

**EPIDEMIOLOGY AND MANAGEMENT OF BITTER
GOURD (*Momordica charantia* L.) MOSAIC**

By

**Mamta Devi
(J-18-M-577)**

**Thesis submitted to Faculty of Postgraduate Studies
in partial fulfillment of requirements
for the degree of**

**MASTER OF SCIENCE
IN AGRICULTURE (PLANT PATHOLOGY)**



**Division of Plant Pathology
Sher-e-Kashmir University of Agricultural Sciences & Technology of Jammu
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M.Sc.

EPIDEMIOLOGY AND MANAGEMENT OF BITTER GOURD (*Momordica charantia* L.) MOSAIC

**Mamta
Devi**

2021

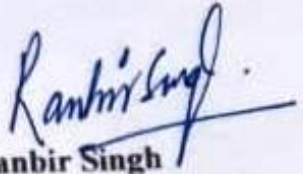
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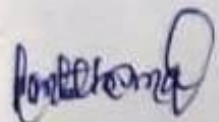
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Major Advisor

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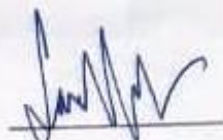
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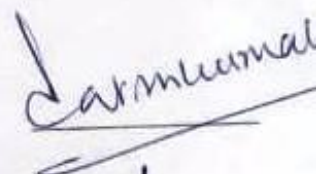
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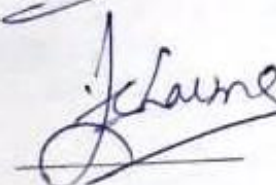
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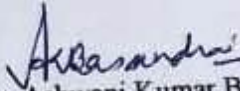


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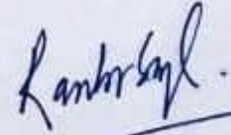
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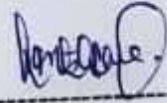

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Date: 02.02.2021

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ABSTRACT

Title of the thesis	:	Epidemiology and Management of Bitter Gourd (<i>Momordica charantia</i> L.) Mosaic
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ABSTRACT

Bitter gourd (*Momordica charantia* L.) is one of the most important and traditional summer season vegetable crop cultivated in India. Diseases caused by viruses are a major problem in bitter gourd causing considerable yield loss. In the present investigation, survey was conducted in the different bitter gourd growing areas of Jammu district particularly R.S. Pura, Akhnoor, Bishnah, Chatha and Marh to determine the incidence of bitter gourd mosaic disease. It was observed that the disease was prevalent in all the locations and per cent disease incidence varied from 17.22 to 35.55 per cent with overall mean of 26.44 per cent. Weather parameters played an important role in disease development and there was a positive and significant correlation between temperature (maximum and minimum) and disease intensity whereas, maximum and minimum relative humidity had negative correlation and rainfall had no significant relationship with disease development. Maximum percentage of disease intensity was recorded at 20th meteorological standard week (MSW), when the corresponding maximum and minimum temperature, and relative humidity were 34.90°C and 19.20°C, 62.00 and 31.00 per cent respectively. Eighteen bitter gourd germplasm line were screened under field conditions against the bitter gourd mosaic disease and it was found that Kathi Selection was highly resistant and Pusa Hybrid 1 and Abhishek were resistant. Palee, F1 Hybrid-spl., Prachi F1, Liberty, Punjab 4 and Pusa Domausmi were moderately resistant. However, Jaunpuri Long, Preethi, Jhalari Long and Jhalari Shilpa were susceptible and Vikrant, Monika, Co, Araya and Aman were moderately susceptible. Different chemical as well as non-chemicals were evaluated against the disease under field conditions. It was observed that application of spiromesifen recorded the lowest disease intensity and foliar and seed application of imidacloprid was also effective against the disease and its vector under field conditions.

Key words: Bitter gourd mosaic disease, epidemiology, host resistance, management.



Signature of Major Advisor



Signature of the Student

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Chapter-1

Introduction

INTRODUCTION

Bitter gourd (*Momordica charantia* L.) is one of the most important and traditional summer season vegetable crop cultivated in India. It is believed to have originated in tropics since ancient times and is widely distributed in China, Malaysia, India and tropical Africa (Varmudy, 2014). It belongs to family cucurbitaceae and genus *Momordica* and is grown for its immature tuberculate fruit having unique bitter taste. The bitterness of bitter gourd is due to the cucurbitacin-like alkaloid momordicine and triterpene glycosides (Jeffrey 1980; Okabe *et al.*, 1982). It is known by different names such as *Balsam pear* or *bitter cucumber* in English, *Karela* in Hindi, *Karla* in Marathi, *Beet karela* in Assamese, *Kakara kaya* in Telugu, *Pavakka* in Malayalam and *Kalara* in Odia. The immature fruits and tender vine tips are used in a variety of culinary preparations. Bitter gourd now occupies a prominent place among vegetables owing to its high productivity, high medicinal value, good storability, long period of availability and better transport potentialities. The highest yield and the maximum returns made it the most preferred vegetable crop of farmers (Nandakumar, 1999). Bitter gourd fruits are highly nutritious (Gopalan *et al.*, 1982). Numerous medicinal properties of nearly all parts of the plant have been reported. The fruit, leaves and roots have several beneficial uses, most notable in regulating diabetes as tonic. Bitter gourd stimulates easy digestion and peristalsis of food through the bowel until it is excreted from the body. Thus, it helps in relieving indigestion and constipation problems. Fresh bitter gourd is excellent source of vitamin C (84 mg/100 g) which is one of the powerful natural antioxidant. It provides very low calories (17calories/100 g) and also contain hypoglycemic agent, which increases glucose uptake and glycogen synthesis in the cells of liver, muscle and adipose tissues together. It is good source of flavonoids such as carotene, α - carotene, lutein and zeaxanthins. There are claims that bitter gourd is also used for prevention of breast cancer, (Ray *et al.*, 2010). Likewise, the extracted juice from leaf, fruit and even whole plant are routinely used for treatment of wounds, infections, parasites (e.g., worms), measles, hepatitis, and fevers (Behera *et al.*, 2008). Considering the above medicinal properties to cure many human health disorders, people have shown interest to include *M. charantia* in their diet and hence, the demand of bitter gourd has increased (Raj *et al.*, 2005). India is a largest producer of bitter gourd with an area

of 78000.89 hectares and production of 807000MT. In Jammu province the crop is cultivated over an area of 365 hectares with the production of 5575.41Mts (Anonymous, 2016).

Thirty-five viruses have been isolated from the cucurbitaceous family, however, the viruses associated with the bitter gourd are bitter gourd mosaic virus, papaya ring spot virus, watermelon mosaic virus-1, bitter gourd yellow mosaic virus, cucumber mosaic virus and watermelon silver mottle virus (Ozaslan *et al.* 2006). Among the various viral diseases affecting the crop, mosaic disease is a major problem worldwide, causing as high as 100 per cent losses (Ullman *et al.*, 1991). As insect vectors spread the virus, bitter gourd mosaic is prevalent throughout the year and is very severe during summer season. The conditions which are congenial for the growth of bitter gourd are also found to be ideal for the multiplication of insect vector. The virus belongs to family Gemini viridae and transmitted by whitefly and causing a crop yield losses between 20-100 % (Brown and Bird, 1992). The yield loss of 30- 40% with an annual economic loss of 1.9-2.7 billion US \$ had been reported due to the disease (Legg and Fauquet, 2004).

The disease causes the symptoms like yellow mosaic, upward leaf curling, shortening of internodes, smaller and distorted leaves. During the last two decades mosaic had emerged as potential threat causing huge economic loss (Verma and Malathi, 2003). Favourable environment for both vector and virus, lack of awareness about viral diseases and abundance of viral vectors result in severe epidemics of bitter gourd mosaic disease.

As the disease causes enormous losses in respect to yield and quality of the fruits however, it has not been studied in detail from Jammu division. Hence, considering the importance of the disease, the present study was undertaken to assess the status of the disease, evaluate available commercial germplasm, determine the efficacy of different new chemicals and non-chemicals singly or in combination and effect of weather parameters on disease development. In this context, the present investigations were undertaken with the following objectives:

1. To ascertain the status of mosaic of bitter gourd in Jammu region.
2. To study the effect of weather parameters on disease development.
3. Management of disease through host resistance, chemical and non-chemical means.

Chapter-2

Review of Literature

REVIEW OF LITERATURE

Bitter gourd (*Momordica charantia* L.) is grown throughout the world for its usage as vegetable and traditionally used as medicine for the treatment of diabetes (Yesilada *et al.*, 1999; Satyawati *et al.*, 1987) and also as carminative purposes. However, majority of the world commonly consume it as vegetable. The production of bitter gourd is hindered due to several biotic factors viz. insect pests and diseases among which, bitter gourd mosaic virus is an important viral disease causing great loss to the crop as the virus is capable of attacking the crop at all stages of growth.

The work done on various aspects of the disease in India and other countries is discussed as under.

2.1 Occurrence

Mosaic disease of bitter gourd was first reported in India by Uppal (1933). Giri and Mishra (1986) reported a virus disease of bitter gourd transmitted through whitefly (*Bemisia tabaci*) to few members of cucurbitaceae plants and tomatoes from New Delhi. Rajnimala and Rabindran (2007) observed characteristic symptoms of mosaic and mottling on young leaves of bitter gourd from Tamil Nadu. Raj *et al.* (2010) reported severe mosaic on bitter gourd (*Momordica charantia* L.) during a survey in different locations in Uttar Pradesh in 2008. However, yellow vein symptom of bitter gourd were also reported by Tahir *et al.* (2010).

Nagendran *et al.* (2014) reported tomato leaf curl New Delhi virus causing mosaic disease in bitter gourd from Tamil Nadu and the plants showing symptoms of mosaic and mild leaf curl. The bitter gourd mosaic is caused by three different viruses viz. *Cucumber mosaic virus* (CMV), *Papaya ring spot virus* (PRSV) and *Bitter gourd distortion mosaic virus* (BDMV). *Cucumber mosaic virus* (CMV) infection of bitter gourd was reported for the first time from Coimbatore, India (Nagarajan and Ramakrishnan, 1971).

2.2 Incidence and yield loss

Mathew *et al.* (1991) reported almost total loss in yield in early infected bitter gourd crop from different parts of Kerala during summer season. Naik *et al.* (2019) reported that in Kharif season, incidence of bitter gourd mosaic disease ranged from 18.18 to 45.44% with vulnerability index 12.12 to 30.30% and whitefly population of 2.54 to 6.51 per plant from Mysuru and Mandya districts, respectively. Legg and Fauquet (2004) reported the yield loss of 30- 40% due to the bitter gourd mosaic disease. Brown and Bird (1992) also reported that the disease is responsible for yield losses between 20-100 per cent.

2.3 Symptomatology

Khan *et al.* (2003) reported upward curling, shortening and distortion of leaves and stunting of fruits on bitter gourd (*Momordica charantia* L.) from Lucknow. However, symptoms like chlorosis, leaf crumpling, vein thickening and stunting of plants were also reported by Ali *et al.* (2010) from Pakistan. Tahir *et al.* (2010) reported that the yellow vein symptoms developed on bitter gourd (*Momordica charantia* L.) were the typical symptoms of begomovirus. Tiwari *et al.* (2010) also studied different symptoms like curling of leaves whereas, in case of severity of the disease, extensive chlorosis and vein banding was also noticed. Nagendran *et al.* (2014) observed bitter gourd (*Momordica charantia* L.) plants showing different symptoms such as mosaic, mild leaf curl and blistering from major bitter gourd (*Momordica charantia* L.) growing areas of Tamil Nadu. Ashwini *et al.* (2016) noted that symptoms like vein clearing filiform leaves, reduced leaf size and yellowing, were the typical symptoms of bitter gourd mosaic disease.

2.3 Transmission

Mathew *et al.* (1991) reported that the disease is neither sap nor seed transmitted but transmit by white flies. Khan *et al.* (2003) reported whitefly (*Bemisia tabaci*) transmitted begomovirus for first time in Lucknow, Uttar Pradesh, India. Begomoviruses are transmitted by *Bemisia tabaci* and have two genomic components (bipartite) designated as DNA-A and DNA-B of ~2600–2800 nucleotides (Hanley-Bowdoin *et al.*, 1999). Weerasinghe (2010) also reported that the transmission of the disease is not by seed or mechanical means but by whiteflies only. Leuschner (1978) reported that the activity of adult whitefly was influenced by temperature, light and

rainfall. Butler *et al.* (1983) reported the multiplication of whitefly was rapid during April to October, when the average temperature ranged from 12 to 33°C. Varma (1955), Capoor and Ahmad, (1975) and Jayashree *et al.* (1999) reported that mosaic of pumpkin is transmissible by whitefly but not by aphids or by sap inoculation. Mansour and Al. Musa (1992) studied the vector-virus relationship and found that a single whitefly was able to transmit the virus. The minimum acquisition and inoculation feeding periods were 60 and 30 minutes, respectively and the virus was retained by whitefly for 11 days. Mathew *et al.* (1991) reported a minimum of 10 whiteflies were enough for 100 per cent transmission. Rajnimala *et al.* (2005) reported that a minimum of 5 whiteflies are required to transmit the virus. However, 100 per cent transmission of bitter melon yellow mosaic virus was obtained when 45 whiteflies were released per plant. Twelve hours of acquisition access feeding period and inoculation access feeding period were required for the whiteflies to transmit the disease. Begomoviruses are mostly transmitted by the whiteflies (*B. tabaci*) and may cause crop yield losses of 20 to 100 per cent (Brown and Bird, 1992).

2.4 Host Range

Mathew and Alice (2002) revealed that the virus had a narrow host range and infecting cucurbitaceous and solanaceous family only. Mathew and Alice (2002) also reported that *Melothria leiosperma*, a wild cucurbitaceous weed was an important collateral host of bitter melon yellow mosaic virus (BGMV) in Kerala.

2.5 Epidemiological studies

Zacharia and Mathew (2016) reported that the influence of mean maximum temperature and mean relative humidity on disease incidence varied with the seasons. Relative humidity showed positive correlation with disease incidence and it was the most important weather parameter in bitter melon yellow mosaic disease. Saikia (1993) reported positive correlation between whitefly population and the temperature and negative association with relative humidity. Leuschner (1978) reported that the activity of adult whitefly was influenced by temperature, light and rainfall. Butler *et al.* (1983) reported that multiplication of whitefly was rapid during April to October when the average temperature ranged from 12 to 33 °C. Dhawan *et al.* (1998) also reported that weather played a significant role in population build up of whitefly on

cotton. Anzola *et al.* (2008) found a negative correlation between whitefly population and rainfall.

2.6 Identification of resistant sources

Thakur *et al.* (1996) evaluated 30 germplasm/ lines against the disease and reported that genotypes BG 14-4, BL 240, BG 14, HK 12 and Palwal Sel-1 were free from yellow mosaic virus. Doraisamy *et al.* (1998) reported that the germplasm IC 68324 was least susceptible to bitter gourd mosaic virus under controlled conditions. Pandey *et al.* (1998) evaluated 15 varieties for their reaction to bitter gourd distortion mosaic virus and found that only two varieties *viz.*, ARBTH 1 and Pusa Do Mausami were resistant. Lakshmanan *et al.* (1998) screened different bitter gourd germplasm against mosaic disease under field conditions and found that 61 white medium, 87 green long, 177 green medium, IC 68234 and IC 45358 were least susceptible to mosaic disease. The varieties such as Priya, Co 1 and Arka Harit were susceptible to bitter gourd mosaic virus (Purushothaman, 1994). Asna *et al.* (2018) screened 50 genotypes of *Momordica charantia* var. *muricata* against bitter gourd mosaic under natural epiphytotic conditions during the years 2016 and 2017 and observed that among 53 accessions evaluated, five were resistant, nine moderately resistant, 25 moderately susceptible, 11 susceptible and two highly susceptible while, none of the genotypes recorded immune response.

2.7 Management

Zacharia and Mathew (2016) reported that imidacloprid @ 0.025 % was effective in reducing bitter gourd mosaic disease. Webb *et al.* (2007) evaluated spiromesifen, pyriproxyfen, and buprofezin under field conditions and observed that secondary spread was reduced within and between fields by slowing the increase of the whitefly population. Sharaf and Allawi (1981) reported that the chemical control of the vector was effective in reducing the incidence of bitter gourd mosaic disease. Salalrajan (1988) reported that pre-inoculation spray with leaf extracts of *Azadiracta indica*, *Mirabilis jalapa* and *Datura metel* significantly reduced the number of infected plants in urd bean yellow mosaic virus disease. He also reported that neem oil @ 1% and 5% concentration reduced the number of infected plants. Rajinimala *et al.* (2009) reported management of bitter gourd mosaic by leaf extracts and insecticides and found that *B. spectabilis* treated plots recorded the least disease

incidence of 33.33%. Unah *et al.* (1999) reported that cypermethrin, decmethrin, carbofuron and formothion were effective against *B. tabaci* on irrigated capsicum in the Nigeria. Rustamani *et al.* (1994) evaluated thiodan 35 EC (endosulfan), anthio 25 EC (formothion) and curacron 35 EC (profenofos) against *B. tabaci* and found that formothion was significantly more toxic. Some systemic insecticides like imidacloprid and thiamethoxam were also effective against sucking insect pests (Ghongale *et al.*, 2003, Katole *et al.*, 2003; Nagangoud and Patil, 2003). The effect of chemical and bio-pesticides like imidacloprid and neem extract on the reduction of whitefly population was also reported by Ali *et al.* (2005). Das and Panjekar (2009) reported that application of imidacloprid @ 0.02% recorded the least infection and the highest yield (131.4 q ha⁻¹) as compared to control plots. A mixture of flubendiamide (24 %) + thiacloprid 48SC @ 200ml/ha resulted in the highest reduction in whitefly population (Ameta, 2008). Salam (2009) found that seed treatment with imidacloprid (5g/kg) followed by its two sprays @ 0.24 ml/l recorded least disease incidence and whitefly populations. Srinivasan and Sundarababu (2001) reported that neem seed kernel extract (5%) was effective against the whiteflies. Plant extracts of *B. spectabilis* or *P. chilensis* (Pun *et al.*, 2005), mint and colothyn (Sayeda *et al.*, 2009) were effective in managing whitefly population. Similarly plant products like neem oil (Pun *et al.*, 2005; Kumar and Poehling, 2007; Wen *et al.*, 2009; Vethanayagam and Rajendran, 2010), neem leaf extract (Kumar *et al.*, 2008), NSKE + dimethoate (Gupta, 2009) were the most effective treatment in minimizing the whitefly population. Prophylactic applications of carbofuran and/or sprays of a neem-based formulation lowered populations of whiteflies to varying extents and increased the yield in jute and hot pepper (Haque, 2008; Karungi *et al.*, 2010).

Chapter-3

Materials and Methods

MATERIALS AND METHODS

The experiments were conducted under field conditions at Research farm Division of Plant Pathology, SKUAST-Jammu to study the host resistance, epidemiology and Management of the disease. The material and experimental procedure and used during the course of study are described as under.

3.1 Survey

The survey was conducted in different bitter gourd growing areas of district Jammu particularly at R.S. Pura, Akhnoor, Bishnah, Chatha and Marh to determine the incidence of bitter gourd mosaic disease. Disease incidence was recorded by counting the number of diseased plants exhibiting characteristic symptoms of the disease. The percentage of disease incidence was calculated by

$$\text{Per cent Disease Incidence (PDI)} = \frac{\text{No. of infected plants}}{\text{Total No. of plants observed}} \times 100$$

Table 1: Locations selected for Survey

District	Location
Jammu	RS Pura
	Marh
	Akhnoor
	Bishnah
	Chatha

3.2 Symptomatology

The characteristic symptoms of the disease observed during the study were yellow mosaic, upward curling of the leaves, shortening of the internodes, reduction in the leaf size, stunting of plant growth and distortion of the leaves (Plate 1)

3.3 Location of the experiment

The field experiments were conducted at the Research Farm, Division of Plant Pathology, Main Campus Chatha, SKUAST, located at 32.69° N latitude, 74.65° E longitude and at an altitude of 336 m above the mean sea level.

3.3.1 Nursery raising

The seedlings were raised in the polythene bags. The bags of 15 x 10 cm size and 100 gauge thickness were punched at the base and were filled with a mixture of soil, sand and well rotten farmyard manure in the ratio of 2:1:1. Before planting of seedlings, seeds were soaked in water for about one hour. The different germplasm lines of bitter melon were planted in the soil filled polythene bags and were placed in the polyhouse for optimum temperature for the seedling growth. The seedlings were ready for transplanting in the main field after 30 days and the healthy seedlings were selected for transplanted in the main experimental field.

3.3.2 Layout of the experimental plot

Land preparation, design, manure and fertilizer

The field was prepared by two times ploughing for the well raised fine tilth beds. All the weeds and stubbles were removed from the field. Bitter melon seedling were transplanted at a spacing of 1.5m between the plant to plant and 90cm between row to row. Well decomposed farmyard manure (FYM) @ 25 tonnes/ha was thoroughly mixed with the soil at the time of field preparation and was supplemented with inorganic N:P:K fertilizers at the rate of 100:50:50 kg/ha. Phosphorous, potassium and other fertilizers along with 1/3 N were also applied as basal application and the remaining nitrogen was top dressed in two split doses at 30 days interval after transplanting.

3.4 Epidemiological studies

The effect of major environmental factors such as average atmospheric temperature, relative humidity and rainfall were studied on the development of



Plate 1. Symptoms of bitter melon mosaic disease

disease under field conditions. The epidemiological studies were undertaken using the susceptible germplasm *viz.* Jaunpuri long, Preethi, Jhalari Long, and Jhalari Shilpa. The data of various weather parameters like temperature, relative humidity and rainfall were procured from the Agromet Centre, Division of Agronomy.

3.4.1 Correlation and regression analysis

To determine the role of abiotic factors on disease progress, the data obtained during the course of epidemic was analyzed through correlation and regression analysis. All simple correlations were calculated between study variables Y and abiotic factors X_1, X_2, \dots, X_5 . Disease severity was represented as dependent variable Y_1 , whereas the independent variables like temperature (maximum), temperature (minimum), relative humidity (maximum), relative humidity (minimum) and rainfall were represented as X_1, X_2, X_3, X_4 and X_5 respectively.

To determine the joint effect of different (independent) variable in the development of disease, multiple correlation coefficients were worked out. Adequacy of the best fitted regression equations were judged with the help of coefficient of multiple determinations (R^2). The data was analyzed with the help of a statistical package SPSS.

3.5 Screening of bitter gourd germplasm

Eighteen germplasm lines *viz.* Liberty, Vikrant, Jaunpuri long, Palee, Preethi, F1 Hybrid-spl., Co1, Pusa Hybrid 1, Prachi F1, Kathi Selection, Jhalari Long, Abhishek, Monika, Jhalari Shilpa, Araya, Aman, Punjab 4 and Pusa Domausmi collected from different sources were screened to identify resistance against bitter gourd mosaic disease under field conditions (Table 2).

Table 2: Source of bitter gourd germplasm

Varieties/ hybrids	Source of procurement
Liberty	Department of Agriculture, Jammu
Vikrant	-do-
Jaunpuri Long	-do-
Palee	Department of Vegetables Science and Floriculture, SKUAST-Jammu
Preethi	Corporation sector, Abohar Punjab
F1 Hybrid-spl.	Local market, Jammu
Co1	-do-
Pusa Hybrid 1	-do-
Prachi F1	Corporation sector, Abohar Punjab
Kathi Selection	Local market, Jammu
Jhalari Long	-do-
Abhishek	-do-
Monika	-do-
Jhalari Shilpa	-do-
Araya	-do-
Aman	-do-
Punjab 4	-do-
Pusa Domausmi	-do-

3.5.1 Disease scoring:

Per cent disease incidence was recorded by using the following formula:

$$\text{Disease incidence (\%)} = \frac{\text{No. of infected plants}}{\text{Total No. of Plant observed}} \times 100$$

The percentage of disease index was calculated by using the following formula:

$$\text{Percent Disease index (PDI)} = \frac{\text{Sum of all numerical ratings}}{\text{Maximum disease grade} \times \text{Total Number of plants observed}} \times 100$$

Observations of disease were recorded at 15 days interval starting from appearance of symptoms and the germplasm lines were categorized as per the scale given by (Asna *et al.*, 2018) (Table 3).

Table 3: Disease rating scale to determine the level of resistance or susceptibility of germplasm lines against bitter gourd mosaic disease

Disease incidence (%)	Reaction group	Grade
0.5 - 5.0	Highly Resistant	HR
5.1 - 10.0	Resistant	R
10.1 - 20.0	Moderately Resistant	MR
20.1 - 40.0	Moderately susceptible	MS
40.1 - 70.0	Susceptible	S
70.0-100	Highly Susceptible	HS

3.6 Chemical control

An experiment was conducted for the management of bitter gourd mosaic disease under field conditions by selecting chemicals and non-chemicals alone or in combination along with untreated control.

Table 4: List of chemical/non-chemicals used in the study

Treatment	Chemicals /Non chemicals	Dosage and time of spray/s
T ₁	Diafenthiuron	3 sprays at an interval of 10 days @ 1gm/l of water.
T ₂	Acetamiprid	3 sprays at an interval of 10 days @ 0.3 gm/l of water.
T ₃	Pyriproxyfen	3 sprays at an interval of 10 days @ 0.1 mg/l of water.
T ₄	Fonicamid	3 sprays at an interval of 10 days @ 0.75 gm/ l of water.
T ₅	Spiromesifen	3 sprays at an interval of 10 days @ 0.5ml /l of water .
T ₆	Imidacloprid 200SL	3 sprays at an interval of 10 days @ 0.3 ml/l of water.
T ₇	Imidacloprid	Seed treatment @ 5 gm./kg of seed .
T ₈	Ethion	3 sprays at an interval of 10 days @ 2.0 ml/l of water.
T ₉	Nimbecidine	3 sprays at an interval of 10 days @ 10% concentration.
T ₁₀	Imidacloprid + Nimbecidine	Seed treatment and foliar spray with Imidacloprid + foliar spray with Nimbecidine [combination treatment]
T ₁₁	Control	No spray.

3.6.1 Observations

Percentage of disease index (PDI) was calculated by using standard formula (McKinney, 1923).

$$\text{Percentage Disease Index (PDI)} = \frac{\text{Sum of all numerical rating}}{\text{Maximum disease grade} \times \text{Total number of plants observed}} \times 100$$

Observation on disease severity were recorded at 15 days interval starting from 30 days after transplanting (DAT). Intensity of the disease was determined by using 0-5 scale as per Arunachalam *et al.*, (2002) as detailed in Table 5.

Table 5: Scale used to measure intensity of mosaic of bitter gourd

Grade	Symptoms
0	No visible symptoms.
1	Minute chlorotic specks on leaf.
2	Wide area of mosaic symptom on leaf without distortion.
3	Distortion and reduction in about 25% of the normal leaf area.
4	Distortion and reduction in about 25% - 75% of the normal leaf area.
5	Distortion and reduction in about more than 75% of the normal leaf area.

3.6.2 Statistical Analysis

Experimental data was analysed following standard methods used for test of significance (Gomez and Gomez, 1984).

Chapter-4

Results

RESULTS

Bitter gourd mosaic is a major viral disease of cucurbits in Jammu. An investigation was carried out on various aspects *viz.* survey, incidence, symptomatology, host resistance, epidemiology and management of disease under field conditions. The results observed during the investigation have been discussed as under:

4.1 Survey

To assess the status of bitter gourd mosaic disease, an extensive survey was conducted in different areas of Jammu province *viz.*, Akhnoor, Bishnah, Marh and R.S. Pura at 15 days interval. It was observed that the disease was prevalent in all the locations surveyed and per cent disease incidence (PDI) varied from 17.22 to 35.55 per cent with overall mean of 26.44 per cent (Table 1). It was observed that in Marh, maximum disease incidence was recorded from Gajansoo (35.55%) followed by Gho Manhasa (31.66%) and Bhadrore (27.22%) while in R.S. Pura the maximum incidence of the disease was recorded from Badayal Brahmna (33.33%) followed by Biaspur (31.66%) and Kullian (19.44%). In Bishnah, maximum incidence of the disease (25.55%) was recorded from Makhanpur followed by Chak Abtara (23.88%) and Deoli (17.22%) while in Akhnoor the maximum incidence of the disease (33.88%) was recorded from Rajpura followed by Bhalwal (29.40%) and Pallan wala (23.66%). However, at Chatha farm the incidence of mosaic was 28.33 per cent.

Table 6: Incidence of bitter gourd mosaic disease at different location in district Jammu

Location	Village	Percent Disease Incidence (%)
Akhnoor	Rajpura	33.88
	Bhalwal	29.40
	Pallan wala	23.66
	Range	23.66-33.88
	Mean	28.98
Bishnah	Makhanpur	25.55
	Chak Abtara	23.88
	Deoli	17.22
	Range	17.22-25.55
	Mean	22.21
R.S. Pura	Badayal Brahmna	33.33
	Biaspur	31.66
	Kullian	19.44
	Range	19.44-33.33
	Mean	28.14
Marh	Gajansoo	35.55
	Gho Manhasa	31.66
	Bhadrore	27.22
	Range	27.22-35.55
	Mean	31.47
Chatha	Chatha farm	28.33
	Overall mean	26.44
	Overall range	17.22-35.55

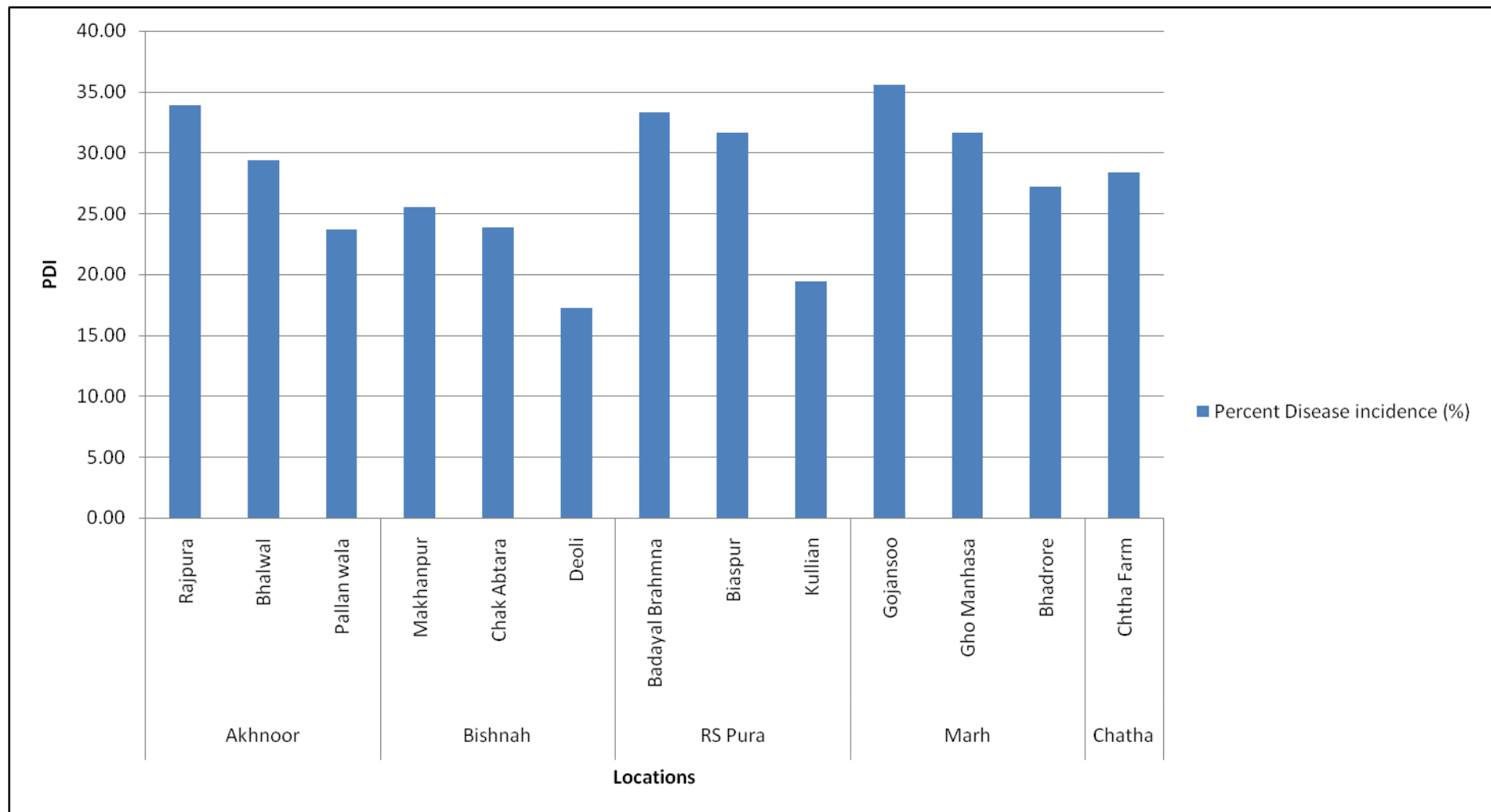


Fig 1: Incidence of bitter gourd mosaic disease at different locations in district Jammu

4.2 Epidemiological studies

It was observed during the study that various weather parameters played an important role in the development of disease.

4.2.1 Effect of various weather factors on disease development

Bitter gourd mosaic disease initiated under field condition during 12th meteorological standard week (MSW) when the crop was 60 days old. There was an abrupt increase in the development of disease in all the genotypes at 20th MSW and with corresponding intensity of 35.00, 23.33, 25.00 and 16.66 per cent in genotypes Preethi, Jhalari Long, Jaunpuri Long and Jhalari Shilpa respectively, thereafter marginal increase in disease intensity was observed during rest of the meteorological standard weeks. It was thus inferred from the data that the minimum and maximum temperature of 19° C and 35° C, minimum and maximum relative humidity of 31 and 62 per cent and rainfall below 22 mm were the most favourable for the development of the disease. (Table 7)

4.2.2 Correlation of disease intensity with various abiotic factors

The relationship between disease development and weather variables was established by correlation and regression analysis to assess the effect of weather parameter on disease progress.

4.2.2.1 Simple correlation

An experiment was conducted to study the correlation of disease intensity (Y_1) with maximum temperature (X_1), minimum temperature (X_2), maximum relative humidity (X_3), minimum relative humidity (X_4) and rainfall (X_5). It was observed during the study that there was simple correlation with the maximum temperature ($r = 0.930, 0.923, 0.907$ and 0.887) and minimum temperature ($r = 0.963, 0.983, 0.972$ and 0.980) in genotypes Preethi, Jhalari Long, Jaunpuri Long and Jhalari Shilpa respectively (Table 8).

The corresponding correlation coefficients (r) for (minimum and maximum) relative humidity and disease intensity in various bitter gourd genotypes *viz.*, Preethi (-0.662 and -0.872), Jhalari Long (-0.647 and -0.857), Jaunpuri Long (-0.623 and -0.831) and Jhalari Shilpa (-0.581 and -0.808) were negative and statistically highly significant (Table 8).

Similarly, negative and significant correlation was observed between disease intensity and rainfall in the test genotypes Preethi, Jhalari Long, Jaunpuri Long and Jhalari Shilpa with the corresponding value of -0.290, -0.279, -0.242 and -0.219, respectively (Table 8).

4.2.3 Fitting of linear Regression analysis

Regression equations were fitted for prediction of disease intensity under given set of environmental conditions and it was observed that temperature (maximum and minimum), relative humidity (maximum and minimum) and rainfall contributed about 97.7, 99.9, 99.4 and 99.5 per cent disease development in Preethi, Jhalari Long, Jaunpuri Long, and Jhalari Shilpa, respectively (Table 9).

Table 7: Relationship of weather parameters with disease intensity in different bitter gourd germplasm

MSW	Disease intensity (%)				Temperature (°C)		Relative Humidity (%)		Rainfall
	Preethi	Jhalari Long	Jaunpuri Long	Jhalari Shilpa	Max.	Min.	Max.	Min.	
12 th	6.66	3.33	5.00	1.66	15.57	6.84	92.71	66.29	24.00
14 th	13.33	6.66	8.33	5.00	15.77	5.76	92.71	66.57	39.40
16 th	20.00	10.00	11.66	6.66	17.74	7.54	90.43	58.00	0.00
18 th	26.66	15.00	13.33	10.00	17.61	6.37	90.40	58.86	18.20
20 th	35.00	23.33	25.00	16.66	17.03	4.50	95.86	60.57	2.80
22 nd	40.00	25.00	26.66	18.33	19.51	5.36	91.57	51.71	1.30
24 th	43.33	28.33	30.00	23.33	24.40	8.54	93.00	65.90	20.61
26 th	45.00	35.00	36.66	26.66	23.61	10.24	92.30	58.60	3.70

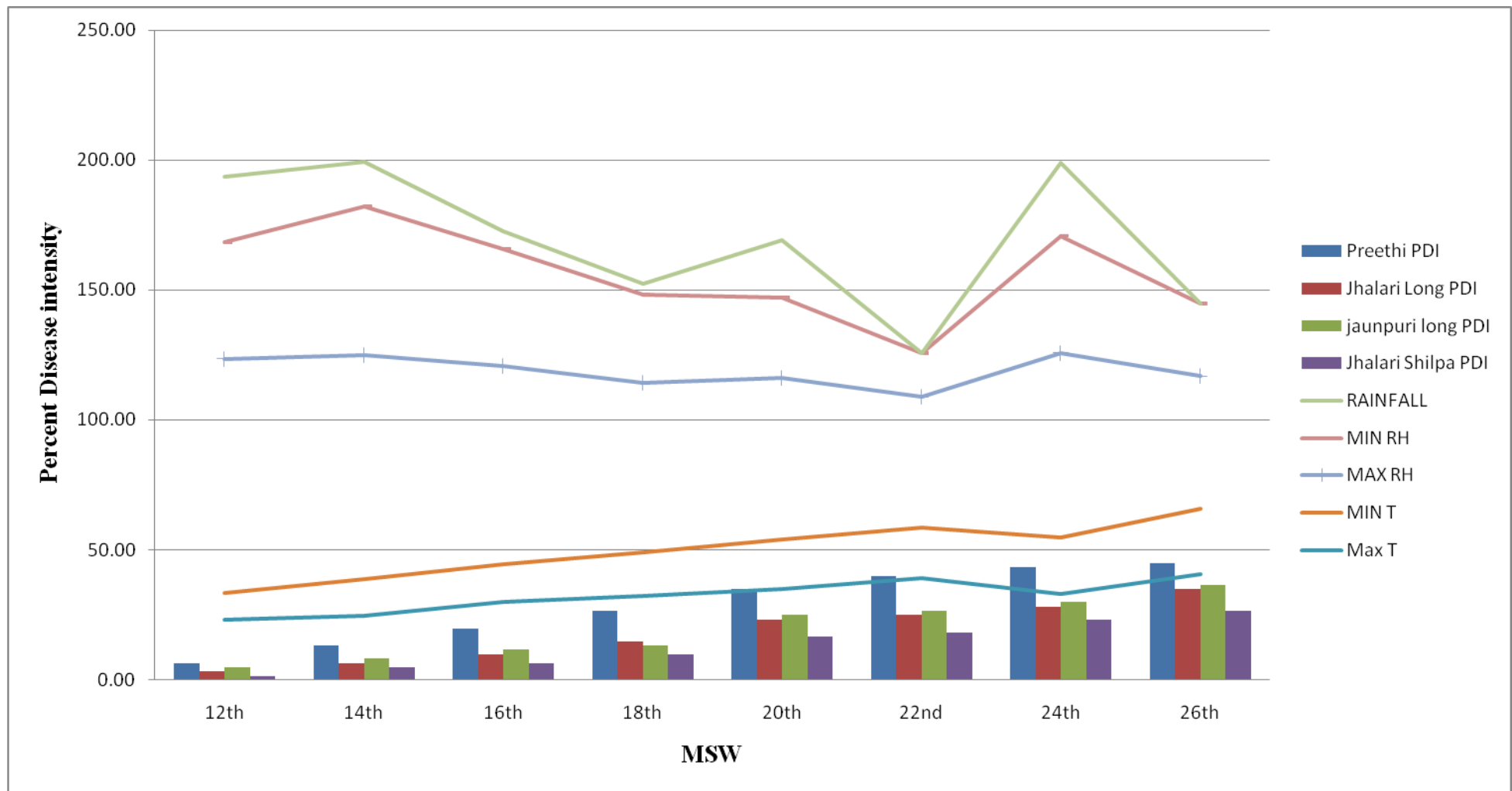


Fig 2: Relationship of weather parameters with disease intensity in different bitter gourd germplasm

Table 8: Correlation of disease intensity with weather parameters in different bitter gourd germplasm

Disease Intensity Germplasm	Temperature (°C)		Relative humidity (%)		Rainfall (mm)
	Max.	Min.	Max.	Min.	
Preethi	0.930*	0.963*	-0.872*	-0.662*	-0.290*
Jhalari long	0.923*	0.983*	-0.857*	-0.647*	-0.279*
Jaunpuri long	0.907*	0.972*	-0.831*	-0.623*	-0.242*
Jhalari Shilpa	0.887*	0.980*	-0.808*	-0.581*	-0.219*

*Significant at 5% probability level (2- tailed)

Table 9: Multiple regression equation for bitter gourd mosaic virus on different bitter gourd genotypes

Genotypes	Best fitted equation	R ²
Preethi	$Y_1 = -39.879 + 1.780X_1 + .815X_2 - .230X_3 + .212X_4 + .357X_5$.977
Jhalari Long	$Y_1 = -74.999 + .907X_1 + 2.247X_2 + .512X_3 - .333X_4 + .108X_5$.999
Jaunpuri long	$Y_1 = -128.158 + 1.953X_1 + 1.971X_2 + .889X_3 - .349X_4 + .132X_5$.994
Jhalari Shilpa	$Y_1 = -78.815 + .829X_1 + 2.056X_2 + .562X_3 - .286X_4 + .088X_5$.995

4.3 Evaluation of germplasm

Eighteen germplasm lines/genotypes of bittergourd *viz.* Liberty, Vikrant, Jaunpuri long, Palee, Preethi, F1 Hybrid-spl., Co1, Pusa Hybrid 1, Prachi F1, Kathi Selection, Jhalari Long, Abhishek, Monika, Jhalari Shilpa, Araya, Aman, Punjab 4 and Pusa Domausmi obtained from different sources were screened for bitter gourd mosaic under field conditions and the results are given in Table 10.

Disease incidence at 30 DAT, Maximum disease incidence was recorded in Preethi (41.66%) followed by Jhalari Long (25.00%), Jaunpuri Long (25.00%), Araya (25.00%), Jhalari Shilpa (16.66%), Aman (16.66%) Vikrant (16.66%), Monika (16.66%), Co1 (16.66%), Liberty (8.33%), Punjab 14(8.33%) while F1 Hybrid-spl, Pusa hybrid 1, Prachi F1, Kathi Selection, Abhishek, Palee and Pusa Domausmi were free from disease.

Disease incidence at 45 DAT of disease was Maximum incidence (50.00%) was recorded in Preethi, Jaunpuri Long and Jhalari Long followed Jhalari Shilpa (41.66%), Araya (41.66%), Monika (33.33%), Co1 (33.33%), Kajal (33.33%), Vikrant (25.00%), Aman (25.00%), Punjab 14 (16.66%), Palee (16.66%), Liberty (16.66%), Prachi F1 (16.66%), Pusa Hybrid 1 (8.33%), F1 Hybrid (8.33%), Pusa Domausmi (8.33%), genotype Kathi Selection showed no disease.

Disease incidence at 60 DAT Maximum disease incidence (75.00%) was recorded in Jhalari Long followed by Preethi (66.66%), Jhalari Shilpa (66.66%), Jaunpuri Long (58.33%), Co1 (58.33%), Aman (58.33%), Araya (50.00%), Monika (41.66%), Vikrant (33.33%), Liberty (25.00%), F1 Hybrid (25.00%), Palee (25.00%), Pusa Domausmi (25.00%), Punjab 14 (16.66%), Abhishek (16.66%), Pusa Hybrid 1 (16.66%), and Kathi Selection (8.33%). It was observed that Kathi Selection was highly resistant with mean disease incidence of 2.77 per cent whereas, Preethi, Jaunpuri Long, Jhalari Long and Jhalari Shilpa were found susceptible against the disease with mean disease incidence of 52.77, 44.44, 50.00 and 41.66 per cent, respectively. Abhishek and Pusa Hybrid 1 were resistant with mean disease incidence of 5.55 and 8.33 per cent while, F1 Hybrid, Pusa Domausmi, Prachi F1, Palee, Punjab 14 and Liberty were found moderately resistant with mean disease incidence of 11.11, 11.11, 13.88, 13.88, 13.88 and 16.66 per cent respectively. However the germplasm lines *viz.* Vikrant, Monika, Aman Co1 and Araya were moderately susceptible against the disease with the mean

disease incidence of 24.99, 30.55, 33.33, 36.10 and 38.88 per cent respectively (Table 10)

Table 10: Incidence of bitter gourd mosaic disease on different germplasm at different days after transplanting (DAT) under field conditions

Germplasm lines	Disease Incidence (%)			Mean %
	30 DAT	45 DAT	60 DAT	
Liberty	8.33	16.66	25.00	16.66
Vikrant	16.66	25.00	33.33	24.99
Monika	16.66	33.33	41.66	30.55
Jaunpuri Long	25.00	50.00	58.33	44.44
Preethi	41.66	50.00	66.66	52.77
F1 Hybrid-spl.	0.00	8.33	25.00	11.11
Co1	16.66	33.33	58.33	36.10
Pusa Hybrid 1	0.00	8.33	16.66	8.33
Prachi F1	0.00	16.66	25.00	13.88
Kathi Selection	0.00	0.00	8.33	2.77
Jhalari Long	25.00	50.00	75.00	50.00
Abhishek	0.00	0.00	16.66	5.55
Palee	0.00	16.66	25.00	13.88
Jhalari Shilpa	16.66	41.66	66.66	41.66
Araya	25.00	41.66	50.00	38.88
Aman	16.66	25.00	58.33	33.33
Punjab 4	8.33	16.66	16.66	13.88
Pusa Domausmi	0.00	8.33	25.00	11.11

DAT= Days after transplanting

Table 11: Disease reaction of different germplasm against bitter gourd mosaic disease under field conditions

Reaction	Disease Incidence (%)	No of entries	Germplasm
Highly Resistant	0.5 - 5.0	1	Kathi Selection
Resistant	5.1 - 10.0	2	Pusa Hybrid 1 and Abhishek
Moderately Resistant	10.1 - 20.0	6	Liberty, F1 Hybrid-spl., Prachi F1, Palee, Punjab 4 and Pusa Domausmi
Moderately Susceptible	20.1 - 40.0	5	Vikrant, Monika, Co1, Araya and Aman
Susceptible	40.1 - 70.0	4	Jaunpuri Long, Preethi, Jhalari Long and Jhalari Shilpa

4.4 Evaluation of different chemicals/non-chemicals for the management of bitter gourd mosaic under field conditions

Different chemicals as well as non-chemicals which were evaluated against the mosaic disease of bitter gourd under field conditions reduced the disease significantly.

At 30 DAT, spiromesifen recorded minimum disease intensity (4.23%) followed by acetamiprid (4.93), imidacloprid (seed treatment) (5.13%), imidacloprid (foliar spray) (5.17%), flonicamid (7.00%), diafenthiuron (9.00%), imidacloprid + nimbecidine (10.00%), pyriproxyfen (11.67%), ethion (13.00%), and nimbecidine (16.00%) as compared to 22.67 per cent in untreated control plots.

Similarly, at 45 DAT, percentage of disease intensity with spiromesifen, imidacloprid (seed treatment), imidacloprid (foliar spray), acetamiprid, flonicamid, diafenthiuron, imidacloprid + nimbecidine, pyriproxyfen, ethion and nimbecidine was 5.83, 6.47, 6.67, 6.73, 9.00, 13.23, 14.33, 16.17, 17.17 and 19.43 per cent respectively, as compared to control with 33.17 per cent disease intensity (Table 12).

At 60 days after transplanting (DAT) spiromesifen was found statistically superior over rest of the treatments and recorded the lowest disease intensity (6.50%) followed by imidacloprid (Seed treatment) (7.50 %), imidacloprid (Foliar spray) (7.83%), acetamiprid (8.27%), flonicamid (12.17%), diafenthiuron (16.63%), imidacloprid + nimbecidine (17.17%), pyriproxyfen (18.50%), ethion (21.27%), and nimbecidine (24.17%) as compared to 42.30 per cent in untreated control plots. Nimbecidine was found the least effective treatment with maximum disease intensity of 24.17 per cent.

However, there was no significant variation among spiromesifen, imidacloprid (seed treatment), imidacloprid (foliar spray) and acetamiprid under field conditions.

Table 12: Evaluation of chemicals/Non-chemicals for the management of bitter gourd mosaic under field conditions

Treatment	Percentage of Disease Index (%)		
	30 DAT	45 DAT	60 DAT
Diafenthiuron	9.00 (17.46)	13.23 (21.33)	16.63 (24.07)
Acetamiprid	4.93 (12.83)	6.73 (15.04)	8.27 (16.71)
Pyriproxyfen	11.67 (19.97)	16.17 (23.71)	18.50 (25.47)
Flonicamid	7.00 (15.34)	9.00 (17.46)	12.17 (20.41)
Spiromesifen	4.23 (11.87)	5.83 (13.98)	6.50 (14.77)
Imidacloprid (Foliar spray)	5.17 (13.14)	6.67 (14.96)	7.83 (16.25)
Imidacloprid (Seed treatment)	5.13 (13.10)	6.47 (14.73)	7.50 (15.89)
Ethion	13.00 (21.13)	17.17 (24.48)	21.27 (27.46)
Nimbecidine	16.00 (23.58)	19.43 (26.16)	24.17 (29.45)
Imidacloprid + Nimbecidine	10.00 (18.43)	14.33 (22.25)	17.17 (24.48)
Control	22.67 (28.43)	33.17 (35.16)	42.30 (40.57)
CD (P= 0.05)	1.779	2.223	1.951

Figures in parentheses are transformed (angular) values
 DAT= Days after transplanting

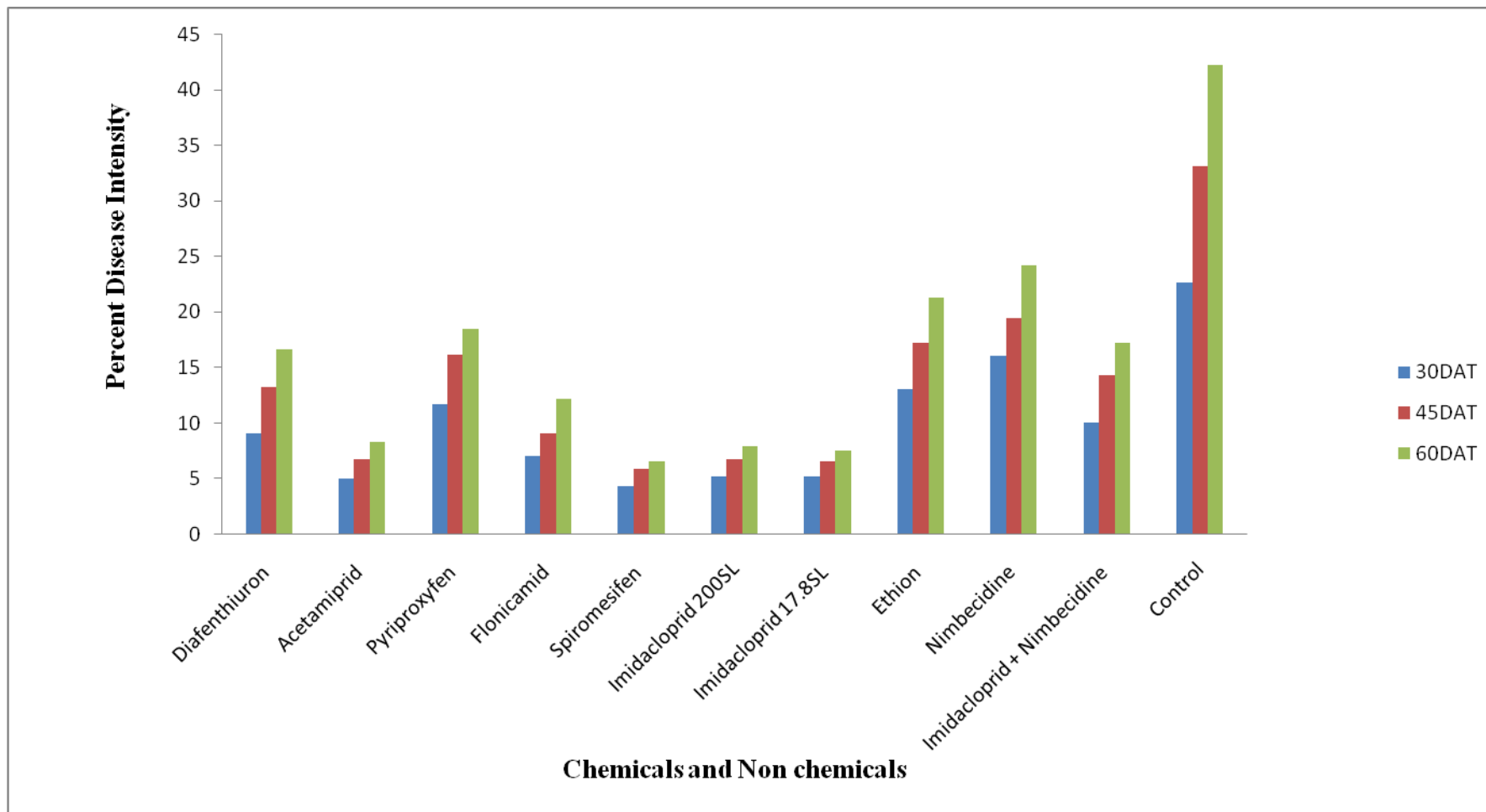


Fig 3: Evaluation of chemicals/non-chemicals for the management of bitter gourd mosaic under field conditions

Chapter-5

Discussion

DISCUSSION

Bitter gourd is one of the important vegetable crops in India. It is popular, due to its medicinal property apart from the high nutritional value. Diseases and pests were the major constraints in the cultivation of bitter gourd and among diseases major disease is a bitter gourd mosaic responsible for its low production.

In the present investigation, major objective was to combat the disease with an emphasis to determine its status and management by using suitable chemicals and non-chemicals.

The symptoms produced by bitter gourd mosaic disease under field conditions were yellow mosaic, upward curling of leaves and severe distortion of leaves. There was reduction in the length of internodes and leaves became smaller resulting in the stunting of plant growth. Fruits produced on diseased plants were small, deformed and stunted. Similar type of symptoms were also reported by Khan *et al.* (2003), Ali *et al.* (2010), Tahir *et al.* (2010), Tiwari *et al.* (2010), Nagendran *et al.* (2014) and Saha *et al.* (2014).

Extensive survey were conducted during summer season 2020 to ascertain the status of bitter gourd mosaic in Jammu province. It was observed that the percentage disease incidence (PDI) varied from 17.22 to 35.55 per cent in Marh block and it was maximum at village Gajansoo (35.55%) and minimum at Bhadrore (27.22%) while in block R.S. Pura maximum incidence of the disease was recorded at Badayal Brahmna (33.33%) and it was minimum at Kullian (19.44%). In Bishnah it was maximum (25.55%) at Makhanpur and minimum at Deoli (17.22%). The maximum incidence in Akhnoor block was recorded from Rajpura (33.88%) and it was minimum at pallanwala (23.66%). However the incidence of disease at Chatha farm was 28.33 per cent. The variation in disease incidence over locations might be due to survival of virus in different hosts and environmental conditions congenial for disease development. As has been observed in the present studies, Raj *et al.* (2010) also reported severe mosaic on bitter gourd (*Momordica charantia* L.) at different locations around Gorakhpur, Uttar Pradesh. Naik *et al.* (2019) conducted survey to record incidence of whiteflies (*Bemisia tabaci* Gen.) and viral diseases on bitter gourd at Bengaluru, Mandya, Mysuru, Tumkur, Kolar and Chikkaballapur districts of South

Karnataka. It was reported that during the Kharif season, incidence of bitter gourd mosaic disease ranged from 18.18 to 45.44 per cent with whitefly population of 2.54 to 6.51 per plant and in rabi season, disease incidence ranged from 27.00 to 48.85 per cent. Radhika *et al.* (2017) conducted a survey at five locations in Thiruvananthapuram district and recorded the highest incidence of bitter gourd mosaic (100 per cent) at Rajkumary, Palakkad, Panackatri and Thekkepotta.

Under field conditions the disease initiated during 12th standard week (SW) and there was an abrupt increase in the development of disease in all the germplasm at 20th SW, suggesting that, the most vulnerable stage of the crop was between 30 to 40 days after transplanting. Significant correlations between disease intensity in bitter gourd genotypes with weather parameters was recorded and it was found that, disease intensity showed significant and positive correlation with temperature (minimum and maximum) whereas, relative humidity (minimum and maximum) and rainfall had significant and negative correlation with the disease development. Multiple correlation coefficients indicated strong relationship between disease intensity and weather variables studied in the study showing that temperature, relative humidity and rainfall contributed more than 90 per cent in disease development in all the test genotypes. Thus it was observed that weather factors played a significant role in the development of disease. Similarly, Zacharia and Mathew (2016) reported that relative humidity showed negative co-relation with disease severity. Saikia (1993) also reported positive correlation between whitefly population and temperature and negative association with relative humidity. Naik *et al.* (2019) also reported negative correlation of relative humidity with disease development. Anzola *et al.* (2008) found a negative correlation between disease development and rainfall.

Bitter gourd germplasm was screened under natural epiphytotic conditions and it was found that maximum disease incidence ranged from 2.77 to 52.77 per cent. Out of eighteen germplasm lines Kathi Selection was highly resistant whereas, Pusa Hybrid 1 and Abhishek were resistant, Palee, F1 Hybrid-spl., Prachi F1, Liberty, Punjab 4 and Pusa Domausmi were moderately resistant, Jaunpuri long, Preethi, Jhalari Long and Jhalari Shilpa were susceptible and Vikrant, Monika, Co1, Araya and Aman were moderately susceptible to bitter gourd mosaic virus. This clearly indicated that test bitter gourd germplasm had variable response to resist the disease

as reported by various workers Purushothaman, (1994) and Arunachalam (2002) also screened bitter gourd germplasm under field conditions against bitter gourd mosaic and reported that genotypes IC 68296, IC68335, IC 682638, IC 68275, IC 68250A, IC 85620, IC 68312, IC 68285, IC 68272 were highly resistant whereas, IC 68330, IC 68338, IC 45339, IC 68310, IC 85618, IC 85633, IC 50523, IC 68286, IC 68232 were resistant genotypes. IC 68306, IC 85603, IC 444, IC 44436A, IC 85608, IIHR-89, MDU local, IC 32817 IC 85619/1(85606), IC 45341, IC 45351, IC 68230, IC 68295, IC 50520A, IC 68345 were moderately resistant whereas, genotypes IC 45346, IC 85611, IC 43261, IC 68294, IC 4441, Co 1, IC 683428, IC 85614, IC 68343, IC 85610, IC 68322, VKV 13S, IC 85605, IC 85616, IC 85624, KMK2, IC 68345, IC 85629, IC 68237, Preethi, IC 44419, IC 683 were moderately susceptible and Priyanka, IC 68326, IC 44114, KMKI, PB 1, Priya, IC 50516, IC 50527, IC 6825, IC 68292, IC44438, VKV 134, IC 65626 were susceptible. Similarly according to Thangamani *et al.*, (2011) out of various bitter gourd accessions screened genotypes Green long and Preethi were moderately susceptible to bitter gourd mosaic. Thus, the present investigations revealed that resistant sources are available against the disease and breeding bitter gourd cultivars resistant to mosaic virus and their development appears to be the best approach for management of the disease.

Among the chemical and non-chemical insecticides, spiromesifen recorded lowest disease intensity of 6.50 per cent at 60 days after transplanting (DAT) followed by imidacloprid (Seed treatment) with disease intensity (7.50%), imidacloprid (Foliar spray) with disease intensity (7.83%), acetamiprid (8.27%), flonicamid (12.17%), diafenthiuron (16.63%), imidacloprid + nimbecidine (17.17%), pyriproxyfen (18.50%), ethion (21.27%) and Nimbecidine (24.17). However, application of non-chemical nimbecidine was found least effective treatment. Based on the results, it is clear that the application of chemical insecticides like spiromesifen, imidacloprid, acetamiprid, flonicamid, diafenthiuron, pyriproxyfen, and ethion alone whereas imidacloprid in combination with nimbecidine were effective in minimizing the disease under field conditions. Bitter gourd mosaic disease has no other vector than the whitefly and spread of the disease under field conditions mainly depends upon its population and availability of source of virus inoculum. Several chemical insecticides have been tested to control the whitefly and many of them showed promising results as Zacharia and Mathew (2016) also reported that

imidacloprid 0.025 % was found effective in reducing bitter gourd mosaic disease. Webb *et al.*, (2007) tested spiromesifen, pyriproxifen, and buprofezin under field conditions and found that they reduce secondary spread within and between fields by slowing the increase of the whitefly population. Salam (2009) found that seed treatment with imidacloprid (5g/kg) followed by two sprays @ 0.24 ml/l recorded least disease incidence and whitefly populations. Several chemical insecticides have been tested to control the whitefly and many of them showed promising results (Sastry and Singh 1973 ; Singh 1977; Chelliah *et al.*, 1976; Datar, 1980; Krishna *et al.*, 1983; Nandihalli and Thontadarya 1986; Khan and Mukhopadhyay, 1985; Rustamani *et al.*, 1994; Borah *et al.*, 1996; Kumar *et al.*, 2001; Debnath and Nath, 2002; Kumar *et al.*, 2004; Ali *et al.*, 2005; Gowdar *et al.*, 2007; Das and Panjekar, 2009; Naik *et al.*, 2009; Salam *et al.*, 2009). The study showed that the incidence of bitter gourd mosaic disease could be checked by controlling the population of its vector by using chemical insecticides in proper spray schedule in the absence of suitable resistant cultivars.

Chapter-6

Summary and Conclusions

SUMMARY AND CONCLUSIONS

Bitter gourd (*Momordica charantia* L.) is a well-known and important *cucurbitaceous* vegetable in India. In Jammu province the crop is cultivated over an area of 365 hectares with the production of 5575.41Mts (Anonymous, 2016). Bitter gourd occupies a prominent place among vegetables owing to its high productivity and high medicinal value, good storability, long period of availability and better transport potentialities. Numerous medicinal properties of nearly all parts of the plant have been reported. The highest yield and the maximum returns make it the most preferred vegetable crop of farmers (Nandakumar 1999). Several viruses have been reported to infect bitter gourd naturally throughout the world causing enormous losses in respect of yield and quality of fruits. Among the various viral diseases affecting the crop, mosaic disease is a major problem worldwide, causing as high as 100 per cent losses (Ullman *et al.* 1991).

Extensive survey of bitter gourd fields conducted in different locations of Jammu province revealed that disease was prevalent in all the locations and per cent disease incidence (PDI) varied from 17.22-35.55 per cent with overall mean of 26.44 per cent. In Marh maximum disease incidence was recorded from village Gajansoo (35.55%) and minimum from Bhadore (27.22%) while in R.S. Pura the maximum incidence of the disease was recorded from Badayal Brahmna (33.33%) and minimum from Kullian (19.44%). In Bishnah block the maximum incidence of the disease (25.55%) was recorded from Makhanpur and minimum from Deoli (17.22%) while in Akhnoor block the maximum incidence of the disease was recorded from Rajpura (33.88%) and minimum from pallanwala (23.66%). However in Chatha Farm the incidence of disease was 28.33 per cent.

The characteristic symptoms of the disease were confined mostly to leaves and were expressed as yellow mosaic, upward curling of leaves, shortening of internodes, stunting of plant growth and distortion of leaves. Scattered, small, irregular yellowish patches was also seen on the leaves. Fruits produced on diseased plants were small, deformed and stunted.

The correlation of disease intensity on susceptible bitter gourd genotypes revealed that temperature (maximum and minimum) exhibited highly significant and positive correlation with disease development while relative humidity (maximum and minimum) and rainfall exhibited significant and negative correlation. Multiple correlation coefficients indicated that temperature (minimum and maximum), relative humidity (minimum), and rainfall had strong relationship with disease development on different bitter gourd germplasm. These findings can be used to develop a disease forecasting model to apply chemicals economically.

Eighteen bitter gourd germplasm lines were screened under field conditions against bitter gourd mosaic disease, and it was found that no germplasm was free from the disease. Kathi Selection was highly resistant whereas, Pusa Hybrid 1 and Abhishek were resistant and Liberty, F1 Hybrid-spl., Prachi F1, Palee, Punjab 4 and Pusa Domausmi were moderately resistant. Genotypes Jaunpuri Long, Preethi, Jhalari Long and Jhalari Shilpa were susceptible and Vikrant, Monika, Co1, Araya and Aman were moderately susceptible.

Field evaluation of various chemical and non-chemical insecticidal combination revealed that application of spiromesifen recorded the lowest disease intensity and thereby indicating their usage in the absence of any suitable variety. Similarly, foliar spray and seed application of imidacloprid was also effective in minimising the losses caused by the disease and its vector under field conditions. Acetamiprid was also effective in controlling the disease and reducing the whitefly population.

The following conclusions were thus drawn from the present investigations:

- The disease was prevalent in all the bitter gourd growing areas of Jammu province with disease incidence ranging from 17.22 to 35.55 per cent. The maximum PDI (35.55%) was recorded from Gajansoo village in Marh block whereas it was minimum (17.22%) at Deoli village of Bishnah block.
- The per cent disease intensity had positive correlation with temperature (maximum and minimum), and negative correlation with relative humidity (maximum and minimum) and rainfall.

- Out of eighteen germplasm lines screened against the disease, Kathi Selection was highly resistant whereas Pusa Hybrid 1 and Abhishek were resistant. Liberty, F1 Hybrid-spl., Prachi F1, Palee, Punjab 4 and Pusa Domausmi were moderately resistant. Genotypes Vikrant, Monika, Co1, Araya and Aman were found moderately susceptible whereas Jaunpuri long, Preethi, Jhalari Long and Jhalari Shilpa were susceptible to bitter gourd mosaic disease.
- Foliar spray of spiromesifen at 15 days interval was found effective in minimising bitter gourd mosaic under field conditions.



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CERTIFICATE-IV

Certified that all the necessary corrections as suggested by the external examiner and the advisory committee have been duly incorporated in the thesis entitled "Epidemiology and Management of Bitter Gourd (*Momordica charantia* L.) Mosaic" submitted by Ms. Mamta Devi, Registration No. J-18-M-577.


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Dated: 2.02.2021.