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Occurrence and seasonal abundance of *Thrips tabaci* Lindeman on onion in the north transition zone of Karnataka, India

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ABSTRACT: Studies were conducted in four consecutive seasons from *kharif,* 2022 to *rabi,* 2023, on onion crop to understand the thrips, *Thrips tabaci* Linderman incidence. The identity of the species was confirmed through morphological characteristics as well as sequence amplified product of *Cytochrome c oxidase subunit I (COI)* gene (GenBank No. PP838743). The phylogenetic analysis revealed that the *T. tabaci* population is closely related to the sequence of MZ882441 and MT991561 from China and New Delhi, India, respectively. Incidence in the *Kharif* season has experienced minimal thrips infestation compared to the *Rabi* season, where severe infestation was noted. The peak thrips population occurred in the 6th Standard Meteorological Week (SMW) of 2022 and 2023, highlighting the role of weather in thrips population dynamics. Correlation analysis indicated that maximum temperature exhibited a significant positive correlation, while relative humidity showed a significant negative correlation. Additionally, rainfall was found to have a cleansing effect on thrips populations, resulting in lower incidences during the *Kharif* season. However, during the *Rabi* season, the coincidence of higher temperatures with low relative humidity contributed to the proliferation of thrips, making them a significant threat to bulb onion production. This study provides a comprehensive information on the occurrence, species confirmation, nature of damage, seasonal incidence and associated weather parameters with *T. tabaci* in onion crops.

Keywords: correlation, *Cytochrome c oxidase subunit I*, incidence, population dynamics, thrips.

INTRODUCTION

Onion, *Allium cepa* L. (Amaryllidaceae), is one of the most widely cultivated and consumed vegetables worldwide. India is the second largest producer of onion in the world, next only to China, and the crop occupies an area of approximately 1.94 million hectares, with a production of 26.64 million MT in the year 2021. Karnataka is ranked the highest onion producer, next to Maharashtra in India. However, the onion market in India is often volatile due to various factors such as weather conditions, pest infestations and fluctuations in demand and supply. Among the biotic factors, onion thrips, *Thrips tabaci* Lindeman (Thysanoptera: Thripidae) is the consensus important pest. The thrips, *T. tabaci* is one of the most economically important insect pests of onion and causes significant yield loss worldwide (Gill *et al.,* 2015). Larvae and adults mainly cause economic damage, and reducing the photosynthetic processes produces smaller bulbs (Boateng *et al.,* 2014). However, the pest status of onion thrips can be attributed to various factors, *i.e.,* polyphagous nature, high reproductive rate, short generation time, high survival of cryptic (non-feeding pre-pupa and pupa) instars, and ability to reproduce without mating. The damage due to the thrips in onion induces more excellent ethylene production when the saliva from the thrips comes into contact with damaged tissues, which causes the ripening and senescence of leaves. Extensive feeding by thrips in onion not only results in plant stunting and reduced bulb yield, but it also predisposes the plants to various fungal and bacterial pathogens, leading to further decreases in bulb yield and could allow pathogens to infect the plant, causing quality reductions in storage.

Climate change has influenced the growth and development of insect pests (Bergant et al., 2005). Although these pests existed earlier with minimal damage, global warming now favors their proliferation, exacerbating the problem. However, there is hope in the form of integrated pest management (IPM) programs. Accurate identification of pest species is a fundamental step in these programs. Thrips, being minute insects, require reliable identification. This study addresses species confirmation, incidence and the potential influence of weather parameters on thrips abundance in the North Transition Zone of Karnataka, India.

MATERIALS AND METHODS

Study site

The present investigation was undertaken at the Main Agricultural Research Station (MARS), University of Agricultural Sciences (UAS), Dharwad (15 0 49'N; 74 0 96'E) for four consecutive seasons from 2022-2023 in field condition. The popular and ruling onion varieties, *Bheema super* and *Bheema Shakti* were taken during the *Kharif* and *Rabi* seasons, respectively. The seedlings were raised as per the practice package developed by UAS Dharwad. The 6-8 weeks onion seedlings were transplanted to the main field with a spacing of 15 × 10 cm and an area of 10 × 10 m. The crop was raised as per the package of practices except for insecticide spray.

Morphological identification

In a fixed plot, observation was taken from pest initiation until the end of the pest activity during the study period. The adult and immature stages of *T. tabaci* insects were collected from the infected plants using a fine camel hair brush and kept in plastic vials containing 70% ethanol. The collected specimens were identified at the species level using the taxonomic key by Amutha and Rachana (2023). Voucher specimens were deposited in the National Insect Museum at the ICAR- National Bureau of Agricultural Insect Resources, Bengaluru, India.

Molecular confirmation

Genomic DNA extraction

Genomic DNA was extracted from the individual sample of thrips using a DNA extraction kit (Qiagen DNeasy, Hilden, Germany) following the manufacturer's protocols with slight modification (Swapnarani *et al*., 2023; Shivakumara*et al*., 2024).

Polymerase chain reaction (PCR) and COI gene sequencing

PCR amplification was performed by using a 658bp region near the 5′ terminus of the COI gene by using a standard protocol (Hebert *et al.,* 2003). The COI gene primers used for amplification were: forward primer (LCO 1490 5′-GGTCAACAAATCATAAAGATATTGG-3′) and reverse primer (HCO 2198 5′-TAAACTTCAGGGTGACCAAAAAATCA-3′) (Folmer *et al.,* 1994). Polymerase Chain Reaction (BioRad C1000™) was carried out by using 200 µL volume PCR tubes (Tarsons, Kolkata, India). An aliquot of 25 µL contained 12.5 µL of 2 × reSource™ Taq Mix (resource Taq DNA Polymerase, 6 mM $MgCl_2$, 2 mMdNTPs) (Source Bioscience, UK), 1 µL of each 10 µM primer, 8.5 µL of molecular biology grade water (Sigma Aldrich) and 2 µL of template DNA. PCR was performed with initial denaturation at 94°C for 5 min, followed by 35 cycles of denaturation at 94 °C for 0.30 min, primer annealing at 48 °C for 0.30 min and extension at 72 °C for 0.30 min. Then, a final extension was performed at 72 °C for 5 min before storing the reaction at 4°C. The PCR products were separated on 1.5% agarose gel electrophoresis (Sambrook and Russell, 2001). PCR products were sequenced by Eurofins Genomics India Pvt Ltd, Bengaluru, India. The homology, insertions, deletions, stop codons and frameshifts were checked by using NCBI-BLAST and ORF finder. The samples were bi- directionally sequenced and checked for homology, insertions and deletions, stop codons and frameshifts by using the Basic Local Alignment Search Tool (BLASTn, http://www.ncbi.nlm.nih.gov), with the sequence of similar or related genera retrieved from National Center for Biotechnology Information (NCBI). The partial sequence of study isolate was deposited in Gen Bank, NCBI database and an accession number was obtained.

Phylogenetic analysis

The phylogenetic analysis was carried out using MEGA-11 (Tamura *et al.,* 2021) to explain the relationship between the study isolate (PP838743) and other thrips populations from different world geographical regions. Similar to our target sequence, the sequences were downloaded from NCBI and GenBank (https://www.ncbi.nlm.nih.gov/nucleotide/). All nucleotide sequences under study were aligned using the Clustal-W tool of MEGA-11. The Neighbor-Joining method inferred the evolutionary history (Saitou and Nei, 1987). The optimal tree is shown. The evolutionary distance was computed using the Maximum Composite Likelihood method (Tamura *et al.,* 2004) and is the unit of the number of base substitutions per site. This analysis involved 27 nucleotide sequences of *T. tabaci*. All ambiguities were removed for each sequence pair (pairwise deletion option). There were a total of 677 positions in the final dataset. The evolutionary history was exhibited based Kimura-two-parameter model with 1000 bootstrap replications (Tamura *et al.,* 2021).

Nature of damage and severity

The thrips population was counted on ten randomly

selected plants at weekly intervals from 15 days after transplanting till harvest. Both adult and immature stages of thrips were counted by opening the neck region of the plant, and the mean thrips per plant were worked out. Thrips damage rating was calculated at 45, 60 and 90 DAT by adopting the following damage scale adopted by Njau *et al.* (2017). Where 0= Damage, 1= 0.1-20% leaf area damaged, 2= 20.1- 40% leaf area damaged, 3=40.1-60% leaf area damaged, 4=60.1-80% leaf area damaged, 5=80.1-100% leaf area damaged.

Correlation of weather parameters with thrips incidence

The effect of different weather parameters i.e. maximum temperature (X_1), minimumtemperature (X_2), morning relative humidity (X_3), evening relative humidity (X_4), and rainfall(X_5) on the incidence of the thrips species on onion crop was worked out to know therelationship of pest incidence with weather parameters. All the statistical analysis was performed using Microsoft Excel 2010 software.

RESULTS AND DISCUSSION

Taxonomic investigations led to the identification of the thrips species as *Thrips tabaci* Lindeman (Thysanoptera: Terebrantia: Thripidae).

Diagnosis

Female macroptera (Fig. 1): Abdominal pleurotergites with closely spaced rows of regular, fine microtrichia; lateral margins of tergites with microtrichia on sculpture lines; tergite IX with one pair of campaniform sensilla, anterior pair absent; antennal segment V not sharply paler than IV.

Fig. 1. *Thrips tabaci*

All the search analysis results revealed that the analyzed species belongs to *T. tabaci.* Alignment of the *T. tabaci* mtCOI sequences was found to have no deletions or insertions and no stop codons, consistent with the amplified DNA arising from functional genes. The sequence generated by the study (PP838743) showed 100% identity with *T. tabaci* (MN036460), which was submitted from China on Onion. Further, the sequence and the specimen details were submitted to the BOLD database and DNA barcodes were generated.

The phylogenetic tree was constructed from *T. tabaci* MtCOI data from this study. The present phylogenetic analysis consisted of 27 MtCOI sequences including one sequence generated from this study, 26 sequences were downloaded from the NCBI Genbank database which includes the sequences across the different geographical regions of the world, showcasing the global reach of our study. One sequence of common blossom thrips, *Frankliniella schultzei* Trybom (Thysanoptera: Thripidae) COl gene with NCBI accession number KF144133 served as an out-group. The evolutionary history was inferred by using the Maximum Likelihood method based on the Tamura-Nei parameter model (Tamura *et al.,* 2013). The tree generated by combining the NCBI Genbank sequences showed one major clade (Fig. 2). All the *T. tabaci* populations were clustered in one clade and had a high degree of geographical representation from different regions, emphasizing the breadth of our study. The study isolate was closely associated with MZ882441 and MT991561 the sequence originated from Yunnan, China and New Delhi, India respectively.

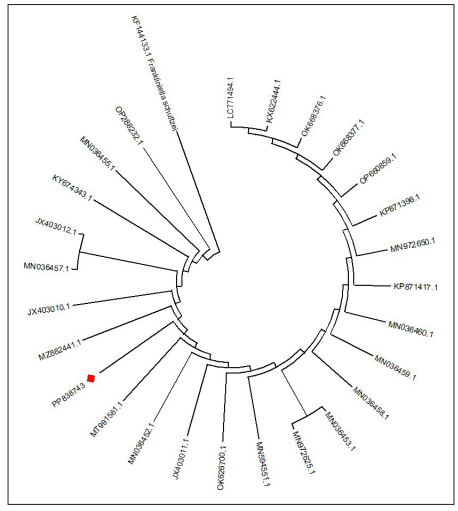

Fig. 2. The phylogenetic relationships of the study isolate from the Onion population using 658 bp mitochondrial cytochrome oxidase I (CO I) sequence of *Thrips tabaci* using the Maximum Likelihood method based on the Tamura-Nei model. The isolate from the current study is marked with a diamond. The tree was formed using the MEGA-11 program.

Both larvae and adults have very distinctive feeding behavior by punching through the leaf surface and then extracting sap from plant and it release substances that helps to pre-digest the leaf tissue and consume mesophyll cells normally. Ultimately leads to loss of chlorophyll and reduced photosynthetic efficiency. The results were by Boating *et al.* (2014). Further, damage appears as silvery patches or streaks on the leaves (Fig 3). Theincidence started from the 31st SMW *i.e.,* August 1st week and reached a peak (10.5 thrips/plant) at the 38th SMW *i.e.,* 3rd week of September in *Kharif* 2022 (Fig 4).

Fig. 3. Damage caused by *Thrips tabaci* on onion

In *Kharif* 2023, thrips infestation began in the 33rd Standard Meteorological Week (SMW), which is the third week of August and peaked in the 38th SMW, which is the last week of September, with a significant infestation of 22.60 thrips per plant (Fig. 4). Unlike in 2022, there was no monsoon rain during the *Kharif* season of 2023. This absence of rain likely contributed to the continuous presence of thrips throughout the season.

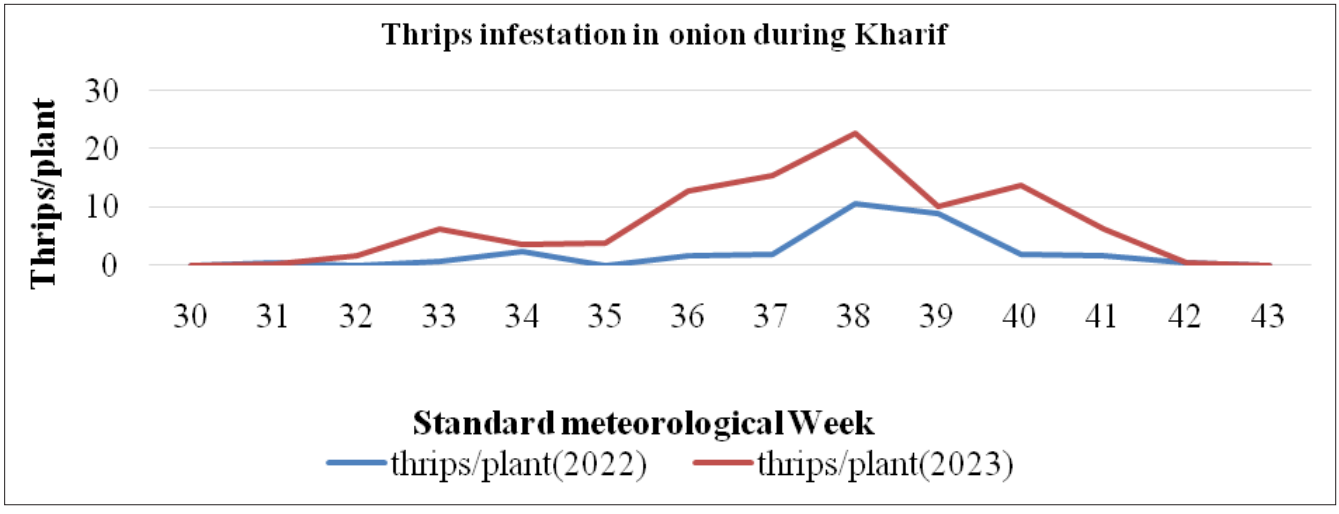

Fig. 4. Population dynamics of thrips in onion during *kharif* 2022 and *kharif* 2023

During this study period, the infestation was much less compared to other season because monsoon rain might have washed out the thrips. Both rainfall and the total number of rainydays showed a negative significant effect on thrips infestation. This suggests that increased rainfall and rainy days correlate with decreased thrips infestation during *Kharif* (Table 1).

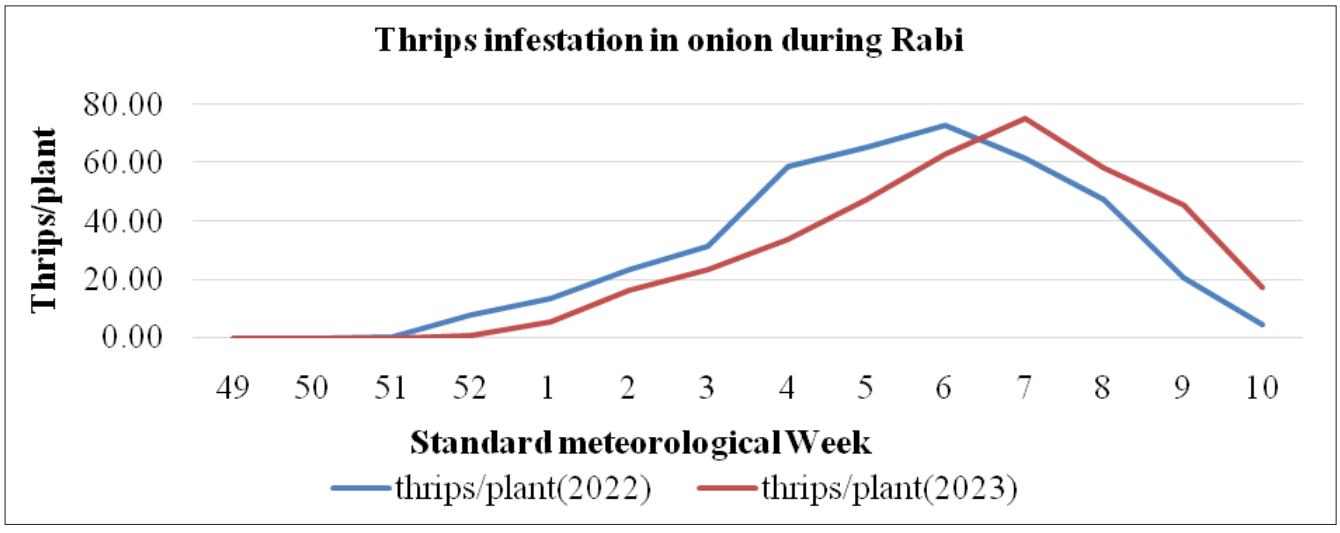

Fig. 5. Population dynamics of thrips in onion during *rabi* 2022 and r*abi* 2023

In *rabi* 2022 and 2023, thrips incidence began in the 51st Standard Meteorological Week (SMW), which corresponds to late December and peaked in the 6th and 7th SMW of the respective years (Fig. 5). The peak populations recorded were 72.60 thrips per plant in 2022 and 75.10 thrips per plant in 2023. Maximum temperature and morning and afternoon relative humidity were significant factors influencing thrips incidence (Table 1), with higher temperatures and lower humidity associated with increased thrips populations. These results align with those given by Akashe *et al.* (2016) where they observed that *Thrips palmi* Karny incidence was positively correlated with maximum temperature while negatively correlated with Morning RH, afternoon RH and rainfall in sunflowers. Linear regression analysis predicted that maximum temperature was the most important weather factor which influenced thrips to the tune of 92.1 % (Fig. 6) while rainfall, morning and afternoon relative humidity had only 18.5 %, 38.2% and 30.2% influence on incidence during *Rabi,* respectively. However, rainfall and rainy days did not significantly affect thrips populations during these *Rabi* seasons (Table 1). Since the thrips population is more during the *rabi* seasons (2022 and 2023), leaf feeding damage also increased, and the damage percentage increased as the crop age progressed. At 90 DAT, the leaf damage scale was three, corresponding to 45.2 and 48.8 percent leaf damage during *Rabi* 2022 and *Rabi* 2023, respectively (Table 3).

Table 1. Correlation matrix of weather parameters with the incidence of thrips in onion from 2022-2023

	Correlation coefficient (r)					
Season	**Max. Temperature**	**Min. Temperature**	**Morning RH**	**Afternoon RH**	**Rainfall (mm)**	**Rainy days**
Kharif 2022	0.389^{NS}	-0.051^{NS}	-0.044^{NS}	-0.155^{NS}	-0.535*	-0.573*
Rabi 2022	0.633*	-0.441^{NS}	-0.647*	-0.617*	-0.375^{NS}	--
Kharif 2023	0.157^{NS}	-0.349^{NS}	-0.259^{NS}	-0.231^{NS}	-0.023^{NS}	-0.092^{NS}
Rabi 2023	0.663**	-0.024^{NS}	-0.553*	-0.609*	-0.223^{NS}	-0.223^{NS}

NS: Non significant; *Significant at 0.05 level; ** significant at 0.01 level; -- : no rainy days; RH: Relative humidity (%)

Table 2. Multiple regression model for thrips incidence

Thrips incidence	Regression equation	R^2
Kharif 2022	Y=(0.677)T.Max + (-2.287) T.Min + (0.829) Morning RH + (-0.351) Afternoon RH + (-0.079) rainfall + (0.243) rainy days + (-16.678)	0.592
Rabi 2022	Y=(7.330) T.Max + (1.410) T.Min + (-1.218) Morning RH + (-0.132) Afternoon RH + (-1.005) rainfall + (-135.263)	0.518
Kharif 2023	Y=(-1.863)T.Max + (-7.618) T.Min + (-0.64) Morning RH + (-0.220) Afternoon RH + (-0.224) rainfall + (3.245)rainy days + 289.13	0.538
Rabi 2023	Y=(11.326)T.Max + (-5.696) T.Min + (-1.574) Morning RH + (0.932) Afternoon RH + (-0.183) rainfall + (-169.23)	0.623

T. Max: Temperature Maximum, T. Min: Temperature Minimum, RH: Relative Humidity

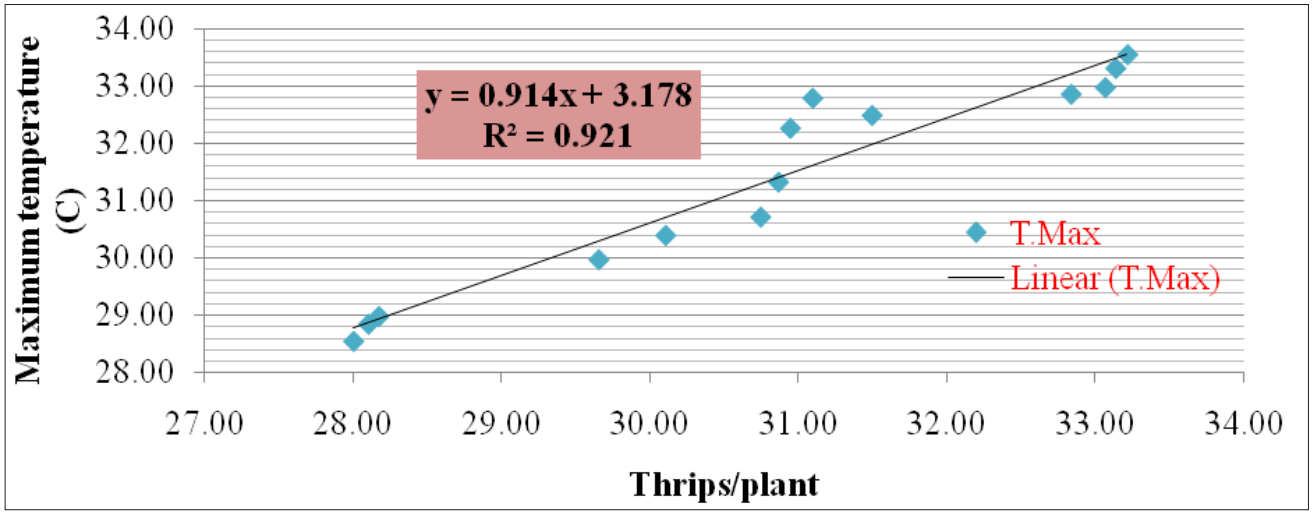

Fig. 6. Effect of Maximum Temperature on incidence of thrips during Rabi (pooled data of 2022and 2023)

This study reveals the influence of weather parameters on the incidence of thrips. In the *Kharif* season, the population was very low, and the same observation was made by Dharmatti and Beeraganni (2013). Likewise, Liu (2005) also recorded a significant difference in thrips population between onion growing seasons. Higher temperature coupled with lesser relative humidity supports the buildup of the thrips population in matured crops, revealing that hot and dry climate promotes higher incidence in onion. These results were on par with observations made by Choudhary (2016) on the incidence of thrips in cowpeas. The peak population of *T. tabaci* occurred within the maximum temperature range of 30-33oC as recorded by Karuppaiah *et al.* (2018) in garlic, and the minimum temperature ranged from 14-19 °C. This suggests that certain temperature thresholds are conducive to thrips proliferation. In this study, rainfall, rainy days, and minimum temperature showed a negative, non-significant effect on thrips incidence in *Rabi*, consistent with findings by Karar *et al.* (2014). Lower relative humidity, both in the morning and afternoon, facilitated thrips establishment in onion crops. This finding is supported by the results of a study by Kumar *et al.* (2015). Foliar feeding damage by the thrips was recorded by giving a leaf damage score. Though the incidence is very low during this season, the maximum damage score was 1, corresponding to 4.27 percent leaf damage at 90 DAT (Table 3). Since thrips were washed out by rain, there was no continuous feeding irritation on foliage. Therefore, the greening appearance was more. Leaf feeding damage score was one throughout the season (Table 3). On the other hand, multiple regression studies revealed that weather factors influenced 59.2, 51.8, 53.8 and 62.3 percent on the incidence of *T. tabaci* on onion in *Kharif* 2022, *Rabi,* 2022, *Kharif,* 2023 and *Rabi,* 2023, respectively (Table 2).

Table 3. Thrips damage rating on onion leaves from *Kharif* 2022-*Rabi* 2023

Cropping Season	45DAT		60DAT		90DAT	
	Percent leaf damage	Damage score	Percent leaf damage	Damage score	Percent leaf damage	Damage score
Kharif 2022	0	0	3.67	1	4.27	1
Rabi 2022	6.0	1	17.3	1	45.2	3
Kharif 2023	0	0	4.5	1	12.0	1
Rabi 2023	6.17	1	16.9	1	48.8	3

DAT: Days after transplanting

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