SINET: Ethiop. J. Sci., 41(1):8-14, 2018 ISSN: 0379–2897 (PRINT)
 ISSN: 0379–2897

EVALUATION OF SHALLOT CULTIVARS AGAINST ONION THRIPS, *THRIPS TABACI* LINDEMAN (THYSANOPTERA: THRIPIDAE) IN BISHOFTU, ETHIOPIA

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ABSTRACT: Onion thrips, *Thrips tabaci* Lindeman (Thysanoptera: Thripidae), is a worldwide pest of allium crops that can reduce shallot yield by more than 50% and even more problematic when it transmits iris yellow spot virus (Family Bunyaviridae, Genus Tospovirus, IYSV). Because of its cryptic nature, it is difficult to control thrips merely with insecticides. Thus, a field experiment was conducted to investigate the effect of shallot cultivars against T. *tabaci*. The study was conducted between June 2017 and March, 2018 in two locations at Debre Zeit Agricultural Research Center (DZARC), Ethiopia. Ten shallot cultivars were evaluated in a complete randomized design with three replications, by counting the number of thrips larvae at weekly interval and recording leaf damage percentage. Most of the cultivars had shown a significant difference (P<0.05) for all recorded evaluation parameters. Five out of the 10 tested cultivars scored low thrips population had very little leaf damage and were considered resistant to T. *tabaci*. Visual assessment to shallot plant canopy indicated that all the cultivars has shown low damage symptom. Moreover, the result revealed that the registered shallot varieties namely Huruta and Minjar were superior in bulb yield and resistant level to thrips damage. Our findings indicate that the presence of thrips resistant/tolerant shallot cultivars in the germplasm collections at DZARC and the potential for developing T. *tabaci* resistance shallot cultivars as part of an overall integrated pest management strategy. Therefore, these cultivars could be used by complementing them with insecticides and cultural practices to manage onion thrips populations.

Key words/phrases: Germplasm, Resistance, Screening, Shallot, *Thrips tabaci*

INTRODUCTION

Shallot (*Allium cepa var ascalonicum* Baker) is an important vegetable crop cultivated in many tropical countries as a substitute for bulb onions (*Allium cepa L. var cepa*) (Wassu Mohammed *et al*., 2018). Farmers in tropical countries preferred shallots than onion for its ability to propagate vegetatively, shorter growth cycle, better tolerance to disease and drought stresses and longer storage life than the common onion and for their distinct flavor that persists after cooking (Getachew Tabor *et al*., 2009; Tiru Tesfaye *et al*., 2014; Askari-Khorasgani and Pessarakli, 2019)

In Ethiopia, shallot is produced mostly at highland areas under rain-fed conditions by smallholder farmers as an income generating spice crop mainly used as condiment in Ethiopian traditional food (Getachew Tabor *et al*., 2009; Shimeles Akililu, 2014; Wassu Mohammed *et al*., 2018). Besides that, the crop is widely adapted to different climatic and edaphic condition and is cultivated both under rain-fed and irrigated conditions (Kebede Woldetasdik, 2003). According to Shimeles Aklilu (2014), the national average bulb yield of shallot is about 7 t ha^{-1}. There are many factors which contribute to low yield and quality of shallot production in Ethiopia, such as insect pests, diseases and lack of improved pre and post-harvest management practices (Getachew Tabor and Asfaw Zeleke, 2004).

Among the various insect pests of allium crops, the onion thrips (*Thrips tabaci* Lind.) is one of the most common and serious pest of shallot. *T. tabaci* is a polyphagous and regular pest of Allium crops (Lewis, 1997). Both adults and larvae are causing plant damage by sucking the plant sap from the leaves, resulting on a silver patchy appearance of leaves due to reduced chlorophyll content. These also results in reduced rate of photosynthesis (Boateng, 2012).

The pest status of onion thrips can be attributed to its polyphagous nature, high reproductive rate, short generation time, high

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survival of cryptic (non-feeding prepupa and pupa) instars, ability to reproduce without mating (parthenogenesis), ability to transmit plant pathogens, and development of resistance to insecticides (Morse and Hoddle, 2006; Diaz-Montano *et al*., 2011). Extensive feeding by onion thrips not only results in plant stunting and reduced bulb weight and if this occurs during the onset of bulb formation, results in reduced bulb weight and size up to 60% yield loss (Rueda *et al*., 2007). It also predisposes onion plants to various fungal and bacterial pathogens that further decrease yield. Onion thrips also transmits iris yellow spot virus (IYSV) (Bunyaviridae: *Tospovirus*), which can ultimately result in complete crop failure (Morse and Hoddle, 2006; Nault and Shelton, 2010). Owing to the irruptive outbreaks of onion thrips in onion fields, insecticides have been considered as the major means to control this pest by shallot and onion growers (Morse and Hoddle, 2006; Nault and Shelton, 2010). According to different authors, the over-reliance on certain insecticides has led to development of insecticide resistance thrips populations (Shelton *et al*., 2006; Herron *et al*., 2008). The merely dependence on chemical control is often insufficient to overcome the economic damage caused by *T. tabaci* (Mayer *et al*., 1987; Shelton *et al*., 1998). Hence, the management of onion thrips must comprise the combination of cultural and chemical controls, and use of resistant and tolerant varieties that suppress onion thrips populations. Thus, host plant resistance (HPR) is an important component of the integrated pest management (IPM) strategies. Therefore, the present study was aimed to assess the level of resistance of different shallot varieties against *T. tabaci* and recommend them as an IPM component.

MATERIALS AND METHODS

Description of the study area

Two field experiments were conducted during the dry seasons of 2017-2018 on the Research Farm of the Debrezeit Agricultural Research Center (DZARC), Ethiopia (08° 44′ N and 38° 58′ E and altitude 1900m above sea level). The Agro-ecological zone of the center (AEZs) is tepid to cool sub-moist highlands (SM_2). The annual minimum and maximum (min/max) temperature of the center is 8.9°C and 28.3°C, respectively, whereas the mean temperature is 19°C and although it has a bimodal type of rainfall. The bimodal type is short rain which is received in February-April and the annual total is 851mm (long term average). The soil type of the center is vertisols/ nitosols and light soils (Alfisols/Mollisols) (http://www. eiar. gov.et/darc).

Experimental details

Ten bulb propagated shallot cultivars including two released varieties and eight genotypes from breeding line were obtained from DZARC vegetable research program and subjected to field evaluation at DZARC experimental filed. Experiments were laid out in a Randomized Complete Block Design (RCBD) with three replications. Each genotype was planted in 3m X 2m plot area with 30 cm inter row and 20cm intra row spacing, respectively. Date of planting were 15/6/2017 for '*Meher*" (Main season) planting and 15/11/2017 for '*Belg*' (Offseason) plantings. Since the Central rift valley is being the hot spot area for onion thrips infestation, maximum naturally occurring thrips population was recorded on both planting dates. All the crop management practices, except plant protection measures were followed as per the recommendations of shallot production in Ethiopia (Asfaw Zelee and Eshetu Dereso, 2015).

Data recorded

The susceptibility of different shallot genotypes to *T. tabaci* was evaluated on the basis of number of thrips per plant and leaf foliage damage scorings. Five plants per plot were selected randomly and number of thrips/plant was recorded by examining each plant. The observations were taken at weekly interval starting from third week after planting till harvesting of the crop. Observations were also made on leaf damage both at vegetative and reproductive phase. The damage scale was assessed visually by following 1-5 scale. (i.e. 1: 1–20 percent foliage damage; 2: 21–40 percent foliage damage; 3: 41– 60 percent foliage damage; 4: 61–80 per cent foliage damage; 5: 81-100 percent foliage damage) (Srinivasan and Mohamed, 2019). Bulb yield (ton/ha), bulb weight (g/bulb), bulb diameter (cm), plant height (cm), number of leaves/plants were measured for all cultivars in each season. Since damage from thrips has the ability to reduce bulb size, the bulbs were sorted based on diameter and bulb diameter was measured. Bulbs were also sorted as marketable and unmarketable.

Data analysis

Mean number of thrips/plant was worked out and the data was checked for normality. Thrips count data were square root transformed. The yield and yield component data and thrips population data obtained in the present study were subjected to analysis of variance (ANOVA) using SAS software. In case of significant F-values, treatment means were separated using Tukey's Studentized Range (HSD) test at 5% level of significance (SAS Institute, 2009). Correlation analysis was made between thrips population and all other dependent variables measured in this study.

Categorization of varieties by level of Resistance

The shallot varieties were also grouped into four categories *viz.,* highly resistant, resistant, susceptible and highly susceptible based on number of thrips per plant. For these purposes, mean value of individual genotype (Xi) was compared with mean value of all genotypes (X) and standard deviation (sd) following the modified scale adopted by Patel *et al*. (2012). The transformed data were used for computation of X, Xi and sd in case of this parameter. Microsoft office 2013, Excel was used for computation of X, Xi and sd. The scale used for categorizing different genotypes was as mentioned under.

Table 1. The scale used for categorizing genotypes in different susceptibility groups

Category of resistance	Scale for resistance
Highly Resistant (HR)	Xi < X- sd
Resistant (R)	Xi > X - sd< X
Susceptible (S)	Xi > X < (X + sd)
Highly Susceptible (HS)	Xi > (X + sd) < (X + 2 sd)
Highly-Highly Susceptible (HHS)	Xi > (X + 2 sd)

RESULTS AND DISCUSSION

Performance of shallot genotypes

T. tabaci infestation was observed in all the genotypes tested from transplanting till harvesting, but the population dynamics was varied along the genotypes during the trial period. As indicated in Table 2, all the shallots genotypes evaluated were significantly (P<0.05) different statistically for all the parameters measured. The highest thrips number, which is not significantly different each other, 18.7 and 18.0 thrips/plant was recorded on cultivars DZSHT-012/02 and DZSHT - 005/02, respectively. It followed by 16.18 and 14.51 thrips/plant on DZSHT -023/03 and DZSHT -009/02, respectively. The lowest *T. tabaci* infestation 5.5 thrips/plant was recorded on Huruta variety. Visual rating for *T. tabaci* leaf damage was done at 90 days after planting (DAP) and there were highly significant differences among cultivars (P < 0.001) (Table 2). Similarly, the leaf foliage damage score has shown statistically significant difference (P < 0.05) among the treatments and the highest damage score 3.0 = 60% leaf damage was recorded on variety DZSHT -005/02, DZSHT -012/52, DZSHT - 023/03 and DZSHT -001-1/02, respectively. The lowest leaf foliage damage score 1.0 = 20% damage was recorded on the registered variety Huruta (Table 2). Similarly, the genotypes have shown statistically significant difference (P<0.05) for fresh bulb yield, bulb weight, bulb diameter, plant height and leaf numbers. The highest fresh bulb yields 13.89, 14.31, 15.55 and 15.94 ton/ha were recorded from DZSHT -003-01/02, DZSHT -023/0.3, Minjar and Huruta, respectively (Table 2). On the contrary, the lowest bulb yields 9.25, 9.0, 9.61 and 9.66 ton/ha was recorded from DZSHT -001-1/02, DZSHT -003-02/02, DZSHT -009/02 and DZSHT - 012/02, respectively (Table 2). As to the correlation analysis, the leaf damage percentage was significant (r = 0.941; P< 0.001) and strongly correlated with thrips population and the other parameters were not significantly correlated (Table 2).

As to the thrips population dynamics, the weekly distribution of the pest was given in Table 3 and the overall mean thrips infestation at initial experimental period was as low as 2.55 thrips/plant and reached peak of 4.48 and 4.95 thrips/plant at 6th and 10th week of evaluation, respectively (Table 3). Besides that, the highest thrips population 25.59, 30.87 and 26.3, 31.58 thrips/plant was recorded on the genotype DZSHT -005/02 and DZSHT -012/02 at the same date 6th and 10th week of evaluation, respectively (Table 3).

Categorization of shallot varieties for thrips susceptibility

According to the scale adopted by Patel *et al*. (2012), the different shallot varieties were grouped in to four susceptibility categories of resistance viz., highly resistant, resistant, susceptible and highly susceptible. The groupings were made in comparison of numbers of thrips/plant on individual verities (Xi) with mean number of thrips for all genotypes. Based on the groupings, the result was presented in Table 4.

Based on the categorization scale and observed thrips population, the genotype DZSHT -003-1/02, DZSHT -003-02/02, DZSHT -018/02, Minjar and Huruta were recorded less than 3.475 thrips/plant and found highly resistant (Table 3). However, there was no genotypes fall in the category resistant and susceptible. On the contrary, the genotype DZSHT -001-1/02 recorded more than 3.65 thrips/plant which is Highly Susceptible and genotypes DZSHT -005/02, DZSHT -009/02, DZSHT -012/02 and DZSHT -023/03 recorded more than 3.73 thrips/plant were found as Highly-Highly Susceptible (Table 4).

Table 2. Mean number of thrips/ plant, leaf damage percentage and plant vegetative parameters as affected by thrips incidence

Cultivars	Number of Thrips / plant	Transformed value of thrips/plant	Leaf foliage damage (0-5scale)	Fresh Bulb yield (ton/ ha)	Fresh Bulb Weight (g)	Bulb dim (mm)	Plant height (cm)	Numbers of leaves /plant
DZSHT -001-1/02	13.63d*	3.67C	2.5AB**	9.25 C	9.5C	7.5C	60.22B	21.44E
DZSHT T-003-1/02	11.53e	3.35C	2.17BC	13.89AB	15.57AB	8.4BC	65.9A	36.82B
DZSHT -003-02/02	10.80e	3.23D	1.50 DE	9.00 C	7.3D	7.93BC	58.77B	34.05B
DZSHT -005/02	18.00a	4.24A	3.00A	12.93B	10.69C	8.26BC	54.63C	27.55D
DZSHT -009/02	14.51c	3.80C	2.0 BCD	9.61 C	14.41AB	9.32B	54.9C	29.08CD
DZSHT -012/02	18.71a	4.33A	3.0A	9.66 C	14.61AB	9.1B	65.3A	34.88B
DZSHT -018/02	10.68e	3.21D	1.67CD	13.42B	13.79B	7.87BC	48.7E	32.58BC
DZSHT -023/03	16.18b	4.01B	3.0A	14.31AB	14.33AB	8.8BC	51.1D	43.78A
Minjar	10.88e	3.25D	1.67CD	15.55A	16.1A	11.73A	43.3F	34.78B
Huruta	5.58f	2.45E	1.00E	15.94A	16.2A	11.5A	55.5C	28.38CD
Mean	13.05	3.56	2.15	12.36	13.24	9.062	55.83	32.34
r =	-	0.941	0.999	-0.444	-0.200	-0.432	0.231	0.130
SE	0.50	0.085	0.31	1.22	0.67	0.525	1.29	2.61
CV	3.48	2.38	14.29	9.85	5.09	5.79	2.31	8.06
LSD(α =0.05)	0.86	0.15	0.53	2.09	1.97	1.54	2.21	4.47

**NB: Within a column, means followed by different letters are significantly different (P < 0.05; Tukey's test). ** Visual rating for T. tabaci leaf damage on a scale ranging from 1 to 5. 1, 1-20% damage; 2, 21-40% of the leaves white or with blotches; 3, 41-60% of leaves white or with blotches; 4, 61-80% of leaves white or with blotches; and 5, complete damage (81-100% leaves white).*

Table 3. Mean incidence of onion thrips (*Thrips tabaci,* Lind.) in different shallot varieties per season.

No.	Genotypes / Varieties	week 1	week 2	week 3	week 4	week 5	week 6	week 7	week 8	week 9	week 10	week 11	week 12	Mean
1	DZSHT-001-1/02	6.42 (2.62)	8.10 (2.93)	7.52 (2.83)	8.92 (3.07)	11.42 (3.45)	21.22 (4.66)	13.82 (3.78)	13.10 (3.69)	18.10 (4.31)	26.50 (5.20)	19.80 (4.50)	8.62 (3.02)	13.63 (3.67)
2	DZSHT-003-1/02	4.32 (2.19)	6.00 (2.54)	5.42 (2.43)	6.82 (2.70)	9.32 (3.13)	19.12 (4.43)	11.72 (3.49)	11.00 (3.39)	16.00 (4.06)	24.40 (4.99)	17.70 (4.26)	6.52 (2.64)	11.53 (3.35)
3	DZSHT-003-02/02	3.59 (2.01)	5.27 (2.39)	4.69 (2.27)	6.09 (2.56)	8.59 (3.01)	18.39 (4.34)	10.99 (3.39)	10.27 (3.28)	15.27 (3.97)	23.67 (4.91)	16.97 (4.18)	5.79 (2.50)	10.80 (3.23)
4	DZSHT-005/02	10.79 (3.36)	12.47 (3.60)	11.89 (3.52)	13.29 (3.71)	15.79 (4.03)	25.59 (5.11)	18.19 (4.32)	17.47 (4.24)	22.47 (4.79)	30.87 (5.60)	24.17 (4.97)	12.99 (3.67)	18.00 (4.24)
5	DZSHT-009/02	7.30 (2.79)	8.98 (3.08)	8.40 (2.98)	9.80 (3.21)	12.30 (3.58)	22.10 (4.75)	14.70 (3.90)	13.98 (3.80)	18.98 (4.41)	27.38 (5.28)	20.68 (4.60)	9.50 (3.16)	14.51 (3.79)
6	DZSHT-012/02	11.50 (3.46)	13.18 (3.70)	12.60 (3.62)	14.00 (3.81)	16.50 (4.12)	26.30 (5.18)	18.90 (4.40)	18.18 (4.32)	23.18 (4.86)	31.58 (5.66)	24.88 (5.04)	13.70 (3.77)	18.71 (4.33)
7	DZSHT-018/02	3.47 (1.98)	5.14 (2.37)	4.57 (2.24)	5.97 (2.54)	8.47 (2.99)	18.27 (4.33)	10.87 (3.37)	10.14 (3.26)	15.14 (3.95)	23.54 (4.90)	16.84 (4.16)	5.67 (2.48)	10.67 (3.21)
8	DZSHT-023/03	8.97 (3.07)	10.64 (3.34)	10.07 (3.25)	11.47 (3.46)	13.97 (3.80)	23.77 (4.93)	16.37 (4.11)	15.64 (4.02)	20.64 (4.60)	29.04 (5.43)	22.34 (4.78)	11.17 (3.41)	16.17 (4.02)
9	Minjar	3.67 (2.03)	5.34 (2.41)	4.77 (2.29)	6.17 (2.58)	8.67 (3.02)	18.47 (4.35)	11.07 (3.40)	10.34 (3.29)	15.34 (3.98)	23.74 (4.92)	17.04 (4.19)	5.87 (2.52)	10.87 (3.25)
10	Huruta	3.83 (2.03)	5.00 (2.32)	5.33 (2.41)	6.00 (2.54)	5.33 (2.41)	7.00 (2.73)	7.17 (2.76)	6.33 (2.60)	6.00 (2.54)	6.00 (2.55)	4.67 (2.27)	4.33 (2.20)	5.58 (2.45)
	Mean	**2.55**	**2.87**	**2.78**	**3.02**	**3.36**	**4.48**	**3.69**	**3.59**	**4.15**	**4.95**	**4.29**	**2.94**	3.56
	SEM ±	*0.214*	*0.185*	*0.148*	*0.114*	*0.074*	*0.087*	*0.11*	*0.06*	*0.064*	*0.041*	*0.06*	*0.09*	
	C.V%	*8.38*	*6.47*	*5.32*	*3.78*	*2.21*	*1.95*	*3.01*	*1.68*	*1.53*	*0.82*	*1.46*	*2.99*	

CD at 5%	*0.37*	*0.32*	*0.25*	*0.20*	*0.13*	*0.15*	*0.19*	*0.10*	*0.11*	*0.07*	*0.11*	*0.151*

Figures in parentheses are square root transformed values and used for statistical analysis.

Table 4. Categorization of different shallot varieties / genotypes for their susceptibility to *T. tabaci*.

Category 1	Scale 2	Varieties / genotypes (Xi) 3	
Based on population of thrips /plant: X=3.56 and sd=0.085			
Highly resistant (HR)	Xi < 3.475	DZSHT-003-1/02	(3.35)
		DZSHT-003-02/02	(3.29)
		DZSHT-018/02	(3.21)
		Minjar	(3.25)
		Huruta	(2.45)
Resistant (R)	Xi > 3.475 < 3.56	-	-
Susceptible (S)	Xi > 3.56 < 3.65	-	-
Highly Susceptible (HS)	Xi > 3.65 < 3.73	DZSHT-001-1/02	(3.67)
Highly-Highly Susceptible (HHS)	Xi > 3.73	DZSHT-005/02	(4.24)
		DZSHT-009/02	(3.80)
		DZSHT-012/02	(4.33)
		DZSHT-023/03	(4.01)

DISCUSSION

Host plant resistance is an important component of the integrated pest management (IPM) strategies (Sharma and Oritz, 2002). The variation in resistance between the cultivars may be due to morphological characteristics and/or chemical and nutritional composition of the plants (Silva *et al.*, 2015). The morphological characteristics might involve thickness and rigidity of the cellular walls, the amount of epicuticular waxes, and the wider central angle between the leaves (Ahmed *et al*., 2017).

In this study, five out of ten evaluated shallot cultivars, (DZSHT -003-1/02, DZSHT -003-02/02, DZSHT -018/02, Minjar and Huruta) were relatively less attractive to thrips and hosted low number of thrips per plant. As described by Riefler and Koschier (2009), this might be due to the presence of antibiosis and antixenosis property in the selected shallot cultivars. Acoording to the findings of Diaz-Montano *et al*. (2010), the onions variety 'Colorado 6' and 'NMSU 03-52-1' had the lowest numbers of *T. tabaci*, suggesting strong antibiosis and/or antixenosis.

Besides that, four of the cultivars (DZSHT -003-02/02, DZSHT -018/02, Minjar and Huruta) had scored the lowest damage symptom, and there were no statistically significant differences among them. This suggests that these four cultivars may possess antibiosis or Antixenosis property, or both, as a category of resistance against *T. tabaci.* Also, there were significant reductions in fresh bulb weight in the cultivars DZSHT -001-1/02, DZSHT -03-02/02, DZSHT -009/02 and DZSHT -012/02. This indicates that even low populations that cause low levels of leaf damage could have an impact on vegetative growth even on resistant cultivars. Similar results were observed on onion cultivars, by Diaz-Montano, *et al*. (2010) and reported that, out of 49 onion cultivars tested eleven had very little leaf damage and were considered resistant to *T. tabaci*.

Even though, there was a significant ($P < 0.05$) difference observed for bulb yield among the tested cultivars, bulb yield of each tested cultivars was not significantly correlated with thrips populations, because there were inherent genetic differences between cultivars in terms of bulb shape and size that caused differences in bulb yield among cultivars.

Results of these experiment showed that screening of variable genetic materials and genotypes, by counting the number of thrips larvae weekly and recording leaf damage could help to identify the desirable shallot cultivars with higher bulb yield and hosting low thrips populations. Earlier workers reported resistance and susceptibility on the basis of mean thrips population/plant (Lewis, 1997).

CONCLUSION

Host plant resistance (HPR) is an effective, economical and ecologically sound insect pest management option with less dependence on synthetic insecticides and reducing associated environmental hazards. It can play a major role in the integrated pest management (IPM) strategy of *T. tabaci*. Among the genotypes screened for HPR, Huruta, Minjar, DZSHT -003-1/02, DZSHT -003-

02/02 and DZSHT -018/02 were found resistant to *T. tabaci* and could be recommended for cultivation along with other IPM strategies in Ethiopia. Generally, this study revealed that the presence of thrips resistant/tolerant shallot cultivars in the shallot germplasm collections at DZARC and could be used for further screening and developing resistant varieties.

ACKNOWLEDGMENTS

This research was fully funded by the Ethiopian Institute of Agricultural Research (EIAR). The authors would like to acknowledge the technical staffs of Debrezeit Agricultural Research Center (DZARC), who working in horticulture research division for providing the necessary facilities and technical support for carrying out the field research.

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