Official publication of Pakistan Phytopathological Society
Pakistan Journal of Phytopathology
ISSN: 1019-763X (Print), 2305-0284 (Online)
http://www.pakps.com

EFFECT OF ENVIRONMENTAL FACTORS ON CHILLI LEAF CURL DISEASE DEVELOPMENT IN CHILLI AND ITS MANAGEMENT

Muhammad S. Hussain, Khalid Naveed*
Department of Plant Pathology, University of Agriculture, Faisalabad, Pakistan.

A B S T R A C T

Leaf curl disease in chilli is an important yield constraint in chilli production in Pakistan and India. In this study, four chilli lines / varieties were grown under field conditions and development of disease on each variety was studied in relation to environmental factors. Effect of environmental factors including maximum and minimum temperature, rainfall and relative humidity on whitefly population and chilli leaf curl disease development was investigated throughout the crop growth period. Increase in maximum and minimum temperature resulted in increase in whitefly population. However, temperature was negatively correlated with disease development. Rainfall had a negative effect on whitefly population whereas it was positively correlated with disease development. Relative humidity was positively correlated with disease development whereas whitefly population was reduced due to increase in relative humidity. Extracts of neem, eucalyptus and akk were used for the management of disease at 1%, 2% and 5% concentrations which were found effective in disease management.

Keywords: Chilli leaf curl disease, temperature, relative humidity, rainfall, *Bemisia tabaci*

INTRODUCTION

Chilli is an important vegetable crop in Pakistan and ranks 3rd position among vegetables after potato and tomato. Capsicum (*Capsicum annuum* L.) is among the world most popular vegetable belonging to the family *Solanaceae* and is being used mainly as spices and condiments. There are about 15 different types of chilli characterized on the basis of color, shape and pungency (Berke, 2002). Commonly grown species of capsicum include *Capsicum annuum* and *Capsicum frutescens*. The immense horticultural, agricultural and biological diversity has helped to make *C. annuum* globally important as a fresh and cooked vegetable and a source of food ingredients for sauces and powders and as a colorant, which is used as well in cosmetics (Bosland and Votava, 2000).

Moreover, chilli is used medicinally and medically, and provides the ingredient for a non-lethal deterrent or repellent to some human and animal behaviors. Hot pepper comprises numerous chemicals including steam-volatile oil, fatty oils, capsaicinoids, carotenoids, vitamins, proteins, fiber and mineral elements (Krishna, 2003). Chilli peppers are also cultivated ornamentally especially for their bright glossy fruits with a wide range of colours (Cronin, 2002; Reilly *et al.,* 2001). Many chilli pepper constituents have importance for nutritional value, flavour, aroma, texture, and colour. The ripe fruits are especially rich in vitamin C (Marin *et al*., 2004). It is estimated that it is annually cultivated on more than 1.5 million hectares, in numerous countries. Forty-six percent of production is in Asia with China as the major chilli producing country. Southern Europe is the second most important chilli producing region, with 24% of world production. The countries with harvest area of more than 70,000 ha are China, India, Indonesia, Mexico, Korea, Nigeria, Ghana and Turkey (FAO, 2003).

In Pakistan, chilli is grown on 20% of vegetable area in all four provinces and its production is mainly concentrated in Sindh and Punjab and on small scale in Baluchistan and Khyber Pakhtunkhwa (Iqbal *et al*., 2012). Main varieties being grown are; Gola Pishawari,

Submitted: March, 16, 2017
Revised: May, 14, 2017
Accepted for Publication: December, 26, 2017
* Corresponding Author:
Email: khalid.naveed@uaf.edu.pk

Ghotki, Talhari, NARC-4, Kurni, Sanum, Tatapuri and Sky Line. Average consumption of chilli per capita per month is 80.50 gm.

Chilli crop is infected by a number of bacteria, fungi, nematodes, viruses, mycoplasmas, phytoplasmas and abiotic factors including temperature and soil pH also affect its yield. Diseases of viral nature are considered to be the major constraint to its production, resulting in heavy crop losses (Makkouk and Gumpf, 1974; Hameed *et al*., 1995). In Pakistan and some other parts of the world *Chilli leaf curl virus* (ChiLCV), *Chilli veinal mottle virus* (ChiVMV) and *Cucumber mosaic virus* (CMV) are the major viruses prevalent in chilli growing areas and reducing yield up to 60, 50 and 40%, respectively (Shah and Khalid, 1999). ChiLCV is the most important pathogen associated with chilli crop that results in severe yield losses in chilli crop (Shah *et al*., 2001). The disease is caused by a begomovirus that is transmitted by whitefly, *Bemisia tabaci* in persistent circulative manner. *Bemisia tabaci* acquires the virus through feeding on in infected plants and transmits it to healthy plants. Most of the chilli varieties being grown in Pakistan are susceptible to ChiLCV. To forecast the disease, epidemiological factors influencing disease development should be studied, so that keeping in view conducive environmental conditions different management strategies could be applied for disease management. In this study, four chilli varieties which are susceptible to *Chilli leaf curl virus* were grown to study the epidemiology of disease.

MATERIALS AND METHODS

To study the epidemiology of ChiLCV an experiment was conducted under natural field conditions in the research area of Department of Plant Pathology, University of Agriculture Faisalabad in 2015-16. Four varieties viz. Tatapuri, Talhari chilli, CH 100 and CBS1292 were used in the experiment. The experiment was conducted in randomized complete block design (RCBD) with three replications. Each variety was planted in a sub-plot with row length 3m, row to row spacing 2ft and plant to plant spacing of 1ft. The disease on each variety was assessed by coefficient of infection, according to the available disease rating scale on weekly basis (Kumar *et al*., 2006).

Epidemiological data: Data of weather parameters (maximum and minimum temperature, rainfall and relative humidity) was collected from the department of Crop Physiology, University of Agriculture, Faisalabad. The data of weather parameters was correlated with ChiLCV disease development and whitefly population data using regression analysis (Steel *et al*., 1997).

Evaluation of plant extracts for the management of whitefly and ChiLCV disease: Water-based extracts from fresh leaves of *Achyranthus aspera linn* (Aak), *Eucalyptus globus* (Safeda) and *Azadirachta indica* (Neem) were sprayed on whitefly infested chilli seedlings of Tatapuri chilli variety grown in pots under glass house conditions, at 1% and 2% concentration (deNardo *et al*., 1997; Gahukar, 2000). Distilled water served as control. The treatments were applied according to the following plan; T1: *A. aspera linn* (1%); T2: *E. globus* (1%); T3: *A. indica* (1%); T4: *A. aspera linn* (2%); T5: *E. globus* (2%); T6: *A. indica* (2%); T7: *A. aspera linn* (1%) + *E. globus* (1%); T8: *A. aspera linn* (1%) + *A. indica* (1%); T9: *E. globus* (1%) + *A. indica* (1%); T10: Control (distilled water)

Each treatment was replicated three times. The experiment was performed in completely randomized design and spraying was repeated fortnightly. Data regarding the appearance of disease symptoms, disease severity, disease incidence and whitefly population were recorded before and after treatment and subjected to analysis of variance. Individual comparison between treatments was done by Tukey's honestly significant difference test at 5% level of significance (Tukey, 1949).

RESULTS AND DISCUSSION

The epidemiological studies showed that environmental factors have a significant effect on leaf curl disease development and whitefly population. Correlation of maximum temperature with whitefly population and disease intensity was highly significant. For whitefly population, the correlation was indicated by 0.88, 0.92, 0.93 and 0.92 'r' values for four varieties. Positive correlation of maximum temperature and whitefly population suggested that the decreasing maximum temperature from October (33.5˚C) to January (19.6˚C) resulted in decrease in whitefly population (Figure 1). For disease intensity the correlation was indicated by -0.92, -0.89, -0.90 and -0.88 'r' values for four varieties. Maximum temperature during the growth period of the crop on the average ranged between 19.6°C and 33.1°C. Negative correlation of maximum temperature and disease intensity suggested that the decreasing maximum temperature from October (33.5˚C) to January (19.6˚C) resulted in increase in disease intensity (Figure 2). Minimum temperature during the growth period of the crop on the average ranged between 7.3°C and

20.2°C. With decrease in minimum temperature during the experiment period, there was increase in disease severity (Figure 4). Positive correlation of minimum temperature and whitefly population suggested that the decreasing minimum temperature from October (20.2˚C) to January (7.3˚C) resulted in decrease in whitefly population. Negative correlation of relative humidity and whitefly population suggested that the increasing relative humidity resulted in decrease in whitefly population whereas declining relative humidity favored the whitefly population. Positive correlation of relative humidity and disease intensity suggested that the increase in relative humidity favored the disease intensity whereas a decline in relative humidity resulted in slow disease development.

A negative correlation was found between rainfall and whitefly population. It suggested that the high rainfall resulted in decrease in whitefly population whereas less rainfall favored the whitefly population. Positive correlation of rainfall and disease intensity suggested that the more rainfall favored the disease intensity whereas less rainfall resulted in slow disease development. The results of the study were in accordance with the findings of Imran *et al*., (2013) who studied the effect of weather parameters on mosaic virus development on tomato cultivars. Maximum temperature had a significant effect on tomato mosaic disease development on three tomato lines. Relative humidity was negatively correlated with tomato mosaic virus disease development on different tomato varieties. The results of the study were also in accordance with the findings of Hassan *et al*., (1993) who studied the epidemiology of tomato viruses. In another study, it was found that tomato plants were easily with tomato mosaic virus by contact. ToMV persisted in dark space for three years however, it was deactivated within few weeks when placed in daylight (Broadbent and Fletcher, 2008).

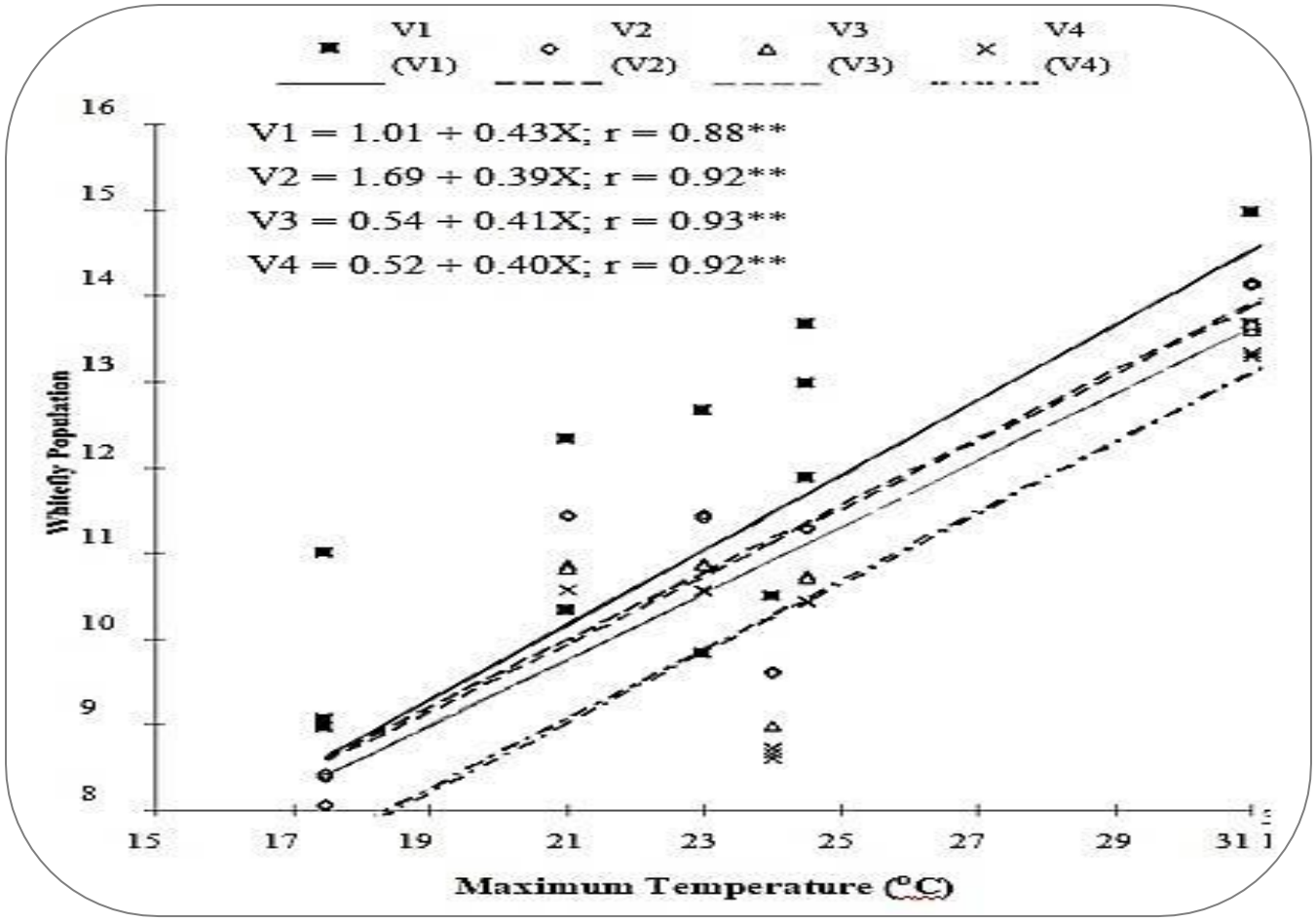

Figure 1. Correlation of maximum temperature with whitefly population in chilli

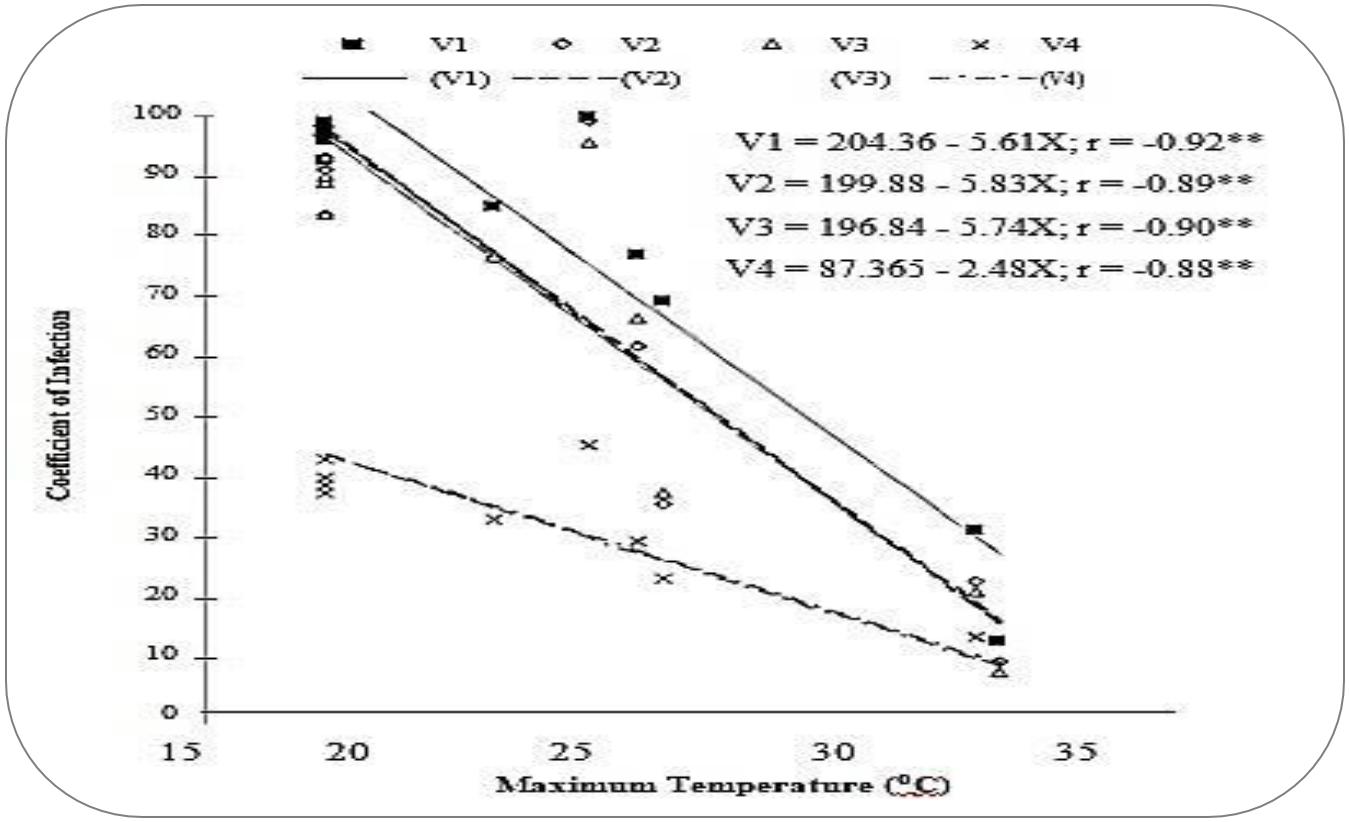

Figure 2. Correlation of maximum temperature with chilli leaf curl disease intensity on four chilli varietie

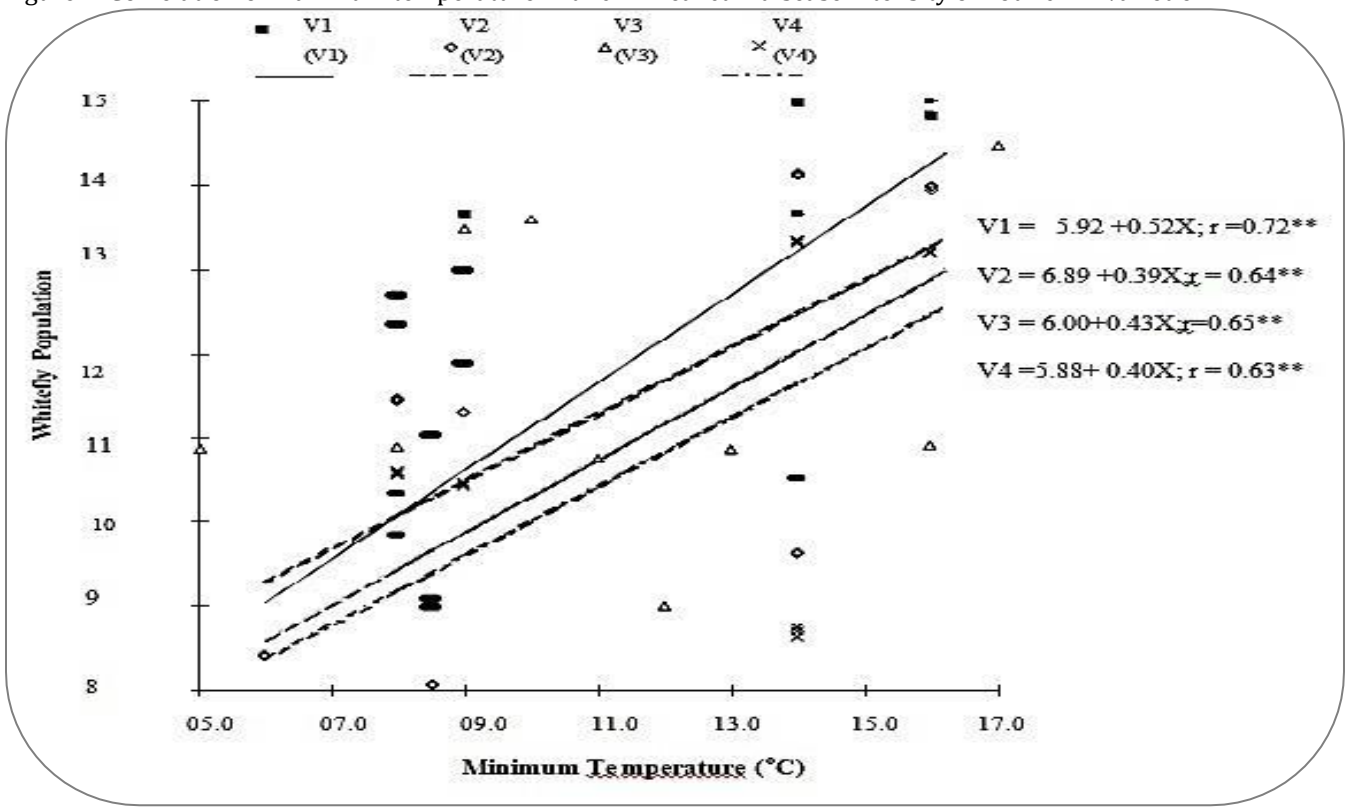

Figure 3. Correlation of minimum temperature with whitefly population on chilli

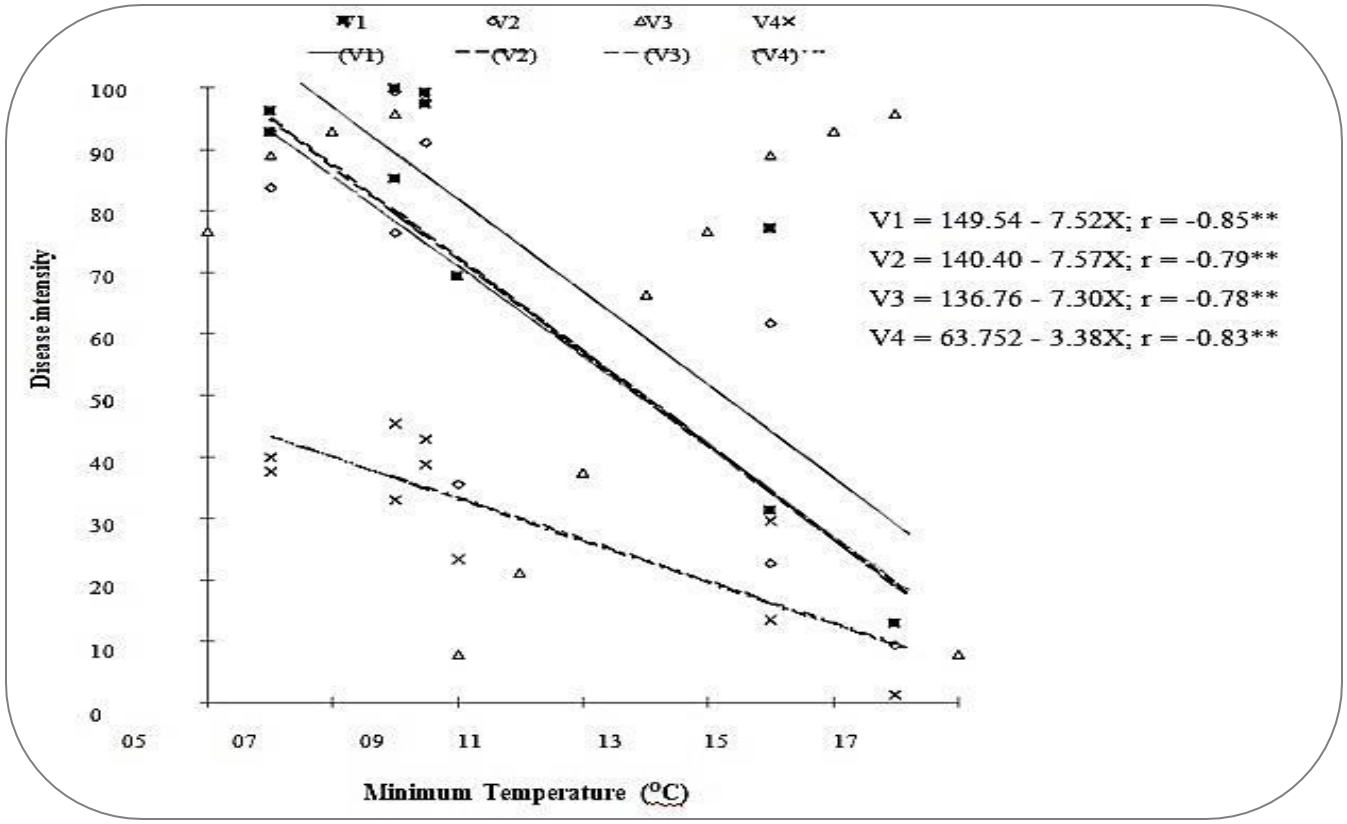

Figure 4. Correlation of minimum temperature with chilli leaf curl disease intensity on four chilli varieties

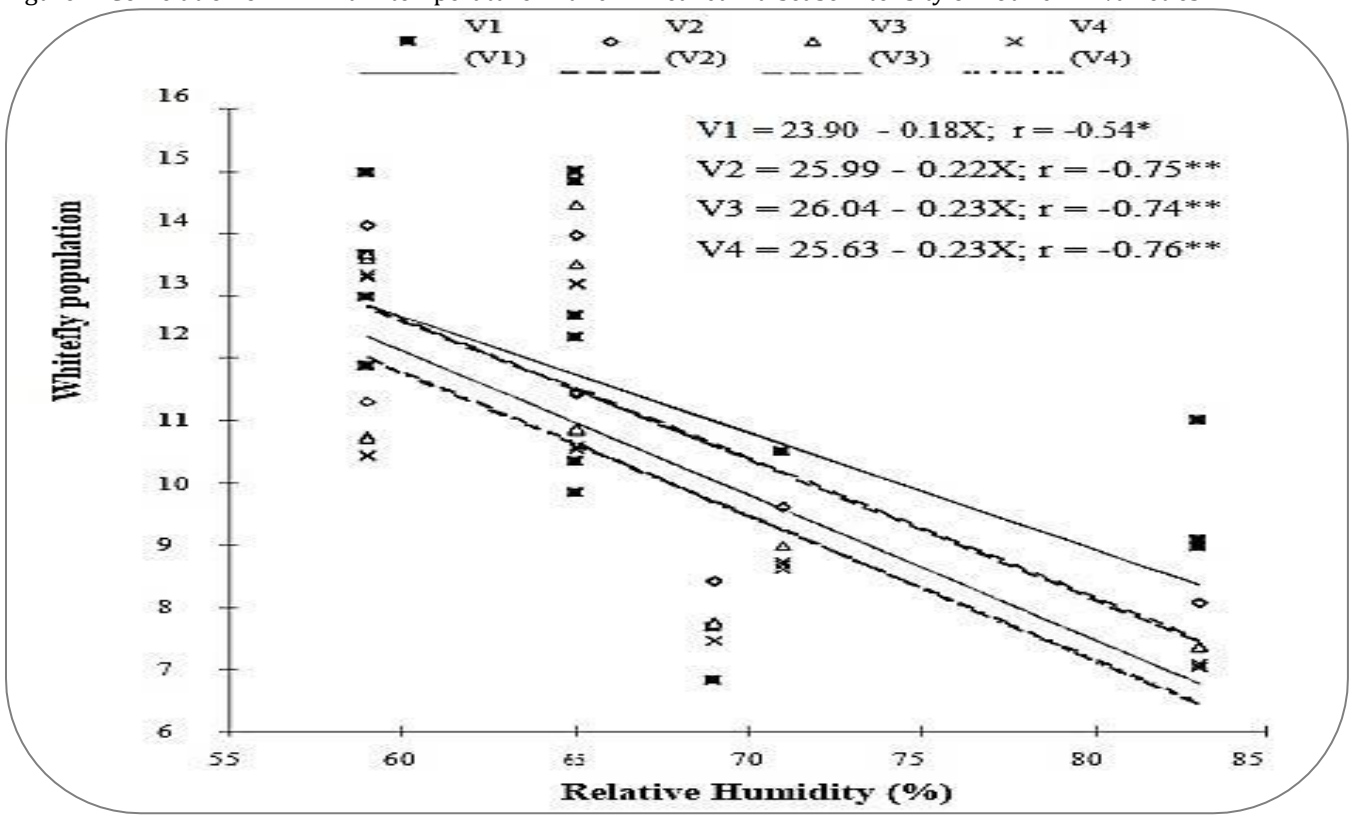

Figure 5. Correlation of relative humidity with whitefly population on four chilli varieties

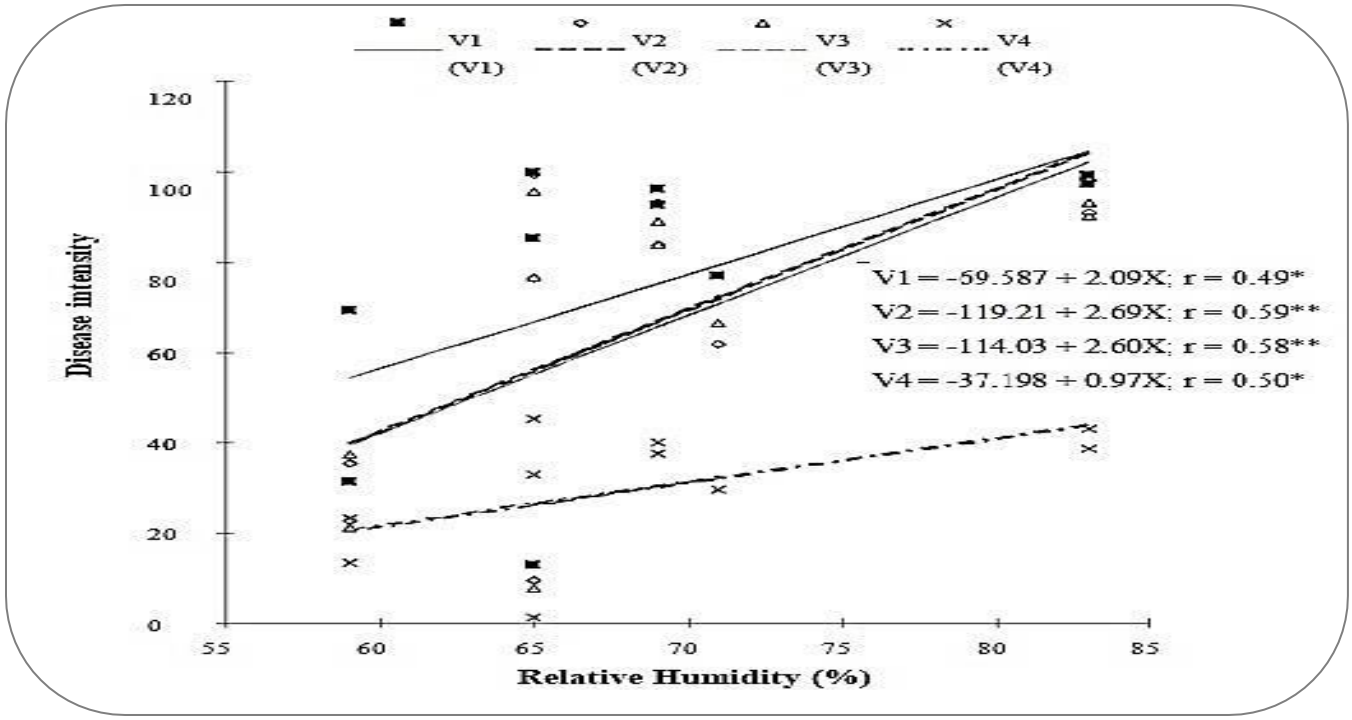

Figure 6. Correlation of relative humidity with chilli leaf curl disease intensity on four chilli varieties

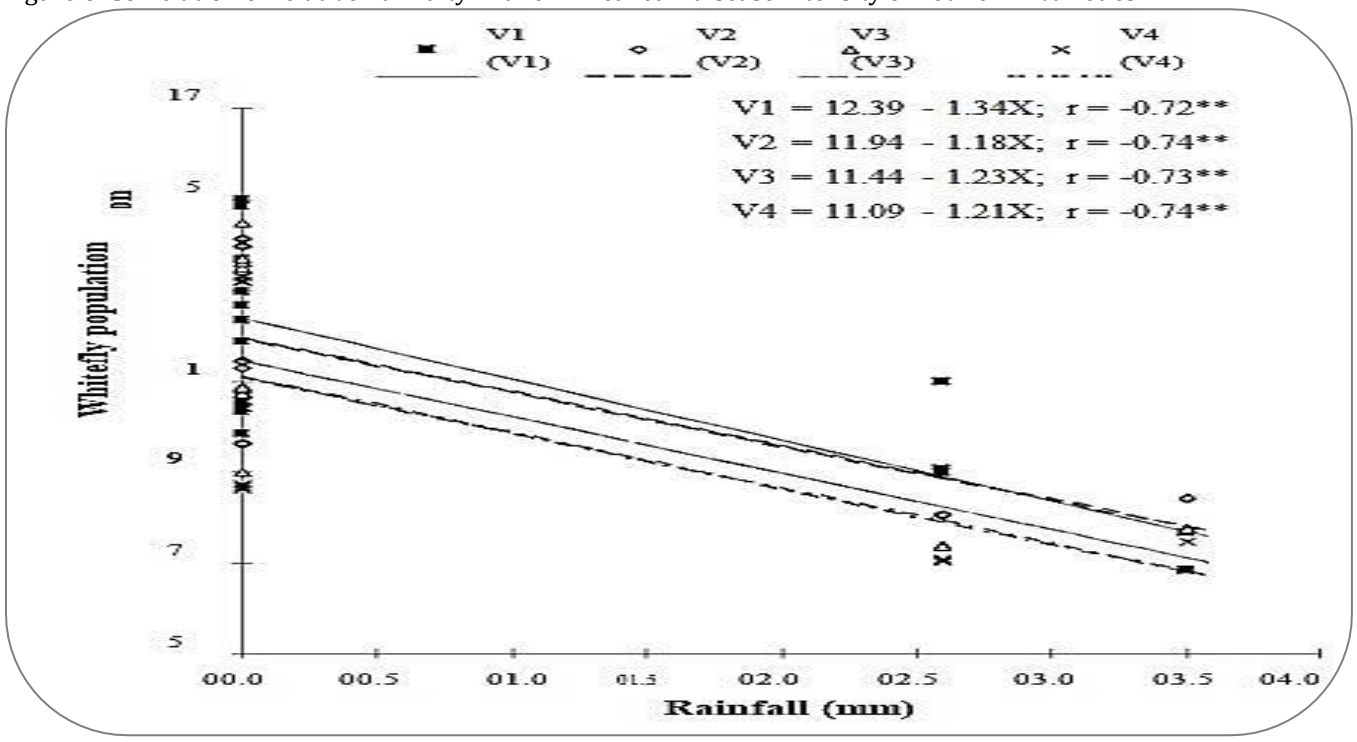

Figure 7. Correlation of rainfall with whitefly population on four chilli varieties

Efficacy of various plant extracts on whitefly population: Data regarding efficacy of plant extracts and time on whitefly population after 24 hours of spray are presented in table. The effect of treatments and times on whitefly population was highly significant. Maximum whitefly population (12.42) was observed in control (T10) followed by (T1) *A.aspera linn* 1% (8.29). T9 (*E.globus* 1% + *A. indica* 1%) gave best results with minimum whitefly population (2.00) followed by (T8) *A.aspera linn* 1% + *A. indica* 1% (2.38), (T7) *A.aspera linn* 1% + *E.globus* 1% (2.50) and (T6) *A. indica* 2% (2.75). T9, T8, T7 and T6 all were statistically at par. T5 (*E.globus*

2%) and T4 (*A.aspera linn* 2%) gave moderate results. T2 (*E. globus* 1%) and T3 (*A. indica* 1%) were statistically at par but both were only better than T1 (*A. aspera linn* 1%).

Whitefly population also significantly varied during the crop growth period. Maximum whitefly population was observed after 150 days of sowing i.e. in the 2nd week of February probably due to favorable environmental conditions. Minimum whitefly population was recorded between 105-120 days after sowing (DAS) i.e. in the first week of January. The time and treatment interaction was also found to be highly significant and exerted variable impact on whitefly population as evident from the given data. Liu *et al*. (2005) found that foraging adults of phytophagous insect were attracted by host-plant volatiles and repelled by volatiles from non-host plants.

According to Dimetry *et al*., (1996), who assessed the bioactivity of different formulations of neem seed extracts against the whitefly *Bemisia tabaci* (Gen.) in semifield trials during 1992, the high concentrations of all the extracts tested exhibited obvious activity. Also, the different treatments reduced the population density of the adult whiteflies compared with the control. The results were in accordance with the findings of Baldin *et al*., (2015) who studied the effect of different botanical plant extracts against whitefly in tomato. Aqueous plant extracts were used at 3% concentration from different plant strcutures of thirteen plant species. Leaf extract of *Toona ciliata* was found as most effective against eggs and adults of whitefly. Leaf extract of *Piper aduncum* had the greatest ovicidal effect whereas it does not have any effect on the eggs and adults of whitefly. Leaf extract of *Trichilia pallida* caused maximum mortality of adults. The study showed that aqueous leaf extracts of *Trichilia pallida*, *Toona ciliata*, and *Trichilia casaretti* can be used effectively for the management of biotype B on tomato.

	Whitefly Population								
	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS	120DAS	135DAS	150DAS	MEAN
A.A.L (1%)	10.0 b-f	10.3 b-e	8.33 b-h	8.67 b-g	6.33 d-l	7.33 c-j	7.67 c-i	7.67 c-i	8.29 B
E.G. (1%)	5.00 g-m	6.00 e-m	5.33 f-m	4.67 g-m	4.67 g-m	3.33 i-m	5.67 e-m	6.67 d-k	5.17 C
A.I. (1%)	4.33 g-m	5.67 e-m	6.00 e-m	4.33 g-m	4.33 g-m	3.33 i-m	5.33 f-m	6.00 e-m	4.91 C
A.A.L (2%)	4.33 g-m	5.00 g-m	3.67 h-m	4.00 g-m	2.33 k-m	3.67 h-m	4.33 g-m	6.33 d-l	4.20 CD
E.G. (2%)	3.00 i-m	4.00 g-m	2.33 k-m	3.00 i-m	2.67 j-m	2.67 j-m	4.00 g-m	3.33 i-m	3.12 DE
A.I. (2%)	3.00 i-m	2.67 j-m	3.00 i-m	2.33 k-m	2.00 k-m	2.00 k-m	3.67 h-m	3.33 i-m	2.75 E
A.A.L+E.G.	2.67 j-m	2.00 k-m	2.67 j-m	2.67 j-m	2.00 k-m	2.00 k-m	3.00 i-m	3.00 i-m	2.50 E
A.A.L+A.I.	2.33 k-m	2.67 j-m	2.67 j-m	1.67 lm	2.00 k-m	2.00 k-m	3.00 i-m	2.67 j-m	2.38 E
E.G.+A.I.	2.00 k-m	2.33 k-m	2.00 k-m	2.00 k-m	2.00 k-m	1.33 m	2.33 k-m	2.00 k-m	2.00 E
Control	12.6 ab	12.6 ab	15.3 a	10.0 b-f	11.0 a-d	10.3 b-e	12.0 a-c	15.3 a	12.4 A
MEAN	4.93 A-C	5.33 AB	5.13 AB	4.33 B-D	3.93 CD	3.80 D	5.10 AB	5.63 A	

Treatments	Coefficient of Infection								
	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS	120DAS	135DAS	150DAS	MEAN
A.L (1%)	0.67 q	6.25 m-q	15.8 h-n	23.3 e-h	29.1 d-g	37.0 d	51.2 c	56.2 c	28.1 B
E.G. (1%)	0.33 q	4.17 m-q	9.17 j-q	12.5 h-q	14.1 h-p	22.0 e-i	31.2 d-f	36.2 d	16.4 C
A.I. (1%)	0.58 q	4.17 n-q	6.25 m-q	12.5 h-q	17.1 h-p	19.1 f-l	20.8 e-k	32.0 de	13.7 CD
A.A.L (2%)	1.00 q	4.58 n-q	7.08 l-q	7.50 l-q	8.33 k-q	18.3 g-m	20.8 e-k	22.5 e-h	11.2 DE
E.G. (2%)	0.00 q	1.25 n-q	1.42 q	3.50 n-q	8.33 k-q	9.17 j-q	14.1 h-p	22.5 e-h	7.54 F
A.I. (2%)	0.33 q	1.00 q	2.83 o-q	6.25 m-q	7.50 l-q	11.6 h-q	19.1 f-l	30.0 d-g	9.84 EF
A.A.L+E.G.	0.17 q	0.75 q	0.92 q	5.00 n-q	6.25 m-q	7.50 l-q	14.5 h-o	21.6 e-j	7.10 F
A.A.L+A.I.	0.17 q	0.25 q	0.58 q	1.75 p-q	3.75 n-q	5.83 m-q	7.92 l-q	9.58 i-q	3.72 G
E.G.+A.I.	0.25 q	0.25 q	0.25 q	0.50 q	0.50 q	3.75 n-q	5.42 n-q	7.08 l-q	2.19 G
Control	0.25 q	7.92 l-q	18.3 g-m	32.5 de	53.7 c	70.8 b	91.6 a	98.3 a	47.3 A
MEAN	0.38 H	3.02 G	6.27 F	10.5 E	14.5 D	20.5 C	27.7 B	33.7 A	

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