of Major Advisor

Dated: _____

Dated: _____

ACKNOWLEDGEMENT

“All praises are to Allah alone, the lord of Kaa’ba and the sovereign of the universe, who found me worthy enough to pursue my postgraduate studies and opened my heart to the knowledge and humbled my being”

*L*anguage seems to be too inadequate to express my sincere and deepest sense of gratitude to my major advisor, **Dr. Munazah Yaqoob**, Associate Professor (Entomology), SKUAST-K, whose expertise, enthusiastic cooperation, consistent encouragement, valuable suggestions, keen interest, sound counselling, patience, sustained interest and above all her positive attitude towards my abilities helped me add considerably to the research plan, its execution and preparation of the manuscript. The way she ignites the imagination, instills a love of learning and turns denial into acceptance, chaos into order, confusion into clarity makes her the most regarded mentor of my life. As each day in my journey comes to me refreshed and anew, so does my gratitude to my major advisor renew itself daily.

It gives me immense pleasure to place on record my profound sense of being indebted to Dr. Sajad Hussain Mir, Assistant Professor (Entomology), SKUAST-K, and Co-chairman of my research program for his valuable suggestions, help and resources during the entire course of investigation and review of this manuscript.

I am highly grateful for constant and painstaking guidance, encouragement, suggestions and sustained efforts of Dr. Angrej Ali (Associate Professor, Division of Horticulture, SKUAST-K)

I am thankful to Dr. Arif Hussain Wani (Assistant Professor, Division of Horticulture, SKUAST-K) for his kind co-operation and colossal help rendered in various ways to make the execution of this venture possible.

I greatly rejoice to express empathetically, with profound sense of gratitude and sincere thanks to Dr. Fehim Jeelani Wani (Assistant Professor, Division of Agri-Statistics, SKUAST-K) for his constant and painstaking guidance during the analysis of data and enabling me to accomplish this husting task.

I also thank Dr. Ayoub Mantoo, Head, Division of Entomology, FOA Wadura, SKUAST-K for his timely support, encouragement, suggestions, positive criticism, affection and morale uplift.

I would be failing in my duty if I do not extend my heartiest thankfulness to the teachers namely Dr. T. H. Askary, Dr. Mudasir Gani and Dr. Ishtiyahq Ahmad for their help, encouragement and resources.

I am thankful to Dr. A. H. Hakeem, Dean Faculty of Agriculture, Wadura, for his whole- hearted guidance and cooperation.

With utmost gratitude, I would like to place on record the help extended by the staff of Division of Entomology, FOA Wadura namely Mr. Ab. Qudoos, Mr. Aijaz Ah. Lone, Mr. Shamsuddin, Mr. Ab. Majeed, Jana begum and Mr. Aasif.

I would like to avail this opportunity to say thanks to all my seniors especially Mr. Liyaqat Ali, Mr. Umar Bin Farooq, Mr. Mohammad Asif Sheikh, Mr. Fazil Fayaz Wani, Mr. Audil Gul, Mr. Ishfaq Majeed Shah, Ms. Jameela Rasool, Ms. Danishta Aziz, Ms. Sheikh Afreen and my juniors Ms. Madhumita, Mr. Janardhan, Mr. Rajesh, Ms. Ruqaya, Ms. Falak, Ms. Saika, Ms. Shabnum, Ms. Harshini, Mr. Saleem and Mr. Asghar who have directly or indirectly helped me for the successful completion of my research work. I am also deeply beholden by the constant support and motivation of all my colleagues especially Ms. Insha Shafi, Ms. Nusrat Fatimah, Ms. Adeeba Rehman, Ms. Noor ul ain, Ms. Saima gani, Ms. A. R. Ramya, Mr. Zuhair Farooq and Mr. Showkat for their timeless help and valuable suggestions.

I would like to give a special thanks to my friends, Bisma jan, Afshana Bano, Farhat Nabi and Saima Khaleef for their constant support and encouragement during the entire course of work, and ensured their presence in all the good and bad.

I also take this opportunity to express my gratitude to my parents, Abu and Ammi, who put me above their own selves and taught me how to work hard by working hard themselves, my siblings, Mr. Anayat ullah and Mr. Ayman Irshad, whose love and affection for me surpassed all worldly definitions and made me feel at zenith of existence. May Allah protect you all!

Sheikh Salma Irshad

Place: Wadura

Dated:

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Chapter - 1

INTRODUCTION

The Kashmir valley is rightly being acknowledged as “Heaven on Earth” because nature has bestowed it with incredible beauty. The mean altitude of the valley is nearly 6000 feet above sea level and unfolds amid 32°17' to 36°58' N latitude and 73° 26' to 80° 30''E longitude (Raina *et al.*, 2017). Since 65 per cent of its area reclines in the Himalayan mountains, it is often labeled as “Global Biodiversity Hotspot” (Mittermier *et al.*, 2005). The exclusive geographical position and climatologically favorable conditions of the valley provides an excellent ground for different types of vegetation such as cereals, pulses, vegetables, fruits, oilseeds, fodder, medicinal and ornamental plants.

Floriculture, one of the important branches of horticulture has emerged “A Dollar Business” sector all over the world. The demand for ornamental flowers is increasing all over the world. This sector can act as immense sector for developing countries due to huge economies of scale and lead to increased farm assets of small and marginal farmers (Singh *et al.*, 2014). Though many people are nostalgic about floriculture, there are others who brush away the idea as a luxury or even a wastage of money but its significance and importance cannot be ignored or bypassed so lightly (Randhawa and Mukhopadhyay, 2001).

Floriculture has progressed both commercially and scientifically due to strong efforts made by floriculture scientists. The sector is growing swiftly all over the world, including India. It is identified as most remunerative profession with a much higher potential for returns per unit area (Datta, 2019). The world consumption of floricultural products is estimated to be worth US \$ 40 billion and of these, cut flowers contribute nearly 60 per cent of the total global floricultural trade.

Government of India has accorded this sector 100 per cent export-oriented status and recognized it as a sunrise industry (Anonymous, 2016). This industry is

flourishing at an annual rate of 7-10 per cent (Raina *et al.*, 2017). The production of floriculture products has increased quiet consistently over the last 20 years with an average yearly growth of 6-9 per cent (Abrol and Baweja, 2019). An important feature of this sector is that it is a good avenue to generate gainful employment for youth and rural areas (Chawla *et al.*, 2016). Estimated area under floricultural crops in India is 309 thousand hectares (Raina *et al.*, 2017). During 2001-2002 to 2018-2019, the area under floriculture in India almost increased three times from 1 lakh ha to 3.39 lakh ha. About 0.87 mT of cut flowers per annum is produced by India (Anonymous, 2020).

In J&K, floriculture sector has increased abundantly which is obvious from the fact that the area has increased from 80 ha in 1996 to 255 ha in 2015-16 (Sheikh *et al.*, 2015). District wise area under floriculture in Kashmir includes 7.37, 46.04, 2.25, 9.21, 41.43, 2.21, 17.28, 2.23, 0.50 and 12.05 ha in Anantnag, Srinagar, Pulwama, Shopian, Budgam, Kulgam, Ganderbal, Bandipora, Baramulla and Kupwara, respectively (Sheikh *et al.*, 2015). The major problems faced by the J&K growers in the production of flowers include advanced structures, lack of information about current advances of floriculture, lack of exporting agencies and lack of knowledge about diseases, insect pests and their control methods (Raina *et al.*, 2017). In the International cut flower trade, Gladiolus occupies the fourth place after Rose, Chrysanthemum and Carnation (Bose and Yadav, 1989) and now is being cultivated all over the India.

Gladiolus is a beautiful and glamorous bulbous flowering plant known for its beautiful and versatile flowers (Serek *et al.*, 1994) hence, called “Queen of Bulb”. It is perennial cormous flowering plant that belongs to family Iridaceae (Ahmed *et al.*, 2002). The name “gladiolus” is plagiaristic to the latin word “Gladius” which insinuates “Sword” for the shape of its leaves. It is also called as “Xiphium”, which is plagiaristic to the Greek word “Xiphios” connotes “Sword” (Nagar *et al.*, 2017). It produces elegant, flower spikes with orchid like bloom. The cultivation of gladiolus plant was introduced by the end of sixteenth century

(Innes, 1985) while it is of comparatively recent introduction to India. It is grown in herbaceous border, bed, rockery, pot and as cut flowers because of its magnificent inflorescence (Baskaran and Misra, 2007). The primary purpose of cultivation of gladiolus is to produce beautiful cut flowers which can be marketed to different flower markets. However, there are some medicinal health benefits of dried bulb which is ground into a powder like curing common cold, diarrhea, constipation etc.

Like other states in the country, gladiolus is assuming great importance in the state of Jammu and Kashmir. It is one of the most important cut flowers, however, its quality and productivity is being affected by several factors *viz.*, climate, cultivar, nutrient management, diseases and pests. Among the insect pests, the sucking type are the most important ones with greater damage caused by thrips (Zeier and Wright, 1995), which pierce the stem, leaves and feed on the cell sap of the gladiolus. Thrips infesting gladiolus are native to Africa and are considered common pest of gladiolus (Milevoj *et al.*, 2008).

Gladiolus thrips were first authentically recorded in Ohio consisting of specimens that were collected in Cleveland during summer of 1929. This pest was also observed in the location of Ontario, Vineland station and Canada in the same year. Scientists were not able to recognise the species. Upon further study, they revealed that insect was a new one which had not been previously given any scientific name (Herr, 1934). Morison (1930) for the first time described gladiolus thrips as *Physothrips simplex*, from the collection of five female specimen on carnation flowers, *Dianthus caryophyllus*, from Urrbrae, South Australia. These thrips were also described by Moulton and Steinweden (1931) under the name *Taeniothrips gladioli* from Ontario, Canada and it was synonymized by Steele (1935). Bhatti (1969) positioned *gladioli* (species) in the genus *Thrips*. With the first appearance of this insect in America, it dispersed like a wildfire. Serious damage was reported in Ontario and Canada in 1929 (Herr, 1934). This pest

possesses six stages in its lifecycle- the egg, two larval instars, two pupal instars and the adult stage (Kaur, 2021).

The flowers of gladiolus are of greater importance for the commercial purpose and therefore, the symptoms are most frequently observed by the grower on the flowers (Herr, 1934; Chyzik *et al.*, 1995). The attack of this pest coincides with peak flowering stage and ultimately the market value of the flowers is reduced. Thrips feed by puncturing the plant cells and sucking the contents of the plant, these cells become filled with the air and give creamy silvery appearance flowering to the damaged leaves and cause the bleached flecks on the gladiolus flowers (Childers and Achor., 1995). Many thrips perish at the end of the growing season but some may survive and the ones that survive move down the plant and attack the corm resulting in the dried grey-brown rash-like patch. The new growth is soon invaded, when the infested corms are replanted (Denmark and Price, 1998; Conijin and Groen, 1990).

Internationally, thrips have become a limiting factor in hampering gladiolus production, vectoring tomato spotted wilt virus (TSWV) causing damage to leaves, flowers and buds and in severe cases, decreasing the regeneration ability of the corms in the next season (Zeier and Wright, 1995; Kindt *et al.*, 2003). A wrong choice of insecticides or inadequate management strategy may result in the poor pest control. Frequent use of synthetic insecticides for control of thrips have developed resistance to different groups of insecticides (Schreiber *et al.*, 1989; Immaraju *et al.*, 1992; Zhao *et al.*, 1995). Thrips are difficult to manage due to their secretive habit, comparatively short life-cycle, polyphagous nature and capacity to develop resistance against insecticides. This pest possesses an ever-increasing threat to commercial cut-flower growers of gladiolus. It is now widespread and is found almost in all areas where gladiolus is grown *viz.*, Africa, southern Asia and Japan, Australia, several Pacific Islands, Europe, and North and South America.

So far, no work has been done on the status and management of this pest on gladiolus in Kashmir. Keeping in view the importance of this growing sector, it therefore, becomes imperative to carry out the studies that shall generate baseline data on the incidence and develop management strategy for this pest. The present study entitled “studies on the incidence and management of thrips on gladiolus, *Gladiolus grandiflorus* L.” was envisaged with the following objectives:

- 1) To study the incidence of thrips on gladiolus.
- 2) To evaluate the efficacy of different insecticides against thrips on gladiolus.
- 3) To evaluate various colour sticky traps against gladiolus thrips.

Chapter - 2

REVIEW OF LITERATURE

The gladiolus plant was considered pest free earlier to the discovery of the gladiolus thrips in North America in 1929 (Tate and Poor, 2017). With the introduction and rapid dispersal of the gladiolus thrips, the study of this pest has gained the attention of Entomologists as well as commercial growers in many countries. The injury caused by this pest is characterized by white or silver spots on the leaves and bud sheath and if widespread, can impart a silvery streaked appearance to the leaves (Tate and Poor, 2017). On flowers, the injury is characterized as discoloured or bleached spots and injured buds may fail to open. The injury caused by this pest may result in damaged and even worthless corms which ultimately reduces its market value. The purpose of the present study is to familiarize the growers with the incidence and the management of thrips on this plant. Globally, limited work has been carried out on the incidence and management of thrips on gladiolus. The relevant literature available in India and abroad on thrips on other crops is reviewed as under:

2.1 Incidence of thrips

The scanning of literature revealed incidence of thrips on gladiolus commencing from mid-June and reaching its peak period in July coinciding with flowering stage (Milevoj *et al.*, 2008). Gupta (2013) found *S. dorsalis* Hood as major sap sucking pest on hybrid roses. Park *et al.* (2002) observed commencement of *Frankliniella occidentalis* in early April and highest population (620 thrips/trap) during June on rose cultivars under greenhouse condition. Duchovskiene (2006) reported highest abundance of onion thrips (13.2 thrips/plant) in late July and early August. Saiyad (2015) observed commencement of gladiolus thrips, *Thrips simplex* from 3rd week after sowing (4.0 thrips/plant) reaching to its peak level at the flowering stage (30.2 thrips/plant). He correlated population of this pest with different weather parameters and

found significant and negative correlation with average temperature ($r = - 0.735$) and positive correlation with wind speed ($r = 0.390$).

Lee and Wen (1982) observed emergence of thrips on onion throughout the year with peak population however, during dry season. Sanap *et al.* (1985) concluded incidence of chilli thrips in August with population increasing gradually till September and declining thereafter.

Legutowska (1997) found minimum incidence of thrips in the starting phase but with very high infestation during harvest of the leek and peak population in the month of August and September. Reddy and Gowdar (2005) observed minimum infestation due to onion thrips in first two weeks after transplantation of onion. They observed peak population of this pest in June and July on transplanted crop while least population of *T. tabaci* in August and September.

Shibao *et al.* (2004) observed peak population of *S. dorsalis* (12 thrips/shoot) from mid- July to mid-August on grape. Gosalwad *et al.* (2009) noticed highest abundance of thrips on cotton in August and October. Padaliya *et al.* (2019) observed first appearance of *S. dorsalis* (0.22 thrips/leaf) during last week of July and population increased till last week of August (1.84 thrips/leaf). Latif *et al.* (2015) observed peak population of thrips on cotton in late July and August with gradually declining till October due to maturity of the crop. Mannion *et al.* (2014) studied population dynamics of *S. dorsalis* on rose and observed peak density (0.002-0.007 thrips/cm²) and maximum damage in August. Sahani *et al.* (2020) observed appearance of *S. dorsalis* at the early growth period (0.16 thrips/leaf) and gradually reached to its peak during the flowering stage (13.81 thrips/leaf) on chilli.

Waiganjo *et al.* (2008) determined the effect of weather on the population of thrips under given climatic conditions and observed an unambiguous rise in the population of thrips under dry weather conditions as compared to the wet season

accompanied with moderately high relative humidity which could lay a negative impact on the thrips population.

Naik *et al.* (2010) found maximum thrip population during January - February and November – December and minimum in the month of June - August with significant positive correlation with temperature (maximum) and sunshine hours and negative correlation with rainfall, relative humidity and temperature (minimum) in cardamom. Neergude *et al.* (2014) however, observed peak population (39.3 thrips/5 plants) of thrips, *T. tabaci* in Kharif season especially during August to October on onion.

Haider *et al.* (2014) observed maximum infestation of thrips at 5-7 leaf stage of onion plant (672.6 thrips/plant) and declining gradually in later bulb stage as the crop reached maturity and found significant and negative effect of this pest with rainfall ($r = -9.3$).

Chandra and Rana (2014) found highest population of thrips on onion during onset of summer season and lowest during the onset of winter season. Kumar *et al.* (2017) found maximum number of onion thrips (20.78 thrips/plant) during the second week of November (46th SMW) and thereafter, declining to 2.14 thrips per plant during third week of December. They observed non-significant negative correlation with maximum/minimum temperature, relative humidity, rainfall and wind velocity.

Moanaro and Chaudhary (2016) observed peak infestation of thrips on cowpea during flowering period on all studied genotypes. They found strong significant positive correlation of this pest with maximum temperature ($p \leq 0.01$) and mean temperature ($p \leq 0.05$), negative correlation of this pest with rainfall and non-significant negative correlation with relative humidity.

Narboo *et al.* (2017) observed maximum (13.98 thrips/leaf/plant) and minimum population of thrips (4 thrips/leaf/plant) in the 48th and 14th standard

week, respectively on rose and found negative significant correlation of minimum temperature, humidity (evening) and rainfall with population of this pest.

Janu *et al.* (2017) studied population dynamics of *T. tabaci* on cotton and found peak population in 31st standard meteorological week ranging from 14.68 to 36.85 thrips/leaf. They observed significant and negative correlation of this pest with maximum temperature while minimum temperature, morning and evening relative humidity positively correlated. Selvaraj and Adirourbane (2012) studied influence of weather parameters on the incidence of *T. tabaci* on cotton and found significant and positive correlation of this pest with temperature, relative humidity and sunshine hours while negative correlation with rainfall, wind velocity and evaporation. Panwar *et al.* (2015) observed peak infestation of thrips (9.35 thrips/leaf) in 31st standard meteorological week on cotton and found positive and significant correlation of this pest with maximum and minimum temperature, morning and evening relative humidity. Syed *et al.* (2015) observed significant positive correlation of thrips with temperature ($r = 0.18$) and relative humidity ($r = 0.77$) on mustard.

Kiran *et al.* (2017) recorded seasonal peak incidence (12.33 thrips /flower cluster) during first fortnight of May and no incidence during July, August and October on Jasmine flower. They found significant positive correlation of this pest with maximum temperature and morning relative humidity and significant negative correlation with evening humidity. Neelima (2005) observed maximum population of thrips on Jasmine during second fortnight of April and found positive correlation of this pest with maximum temperature and negative correlation with relative humidity and rainfall.

Saicharan *et al.* (2017) recorded peak population of thrips on chrysanthemum from first fortnight of January (3.60 thrips/plant) to first fortnight of February (5.58 thrips/ plant) coinciding with the peak flowering season.

Sumalatha *et al.* (2017) observed maximum (16.4 thrips/plant) and minimum population (1.5 thrips/plant) of onion thrips in 44th and 27th standard meteorological week, respectively. They found non-significant and negative correlation ($r = -0.404$) of this pest with rainfall, highly significant and negative correlation with morning relative humidity ($r = -0.635$), evening relative humidity ($r = -0.733$), wind velocity ($r = -0.652$) and minimum temperature ($r = -0.709$) while maximum temperature ($r = 0.284$) and evaporation ($r = 0.407$) positive and non-significant.

Saini *et al.* (2017) studied population dynamics of sucking pests infesting chilli and found incidence of thrips commencing in second week of August and touching the peak during third week of September (10.2 thrips/ 3 leaves). They found negative correlation of this pest with temperature and rainfall whereas, positive correlation with relative humidity. Sri *et al.* (2017) observed significant and negative correlation of thrips with maximum, minimum and average relative humidity on tomato. Samanta *et al.* (2017) found highest (6.15 thrips/leaf) and lowest mean population of thrips (1.85 thrips/leaf) in chilli during April and May, respectively. They found positive correlation of this pest with mean temperature and negative correlation with total rainfall.

Vinuthan *et al.* (2018) observed peak activity of onion thrips (27.16 thrips/plant) during September and found significant positive correlation of this pest with maximum temperature and negative correlation with rainfall. Kumavat *et al.* (2018) recorded incidence of onion thrips commencing from third week of February and reaching its peak period in the last week of March. They observed non-significant positive correlation of this pest with temperature and non-significant negative correlation with relative humidity. Mansuri *et al.* (2014) found peak period (35.0 thrips/plant) of thrips, *T. tabaci* during last week of March on onion and observed positive and significant correlation of population of thrips with atmospheric temperature (maximum, minimum and mean) with

correlation coefficient (r) values 0.81, 0.70 and 0.79, respectively while negative non-significant correlation with minimum relative humidity ($r = -0.55$).

Raj *et al.* (2019) found peak population (3.41 thrips/leaf) and minimum population (0.07 thrips/leaf) during May and November, respectively on carnation under protected conditions in Kashmir.

Bhonde *et al.* (2019) studied seasonal incidence of *T. tabaci* on onion and recorded highest population of thrips in 44th meteorological week (34.56 thrips/plant) and significant positive correlation of this pest with maximum temperature ($r = 0.61$) while rainfall, minimum temperature, relative humidity was non-significant and negatively correlated.

Qurat *et al.* (2020) observed increased population of thrips (129.89 thrips/plant) in the month of March with increase in temperature (13th SW) and steadily declined (10.41 thrips/plant) in the month of April due to intensive rainfall.

Sherwani *et al.* (2020) observed peak population of thrips on onion from second week of June and continued till fourth week of July (30 thrips/plant). They found positive correlation of temperature with the population of this pest.

Karuppaiah *et al.* (2020) confirmed maximum and minimum temperature, average relative humidity has significant influence on the population dynamics of thrips on onion. They found significant negative correlation of this pest with maximum ($r = 0.726$, $p = 0.01$) and minimum temperature (-0.670 , $p = 0.01$) and significant positive correlation with relative humidity ($r = 0.566$, $p = 0.01$).

2.2 Management of thrips

Gahukar (2003) observed 28 – 95 per cent damage in rose by *S. dorsalis* with a population density of 11 – 33 thrips per flower as this pest feeds on tender leaves, buds and flowers causing deformities with burnt margins resulting drying of flower buds and flowers (Jhansirani and Sridhar, 2003; Duraimurugan and Jagadish, 2002). This reduces the market value of commercial cut flowers;

therefore, proper management strategies are required to help cut flowers to flourish in the market field. Limited work has been done regarding the efficacy of different insecticides against gladiolus thrips, hence, similar work on other crops has been reviewed as under:

Holloway and Forrester (1998) after studying different noval insecticides found imidacloprid, fipronil, buprofezin and spinosad most effective ones in reducing the population of sucking pests.

Cloyd and Sadof (2000) observed spinosad @ 50, 100 and 200 ppm and acephate @ 600 ppm promising in increasing the mortality percentage of western flower thrips (*F. occidentalis*) on gerbera.

Kadam and Dethle (2002) evaluated insecticide fipronil 0.3 G for the management of thrips on chilli and found it effective after applying it in the form of granules in soil @ 40 to 60 g/bed before sowing of chilli. They also found spray treatment of fipronil 5 SC @ 40-60 g a.i/ha better for control of chilli thrips.

Jadhav *et al.* (2004) observed minimum population of sucking pests in the plots treated with fipronil 5 SC @ 100 g a.i/ha and highest yield of chilli was also observed in these treatments.

Reddy *et al.* (2005) evaluated the bioefficacy of certain insecticides against chilli thrips, *S. dorsalis*. Seventeen insecticides were sprayed three times at an interval of ten days viz., dimethoate 30 EC (0.06 %), quinolphos 25 EC (0.05 %), endosulfan 35 EC (0.07 %), carbaryl 50 WP (0.15 %), imidacloprid 200 SL (0.02%), chlorpyrifos 20 EC (0.05 %), profenofos 50 EC (0.05 %), dichlorvos 76 EC (0.076 %), dicofol 18.5 EC (0.09 %), phosalone 50 EC (0.07 %), triazophos 40 EC (0.06 %), fipronil 5 SC (0.01 %), azadirachtin 300 ppm (0.000015 %), indoxacarb 14.5 SL (0.0145 %), thiamethoxam 25 WG (0.005 %), acetamiprid 20 SP (0.002 %) and monocrotophos 36 SL (0.06 %). Out of these seventeen treatments, they found fipronil 5 SC most effective followed by thiamethoxam, acetamiprid and dimethoate in reducing the population of thrips.

Ambekar and Nayakwadi (2008) evaluated different insecticides against onion thrips and observed lambda cyhalothrin (0.005 %) most effective in minimising thrips population (2.63 thrips/plant) followed by fipronil 5 SC (0.001%) with thrip population 2.87 per plant.

Gosh *et al.* (2009) observed thiamethoxam (90.1%) most effective followed by acetamiprid (89.8 %), fipronil (88.8 %), clothionidin (87.4 %) and oxy-demeton methyl (76.9 %) for reducing the population of thrips on chilli.

Malik *et al.* (2012) found acetamiprid 20 SP more effective resulting in the maximum mortality (87%) of thrips after 24 hours in rose. Hedge *et al.* (2011) however, recommended the use of neem seed kernel extract (5%), monocrotophos (0.15%) or imidacloprid 200 SL (0.1%) for the control of thrip population on rose.

Verma *et al.* (2012) found maximum mortality percentage (4.83 thrips/plant) and highest bulb yield (172.49 q/ha) in the plots treated with imidacloprid 17.8 SL followed by fipronil 5SC with mortality of 68.47 per cent.

Hosamani *et al.* (2012) found fipronil 80 WG @ 60g a.i/ha effective in reducing population of onion thrips from 22.46 to 1.13 thrips per plant with highest bulb yield (29.16 t/ha). Badgular *et al.* (2014) after spraying fipronil 5 SC against cotton thrips found it most effective in reducing thrips population and was significantly superior over all the treatments with highest cotton yield (2087 kg/ha). Vijay *et al.* (2013) however, recorded lowest number of thrips in the plots treated with fipronil @ 50g a.i /ha as compared to other treatments after 3 days of spray in cotton.

Mehra and Singh (2013) tested different insecticides/botanicals and found significantly low mean population of thrips in garlic plots treated with imidacloprid 17.8 SL (94.38 %) followed by thiamethoxam and dimethoate while azadirachtin and NSKE were found least effective. Ayalew (2005) however, observed ethanol extracts of neem seed powder effective in reducing thrips on onion under field condition.

Singh *et al.* (2013) concluded fipronil 5 SC most promising insecticides in increasing mortality percentage (98.56%) and increasing the weight of exportable bulb and yield of onion when compared with the control and other insecticides.

Gupta (2013) observed imidacloprid (1 ml/ 4.5L of water) in combination with spinosad effective in controlling thrip population and other sucking pests on roses. Also, Narboo *et al.* (2017) found imidacloprid (0.0025%) most effective followed by dimethoate (0.05%) in controlling population of thrips on rose.

Pandey *et al.* (2013) found fipronil (1.5 ml/L of water) effective resulting in lowest mean thrip population (8 nymphs/plant) with highest bulb yield (362 q/ha) and highest cost benefit ratio (1:11.55). Patil and Patil (2018) found fipronil effective in reducing thrip population on onion with highest yield of onion bulbs.

Laxman (2014) evaluated different insecticides against onion thrips and found lowest mean thrips population (4.38 thrips/plant) in the plots treated with fipronil 5 SC which was at par with clothianidin 50 WDG (4.69 thrips/plant).

Babar *et al.* (2014) found curacron 500 EC (Profenphos) more effective in increasing mortality of thrips (74.29%) on onion after 24 hours of spray. Uddin *et al.* (2019) found curacron 500 EC (500 ml/acre) most effective in increasing mortality percentage (91.6 %) of onion thrips, *T. tabaci* in Awaran district.

Saiyad (2015) studied the effect of different insecticides against *T. simplex* on gladiolus and found fipronil 5 SC (7.59 thrips/plant) best in reducing population of thrips followed by acetamiprid 0.006 per cent (8.36 thrips/plant), triazophos 0.05 per cent (9.12 thrips/plant), profenophos 0.05 per cent (9.88 thrips/plant) and spinosad 0.0135 per cent (10.65 thrips/plant). Kumar (2017) found acetamiprid 20 SP (58.71%) most effective followed by emamectin benzoate 5G (56.01 %), spinosad 45SC (49.17) and neem oil (45.43 %) against gladiolus thrips.

Bharani *et al.* (2015) studied efficacy of bio-pesticides and novel insecticides *viz.*, imidacloprid 30.5 SC (100 ml/ha) and thiamethoxam 25 WG

(75g.a.i/ ha) against the *T. tabaci* Lind. and predatory coccinellids in tomato ecosystem. They observed significantly minimum thrip population in imidacloprid 30.5 SC + thiomethoxam 25 WG (1.15 nymphs/plant) followed by thiomethoxam 25 WG (1.35 nymphs/ plant) and imidacloprid 30.5 SC (1.37 nymphs/plant) besides being less toxic to natural enemies and suggested use of bio-pesticides and neonicotinoids in compatible manner in Integrated Pest Management programmes for controlling thrips and minimising effect on natural enemies.

Satyanarayana and Singh (2016) conducted an experiment for evaluating efficacy of different insecticides against onion thrips (*T. tabaci* Lind) and found fipronil 5 SC (0.01 %) and imidacloprid 17.8 SL (0.03 %) most effective in reducing thrips population by 84.40 and 76.51 per cent, respectively. They further observed highest bulb yield 238.60 q/ha and 226.38 q/ha in plots treated with fipronil 5 SC and imidacloprid 17.8 SL, respectively.

Manju *et al.* (2016) found neem seed kernel extract (0.5%) one among the top three biorationals that proved effective in controlling the population of thrips infesting carnation flowers. Mishra *et al.* (2007) observed the impact of neem oil against thrips on onion and found it promising in reducing thrip population on onion under field conditions as compared to untreated plot. They recommended its use to farmers against onion thrips as it is easily available to the farmers and is eco-friendly.

Din *et al.* (2016) observed imidacloprid + fipronil 80 WG most effective (94.28 %) combination for decreasing the population of thrips on onion followed by chlorfenapyr 36 SC (93.37 %), chlorfenapyr 50 WDG (91.26) and imidacloprid 200 SL (85.06 %). Kumar *et al.* (2019) found fipronil 5 SC + buprofezin 20 SC most effective and significantly superior over other treatments in reducing the thrip population (69.8 %) on chilli crop.

Gangwar *et al.* (2016) observed lowest number of thrips population (6.48 thrips/plant) at 15 days after spray of fipronil 5 SC (2ml) + surfactant (0.5 ml/l of

water) on onion with highest bulb yield (254.83 q/ha) and highest cost benefit ratio (1:6.84). Das *et al.* (2017) found minimum population of thrips in the plots treated with imidacloprid 17.8 SL on onion with improved total yield (263.56 q/ha) and marketable yield (247.55 q/ha).

Wagh *et al.* (2016) observed fipronil @ 0.0075 % most effective insecticide resulting in minimum thrip population (4 thrips/plant) and maximum onion bulb yield (25.67 t/ha) followed by spinosad @ 0.018 %, acetamiprid @ 0.005 % and clothianidin @ 0.0075 %. Patil *et al.* (2013) found fipronil 5 SC most effective in increasing the mortality percentage of mulberry thrips, *Pseudodendrothrips mori*.

Patel and Kumar (2017) found spinosad (79.79 %) followed by imidacloprid (76.81 %), cypermethrin (71.38 %) most effective among all the treatments in increasing the mortality percentage of thrips, *S. dorsalis* on chilli.

Sallam *et al.* (2018) found methomyl effective in increasing the mortality percentage of thrips on onion while as azadirachtin recorded minimum mortality percentage of onion thrips in the treated plots.

Kansagara *et al.* (2018) studied different insecticides for the management of thrips, *S. dorsalis* Hood infesting green gram with different combinations of seed treatments viz., imidacloprid 30.5 SC @ 0.12 per cent, clothianidin 50 WDG @ 0.20 per cent and thiamethoxam 25 WG @ 0.01 per cent and foliar application of insecticides profenophos (40%) + cypermethrin (4%) 44 EC @ 0.044 per cent, spinosad 45 SC @ 0.0135 per cent and flonicamid 50 WG @ 0.015 per cent. Out of these treatments, they found seed treatment of thiamethoxam 25 WG @ 0.10 per cent and insecticidal spray of spinosad 45 SC (0.0135%) most effective for reducing population of thrips with maximum (1066 kg /ha) seed yield from the plots treated with thiamethoxam 25 WG (0.10 %) + spinosad 45 SC (0.0135 %) followed by imidacloprid 30.5 SC (0.12 %) + spinosad 45 SC (0.0135 %).

Pathak *et al.* (2018) found basal application of chlorantraniliprole 0.4 per cent @ 10 Kg/ha and sequential sprays of fipronil @ 0.1 per cent, carbosulfan @ 0.2 per cent, profenofos @ 0.1 per cent and spinosad @ 0.03 per cent effective for managing thrips and increasing the yield of onion seed with highest cost benefit ratio.

Aslam *et al.* (2018) found curacron 500 EC (profenphos) @ 4 ml/L of water best by showing minimum thrip population after every application with least negative effect on vegetative and reproductive structures of onion bulbs and observed significant difference among insecticides affecting flowering characters of onion. Begna (2019) however, observed significant difference among vegetative characters of onion plants treated with different insecticides. Abdurezake and Eshetu (2021) found significant difference between plots treated with insecticides and untreated ones with maximum plant height in insecticide treated plots.

Ahmad *et al.* (2018) found maximum mortality (79%) of thrips at 24 hours after spray due to imidacloprid in combination with fipronil (Lacenta) followed by chlorfenapyr (75.55%), spintoram (72.47%) and spinosad (66.53%) respectively on gladiolus cv. white prosperity. Sathyan *et al.* (2017) found fipronil 5 SC most effective insecticide with 82.35 per cent reduction in thrip population followed by imidacloprid 17.8 SL (78.55 %) on rose.

Khazada *et al.* (2018) tested the efficacy of chlorphenpyre 5SC (50 g a.i/ha), cypermethrin 25EC (30 g a.i/ha) and profenofos 5SG (10 g a.i/ha) against onion thrips at Khazada Research Farm, Nasarpur and found chlorphenpyre 5SC most effective in increasing mortality and reducing the population of thrips (0.73 thrips/plant) on onion.

Shweta *et al.* (2019) laid a field experiment to evaluate the efficacy of different synthetic insecticides against onion thrips during *Kharif* 2017-18 at University of Horticultural sciences, Bagalkot. Their findings indicated

significantly lower population of onion thrips in thiamethoxam 25WG which was at par with imidacloprid 17.8 SL and thus both the chemicals were equally superior in reducing population of onion thrips. They found cyazypyr 10.26 OD, diafenthiuron 50 WP and tolfenpyrad 15 EC medium effective against onion thrips. Sherwani *et al.* (2020) observed thiacloprid 21.7 SC (73.49%) followed by spiromesifen 22.9 SC (66.68 %) and imidacloprid 17.8 SL (63.90 %) most effective in increasing the mortality percentage of thrips on onion.

Shiberu (2020) recommended the newly introduced insecticide sivanto energy 85 EC (1200 ml/ha) as the most promising insecticide for increasing the mortality percentage of onion thrips, *T. tabaci* and did not observe any significant difference in leaf number per plant and leaf length per plant among the treatments but highest mean bulb diameter was observed in plot sprayed with sivanto energy EC 85.

Negash *et al.* (2020) observed imidacloprid and spinetoram most effective insecticides in reducing the population of thrips with increased onion bulb yield as compared to profenofos and λ -cyhalothrin and insecticides with surfactant resulted in furthermore reduction of thrips population and higher bulb yield as compared to the insecticides applied without surfactant.

Yadav *et al.* (2020) evaluated different insecticides for the management of *T. tabaci* on onion and found fipronil (0.01 %) most effective followed by clothianidin (0.01 %), acetamiprid (0.004 %) and thiamethoxam (0.023 %).

2.3 Evaluation of various colour sticky traps against thrips

Thrips are very cryptic in nature and difficult to trace and initiate control measure under field condition till damage symptom appears. Thrips generally move long distances by floating with the wind and get trapped on the sticky board while moving between rows of plants as traps are better indicators of thrips activity (Waiganjo *et al.*, 2008). Evaluation of colour preference of thrips may help to develop traps using various attractive colours, thus providing opportunities for

the control of this pest by integrating specific colours into crop management methods. This can help to minimise the use of synthetic insecticides and therefore, helping to prevent the build-up of insecticide residues in the environment and food. Use of coloured sticky traps at different heights could be simple and cost effective for determining the relative abundance of insects. The attractiveness of different coloured sticky traps to many thrips species has been demonstrated (Hoddle *et al.*, 2002; Chen *et al.*, 2004; Broughton and Harrison., 2012). Many species of thrips have been studied by various authors to evaluate efficacy of attraction to different colours whose work have been reviewed as under:

Atakan and Canhilal (2004) observed similar number of western flower thrips at 60, 80, and 100 cm but significantly lower at 120 cm. They further found trap heights of 60 –100 cm, suitable for estimating flower thrips in cotton fields.

Chen *et al.* (2004) found blue coloured sticky trap (125.1/trap/week) most effective for monitoring western flower thrips than yellow and white.

Demirel and Cranshaw (2005) evaluated efficacy of different coloured sticky traps against *F. occidentalis* and *T. tabaci* on onion and observed neon yellow-coloured sticky traps effective in attracting *F. occidentalis* and *T. tabaci* population. blue and white coloured sticky traps however, failed to attract thrips population.

Trdan *et al.* (2005) did not found blue coloured sticky traps effective in management of thrips population. Therefore, they concluded that blue coloured sticky traps have importance only in monitoring this pest and not in its control.

Allen *et al.* (2005) studied the efficacy of white coloured sticky traps when installed at different heights above the ground surface and concluded white sticky traps installed between 70 cm and 95 cm above the ground most attractive towards thrip population.

Ranamukhaarachchi and Wickramarachchi (2007) observed that blue- and white-coloured sticky cards attract more thrips, *Ceratothripoides claratris* as compared to other colours on tomato.

Demirel and Yildirim (2008) found blue coloured sticky traps (146.75 thrips/plant) more effective for attracting thrips than yellow, white, red and orange.

Al-karboli and Al-Anbaki (2014) after performing field experiment on efficacy of sticky traps against onion thrips at College of Agriculture, Baghdad and found white and blue sticky traps effective in controlling onion thrips as compared to yellow-coloured traps and thus concluded that blue and white sticky traps could be used for monitoring and reducing population density of *T. tabaci* in onion field.

Gharekhani *et al.* (2014) found yellow sticky traps, the most appropriate ones for trapping onion thrips, which were installed at a height of 70 cm above the ground.

Muvea *et al.* (2014) indicated *M. sjostedti*, *F. schultzei* and *F. occidentalis* more responsive to blue sticky traps as compared to yellow and clear sticky traps.

Sridhar and Naik (2015) found the blue colour sticky traps (19.40 thrips/trap) attracted highest number of adult thrips, *S. dorsalis* followed by yellow (10.40 thrips/trap) and pink (8.60 thrips/trap) on rose.

Blatt *et al.* (2015) observed maximum number of thrips on the blue sticky trap in the month of August on cabbage.

Raheem (2016) reported that yellow and white sticky traps when installed 30cm above ground recorded maximum number of thrips at the first peak. In contrary, the sticky traps installed at 60cm height above ground surface recorded highest number of thrips at the second peak. However, during both peaks, the sticky traps that were installed at 90cm height above ground recorded lowest

population of thrips. Mo *et al.* (2008) observed maximum thrips in the upper part than the basal plant sections.

Mohan *et al.* (2016) evaluated the efficacy of five different coloured sticky traps *viz.*, green, yellow, orange, violet and white and recorded green colour sticky boards more effective in attracting onion thrips (16.88 thrips/board) than yellow (11.27 thrips/board) violet, orange and white (3.65, 3.02, 2.53 thrips/board), respectively.

Devi and Roy (2017) found blue coloured sticky trap (8.34 thrips/board) more attractive towards onion thrips, *T. tabaci* over the crop growth period than white (5.32 thrips/board), fluorescent green sticky traps (4.30 thrips/board) and yellow (3.40 thrips/board).

Prema *et al.* (2018) observed yellow-coloured sticky traps resulted in maximum thrip capture in cotton and recommended its use to the farmers to protect the crop at the early stage of thrip infestation.

Pobozniak *et al.* (2020) found the blue-coloured sticky traps (10 thrips/board) most effective ones for monitoring thrips in pea fields than yellow (7.4 thrips/board) and white (4.7 thrips/board).

Chapter - 3

MATERIALS AND METHODS

The investigation on “Studies on the incidence and management of thrips on gladiolus, *Gladiolus grandiflorus* L.” were carried out at Faculty of Agriculture, Wadura, SKUAST-K situated at an altitude of 1610 meters above mean sea level between 34°20′ North latitude and 74°24′ East longitude. The details of materials and methodologies followed during the course of investigation are as under:

3.1 To study the incidence of thrips, *Scirtothrips dorsalis* (Hood) on gladiolus, *Gladiolus grandiflorus* L.

3.1.1 Raising of crop

Gladiolus corms were planted in an open field condition at Faculty of Agriculture, Wadura, SKUAST-K. Gladiolus corms were procured from the Division of Horticulture, FoA, Wadura, SKUAST-K. All the recommended agronomical practices were adopted for raising the crop. The corms were planted at a depth of 5 cm and the distance from row to row and plant to plant was maintained at 30 × 20 cm, respectively (Plate 1).

3.1.2 Cultural operations

The preparation of land was done according to requirement of the gladiolus crop. Different agronomic operations viz., weeding, earthing up, staking etc were done as per the recommendations. To keep the soil porous and to provide support to plants, two earthing up operations were done at 30 and 60 days after planting of corms and to avoid lodging of plants, staking was done with the help of wooden sticks after 50-60 days of planting of corms.



Plate 1: *Gladiolus*, *Gladiolus grandiflorus* L. grown at FoA, Wadura, SKUAST-K

3.1.3 Occurrence of thrips, *Scirtothrips dorsalis* (Hood) on gladiolus, *Gladiolus grandiflorus* L.

To study the incidence of thrips on gladiolus, twenty-five plants were selected randomly for monitoring thrips upto harvest. Innermost leaves of the plants were observed for the presence of thrips. Observations were recorded irrespective of the stage of thrips present on the plants. Affected plant parts *viz.*, leaves and flowers were gently tapped on the white sheet of paper to dislodge thrips. Number of thrips present were counted with the help of magnifying lens and monitoring was carried out on weekly intervals. The thrips were collected and preserved in AGA (12 parts of alcohol, 1 part glycerine and 1-part acetic acid). The thrip, *S. dorsalis* (Hood) was identified in the Division of Entomology, FoA Wadura, SKUAST-K and cross checked by the Google lens software (Plate 2).

3.1.4 Correlation of population of thrips, *Scirtothrips dorsalis* (Hood) on gladiolus, *Gladiolus grandiflorus* L. with weather parameters

The meteorological data on different abiotic factors during the period of investigation were obtained from Division of Agronomy, Wadura campus. The data generated on the population of thrips on gladiolus was correlated with temperature (°C), relative humidity (%), rainfall (mm).

3.2 To evaluate efficacy of different insecticides against thrips, *Scirtothrips dorsalis* (Hood) on gladiolus, *Gladiolus grandiflorus* L.

To study the efficacy of different insecticides against thrips, *S. dorsalis* (Hood) on gladiolus, *G. grandiflorus* L. a trial was laid at FoA, SKUAST-K Wadura where gladiolus corms were planted with suitable agronomic practices. Insecticides were procured from local market of Jammu and Kashmir. The detail of insecticides used during the course of investigation is given in Table 1. Insecticides were applied uniformly using pressure sprayer to obtain complete coverage of all the plants of the specific plots (Plate 3). Proper precautions were



Plate 2: *Scirtothrips dorsalis* (Hood) collected from gladiolus, *Gladiolus grandiflorus* (Hood)



Plate 3: Application of insecticides on gladiolus, *Gladiolus grandiflorus* L. under field conditions

taken during the spray of insecticide to avoid drift of the insecticide to the adjacent plants.

All the insecticides were properly sprayed at their respective recommended doses. There were 5 treatments including control (water) and each treatment was replicated four times.

The data on population of thrips per plant and their mortality percentage on gladiolus was recorded on one day before spray and 1, 3, 5 and 7 days after spray (DAS). The data on mortality (%) was computed as per below mentioned formula:

$$\text{Mortality (\%)} = \frac{\text{Pre count} - \text{Post count}}{\text{Pre count}} * 100$$

Pre- count = Population before treatment

Post- count = Population after treatment

The data generated on mortality (%) was subjected to Abbott's formula (1925) for obtaining corrected mortality:

$$\begin{aligned} \text{Corrected Mortality (\%)} \\ = \frac{\text{Mortality in treatment} - \text{Mortality in control}}{100 - \text{Mortality in control}} \end{aligned}$$

3.2.1 Effect of different insecticides on the growth parameters of gladiolus, *Gladiolus grandiflorus* L.

Different insecticides *Viz.* fipronil 5 SC (0.005 %), imidacloprid 17.8 SL (0.003 %), neem oil (0.005 %) and NSKE 0.15 EC (0.0006 %) used for the management of thrips, *S. dorsalis* L. on gladiolus, *G. grandiflorus* L. were evaluated during the course of investigation to determine their impact on growth parameters *Viz.* vegetative, floral characters and corm production (Plate 4).



Plate 4: Measurement of growth parameters of gladiolus, *Gladiolus grandiflorus* L.

Table – 1: List of insecticides sprayed on gladiolus, *Gladiolus grandiflorus* L. under field conditions

Insecticide	Dosage (ml/L of water)	Concentration (%)	Trade Name	Chemical Name	Manufacturer
NSKE 0.15 EC	04	0.0006	BIOPEST	-	MD Biocoals Private Limited
Neem oil	04	0.005	NEEM ACTIVE	-	B.P. Agro Chemicals
Fipronil 5 SC	1.0	0.005	REGENT	(<i>RS</i>)-5-Amino-1-[2,6-dichloro-4-(trifluoromethyl-4-(trifluoromethylsulfinyl)pyrazole-3-carboonitrile	RALLIS A TATA Enterprise
Imidacloprid 17.8 SL	0.2	0.003	TATAMIDA	<i>N</i> -{1-[(6-Chloro-3-pyridyl)methyl]-4,5-dihydroimidazol-2-yl} nitramide	RALLIS A TATA Enterprise

3.2.1.1 Vegetative Characters

3.2.1.1.1 Plant height (cm)

The height from the base upto the tip of five randomly selected plants in each treated plot was recorded with the help of a scale.

3.2.1.1.2 Number of leaves per plant

Total number of leaves per sampled plant was counted in different treated plots and mean numbers per plant was obtained by calculating the average number of leaves.

3.2.1.1.3 Leaf length (cm)

Length from base of the leaves to the tip of the leaves per plant was measured using scale.

3.2.1.1.4 Leaf breadth (cm)

Leaf breadth was measured across the middle of the leaf from each observational plant in each treated plot with the help of scale and average was worked out.

3.2.1.2 Floral Characters

3.2.1.2.1 Number of spikes per plant

Number of spikes produced from each observational plant was recorded and the average was worked out.

3.2.1.2.2 Rachis length (cm)

Rachis length of each observational plant was measured from basal floret to the tip of the spike with the help of scale and the mean was recorded in centimeter.

3.2.1.2.3 Spike length (cm)

Spike length of each observational plant was measured from the point of its emergence to the tip of the spike with the aid of scale and the mean was calculated in centimeter.

3.2.1.2.4 Number of florets per spike

Number of florets per spike was counted from each observational plant in different treated plots and the average was calculated.

3.2.1.2 Floret size

Length and breadth of three florets per spike of each observational spike was measured with the aid of scale horizontally and vertically and the average was worked out.

3.2.1.3 Corm Parameters

3.2.1.3.1 Number of corms/cormels per plant

Number of corms/cormels was counted from observational plants and mean was calculated.

3.2.1.3.2 Weight of corms/cormels per plant

Weight of corms/cormels per plant was recorded with the help of digital weighing balance from five tagged plants and mean was calculated.

3.3 To evaluate various colour sticky traps against thrips, *Scirtothrips dorsalis* (Hood) on gladiolus, *Gladiolus grandiflorus* L.

The interaction of trap colour with different heights (25 cm, 50 cm, 75 cm and 100 cm) was determined for trap capture of thrips. Yellow, blue and white coloured sticky traps (25 × 10 cm) were ascended with the help of sticks placed vertically very close to the plants under observation at four different heights viz., 25 cm, 50 cm, 75 cm and 100 cm. The number of thrips stuck to the sticky traps was counted weekly with the aid of 10x hand lens. The effect of colour as well as

height of sticky trap for thrip capture was evaluated in each treatment. 10 counts were taken during the plant growth period and the cumulative data generated was analyzed statistically using R software.

Number of Treatments (Factor A = Colour)	:	03
Number of Treatments (Factor B = Height)	:	04
Number of Treatment Combinations	:	12
Number of Replications	:	05
Design	:	Factorial (RCBD)

3.4 Statistical Analysis

Data generated during the investigation of each experiment was analyzed using R software. Significant results were compared on the basis of critical differences.

Chapter - 4

EXPERIMENTAL FINDINGS

The findings of present investigation “Studies on the incidence and management of thrips on gladiolus” are presented in this chapter under the following headings:

4.1 To study incidence of thrips, *Scirtothrips dorsalis* (Hood) on gladiolus, *Gladiolus grandiflorus* L.

The data on the incidence of thrips, *S. dorsalis* (Hood) on gladiolus, *G. grandiflorus* L. is presented in Table 2 and illustrated in Fig 1. The perusal of data revealed commencement of this pest from 24th standard week with average number 0.27 ± 0.05 per plant and its peak population (26.96 ± 0.78) in 31st standard meteorological week (SMW). The pest population started declining after 31st SMW and attained minimum (0.20 ± 0.10 thrips/plant) in 41st SMW. The population per plant ranged from 1.0 to 3.0, 14.0 to 28.0 and 1.0 to 2.0 per plant in 24th, 31st and 41st standard meteorological weeks, respectively.

4.1.1 Correlation of population of thrips, *Scirtothrips dorsalis* (Hood) on gladiolus, *Gladiolus grandiflorus* L. with weather parameters

The data on correlation of weather parameters with the population of thrips on gladiolus from 24th to 42th standard week is presented in Table 3 and Fig 2. The perusal of data revealed that population of *S. dorsalis* (Hood) had a positive and significant correlation with maximum temperature ($r=0.69$), minimum temperature ($r=0.70$) and evening relative humidity ($r = 0.54$). Morning relative humidity was non-significant and positively correlated ($r=0.29$) with the population of *S. dorsalis* (Hood) while negative and non-significant with rainfall ($r = - 0.07$). Considering multiple factors effecting population of thrips as dependant variable, regression analysis was also worked out which is depicted in Table 4.

Table- 2: Incidence of thrips, *Scirtothrips dorsalis* (Hood) on gladiolus, *Gladiolus grandiflorus* L. under field conditions during *Kharif* 2020

Standard Meteorological Week	Temperature (°C)		Rainfall (mm)	Relative Humidity (%)		Average No. of Thrips plant ⁻¹
	Maximum	Minimum		Morning	Evening	
24	27.9	10.8	2.9	81.6	59.9	*0.27 ± 0.05
25	30.8	12.1	0.4	74.3	45.7	1.20 ± 0.19
26	30.8	13.5	0.2	75.0	47.7	1.76 ± 0.23
27	32.5	14.1	0.7	73.6	45.3	5.56 ± 0.25
28	31.9	14.8	0.0	74.6	51.1	12.12 ± 0.47
29	31.1	15.1	1.2	80.3	64.0	14.92 ± 0.51
30	32.3	15.3	0.4	83.0	55.0	19.84 ± 0.60
31	33.0	15.9	1.0	83.1	63.9	26.96 ± 0.78
32	33.9	17.8	0.4	82.1	59.6	21.00 ± 1.67
33	35.0	18.1	0.7	81.0	56.4	15.52 ± 0.60
34	32.0	16.9	1.1	82.9	51.3	11.56 ± 0.40
35	24.2	15.7	9.8	90.9	76.0	4.04 ± 0.34
36	27.8	15.1	3.3	90.6	63.4	9.20 ± 0.40
37	30.4	10.5	0.0	86.7	50.6	7.52 ± 0.55
38	31.2	7.5	0.0	82.9	39.7	3.72 ± 0.31
39	27.8	7.4	0	73.3	45.3	2.08 ± 0.19
40	27.9	4.5	0	80.1	36	1.44 ± 0.38
41	26.9	3.3	0	79	32.8	0.20 ± 0.10
42	26	3.2	0	80.8	31	0.00 ± 0.00

*Mean of 25 plants ± S.E

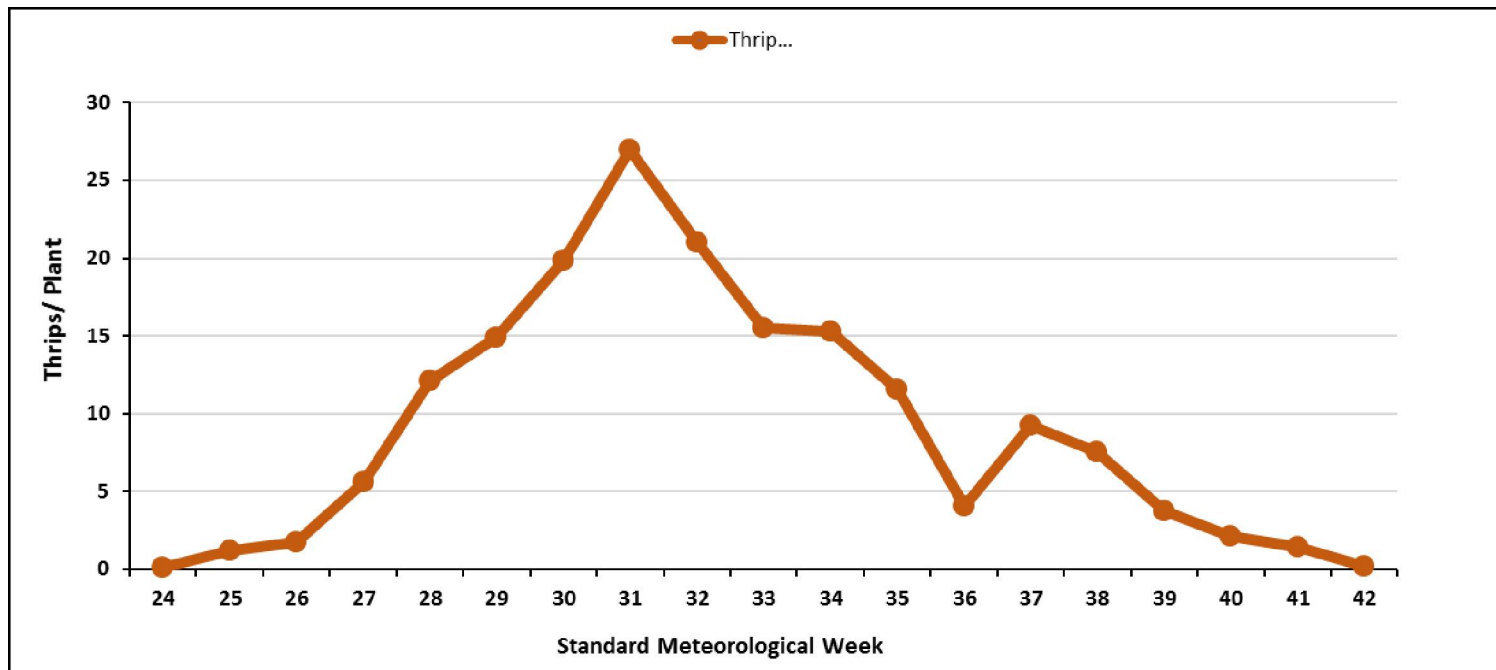


Fig. 1: Incidence of *Scirtothrips dorsalis* (Hood) on *Gladiolus grandiflorus* L. under field conditions during *Kharif* 2020

Table- 3: Correlation of population of thrips, *Scirtothrips dorsalis* (Hood) on gladiolus, *Gladiolus grandiflorus* L. with weather parameters

Particulars	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)
	Maximum	Minimum	Morning	Evening	
Correlation Coefficient (r)	0.69 (0.001**)	0.70 (0.001**)	0.29 (0.323) ^{NS}	0.54 (0.017*)	-0.07 (0.766) ^{NS}

*Significant at 0.05 level;

**Significant at 0.001 level; NS = Non significant

Table-4: Regression analysis of population of thrips, *Scirtothrips dorsalis* (Hood) on gladiolus, *Gladiolus grandiflorus* L. with weather parameters

	Coefficients	Standard Error	t Stat	P-value
Intercept	-63.76	29.248	-2.180	0.048
Maximum Temperature	0.892	0.962	0.926	0.370
Minimum Temperature	0.459	0.662	0.693	0.500
Rainfall (mm)	-0.005	1.076	-0.005	0.996
Morning Relative Humidity	0.532	0.231	2.298	0.038
Evening Relative Humidity	-0.139	0.210	-0.661	0.519
Regression Equation	$Y = -63.76 + 0.89(T_{\max}) + 0.45(T_{\min}) - 0.005(R) + 0.53(RH_1) - 0.13(RH_2)$			
Coefficient of Determination (R²)	0.60			

T_{max}=maximum temperature, T_{min}= minimum temperature, R= rainfall, RH₁= morning relative humidity, RH₂= evening relative humidity

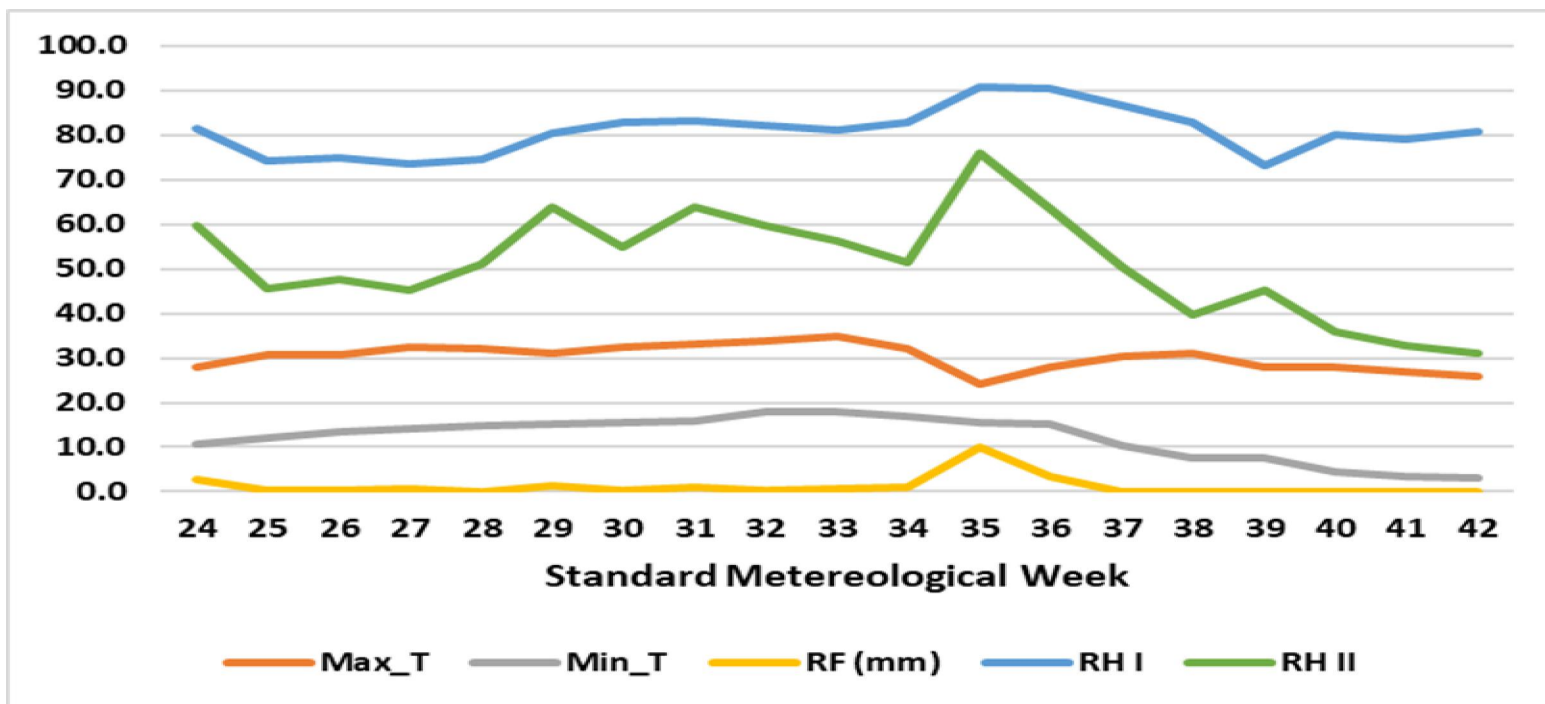


Fig. 2: Correlation of population of thrips, *Scirtothrips dorsalis* (Hood) on gladiolus, *Gladiolus grandiflorus* L. with weather parameters

4.2 To evaluate different insecticides against thrips, *Scirtothrips dorsalis* (Hood) on gladiolus, *Gladiolus grandiflorus* L.

The insecticides viz., fipronil 5 SC (0.005 %), imidacloprid 17.8 SL (0.003%), NSKE 0.15 EC (0.0006%) and neem oil (0.005 %) were evaluated against thrips, *S. dorsalis* (Hood) on gladiolus.

4.2.1 Efficacy of insecticides against *Scirtothrips dorsalis* (Hood) on gladiolus, *Gladiolus grandiflorus* L.

The data on the efficacy of different insecticides on the population of thrips is presented in Table 5 and illustrated Fig 3. The data revealed population of thrips ranging from 24.75 to 27.25 per plant before the application of insecticides. The population significantly reduced from 1 to 7 days after spraying of insecticide in all treatments. All the treatments were significantly superior over control. Among different insecticides sprayed, the minimum population of thrips (0.75 thrips/plant) however, was observed in fipronil 5 SC (0.005 %) after 7 days of spray. Imidacloprid 17.8 SL (0.003 %) was at par with the fipronil 5SC (0.005 %) with mean thrips population as 2.25 after 7 days of spray. NSKE (0.0006 %) and neem oil (0.005 %) recorded minimum population of 8.50 and 7.00 after 7 days of spray, respectively. The cumulative mean population of 6.96, 8.98, 14.56 and 15.50 was recorded in fipronil 5 SC (0.005 %), imidacloprid 17.8 SL (0.003 %), neem oil (0.005 %) and NSKE 0.15 EC (0.0006 %), respectively. The population of thrips per plant was found maximum (25.50) at 7 days after spray in control (water) with highest cumulative mean of 25.88 thrips per plant.

4.2.2 Mortality percentage of *Scirtothrips dorsalis* (Hood) on gladiolus, *Gladiolus grandiflorus* L.

The data on percentage mortality of *S. dorsalis* (Hood) on gladiolus, *G. grandiflorus* L. under field conditions after spray of insecticides is presented in Table 6 and illustrated in Fig 4. The perusal of data revealed a significant increase in mortality of *S. dorsalis* (Hood) on gladiolus at 1, 3, 5 and 7 days after spray

(DAS) in all the insecticides over control. The highest mortality percentage of 97.11 of thrips was observed in fipronil 5 SC (0.005 %) after 7 days of spraying which was at par with imidacloprid 17.8 SL (0.003 %) with mortality percentage of 95.03. The cumulative mortality percentage of 74.34 and 72.24 was observed in fipronil 5 SC and imidacloprid 17.8 SL, respectively. It was followed by neem oil (0.005 %) and NSKE 0.15 EC (0.0006 %) with cumulative mortality percentage of 42.88 and 37.89, respectively. All these treatments were significantly superior over control in which lowest cumulative mortality percentage of 1.30 was observed.

4.2.3 Effect of different insecticides on growth parameters of gladiolus, *Gladiolus grandiflorus* L.

Different insecticides *Viz.* fipronil 5 SC (0.005 %), imidacloprid 17.8 SL (0.003 %), neem oil (0.005 %) and NSKE 0.15 EC (0.0006 %) used for the management of thrips, *S. dorsalis* (Hood) on gladiolus, *G. grandiflorus* L. were evaluated during the course of investigation to determine their impact on growth parameters *Viz.* vegetative, floral characters and corm production.

Table- 5: Efficacy of insecticides against thrips, *Scirtothrips dorsalis* (Hood) on gladiolus, *Gladiolus grandiflorus* L.

Treatment	Concentration (%)	Dosage (ml/L of Water)	Pre-count (No./plant)	*Population Per Plant				Cumulative mean
				Days After Spray				
				1	3	5	7	
NSKE 0.15 EC	0.0006	4.00	24.75	19.00	18.00	16.50	8.50	15.50 ^c
Neem oil	0.005	4.00	25.5	19.00	17.00	15.25	7.00	14.56 ^b
Fipronil 5 SC	0.005	1.00	27.25	13.62	9.25	4.25	0.75	6.96 ^a
Imidacloprid 17.8 SL	0.003	0.20	25.5	15.50	11.67	6.50	2.25	8.98 ^a
Control	-	-	26.25	26.18	26.0	25.87	25.50	25.88 ^d
C.D (p ≤ 0.05)				2.90	2.42	2.28	1.77	

* Mean of 4 replications

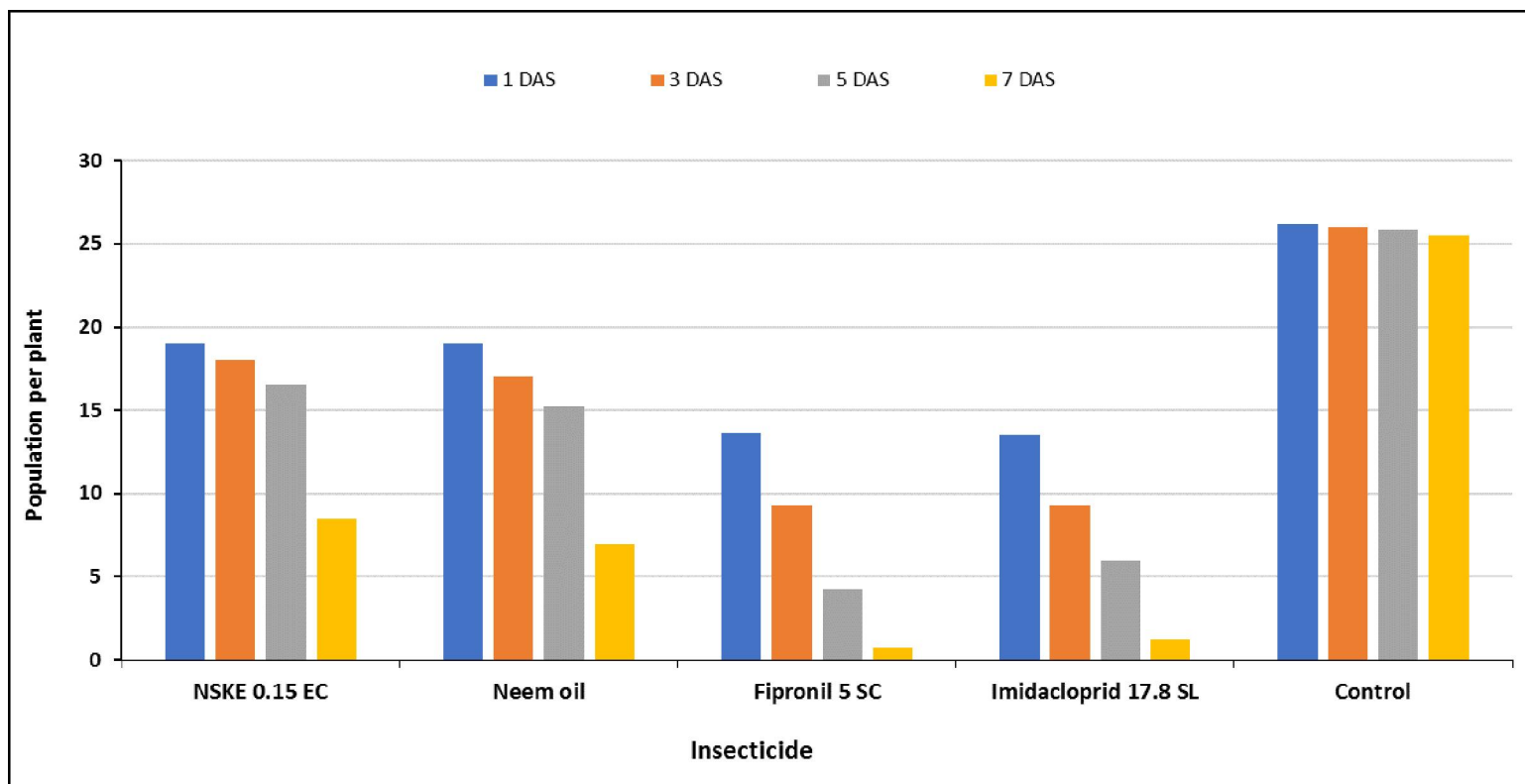


Fig. 3: Efficacy of insecticides against thrips, *Scirtothrips dorsalis* (Hood) on gladiolus, *Gladiolus grandiflorus* L.

Table- 6: Mortality percentage of thrips, *Scirtothrips dorsalis* (Hood) on gladiolus, *Gladiolus grandiflorus* L.

Treatment	Concentration (%)	Dosage (ml/L of Water)	Pre-count (No./plant)	*Population Per Plant				Cumulative mean
				*Mortality (%)				
				1	3	5	7	
NSKE 0.15 EC	0.0006	4.00	24.75	25.43 (30.14) ^h	27.15 (31.34) ^{gh}	33.34 (35.22) ^g	65.64 (54.10) ^{cd}	37.89
Neem oil	0.005	4.00	25.5	25.34 (30.19) ^{gh}	33.29 (35.22) ^g	40.24 (39.34) ^f	72.65 (58.48) ^c	42.88
Fipronil 5 SC	0.005	1.00	27.25	49.99 (44.97) ^{ef}	65.97 (54.29) ^{cd}	84.30 (66.65) ^b	97.11 (81.50) ^a	74.34
Imidacloprid 17.8 SL	0.003	0.20	25.5	46.87 (43.18) ^{ef}	63.78 (52.98) ^d	83.31 (65.96) ^b	95.03 (78.89) ^a	72.24
Control	-	-	26.25	0.22 (1.35) ⁱ	0.89 (2.72) ⁱ	1.35 (4.67) ⁱ	2.77 (8.31) ⁱ	1.30
C.D (p ≤ 0.05)				4.81	3.52	4.98	4.86	

*Mean of 4 replications

The values in parenthesis are arc sine transformed values

Values with superscripts differ significantly

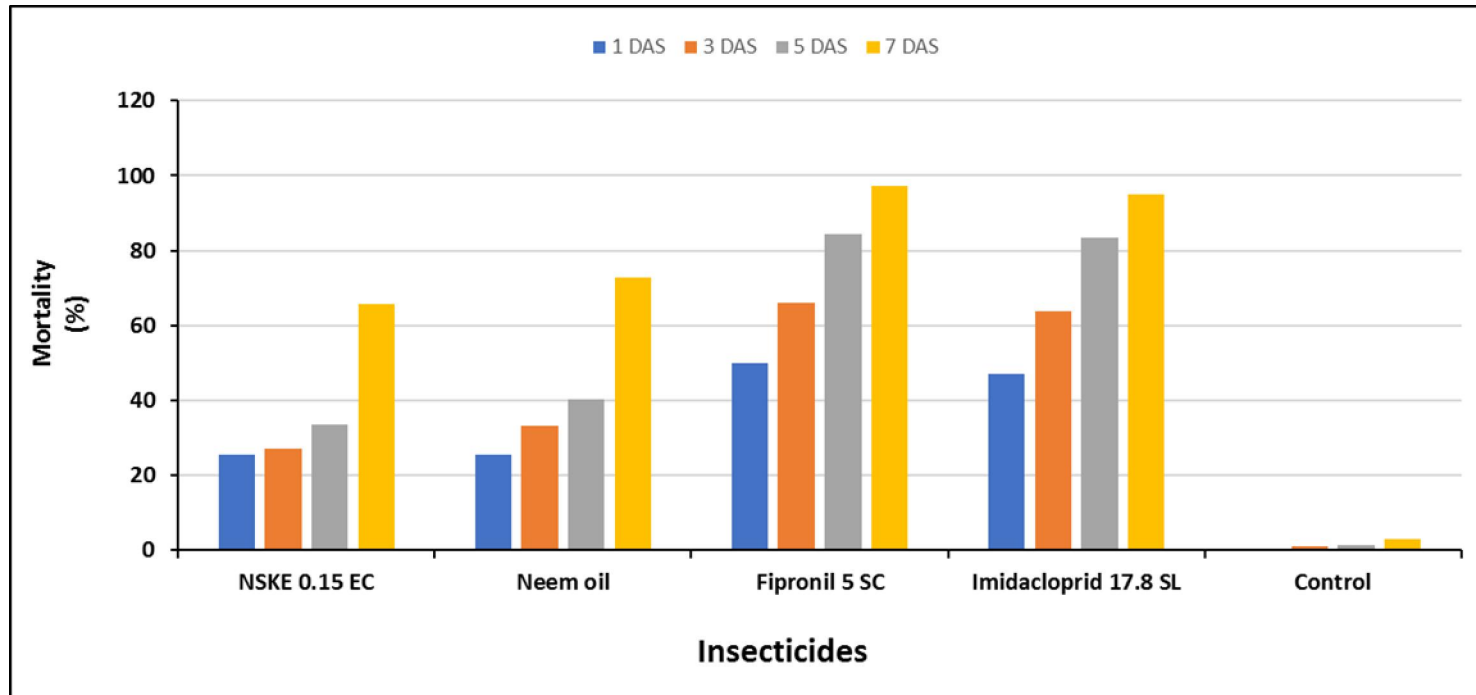


Fig. 4: Mortality percentage of *Scirtothrips dorsalis* (Hood) on *Gladiolus grandiflorus* L.

4.2.3.1 Effect of different insecticides on vegetative characters of gladiolus, *Gladiolus grandiflorus* L.

The data on the effect of different insecticides on vegetative characters of *G. grandiflorus* L. is presented in Table 7 and Fig 5. The data revealed significant difference among treatments affecting plant height. All the treatments were found superior over control. Plants sprayed with fipronil 5 SC (0.005 %) however, attained maximum height (121.13 cm) which was at par with Imidacloprid 17.8 SL (119.54 cm). The plants treated with neem oil (0.005 %) and NSKE 0.15 EC (0.0006 %) attained a height of 115.27 and 114.46 cm, respectively. The shortest plants were found in control plots with average height of about 111.50 cm.

The data on number of leaves per plant revealed non-significant difference among the treatments. However, all the treatments were superior over control. The data on average leaf length and breadth showed non-significant difference among treatments including control.

4.2.3.2 Effect of different insecticides on floral characters of gladiolus, *Gladiolus grandiflorus* L.

The data on effect of different insecticides on floral characters of *G. grandiflorus* L. is presented in Table 8 and illustrated in Fig 6. The perusal of data revealed statistically non- significant difference in number of spikes per plant in all treatments. The application of insecticides, however had a significant effect on spike length, rachis length, floret number per spike and floret size. The data indicated significantly maximum spike length in plants treated with fipronil 5 SC (64.82 cm) which was at par with imidacloprid 17.8 SL (64.57). Neem oil (0.005 %) and NSKE 0.15 EC (0.0006 %) recorded average spike length of 59.67 and 58.01 cm, respectively. All the treatment were found superior over control. The shortest spikes were found in control plots with average length of 56.01 cm. Same trend was followed in case of rachis length.

Fipronil 5 SC (0.005 %) and imidacloprid 17.8 SL (0.003 %) recorded maximum rachis length of 55.64 and 54.95 cm, respectively, followed by neem oil (0.005 %) and NSKE 0.15 EC (0.0006 %). The average rachis length of plants treated with neem oil (0.005 %) and NSKE 0.15 EC (0.0006 %) was 54.29 and 53.23, respectively. Minimum rachis length of about 52.02 cm was found in control.

The data regarding the number of florets per spike is presented in Table 8 revealed significant differences among treatments. Maximum number of florets per spike (17.10) were recorded in plants treated with fipronil 5 SC (0.005 %) which was at par with imidacloprid 17.8 SL (16.80 per spike). Neem oil (0.005 %) and NSKE 0.15 EC (0.0006 %) recorded 14.00 and 14.04 florets per spike and were at par with each other. Minimum number of florets per spike (12.80) were found in control plots.

The data regarding floret length and breadth presented in Table 8 revealed a significant effect of insecticides on average length and breadth of floret. The maximum floret length (7.59 cm) and breadth (7.25 cm) was found in plants treated with fipronil 5 SC (7.55) which was at par with imidacloprid 17.8 SL (0.003 %) with floret length and breadth of and 7.12 cm, respectively. Neem oil (0.005 %) and NSKE 0.15 EC (0.0006 %) recorded floret length 7.40 and 7.29 cm and floret breadth 6.70 and 6.12 cm, respectively. Minimum floret length (6.96 cm) and breadth (5.89 cm) was noticed in control.

Table- 7: Effect of different insecticides on the vegetative characters of gladiolus, *Gladiolus grandiflorus* L.

Treatments	Dosage (ml/L of water)	*Plant Height (cm)	*No. of leaves plant⁻¹	*Leaf Length (cm)	*Leaf Breadth (cm)
NSKE 0.15 EC	4.00	114.46 ± 1.05 ^{bc}	9.80 ± 0.00 ^a	37.62 ± 0.42 ^a	2.95 ± 0.11 ^a
Neem oil	4.00	115.27 ± 1.03 ^b	9.80 ± 0.00 ^a	38.17 ± 0.35 ^a	2.89 ± 0.04 ^a
Fipronil 5 SC	1.00	121.13 ± 1.14 ^a	9.80 ± 0.00 ^a	38.25 ± 0.71 ^a	3.00 ± 0.13 ^a
Imidacloprid 17.8 SL	0.20	119.54 ± 0.28 ^a	9.80 ± 0.00 ^a	38.22 ± 0.98 ^a	3.00 ± 0.09 ^a
Control (water)	-	111.50 ± 0.57 ^c	9.60 ± 1.21 ^b	36.90 ± 0.88 ^a	2.73 ± 0.08 ^a
C.D (p≤ 0.05)		3.22	0.19	1.93	0.38

*Mean of 4 replications ± SE
means with different superscripts differ significantly

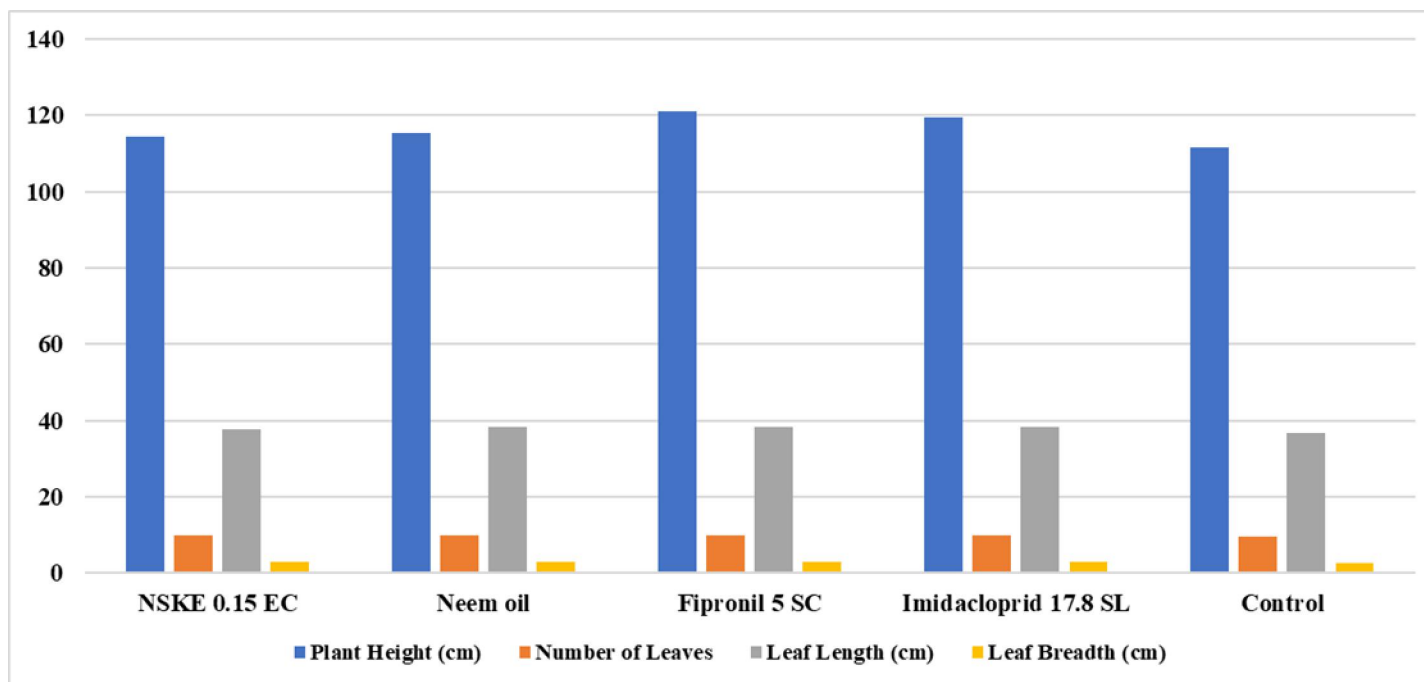


Fig. 5: Effect of different insecticides on the vegetative characters of gladiolus, *Gladiolus grandiflorus* L.

Table – 8: Effect of different insecticides on the floral characters of gladiolus, *Gladiolus grandiflorus* L.

Treatments	Dosage (ml/L of water)	*Spike No. Plant ⁻¹	*Spike Length Plant ⁻¹ (cm)	*Rachis Length (cm)	*Floret No. Spike ⁻¹	*Floret Length (cm)	*Floret Breadth (cm)
NSKE 0.15 EC	4.00	1.00 ± 0.00	58.01 ± 0.54 ^b	53.23 ± 1.38 ^c	14.00 ± 0.50 ^b	7.29 ± 0.16 ^{bc}	6.12 ± 0.23 ^{bc}
Neem oil	4.00	1.00 ± 0.00	59.67 ± 0.27 ^b	54.29 ± 1.39 ^b	14.04 ± 0.52 ^b	7.40 ± 0.17 ^b	6.70 ± 0.29 ^{ab}
Fipronil 5 SC	1.00	1.00 ± 0.00	64.82 ± 1.31 ^a	55.64 ± 1.19 ^a	17.10 ± 0.69 ^a	7.59 ± 0.10 ^a	7.25 ± 0.18 ^a
Imidacloprid 17.8 SL	0.20	1.00 ± 0.00	64.57 ± 1.41 ^a	54.95 ± 1.11 ^a	16.80 ± 0.56 ^a	7.55 ± 0.10 ^a	7.12 ± 0.15 ^a
Control (water)	-	1.00 ± 0.00	56.01 ± 0.34 ^c	52.02 ± 1.30 ^d	12.80 ± 0.37 ^b	6.96 ± 0.02 ^c	5.89 ± 0.03 ^c
CD (p≤ 0.05)		NS	3.25	1.11	1.80	0.42	0.75

*mean of 4 replications ± S.E, NS = Non-Significant
Means with different superscripts differ significant

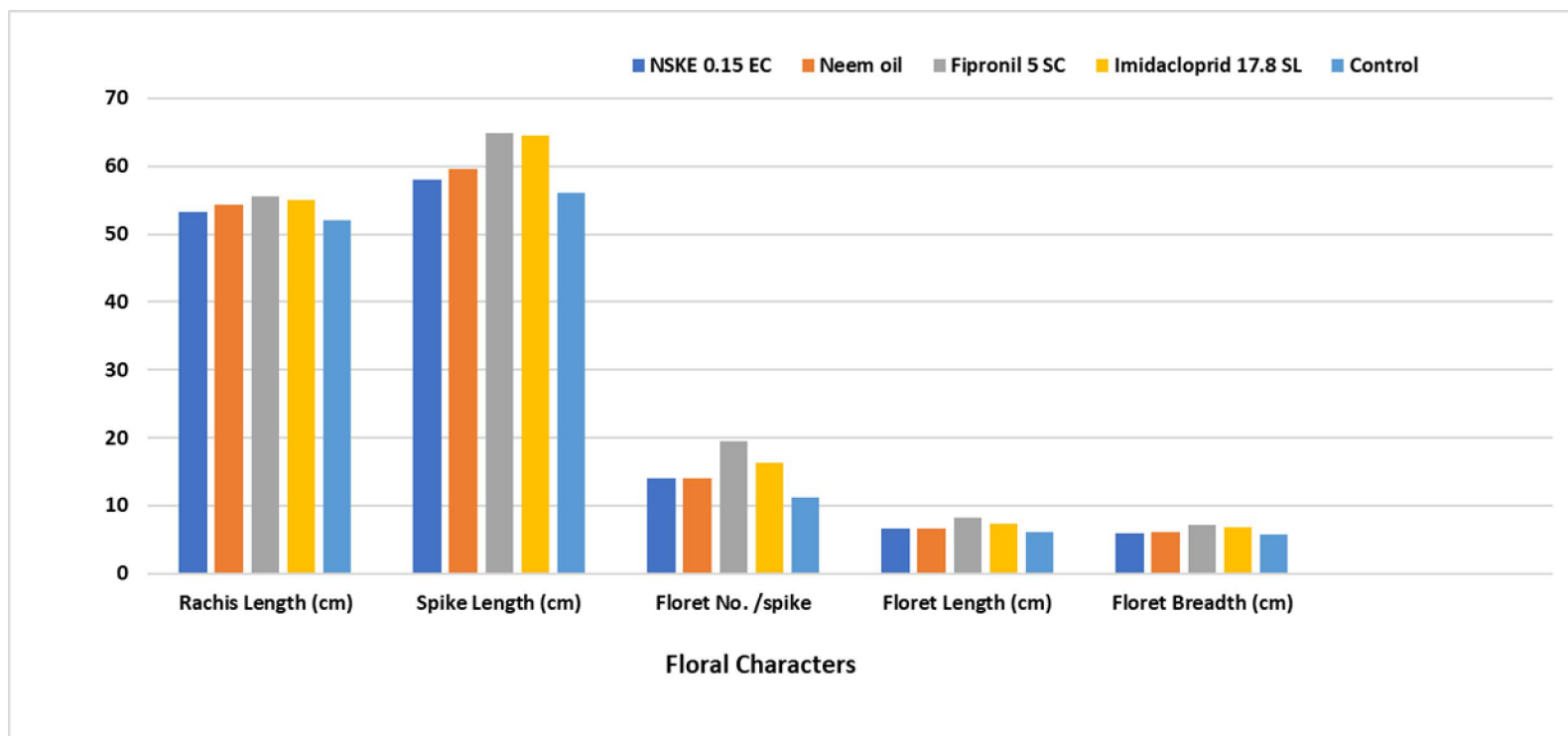


Fig. 6: Effect of different insecticides on the floral characters of *Gladiolus grandiflorus* L.

4.2.3.3 Effect of different insecticides on corm production of gladiolus, *Gladiolus grandiflorus* L.

The data on corm production of *G. grandiflorus* L. is presented in Table 9 and Fig 7. The influence of insecticides on number of corms per plant was statistically found non-significant. However, significant difference was observed among treatments on number of cormels, weight of corms and weight of cormels per plant. The maximum number of cormels per plant were found in plants treated with fipronil 5SC (57.95) which was at par with imidacloprid 17.8 SL (57.38). These treatments were followed by neem oil (0.005 %) and NSKE 0.15 EC (0.0006 %) with number of cormels 50.29 and 48.90 per plant, respectively. Minimum number of cormels (45.01/plant) were found in control plots.

Same trend was observed in case of weight of corms and cormels per plant. Plants treated with fipronil 5 SC (0.005 %) resulted in maximum corm weight (60.26 g/plant) which was at par with imidacloprid 17.8 SL (59.25 g/plant). Corm weight of 53.38 and 51.92 grams was observed in neem oil (0.005 %) and NSKE 0.15 EC (0.0006 %), respectively. Minimum corm weight (48.10) was observed in control.

Plants treated with fipronil 5 SC (0.005 %) recorded maximum cormel weight (35.98 g/plant) which was at par with imidacloprid 17.8 SL (35.56 g/plant). Weight of cormels per plant in neem oil (0.005 %) and NSKE 0.15 EC (0.0006 %) was found to be 25.6 and 24.2 grams, respectively and both were at par with each other. Control plots however, recorded lowest weight of cormels (20.17 g/plant).

Table - 9: Effect of different insecticides on the corm production of gladiolus, *Gladiolus grandiflorus* L.

Treatments	Dosage (ml/L of water)	*Number of Corms Plant⁻¹	*Number of Cormels Plant⁻¹	*Weight of Corms Plant⁻¹ (g)	*Weight of Cormels Plant⁻¹ (g)
NSKE 0.15 EC	4.00	1.00 ± 0.00 ^a	48.90 ± 0.54 ^{bc}	51.92 ± 0.92 ^b	24.37 ± 0.23 ^c
Neem oil	4.00	1.00 ± 0.00 ^a	50.29 ± 1.65 ^b	53.38 ± 1.19 ^b	25.44 ± 0.44 ^b
Fipronil 5 SC	1.00	1.00 ± 0.00 ^a	57.95 ± 2.25 ^a	60.26 ± 1.91 ^a	36.74 ± 0.25 ^a
Imidacloprid 17.8 SL	0.20	1.00 ± 0.00 ^a	57.38 ± 2.34 ^a	59.25 ± 2.02 ^a	36.50 ± 0.34 ^a
Control (water)	-	1.00 ± 0.00 ^a	45.01 ± 1.46 ^c	48.10 ± 0.59 ^c	21.87 ± 0.12 ^d
CD (p≤ 0.05)		NS	3.89	3.05	0.99

*Mean of 4 replications ± SE; NS= Non- Significant
Means with different superscripts differ significantly

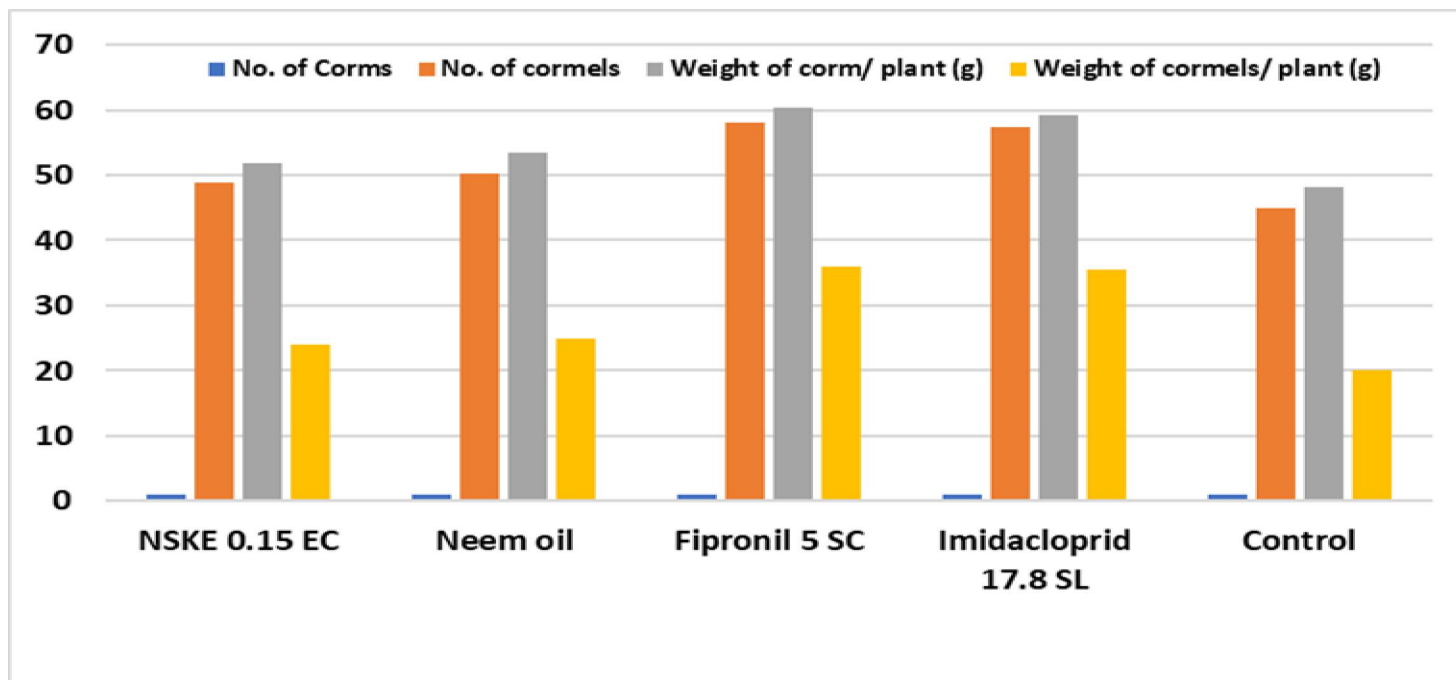


Fig. 7: Effect of different insecticides on corm production of gladiolus, *Gladiolus grandiflorus* L

4.3 To evaluate of different sticky traps against thrips, *Scirtothrips dorsalis* (Hood) on gladiolus, *Gladiolus grandiflorus* L.

To evaluate different sticky traps against thrips, *S. dorsalis* (Hood) on gladiolus, *G. grandiflorus* L. three different coloured sticky traps viz. yellow, blue and white (Plate 5) were evaluated at four different heights (100 cm, 75 cm, 50 cm and 25 cm) to check their efficacy against *S. dorsalis* (Hood).

4.3.1 *Scirtothrips dorsalis* (Hood) on different coloured sticky traps raised at various heights close to *Gladiolus grandiflorus* L.

Three different coloured sticky traps (yellow, blue and white) were installed at four different heights viz., 100 cm, 75cm, 50cm and 25cm to check the most effective height for installation of sticky traps against *S. dorsalis* (Hood) on gladiolus. The population of *S. dorsalis* (Hood) on different coloured sticky traps raised at different heights close to *G. grandiflorus* L. is presented in Table 10, 11 and 12 and illustrated in Fig 8, 9 and 10, respectively. The observations were made at weekly intervals from 7 to 70 days after installation of traps.

The perusal of data revealed blue sticky traps installed at 75 cm (39.37 ± 0.09 thrips/plant) most effective in attracting the population of *S. dorsalis* (Hood). It was followed by 100cm, 50cm and 25cm which recorded mean population of 34.6 ± 0.15 , 26.50 ± 0.15 and 19.47 ± 0.58 thrips per trap, respectively after installation of blue sticky traps.

Yellow sticky traps recorded maximum population of thrips (37.47 ± 0.39 thrips/trap) when installed at 75cm above ground. The yellow sticky traps installed at 100cm, 50cm and 25cm attracted mean population of 31.23 ± 0.61 , 22.87 ± 0.54 and 17.53 ± 0.19 thrips per trap, respectively.

The similar trend was observed in white sticky traps where traps installed at 75cm from the ground attracted a greater number of thrips (26.97 ± 0.39 thrips/trap) than the traps installed at 100cm, 50cm and 25cm with mean



Plate 5: Different coloured sticky traps installed for trapping *Scirtothrips dorsalis* (Hood)

population of 20.93 ± 0.61 , 14.83 ± 0.54 and 12.13 ± 0.23 thrips per trap, respectively.

4.3.2 Effect of different colour sticky traps on population of thrips, *Scirtothrips dorsalis* (Hood)

The effect of different colour sticky traps against *S. dorsalis* (Hood) is presented in Table 13 and illustrated in Fig 11. Three different coloured sticky traps viz., blue, yellow and white were installed and evaluated for their efficacy against *S. dorsalis* (Hood) on gladiolus. The observations were made on weekly intervals from 7 up to 70 days after installation of traps. The data revealed maximum population of *S. dorsalis* (Hood) on blue coloured sticky traps (29.98 ± 3.84 thrips/trap) after 70 days after installation of traps in the field. It was followed by yellow-coloured sticky traps which recorded the mean population of 27.27 ± 4.64 thrips per trap. White coloured sticky traps however, were least effective in attracting the population of *S. dorsalis* Hood with cumulative mean population of 18.71 ± 4.68 thrips per trap at 70 days after installation of traps.

4.3.3 Influence of colour and height of sticky trap on population of thrips, *Scirtothrips dorsalis* (Hood)

The data on the influence of colour and height of sticky trap on population of thrips, *S. dorsalis* (Hood) is presented in Table 14 and illustrated in Fig 12. The effect of colour and height of sticky trap had a significant difference on the population of *S. dorsalis* (Hood). The perusal of data revealed maximum population of *S. dorsalis* (Hood) on blue coloured sticky trap (39.37 ± 0.09 thrips/trap) when installed at 75 cm followed by yellow sticky trap installed at 75 cm (37.47 ± 0.39 thrips/trap). Blue, yellow and white coloured sticky trap installed at 100 cm above ground recorded 34.6 ± 0.15 , 31.23 ± 0.61 and 20.93 ± 0.61 thrips per trap, respectively. Blue, yellow and white coloured sticky trap installed at 50 cm attracted 26.5 ± 0.41 , 22.87 ± 0.54 and 14.83 ± 0.54 thrips per trap. Traps installed at 25 cm recorded 19.47 ± 0.58 , 17.53 ± 0.19 and 12.13 ± 0.23 on blue, yellow and white, respectively. The maximum cumulative mean population (29.98 ± 3.84 thrips/trap) of *S. dorsalis* (Hood) was observed on blue coloured sticky trap followed by yellow and white sticky traps with cumulative mean population 27.27 ± 4.64 and 18.71 ± 4.68 thrips per trap, respectively.

Table -10: *Scirtothrips dorsalis* (Hood) on yellow sticky trap raised at various heights close to *Gladiolus grandiflorus* L.

Height (cm)	*Population/Trap										Mean
	Days After Installation										
	7	14	21	28	35	42	49	56	63	70	
25	8.60	11.80	13.20	16.20	21.20	21.40	22.60	23.80	18.40	13.60	17.08
50	11.60	14.20	18.40	21.00	25.60	30.60	30.40	26.80	22.80	17.00	21.84
75	29.00	30.00	33.00	36.40	35.60	42.60	42.60	38.230	41.00	33.00	36.14
100	14.60	20.40	24.40	33.80	38.20	33.60	41.40	34.80	33.60	28.80	30.36
C.D (p ≤ 0.05)	3.65	2.90	3.76	2.81	3.66	4.60	4.08	4.49	4.96	4.71	

*Mean of 5 replications

Table -11: *Scirtothrips dorsalis* (Hood) on blue sticky trap raised at various heights close to *Gladiolus grandiflorus* L.

Height (cm)	*Population/Trap										Mean
	Days After Installation										
	7	14	21	28	35	42	49	56	63	70	
25	10.40	13.60	16.80	16.80	22.20	26.00	25.60	23.40	19.80	2.60	17.72
50	14.60	18.40	21.20	23.80	29.60	34.80	33.80	32.40	27.80	21.80	25.82
75	29.60	35.20	38.80	43.40	45.60	46.20	44.40	40.20	37.20	28.40	38.90
100	20.40	25.60	28.80	37.20	39.60	42.40	45.20	38.40	36.20	26.60	34.04
C.D (p ≤ 0.05)	3.21	3.87	4.13	3.70	3.01	2.92	3.80	3.25	2.47	4.27	

*Mean of 5 replications

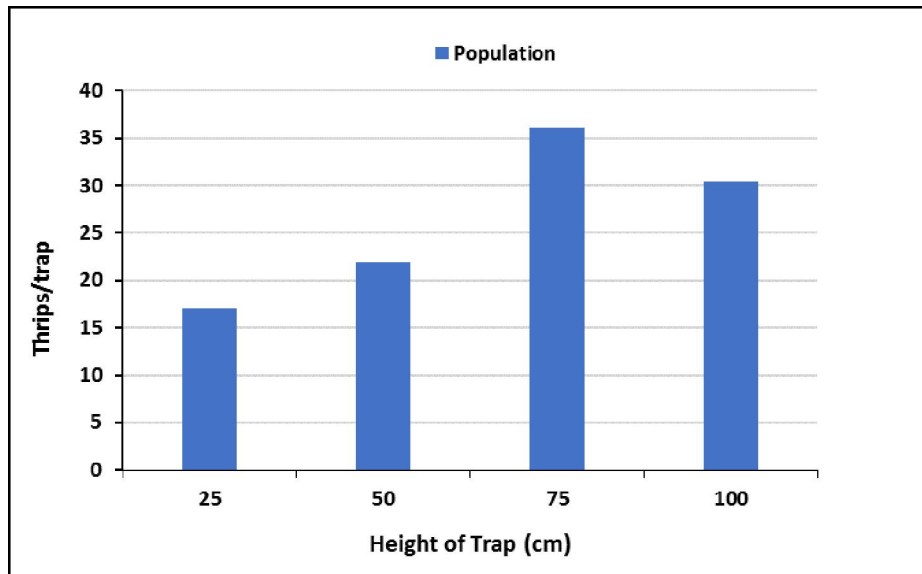


Fig. 8: *Scirtothrips dorsalis* (Hood) on yellow sticky trap raised at various heights close to *Gladiolus grandiflorus* L.

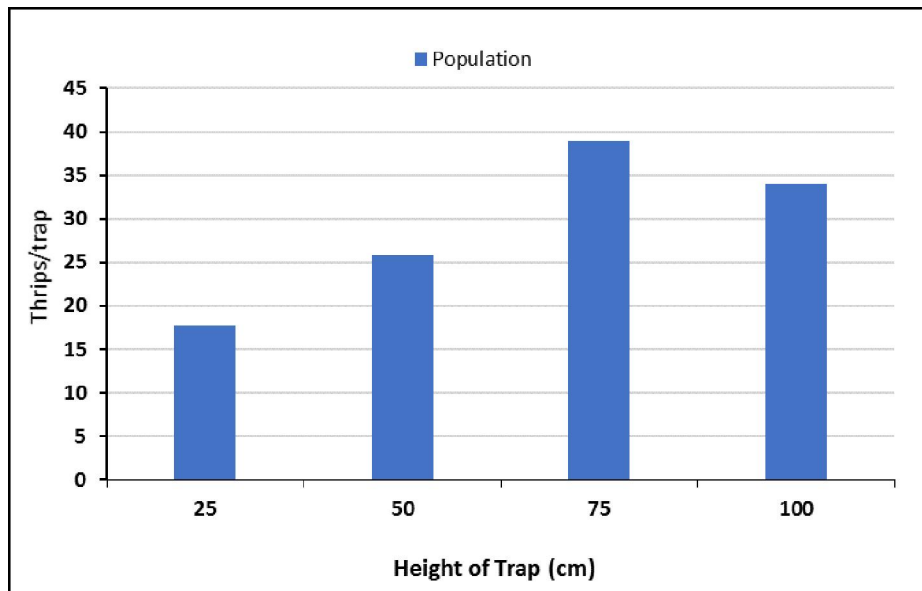


Fig. 9: *Scirtothrips dorsalis* (Hood) on blue sticky trap raised at various heights close to *Gladiolus grandiflorus* L.

Table 12: *Scirtothrips dorsalis* (Hood) on white sticky trap raised at various heights close to *Gladiolus grandiflorus* L.

Height (cm)	*Population/Trap										Mean
	Days After Installation										
	7	14	21	28	35	42	49	56	63	70	
25	8.00	7.40	9.80	12.00	12.60	16.60	21.00	14.00	10.40	7.00	11.88
50	13.60	8.00	11.80	14.60	15.20	18.80	22.00	18.20	14.60	10.40	14.72
75	14.40	21.80	23.60	27.60	31.40	32.60	38.00	33.00	22.80	14.60	25.98
100	12.40	14.80	17.60	20.60	24.40	26.60	31.60	24.40	21.80	13.60	20.78
C.D (p ≤ 0.05)	5.79	2.93	5.44	5.43	6.69	5.92	4.83	2.77	3.78	3.30	

*Mean of 5 replications

Table -13: Effect of different colour sticky traps on population of *Scirtothrips dorsalis* (Hood)

Sticky Trap	*Population/Trap										Mean
	Days After Installation										
	7	14	21	28	35	42	49	56	63	70	
Yellow	16.91	19.91	23.08	27.58	30.91	33.00	35.33	32.41	30.00	23.58	27.27
Blue	19.75	23.66	27.16	31.00	34.83	37.91	37.83	33.75	30.75	23.16	29.98
White	11.66	13.83	16.00	19.16	21.50	24.16	28.75	22.75	17.75	11.58	18.71
C.D ($p \leq 0.05$)	2.97	2.07	3.36	3.10	3.14	3.96	3.50	2.44	3.27	3.27	

*Mean of 5 replications

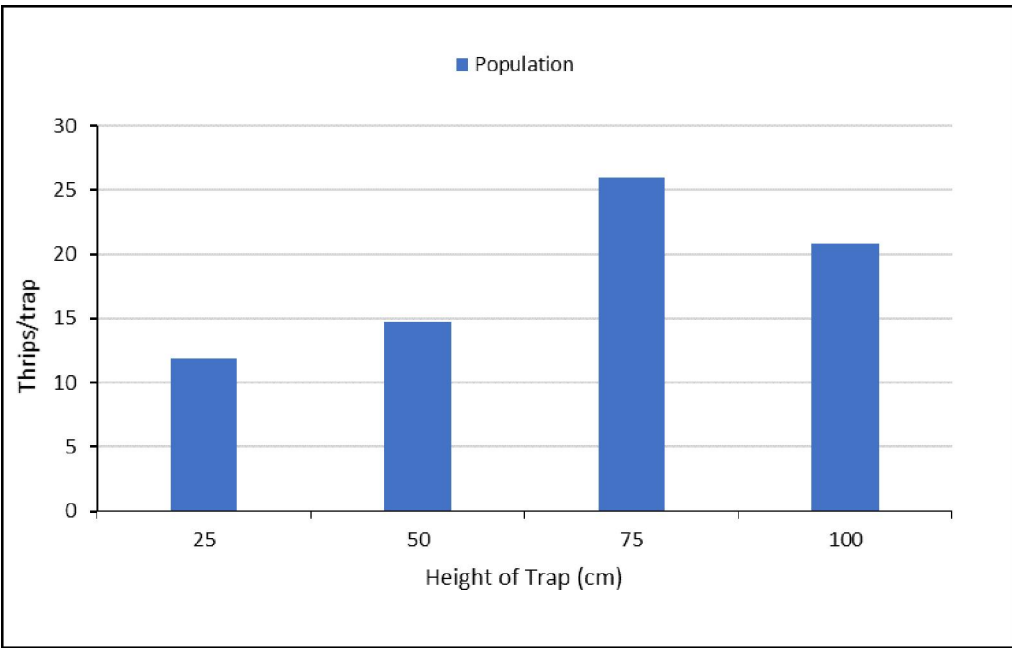


Fig. 10: *Scirtothrips dorsalis* (Hood) on white sticky trap raised at various heights close to *Gladiolus grandiflorus* L.

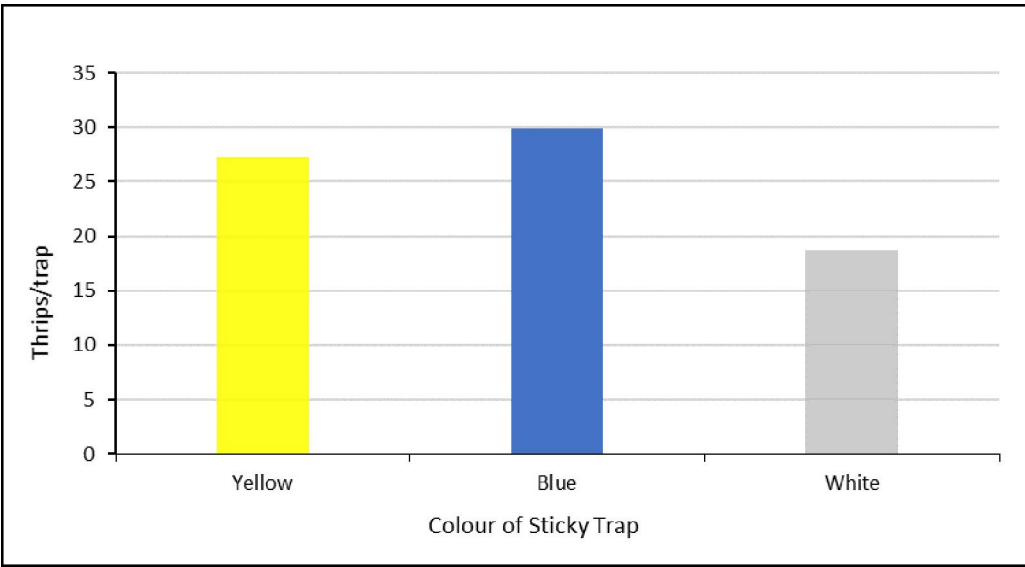


Fig. 11: *Scirtothrips dorsalis* (Hood) on different coloured sticky traps raised at various heights close to *Gladiolus grandiflorus* L.

Table -14: Influence of colour and height of sticky traps on population of thrips, *Scirtothrips dorsalis* (Hood)

Sticky Trap	Height of Trap (cm)				
	25	50	75	100	Mean
Yellow	*17.53 ± 0.19 ^{fg}	22.87 ± 0.54 ^e	37.47 ± 0.39 ^{ab}	31.23 ± 0.61 ^c	27.27 ± 4.64^b
Blue	19.47 ± 0.58 ^{ef}	26.5 ± 0.41 ^d	39.37 ± 0.09 ^a	34.6 ± 0.15 ^{bc}	29.98 ± 3.84^a
White	12.13 ± 0.23 ^h	14.83 ± 0.54 ^{gh}	26.97 ± 0.39 ^d	20.93 ± 0.61 ^{ef}	18.71 ± 4.68^c
Mean	16.37 ± 0.50	21.40 ± 0.76	34.60 ± 0.93	28.92 ± 1.00	
C.D (p ≤ 0.05)		Colour (C) = 1.78 Height (H) = 2.05 Colour*Height (C:H) = 3.56			

*Mean of 5 replications ± S.E

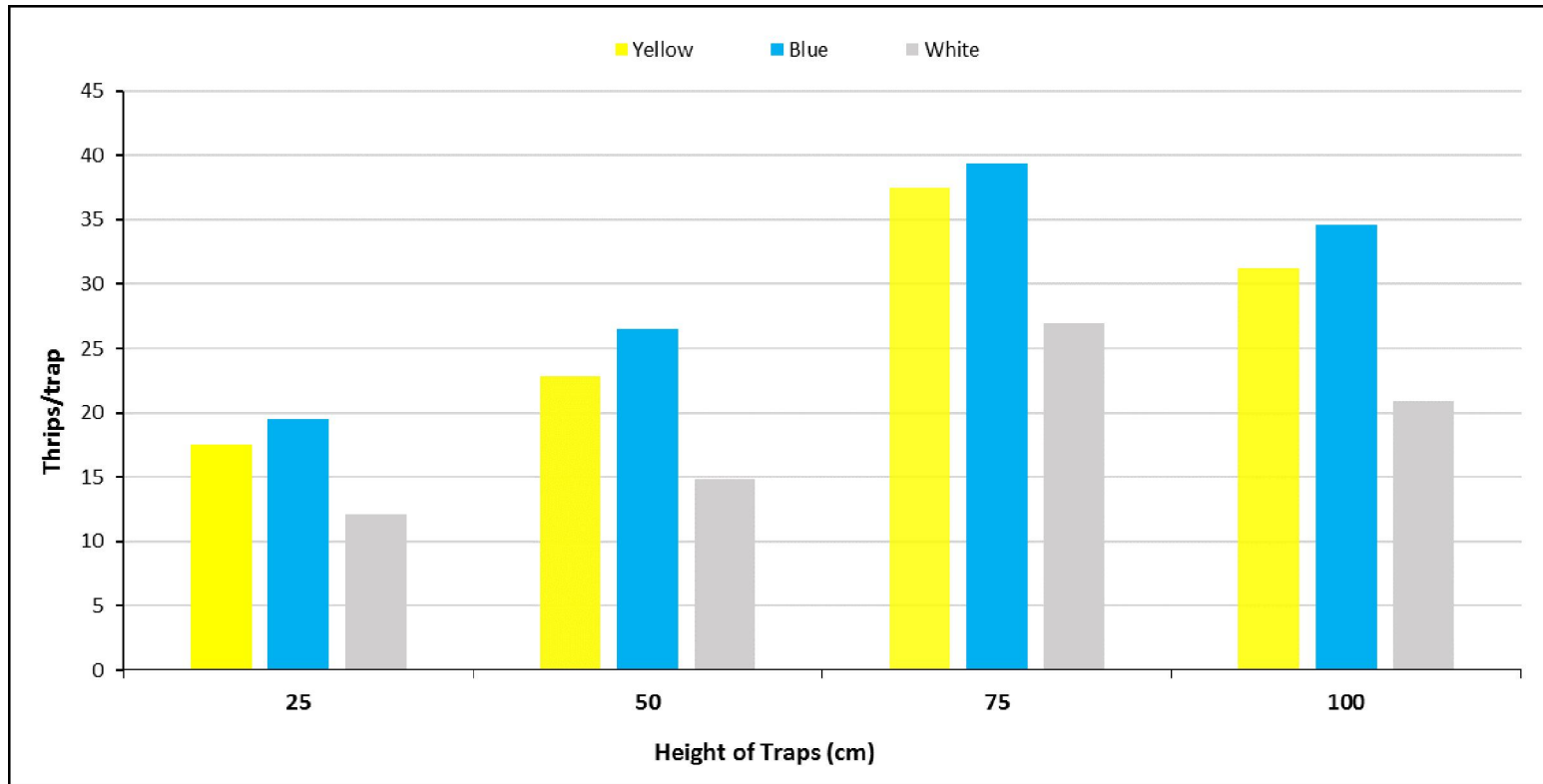


Fig. 12: Influence of colour and height of sticky traps on population of thrips, *Scirtothrips dorsalis* (Hood)

Chapter - 5

DISCUSSION

Gladiolus is a beautiful and glamorous bulbous flowering plant known for its beautiful and versatile flowers hence, called “Queen of Bulb”. It is perennial cormous flowering plant that belongs to family Iridaceae. Like other states in the country, gladiolus is assuming great importance in the state of Jammu and Kashmir. It is one of the most important cut flowers, however, its quality and productivity is being affected by several factors *viz.*, climate, cultivar, nutrient management, diseases and pests. Among the insect pests, the sucking type are the most important ones with greater damage caused by thrips which pierce the stem, leaves and feed on the cell sap of the gladiolus. The attack of this pest coincides with peak flowering stage and ultimately the market value of the flowers is reduced. This pest possesses an ever-increasing threat to commercial cut-flower growers of gladiolus. An effort to generate baseline data on the incidence and develop management strategy for this pest, the present investigation entitled “Studies on the Incidence and Management of Thrips on Gladiolus, *Gladiolus grandiflorus* L.” was carried out during the year, 2020. The discussion of the present study is briefly discussed as under:

5.1 To study the incidence of thrips, *Scirtothrips dorsalis* (Hood) on *Gladiolus grandiflorus* L.

The thrips, *S. dorsalis* (Hood) on gladiolus commenced from 24th standard week with average number of thrips as 1.76 ± 0.23 per plant. The pest attained its peak population (26.69 ± 0.59 per plant) in 31st standard week from where it started declining and reached to minimum (0.2 ± 0.1 per plant) in 41th standard week. The population per plant ranged from 1.0 to 3.0, 14.0 to 28.0 and 1.0 to 3.0 per plant in 24th, 31st and 41st standard week, respectively. The maximum number of thrips were found during the flowering stage. Our findings are in line with Milevoj *et al.* (2008) who reported appearance of gladiolus thrips in mid-June and

reaching its peak in July coinciding with flowering stage. Saiyad (2015) observed highest population of gladiolus thrips during the flowering stage which corroborate our present findings. Shibao *et al.* (2004) also observed peak population of *S. dorsalis* from mid- July to mid-August which is in congruence with the present findings.

5.1.2 Correlation of population of *Scirtothrips dorsalis* (Hood) on gladiolus, *Gladiolus grandiflorus* L. with weather parameters.

The data on correlation of population of thrips on gladiolus from 24th to 42th standard meteorological week with temperature (°C), rainfall (mm) and relative humidity (%) under field conditions revealed significant positive correlation of *S. dorsalis* (Hood) with maximum temperature ($r = 0.69$), minimum temperature ($r = 0.61$), and evening relative humidity ($r = 0.61$) and non-significant negative correlation with the rainfall ($r = - 0.002$). Morning relative humidity had a non-significant and positive correlation with population of *S. dorsalis*. Naik *et al.* (2010) reported a significant positive correlation of temperature ($r = 0.645$) with thrips population which supports the present findings. The findings are further supported by Syed *et al.* (2015) who depicted a significant positive correlation of thrips with temperature (0.18) and relative humidity (0.77). The positive correlation of temperature and relative humidity with thrips population as depicted by Kiran *et al.* (2017) also confirm the present findings. Vinuthan *et al.* (2018), Samanta *et al.* (2017) and Satyanarayana and singh (2015) observed positive correlation of thrips with temperature and negative correlation with rainfall which are in congruence with the present findings.

5.2 To evaluate different insecticides against thrips, *Scirtothrips dorsalis* (Hood) on gladiolus, *Gladiolus grandiflorus* L.

The insecticides viz., fipronil 5SC (0.005 %), imidacloprid 17.8 SL (0.003 %), NSKE 0.15 EC (0.0006 %) and neem oil (0.005 %) were evaluated against thrips on gladiolus during the present study.

5.2.1 Efficacy of insecticides against thrips, *Scirtothrips dorsalis* (Hood) on gladiolus, *Gladiolus grandiflorus* L.

The population of thrips varied from 24.75 to 27.25 individuals per plant on gladiolus before application of insecticides and did not vary significantly among treatments. There was significant reduction in thrip population on 1, 3, 5 and 7 days after spray (DAS) of insecticides compared to untreated control. The minimum population (0.75 thrips per plant) was observed with fipronil 5 SC (0.005 %) after 7 days of spray with mortality percentage of 97.11. The highest cumulative mortality percentage of thrips was also observed with fipronil 5SC (0.005 %) followed by imidacloprid 17.8 SL (0.003 %). Sathyan *et al.* (2017) came up with the same results where they found fipronil 5 SC most effective with 82.35 per cent reduction in thrip population followed by imidacloprid 17.8 SL (78.55 %) on rose. Ahmad *et al.* (2018) found maximum mortality (79.0 %) at 24 hours after spray due to imidacloprid in combination with fipronil (Lacenta) followed by chlorfenapyr (75.55%), spintoram (72.47%) and spinosad (66.53%), respectively on gladiolus cv. white prosperity which corroborates our present findings. Our findings are also supported with the results of Singh *et al.* (2013) who concluded fipronil 5 SC most promising insecticides in increasing mortality percentage (98.56 %) and increasing the weight of exportable bulb and yield of onion when compared with the control and other insecticides. The results of present findings are supported by Patil and Patil (2018) who found fipronil 5SC (0.005 %) most effective in increasing mortality percentage of thrips (86.44 %) on onion with highest yield (8.87 t/ha) of onion bulbs.

5.2.2 Effect of different insecticides on the growth parameters of *Gladiolus grandiflorus* L.

The different observations regarding impact of different insecticides on the growth parameters of gladiolus *viz.*, vegetative, reproductive and corm characters of the plant were recorded during the course of investigation.

5.2.2.1 Effect of different insecticides on the vegetative characters of *Gladiolus grandiflorus* L.

The data revealed significant difference among treatments affecting plant height. All the treatments were found superior over control. Plants with maximum height were observed in plots treated with fipronil 5 SC (0.005%) and imidacloprid 17.8 SL (0.003%) with average height of about 121.13 and 119.54 cm, respectively. The plants treated with neem oil and NSKE 0.15 EC recorded average height of 115.27 and 114.46 cm respectively. The shortest plants were found in control plots with average height of about 111.50 cm. The present findings are in line with the results of Begna (2019) who observed significant difference among vegetative characters of onion plants treated with different insecticide as insecticide reduces the insect population on plants and hence better growth of the plant. The results are also in line with the findings of Abdurezake and Eshetu (2021) who found significant difference between plots treated with insecticides and control and observed maximum plant height in insecticide treated plots.

Non-significant difference was observed among the treatments affecting number of leaves. However, all the treatments were superior over control. The data on average leaf length and breadth showed non-significant difference among treatments including control. Begna (2019) also found non-significant difference among the insecticides affecting number of leaves, leaf size which corroborate our findings.

5.2.2.2 Effect of different insecticides on the floral characters of *Gladiolus grandiflorus* L.

The data on number of spikes per plant was found statistically non-significant in all treatments. The application of insecticides however, had a significant effect on spike length, rachis length, floret number per spike and floret size. The data indicated significantly maximum spike length, rachis length, floret number and floret size in plants treated with fipronil 5 SC (0.005%) which was at par with imidacloprid 17.8 SL (0.003%). Aslam *et al.* (2018) observed significant difference among insecticides affecting the flowering characters of onion which supports the present findings.

5.2.2.3 Effect of different insecticides on the corm production of *Gladiolus grandiflorus* L.

The effect of insecticides on number of corms per plant was found statistically non-significant. However, significant difference was observed among treatments in case of number of cormels, weight of corms and weight of cormels per plant. Maximum number of cormels, maximum weight of corms and cormels were found in the plots treated with fipronil 5SC and was at par with imidacloprid 17.8 SL because of their efficacy in reducing thrips population. The present findings are supported by the results of Abdurezake and Eshetu (2021) who recorded higher onion bulb yield and weight from insecticide treated plots. The findings of Verma *et al.* (2012) are also in line with the present results who recorded highest onion bulb yield in the plots treated with imidacloprid 17.8 SL (0.003 %) followed by fipronil 5SC (0.005 %).

5.3 To evaluate different coloured sticky traps against thrips, *Scirtothrips dorsalis* (Hood) on gladiolus, *Gladiolus grandiflorus* L.

Three different coloured sticky traps (yellow, blue and white) were installed at four different heights *viz.*, 100 cm, 75cm, 50cm and 25cm to check the most

effective height for installation of sticky traps against *S. dorsalis* (Hood) on gladiolus.

5.3.1 *Scirtothrips dorsalis* (Hood) on different coloured sticky traps raised at various heights close to *Gladiolus grandiflorus* L.

The traps installed at 75 cm and 100 cm from the ground proved more effective in attracting the population of *S. dorsalis* (Hood) in all the three coloured sticky traps followed by 50 and 25 cm. Population of *S. dorsalis* (Hood) were mostly observed at the upper parts rather than the lower parts of the plant assembled at 75-100 cm height above ground and same trend has been observed by the Mo *et al.* (2008). Blue sticky traps installed at 75 cm (39.37 ± 0.09 thrips/plant) was found most effective in attracting the population of *S. dorsalis* (Hood) than traps installed at 100, 50 and 25 cm with 34.6 ± 0.15 , 26.50 ± 0.15 and 19.47 ± 0.58 thrips per trap, respectively. Similar trend was observed in yellow and white coloured sticky traps where traps installed at 75 cm were more efficient than installed at 100, 50 and 25 cm. The findings are supported by Gharekhani *et al.* (2014) who found sticky traps installed at 70 cm above ground surface attracted maximum population of thrips as compared to the traps installed at 100, 50 and 30cm above the ground. The results are also corroborated by Allen *et al.* (2005), who studied the population of thrips on onion and found sticky traps installed between 70 cm and 95 cm above the ground surface most effective in attracting population of *T. tabaci*. Atakan and Canhilal (2004) found trap heights of 60 –100 cm, suitable for estimating flower thrips in cotton fields which supports our findings.

5.3.2 Effect of different colour sticky traps on population of thrips, *Scirtothrips dorsalis* (Hood)

Different coloured sticky traps *viz.* blue, yellow and white installed at varying heights in the field proved attractive to the thrips population. The maximum population of *S. dorsalis* (Hood) on gladiolus however, was attracted

to blue coloured sticky traps (37.91 thrips/trap) followed by yellow (27.27 thrips/trap) and white sticky traps (18.71 thrips/trap).

Chen *et al.* (2004) found blue coloured sticky trap (125.1/trap/week) most effective for monitoring western flower thrips than yellow and white. Naik (2015) found blue colour sticky traps attracted highest number of adult thrips, *S. dorsalis* (19.40 thrips/trap) followed by yellow (10.40 thrips/trap) and pink (8.60 thrips/trap) on rose, which supports our results. Pobożniak *et al.* (2020) found the blue-coloured sticky traps (10 thrips/board) most effective one for monitoring thrips in pea fields than yellow (7.4 thrips/board) and white (4.7 thrips/board) which corroborates the present findings. Ranamukhaarachchi and Wickramarachchi (2007) observed blue and white coloured sticky cards effective in attracting more thrips, *C. claratris* as compared to other colours on tomato also favour our present findings. Devi and Roy (2017) found blue coloured sticky trap (8.34 thrips/board) more attractive towards onion thrips, *T. tabaci* over the crop growth period than white (5.32 thrips/board), fluorescent green sticky traps (4.30 thrips/board) and yellow (3.40 thrips/board).

5.3.3 Influence of colour and height of sticky trap on population of thrips, *Scirtothrips dorsalis* (Hood)

Various coloured sticky traps *viz.* blue, yellow and white installed at varying heights in the field were attractive towards thrip population. The maximum population of *S. dorsalis* (Hood) on gladiolus however, was attracted to blue coloured sticky traps installed at 75 cm and 100 cm with mean population of 39.37 and 34.6, respectively followed by yellow installed at 75 cm. Pobożniak *et al.* (2020) found the blue-coloured sticky traps (10 thrips/board) most effective one for monitoring thrips in pea fields than yellow (7.4 thrips/board) and white (4.7 thrips/board) which corroborates the present findings. The findings are supported by Gharekhani *et al.* (2014) who found sticky traps installed at 70 cm above ground surface most effective in attracting maximum population of thrips as compared to the traps installed at 100, 50 and 30 cm above the ground.

Chapter - 6

SUMMARY AND CONCLUSION

The investigations on “Studies on the Incidence and Management of thrips on Gladiolus, *Gladiolus grandiflorus* L.” were carried out at FoA, Wadura Sopore. The findings of the study are summarized as under:

- Thrips commenced from 24th standard week on *Gladiolus grandiflorus* L. with average population as 0.2 ± 0.23 per plant, reaching its peak (29.96 ± 0.78 per plant) in the 31st standard week after which it started declining and reached to minimum (0.2 ± 0.1 per plant) in 41st standard week.
- Population of *S. dorsalis* (Hood) revealed significant and a positive correlation with maximum ($r = 0.69$) and minimum temperature ($r = 0.70$), evening relative humidity ($r = 0.54$) and negative correlation ($r = - 0.002$) with rainfall (mm) in gladiolus. Morning relative humidity however, was found non- significant and positively correlated ($r = 0.29$).
- Different insecticides viz., NSKE 0.15 EC (0.0006 %), neem oil (0.005 %) fipronil 5 SC (0.005 %) and imidacloprid 17.8 SL (0.003 %) were evaluated against thrips on gladiolus under open field conditions.
- The spray was carried out in 30th standard week and observations on mean population and mortality (%) were recorded on 1 day before spray and 1, 3, 5 and 7 days after spray (DAS).
- All the treatments were significantly superior over control (water) in reducing thrip population on gladiolus
- Fipronil 5 SC (0.005 %) was most effective in reducing thrip population (6.96 thrips/plant) and increasing mortality percentage (74.34 %).
- Fipronil 5 SC (0.005 %) was followed by imidacloprid 17.8 SL (0.003 %) with mortality of 72.24 percent on gladiolus and both were at par with each other.

- The different observations regarding impact of different insecticides on the growth parameters of gladiolus viz., vegetative, reproductive and corm characters of the plant was studied during the course of investigation.
- Plants sprayed with fipronil 5 SC (0.005 %) attained maximum height (121.13 cm) which was at par with Imidacloprid 17.8 SL (119.54 cm).
- Number of leaves per plant had non-significant difference among the treatments. All the treatments however, were superior over control. Average leaf length and breadth showed non-significant difference among treatments including control.
- Number of spikes per plant had a non-significant difference in all the treatments. Insecticides, however, had a significant effect on spike length, rachis length, floret number per spike and floret size.
- Maximum spike length, rachis length, floret number, floret length and breadth were found in plants treated with fipronil 5 SC (0.005 %) which was at par with imidacloprid 17.8 SL (0.003 %).
- The influence of insecticides on number of corms per plant was statistically found non-significant. Number of cormels, weight of corms and weight of cormels per plant however, resulted in significant difference in all treatments.
- The interaction of blue, yellow and white sticky trap colour with different heights (25 cm, 50 cm, 75 cm and 100 cm) was determined for trap capture of thrips, *S. dorsalis* (Hood)
- Blue colour sticky trap installed at 75 cm was found most effective in attracting gladiolus thrips than yellow and white

To sum up information generated from the present studies, it is concluded that:

- Thrips on gladiolus appeared from 24th to 42nd standard week, therefore, this plant needs a careful monitoring and proper management during this period

- Among different insecticides used for the management of thrips on gladiolus under open-field conditions, fipronil 5 SC (0.005%) followed by imidacloprid (0.003%) proved superior over other insecticides and control.
- Among different sticky traps used for capturing *S. dorsalis* (Hood), blue-coloured sticky traps installed at 75 cm above the ground level proved most effective against gladiolus thrips and thus can be used for effective and eco-friendly management under field conditions. The further studies, however, in this aspect are warranted for any recommendation.

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CERTIFICATE

Certified that all the corrections/amendments as suggested by External Examiner. **Dr. Pawan Kumar Sharma** during Viva-Voce examination held on 14-09-2021 have been incorporated in the manuscript entitled “**Studies on the Incidence and Management of Thrips on Gladiolus, *Gladiolus grandiflorus* L.**” submitted by **Ms. Sheikh Salma Irshad** (Regd. No. MSA-2019-1272).

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