EFFECTS OF BIOTIC STRESS (SPIDER MITE INJURY) ON LEAF WATER STATUS, TOTAL ANTIOXIDANT CAPACITY AND LIPID PEROXIDATION IN STRAWBERRY PLANTS

Baikov Alexey A. - All-Russian Research Institute of Vegetable Breeding and Seed Production, tel. (906) 702-79-59; e-mail: lab308@vniissok.ru
Kvitka Alena Yu. - Russian Timiryazev State Agrarian University, tel. (499) 976-02-20
Popov Sergey Ya. - Russian Timiryazev State Agrarian University, tel. (499) 976-02-20; e-mail: sergei_ya_popov@timacad.ru
Solntsev M.K. - M.'V. Lomonosov Moscow State University
Gins Murat S. - All-Russian Research Institute of Vegetable Breeding and Seed Production; tel. (903) 747-91-63; e-mail: anirr@bk.ru

Abstract: effect of feeding of spider mite Tetranychus atlanticus McGregor (Acari: Tetranychidae) on physiological parameters of strawberry leaves (Fragaria x *ananassa Duch) was investigated. It was shown that under low mite infestation, when the level of injury is low, the water content in the leaves depends on the feeding intensity of mites rather than on the area of leaf injury The obsen'ed decrease of the total antioxidant content, and the simultaneous increase of the intensity in high-temperature thermoluminescence, may be evidence of the membrane lipids degradation as a result of oxidative stress.*

Key words: spider mites, high-temperature thermoluminescence, total antioxidant content, water content.

The process of change in plant physiological responses at the beginning of phytophage infestation, when the level of injury is low, has been received little attention. There are few publications describing the sequence of mite damage events in the infested leaves in detail [1, 3]. It was shown that stomatal closure was the major plant physiological response to spider mite injury. As a consequence, there was reduction in photosynthetic rates. The initial rapid decline in photosynthesis was probably driven primarily by rapid stomatal closure, thereby limiting gas exchange rather than by loss of chlorophyll.

The aim of this study was to investigate the relationship between the intensity of spider mite infestation and leaf physiological responses. The leaf water content was used as a parameter which is intimately related to several leaf physiological variables (such as stomatal conductance and transpiration).

Methods

In investigations we used the total antioxidant content measured by amperometric flow injection method [6] as a possible indicator of oxidative stress caused by mite feeding, high-temperature thermoluminescence (HTL) band [4] to detect lipid peroxidation in thylakoid membranes (light sum $.S_{[60,\ 100]}$, i.e. area under the thermoluminescence curve measured in the interval [+60; +100] degrees of centigrade) [5]. Leaf water status was

evaluated as water content $W = \frac{fresh\ weight - dry\ weight}{fresh\ weight} \times 100\%$ and relative water content $RW = \frac{fresh\ weight - dry\ weight}{turgid\ weight - dry\ weight} \times 100\%$. Field experiment was carried out on strawberry plants of variety "Red Gauntlet" grown in industrial plantations of LLC "Lenin State Farm", Lenin district, Moscow region. Samplings were carried out on 20 July 2010 and 13 and 20 July 2011. In 2010 the leaves of the second wave of grown (summer leaves) were separated in two groups: intact (control - without any damage) and injured leaves (1-8%). In 2011 selected samples were conditionally separated in four groups: intact (control), 1-5, 6-10 and 11-15% leaf injury, respectively.

Results

In 2010 the spring strawberry leaves were severely damaged by the hot weather and high spider mite density. As a result at the end of June - the beginning of July the new wave of summer leaves appeared on plantations. Spider mite population density decreased on damaged leaves. Moreover in response of strong damage of feeding resources the mites entered in forced diapause and stopped the feeding. The population densities of mites at that period were: 07 July- 17.6±1.91, 13 July- 10.5±0.81 and20 July- 1.20±0.10 postembryonic individuals per leaflet.

As can be seen from table, in 2010 the water content (W, RW) in summer leaves infested by *T. attentions* was a little higher in compare with control. This situation was explained by the presence on the leaves mainly of diapausing red spider mite females that did not feed. The leaves had slight symptoms of damage.

In 2011 during the period of observation the range of damage in strawberry leaves on the fields was big. On the first date of sampling (13 July) the population densities of spider mites were: 3.14±0.24 (level of damage - 1-5%), 7.01±0.21(level of damage - 6-10%) and 12.76±0.53 (level of damage - 11-15%) individuals per leaflet. On the second date (20 July) it was decreased before: 2.89±0.19, 6.38±0.37 and 6.26±0.42 individuals per leaflet under mentioned levels of damage.

On the first date of sampling (July 13) the water content (W) and relative water content (RW) in the damaged leaves was sufficiently less in compare with the intact leaves.

Effect of *Tetranychus atlanticus* damage on physiological parameters in strawberry leaves

Date of sampling	No. of mites/ leaflet*	Level of leaflet injury, %	W, %	RW, %	Total antioxidant content, mg gallic acid equivalent/g FW
Jul 20, 2010	–	intact	63±1	81 ±1	6,3±0,2
	1.20±0.10**	1-8	66±1	85±1	5,3±0,2
Jul 13, 2011	–	intact	64±1	83±1	17,6±0,5
	3.14±0.24	1-5	54±1	69±1	16,4±0,5
	7.01±0.21	6-10	57±1	74±1	15,7±0,5
	12.76±0.53	11-15	54±1	66±1	15,7±0,5
Jul 20, 2011	–	intact	62±1	83±1	18,3±0,3
	2.89±0.19	1-5	61±1	84±1	16,2±0,3
	6.38±0.37	6-10	62±1	86±1	15,3±0,3
	6.26±0.42	11-15	61±1	86±1	15,3±0,3

* Only postembryonic individuals; ** history of damage is presented in a text.

It can be explained by the increase in water loss after the start of mite feeding. In the second survey date (July 20) no statistically significant differences were observed between two categories of leaves. Stomatal closure in the infested leaves decreased transpiration and reduced water loss through evaporation. In consequence of suppressing spider mite population and lowering transpiration rate in the injured leaves water content as the most labile physiological parameter could be restored to the level of control (July20, 2011) and even slightly exceed it (July 20, 2010).

We may conclude that under low mite infestation, when the level of injury is low, the water content in the leaves depends on the feeding intensity of mites rather than on the area of leaf injury. This may be due to the fact that in relatively undamaged areas (distal portions), reductions in stomatal conductance occurred even though there was no direct feeding damage [3]. The total antioxidant content in the infested leaves was lower compared to control during the all period of observations. This effect may be due to reduction in leaf gas exchange parameters, especially $C0_2$ fixation with the resultant generation of reactive oxygen species [2]. This assumption is consistent with the HTL data for leaves sampled in July 2010. In injured leaves the HTL band area, i.e. $S_{[60,\ 100]}$,, two times higher (59±4 a.u.) compared with control (27±3 a.u.), that may indicate a partial degradation of membrane lipids during oxidative stress.

References

1. *De Freitas Bueno A., De Freitas Bueno R.C.O, Nabity P.D., Higley L.G., Fernandes O.A.* Photo synthetic response of soybean to twospotted spider mite (Acari: Tetranichidae) injury // Braz. Arch. Boil. Technol., 2009. V. 52. P."825-834.

2. *Murata N., Takahashi S., Nishiyama Y, Allakhverdiev S.I.* Photoinhibition of photosystem II under environmental stress //Biochim. Biophys. Acta, 2007. V. 1767. P. 414-421.

3. *Reddall A., Sadras VO., Wilson L.J, Gregg P.C.* Physiological responses of cotton to two-spotted spider mite damage // Crop Sci., 2004. V. 44. P. 835-846.

4. *Solntsev M.K., Ekobena H.P.F., Karavaev V.A., Yurina T.P.* Dynamics of the action of various physical and chemical factors on the themoluminecence of photo synthetic systems // Journal of Luminescence, 1998. V. 76-77 P. 349-353.

5. *Stallaert V.M., Ducruet J.M., Tavemier E., Blein J.P.* Lipid peroxidation in tobacco leaves treated with the elicitor cryptogein: evaluation by high-temperature thermoluminescence emission and chlorophyll fluorescence //Biochim. Biophys. Acta, 1995. V. 1229 P. 290-295.

6. *Yashin A.Y* A flow-injection system with amperometric detection for selective determination of antioxidants in foodstuffs and drinks // Russian Journal of General Chemistry, 2008. V. 78. P. 2566-2571.

ВЛИЯНИЕ БИОТИЧЕСКОРО СТРЕССА (ПОВРЕЖДЕНИЯ ПАУТИННЫМИ КЛЕЩАМИ) НА ОВОДНЕННОСТЬ, СУММАРНОЕ СОДЕРЖАНИЕ АНТИОКСИДАНТОВ И ПЕРИКИСНОЕ ОКИСЛЕНИЕ ЛИПИДОВ ЗЕМЛЯНИКИ САДОВОЙ

Аннотация: в работе изучено влияние питания паутинного клеща Tetranychus atlanticus McGregor (Acari: Tetranychidae) на физиологические показатели листьев садовой земляники. Показано, что при малой плотности клещевого поражения, когда уровень повреждения листовой пластинки невелик, оводнённость листьев в большей степени зависит от активности питания клеща, нежели от площади повреждения листа. Наблюдаемое снижение суммарного содержания антиоксидантов и одновременное увеличение светосуммы высокотемпературной полосы термолюминесценции может свидетельствовать о деградации мембранных липидов в результате окислительного стресса.

Ключевые слова: паутинные клещи, высокотемпературная термолюминесценция, суммарное содержание антиоксидантов, оводненность листьев.

Автор для корреспонденции: Попов Сергей Яковлевич - д. б. н., e-mail: sergei_ya_popov@timacad.ru.