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EFFECT OF POPULATION DYNAMICS OF THRIPS ON BLEMISHES IN RELATION TO ABIOTIC FACTORS ON FRUITER EARLY CULTIVAR OF CITRUS

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ABSTRACT

Thrips are serious pests of crops, vegetables and fruiting trees. Various species of thrips infest citrus at fruit formation as well as the new leaves sprouts. Their presence and damage ultimately reduce the export value of fruits, therefore, field studies were carried out to check the biodiversity of citrus thrips on a citrus cultivar fruiter early in experimental and commercial orchards of Faisalabad for pest abundance. Studies were focused on the population of thrips with particular reference to temperature and humidity population, ring spots formation on fruits and thus observe the causes of citrus blemishes in orchards in relation to insect pests. The species collected were identified with the help of available literature. Determining the relationship of citrus blemishes with respect to thrips showed that the temperature and relative humidity have a direct relation to the population of thrips. Results revealed that female and male thrips show significant relation to temperature and humidity on flowers, branches, fruits and leaves. Rainfall was significantly negatively correlated while highly significant in negative correlation on flowers, branches and leaves. Effect of humidity on the population of thrips was found significantly negatively correlated while the temperature was positively correlated with the different life stages of the population of thrips at different plant parts. It was conclusive from the study that the population of thrips was positively correlated with blemishes and ring spot formation of fruiter early.

Keywords: Population dynamics, Thrips, Citrus, Fruiter Early, Biotic and Abiotic factors

INTRODUCTION

Climates that receive moderate to high rainfall, temperatures and humidity experiences high insect, weed, and disease pressure (Morelissen and Harley, 2007). While working with the citrus orchards farmer faces problems including diseases, insects and many other factors, including the irrigation problems, injuries and also nutritional wind loses (Ashraf *et al.,* 2015, Khan *et al.,* 2016). While diseases such as citrus canker (Ashraf *et al.,* 2014), fungal diseases (Mustafa *et al.,* 2013), wither tip dieback (Raza *et al.,* 2019), citrus tristeza virus (Stewart *et al.,* 2014) and most important disease is citrus greening (Batool *et al.,* 2007) posing a tremendous threat to citrus orchards. In case of insects and parasites citrus is host to a wide range of insect pests, including the scales (Hollingsworth, 2005), citrus leaf-minor (Bellows and Morse, 1993), thrips (Broughton and De Lima, 2002; Conti *et al.,* 2003; Grafton-Cardwell and Gu, 2003), mites (Vacante, 2010) and citrus psyllid (Grafton-Cardwell *et al.,* 2005). Aphid is also known to be the vector of Citrus Tristeza Virus (Loconsole *et al.,* 2012) many of the other insects also attacks on citrus plants but less number of these cross the economic thresh hold level (Hunter *et al.,* 2011; Mahmood *et al.,* 2014). The study was focused on Thrips (Thysanoptera) which exist in a wide array of habitats and hosts (Yudin *et al.,* 1986), almost all types of ecological habitats like grasslands, forests gardens and crops (Ananthakrishnan and James, 1983). Studies in the last one to two decades shows that thrips has become a prominent pest of many crops (Lewis, 1973; Ananthakrishnan, 1984; Lacasa and Llorens, 1996; Mound and Marullo, 1996; Lacasa and Llorens, 1998; Bielza *et al.,* 2007; Morsello *et al.,* 2014). Many of the species from this order (Thysanoptera) attacks the plants (Batool *et al.,* 2007). This insect can cause either direct damage by feeding or

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indirect effect by transmitting pathogens (Mound and Teulon, 1995). Thrips are playing various roles in the cropping and ecological system as they act as phytophagous (McLeish *et al.,* 2007), mycophagous (Nagrale, 2012), carnivorous predators (Cox *et al.,* 2006), gall makers (Raman, 2003), pollinators (Peñalver *et al.,* 2012) and vector transmitter (Maharijaya *et al.,* 2011). These insects can survive in a variety of conditions and environments even on plant litter and maybe in dead or living bark of trees (Vierbergen, 2004; Mirabbalou, 2013). Many species are serious economic pests of various crops (Okajima and Masumoto, 2014).

These insects feed on leaves, flowers and twigs and also on the fruits (Ananthakrishnan and Parkash, 1982). Feeding injury by these species results in scarring of rind tissue in a fairly uniform ring encircling the stem end of the fruit and subsequent rind blemish injury results in the rejection of fruit for the fresh market (Baker *et al.,* 2011). The damage is not only by feeding but also by the oviposition on the different parts of the plants (Bournier, 1983). Young twigs, leaves, and leaf buds are also fed upon by citrus thrips resulting in non-economic types of injury to the trees (Costa *et al.,* 2006). Both nymphal and adult stages feed on plants and show their presence by damage but nymphs do much than the adults because they are less mobile (Kawai, 1995). Eggs are oviposited in the tissues of host plants, both larval and adult stages are active and they do the most damage, the second stage of larvae mostly search for a safe place for pupation and mostly select soil, leaf litter or in the debris (Kumm and Moritz, 2008). Thysanoptera has piercing-sucking type of mouthparts by which they pierce the epidermis and suck the exuding fluid (Reitz, 2009) when they rupture the epidermis tissues and suck the sap the walls of those effected cells collapses (Conti *et al.,* 2003). The well-known "tear staining" and "russety marking" in oranges, also known as brown scares are caused by the feeding of citrus thrips (Blasco *et al.,* 2007; Belaam and Boulahia-Kheder, 2012).

Keeping in view the importance of this pest, present study is focused on the population dynamics of citrus thrips and scaring of citrus fruit due to feeding effect of thrips and indicates the damage pattern in the orchards on five different cultivars with relation to the different climatic factors of agro-ecosystem of Faisalabad.

MATERIALS AND METHODS

Sampling Locality

The study was carried out at Entomological Areas (Square No. 9), University of Agriculture, Faisalabad, from 04-06-2017 to 04-01-2018. The selection was based on the availability of the required cultivar of citrus.

Sampling Protocol

Data was collected on feeding preferences, population dynamics of thrips on a non-transgenic cultivar of citrus. The comparative population of nymphs and adults both winged and wingless along with most preferred feeding sites was collected from leaves, branches, flowers and fruits (Childers and Nakahara, 2006). Effect of abiotic factors on the population of thrips, impact of insecticide application on thrips population and also the time of appearance of thrips after the application of insecticide in the field, population of thrips and species at the time of picking along with the abundance of thrips either at upper, middle or lower part of the plant was noted (Grove *et al.,* 2000). Composition of species i.e. male and female proportion, stage of plant at which maximum infestation occurs along with temperature and relative humidity was recorded (Kudô, 1989). To collect data proper boundaries of the field were kept in mind and twenty (20) plants were selected and also marked. Population and all other parameters were observed from four sides of each plant thrice a day morning, midday and evening twice a week (Morishita, 2005).

Insect collection

Thrips were collected either by removing them directly from the surface of the foliage with the help of a fine wet camel-hair brush or by dusting leaves, branches, flowers and small fruits on white paper or white plastic tray and thereafter picking them up by wet camel brushes (Froud *et al.,* 2001). Finally, these were put in vials containing 75% ethanol and two drops of glycerin and labeled (Tanigoshi *et al.,* 1985).

Dehydration

1. About alcohol (60%) was replaced with 10 % alcohol and left for 1 hour; un-macerated specimens were punctured to speed the entry of alcohol; the legs, antennae and wings were then spread (Akbarzadeh and Shayesteh, 2006).
2. Alcohol (10%) was replaced with 80, 95 and 100% absolute alcohol and left for 20, 10 and 5 minutes respectively (Shoukat and Shayesteh, 2006).
3. Absolute alcohol was replaced with fresh absolute alcohol and left for another 5 minutes.
4. Absolute alcohol was then replaced with the clove oil and left for about half an hour before mounting (Akbarzadeh and Shayesteh, 2006).

Mounting

1. A small mounting block was prepared by fixing a 2 mm deep layer of 1-inch square white card on to the center of this was marked with crossed lines and then covered it with plastic (scotch) tape to have a clean, shiny surface (Rafter and Walter, 2012).
2. A clean 13 mm- diameter coverslip was placed onto the mounting block; a drop of Hoyer's medium was put on to the center of the cover slip and a thrips sample with ventral side up-ward was placed into it (Greenberg *et al.,* 2009).
3. The legs and wings were spread and the antennae were straightened by pressing on the basal segments with a fine needle. The specimen was left as such for 5 to 10 minutes (Childers and Stansly, 2005).
4. Then another drop of Hoyer's medium was placed on the coverslip having the specimen and a microscopic slide was placed on it (Tekşam and Tunç, 2009).
5. The slide was then inverted in order to have the dorsal side of the specimen upward, re-examined the specimen under the binocular and final adjustment of the body parts was made by gently pressing the coverslip (Aliakbarpour and Rawi, 2010).
6. The slides were bubbled off by heating them under the ordinary electric bulb (Rafter and Walter, 2012).

Identification

For identification, the literature of Stannard, 1968; Pitkin, 1976; Palmer and Mound, 1979; Ananthakrishnan and Sen, 1980; Saeed and Yousaf, 1994 and Mirab-balou *et al.,* 2017 was followed. The labeled specimens were identified properly by using the swift microscope M 3300D with different magnifications of 40 X, 100 X and 400 X fitted with a camera (Childers *et al.,* 1990).

Statistical Analysis

The data collected was analyzed statistically by applying Fisher's ANOVA technique and least significant difference test was applied at 5% probability level to test the significance of the treatment means. All the population data was statistically correlated with all abiotic factors considered in this study.

RESULTS

Data revealing the population dynamics of thrips, predators, parasitoids and other insects before and after application of pesticides on fruiter early cultivar of citrus is given in tables. The population of thrips and other insects was recorded on leaves, branches, fruits and flowers in relation to abiotic factors. Analysis of population data resulted in a significant difference in the population of thrips and all other insects (predators and parasitoids) from the observations before and after the application of insecticides in the citrus orchards.

The mean population of thrips was higher (2.74) than after application (0.60) of insecticide on the fruiter early cultivar in the area of Faisalabad in all six different locations where the sampling was done regarding the date intervals. Same is the case with all other insects' pests observed in the same locations there was a significant difference in the population before (9.65) and after (1.65) the application of the insecticide but the population of the predators was not affected much by this action of the insecticides applied at different intervals (Table 1).

As represented by the figures, the temperature and humidity are positively correlated to the population of thrips in the orchards of fruiter early in Faisalabad area. Different plant parts show different levels of significance for population of both males and females. The values of the immature fruits ranging from 0.001 to 0.003 for female and 0.002 to 0.007 for male show its significance that thrips on the immature fruits is relative to the temperature and humidity as the temperature increase population of thrips increase and cause more blemishes to the fruits in the form of rings on the stem end

Table 1

Descriptive statistics for population of thrips, predators, parasitoids and other insects before and after the insecticidal application regarding fruiter early.

Population of insects		Mean	N	SD	SEM
Thrips	Before IA	2.74	350	1.702	0.091
	After IA	0.60	350	0.56	0.021
Predators	Before IA	0.61	350	0.839	0.045
	After IA	0.61	350	0.839	0.045
Parasitoids	Before IA	0.00	350	0.000	0.000
	After IA	0.00	350	0.000	0.000
Others insects	Before IA	9.65	350	9.650	0.560
	After IA	1.65	350	1.650	0.172

IA = Insecticidal application; **N** = Number of observations, **SD** = Standard deviation; **SE** = Standard error of mean

Table 2

Correlation between thrips population on leaves of fruiter early and the environmental factors (temperature, humidity and rainfall).

Thrips population on leaves	Temperature	Humidity	Rainfall
Leaves (Mature male)	0.449**	-0.189**	-0.078
P-value	0.000	0.000	0.144
Leaves (Mature female)	0.219**	-0.132*	-0.126*
P-value	0.000	0.013	0.018
Leaves (Immature male)	0.264**	-0.071	-0.025
P-value	0.000	0.186	0.645
Leaves (Immature female)	0.123*	-0.041	0.062
P-value	0.022	0.449	0.247

Upper values indicated Pearson's correlation coefficient; Lower values indicated level of significance at 5% probability.
* = Significant ($P < 0.05$); ** = highly significant ($P < 0.01$)

Table 3.
Correlation between thrips population on branches of fruiter early and the environmental factors (temperature, humidity and rainfall).

Thrips population on branches	Temperature	Humidity	Rainfall
Branches (Mature male)	0.189**	-0.095	-0.004
P-value	0.000	0.077	0.934
Branches (Mature female)	0.303**	-0.007	-0.168**
P-value	0.000	0.891	0.002
Branches (Immature male)	0.152**	-0.067	0.103
P-value	0.004	0.211	0.054
Branches (Immature female)	0.231**	-0.216**	-0.122*
P-value	0.000	0.000	0.022

Upper values indicated Pearson's correlation coefficient; Lower values indicated level of significance at 5% probability.
* = Significant ($P < 0.05$); ** = highly significant ($P < 0.01$)

Table 4.
Correlation between thrips population on flowers of fruiter early and the environmental factors (temperature, humidity and rainfall).

Thrips population on flowers	Temperature	Humidity	Rainfall
Flowers (Mature male)	0.307**	-0.188**	-0.156**
P-value	0.000	0.000	0.003
Flowers (Mature female)	0.124*	0.032	-0.139**
P-value	0.020	0.547	0.009
Flowers (Immature male)	0.164**	-0.086	-0.075
P-value	0.002	0.109	0.159
Flowers (Immature female)	0.120*	0.143**	-0.023
P-value	0.025	0.007	0.664

Upper values indicated Pearson's correlation coefficient; Lower values indicated level of significance at 5% probability.
* = Significant ($P < 0.05$); ** = highly significant ($P < 0.01$)

Table 5.
Correlation between thrips population on fruits of fruiter early and the environmental factors (temperature, humidity and rainfall).

Thrips population on fruits	Temperature	Humidity	Rainfall
Fruit (Mature male)	0.146**	0.052	-0.008
P-value	0.006	0.332	0.886
Fruit (Mature female)	0.097	-0.108*	-0.123*
P-value	0.071	0.044	0.022
Fruit (Immature male)	0.161**	-0.002*	-0.039
P-value	0.002	0.007	0.471
Fruit (Immature female)	0.159**	0.192**	-0.174**
P-value	0.003	0.001	0.001

Upper values indicated Pearson's correlation coefficient; Lower values indicated level of significance at 5% probability.
* = Significant ($P < 0.05$); ** = highly significant ($P < 0.01$)

(Table 5). Population relation to these two factors on flowers (Table 4), branches (Table 3) and leaves (Table 2) was also found significant. The differences are because of the inner and outer position of the plant parts inner parts receive more population and outer parts have less of their number. Effect of rainfall on the population of thrips was found significantly negatively correlated with the population of mature females from leaves (-0.126) while mature females (-0.168) and immature females (-0.122) were also significantly negatively correlated on braches of citrus. Similarly mature males (-0.156) and females (-0.139) were highly significant in negative correlation on flowers while negative correlation between population of thrips and rainfall on fruits was also significant for mature females (-0.125) and immature females (-0.174).

Effect of humidity on the population of thrips was found significantly negatively correlated on the population of mature males (-0.189) and mature females (-0.132) from leaves while immature females (-0.216) were also highly significantly negatively correlated on braches of citrus. Similarly mature males (-0.188) highly significantly negatively correlated but immature females (0.145) were highly significant in positive correlation on flowers while a negative correlation between the population of thrips and rainfall on fruits was also significant for mature females (-0.108), immature females (-0.192) and immature males (-0.002). In comparison to rainfall and humidity, the effect of temperature on the mature and immature population of both male and female thrips was recorded positively correlated except on the mature female population observed on fruits of citrus (Tables 2-5).

DISCUSSION

The population of thrips was very much dependent on the temperature and relative humidity as found in the results of the study. The population increased with increase in temperature however the results of (*Raza et al.,* 2015) showed higher thrips population on *Bt*. cotton in different varieties. This may be due favorable environmental conditions or varietal response yet these results correlate with other findings (Men *et al.,* 2005; Naveen *et al.,* 2007) and the present study. Temperature and relative humidity may fluctuate the population and rate of population elevation of thrips may be intrinsically influenced (Murai, 2000). Diversity of weather factors such as relative humidity and temperature are positively associated with population of cotton thrips (Li *et al.,* 1992) which completely aligns with the findings of current study and Malik *et al.* (2010).

The results of this study are in complete agreement with a study of Wahla *et al.* (1996) from Pakistan where the population of thrips was found negatively correlated with the air temperature at a minimal level, relative humidity and rainfall. The population of thrips is found significantly dependent on abiotic factors such as wind, relative humidity, rainfall and temperature (Ananthakrishnan, 1993; Legutowska, 1997; Lewis 1997). Lack of rainfall along with high temperature affected thrips population in onion fields positively while increase in rainfall and relative humidity reduced the population of thrips (Hamdy and Salem, 1994) as it was concluded in the present study.

Insecticides showed significant results on the population of all insects but some predators known to be ladybird beetle larvae (Coccinallidae) and lacewing larvae (*Chrysoperla* spp.) showed less mortality as compared to the other pests. So this study led us to the result that damage to the different citrus cultivars causing ring scaring was due to *Heliothrips haemorrhoidalis* Bouche as described earlier by Roditakis and Roditakis, 2007 and Hyun *et al.* (2012). On the other hand, *Megalurothrips kellyanus* (Bagnall) was also found to be damaging on citrus fruits for ring scaring as described earlier by Blank and Gill, 1997. Most of the population of the thrips was found on the leaves and flowers but the immature population was abundant on the flowers which mean the breeding site for the thrips is flowers. The other species of thrips found in citrus are *Scirtothrips citrii*, *Danotothrips trifasciatus*, *Haplothrips gowdeyi* and *Thrips meridionalis* collected from the six citrus orchards from the citrus plants and also from the vegetation other than citrus especially weeds as reported earlier (Khan and Morse, 1999; Malik *et al.,* 2004; Malik *et al.,* 2010; Khan *et al.,* 2012).

CONCLUSION

From the results of present study, it is concluded that different species of thrips are involved in ring scaring of citrus in different cultivars. Temperature and humidity affect the population and tended to increase the number of thrips but rainfall instantly decreases the number of thrips by washing it down to the soil from the plant but thrips hiding beneath the petal of the fruit and is safe from direct rain splash and also from the insecticidal touch.

Authors' contributions

MAF, BA and SN designed the study and wrote the manuscript with input from all authors. MJA, MJS and MAA analyzed the data while MFAand MBAhelped to improve the manuscript. All authors read and approved the final manuscript.

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