



Effectiveness of three plant hormones on some physiological processes of Greenhouse Whitefly, *Trialeurodes vaporariorum* (Westwood) infesting strawberry plants

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Abstract

Current study was carried out to study recent and untraditional methods for pest control operations far away chemical insecticides and its bad side effects on human and environment. These methods include treating the plants with special concentrations of some plant hormones before and after planting with a note and record effectiveness of these hormones on the physiological characteristics of successive insect. So, current study aim to study effectiveness of three plant hormones; Cytokinin (CKs), Gibberellin (GAs) and Auxin (IAA) on the controlling operation of the serious pest Greenhouse Whitefly, *Trialeurodes vaporariorum* (Westwood) (Hemiptera: Aleyrodidae) infesting strawberry plants *Fragaria ananassa* (L.) through treatment strawberry seedlings by these hormones before and after planting. Results obtained show that when treatment strawberry plants by cytokinin hormone (CKs) led to decrease mean population number of the successive insect *T. vaporariorum* more than when treatment these plants by gibberellin hormone (GAs) and auxin hormone (IAA) respectively. Results obtained also show that cytokinin hormone (CKs) was higher effectiveness on the physiological adjectives were examined of the successive insect *T. vaporariorum* more than both gibberellin hormone (GAs) and auxin hormone (IAA) respectively. These physiological adjectives were tested stimulated in concentration of two important genes (sucrase gene and alpha glucosidase gene AGLU) and two important hormones (juvenile hormone and molting hormone) which secreted inside the successive insect *T. vaporariorum*. Whereas results obtained indicated to that effectiveness of cytokinin hormone (CKs) was higher than both gibberellin hormone (GAs) and auxin hormone (IAA) respectively on decreasing concentration of these important genes and hormones which secreted inside the successive insect *T. vaporariorum*

Keywords: Plant hormones, Cytokinin (CKs), Gibberellin (GAs), Auxin (IAA), *Trialeurodes vaporariorum*, strawberry plants, physiological adjectives

Introduction

Strawberry plants *Fragaria ananassa* (L.) is one of the important crops all over the world which cultivated both in the open field and under greenhouses which is widely cultivated especially in the last recent years, Francisco *et al.* (2011) [7]. Egypt is one of the largest strawberry producers all over the world whereas it ranking fifth level in the world in the production of strawberry fruits, Food and Agriculture Organization (F.A.O) 2017. Also, David (2018) [2] indicated to that strawberry crop has very economic importance all over the world and it produced commercially in about 76 countries and China is the largest producer and the top five producing nations also include USA, Mexico, Turkey and Spain.

Greenhouse Whitefly, *Trialeurodes vaporariorum* (Westwood) (Hemiptera: Aleyrodidae) is one of the most serious pests infesting strawberry plants in both of open fields and under greenhouses, Toscano and Jian (2015) [15] who indicated also to that Greenhouse Whitefly *T. vaporariorum* consider recently a serious and dangerous insect pest of many horticultural crops planted in California and causes serious damages to quantity and quality of strawberry crop. Also, Jian and Nick (2007) [10] indicated to that The Greenhouse Whitefly, *T. vaporariorum* has emerged as a major insect pest of many horticultural crops in coastal California and this insect pest become a serious pest for strawberry crops.

Plant hormones produced within plants that occur in extremely low concentrations. Plant hormones control all aspects of plant growth and development, embryogenesis,

the regulation of organ size, pathogen defense, stress tolerance and through to reproductive development, Bari and Jones (2009) [1] who also add that plant hormones play important roles in regulating developmental processes and signaling networks involved in plants. Also, Peter (2012) [12] indicated to that plant hormones play a crucial role in controlling the way in which plants growth, development, metabolism and reproduction. David *et al.* (2013) [3] indicated to these plant hormones play important roles in regulating plant growth and defense by mediating developmental processes.

Current study aim to study effectiveness of three plant hormones; Cytokinin hormone (CKs), Gibberellin hormone (GAs) and Auxin hormone (IAA), on controlling the serious pest Greenhouse Whitefly, *T. vaporariorum* infesting strawberry plants *F. ananassa* through effectiveness on some important physiological adjectives of that insect.

Materials and Methods

Experimental design

Population fluctuation of *Trialeurodes vaporariorum*

Current study was carried out on strawberry plants *Fragaria ananassa* (L.) at two different locations (Governorates), Perkash (Giza Governorate) and Tokh (Qaliobya Governorate) during successive season 2021/2022 under greenhouses. Strawberry seedlings were planted at both of the two successive locations at the same time on mid of September month 2021. Experiments were carried out under greenhouses at both of the two successive locations, each greenhouse divided into four separated parts isolated from

each other by polyethylene wire with fine halls (0.5 mm). Strawberry seedling also divided into four separated groups, 1st one planted without treatment with any plant hormone, 2nd one planted after immersion in cytokinin hormone CKs (25 ppm) for period 8 hours before planting, 3rd one planted after immersion in gibberellin hormone GAs (25 ppm) for period 8 hours before planting and 4th one planted after immersion in auxin hormone IAA (25 ppm) for period 8 hours before planting. All recommended agricultural operations were carried out similarly in boss of the two successive locations and non- chemical control against pests were carried out during experimental period. When the first leaves of the strawberry seedlings began to appear twice sprayed were done by the successive hormones between of them 21 days, and after that an artificial infestation with the successive insect *T. vaporariorum* were done at the same time in both of the two successive locations. It is proven accurate observations of the infestation with greenhouses whitefly numbers (adults and nymphs) in random plants biweekly. Directly counting was done biweekly during experimental period.

Physiological analysis of the internal substances secreted inside *T. vaporariorum*

Experiments were carried out to study physiological analysis of the internal substances secreted inside *T. vaporariorum*. These internal substances stimulated in two important genes and two important hormones secreted by the successive insect, *T. vaporariorum*.; the two genes were; sucrose gene and alpha glucosidase gene (AGLU), and the two hormones were; juvenile hormone and molting hormone. These analyses were carried out on *T. vaporariorum* individuals who fed on strawberry plants both of treated and non-treated with the successive plant hormones. *T. vaporariorum* individuals were collected separated from each part of the greenhouse and examined in the entomology lab, Faculty of Science, Ain Shams University.

Statistical analysis

In these experiments, population fluctuation of *T. vaporariorum* (adults and nymphs) were counted and effectiveness of the three plant hormones on some physiological adjectives of *T. vaporariorum* were subjected to analysis of variance (ANOVA) and the means were compared by L.S.D. test at 0.05 level, using SAS program (SAS Institute, 1988).

Results and Discussion

Current study aim to study effectiveness of three plant hormones; Cytokinin (CKs), Gibberellin (GAs) and Auxin (IAA) on the control operation of the serious pest Greenhouse Whitefly, *Trialeurodes vaporariorum* (Westwood) (Hemiptera: Aleyrodidae) infesting strawberry plants *Fragaria ananassa* (L.). Experiments were carried out at two different locations (Governorates), Perkash (Giza Governorate) and Tokh (Qaliobyah Governorate) during successive season 2021/2022.

Population fluctuation of *T. vaporariorum* at both of Giza and Qaliobyah Governorates during season 2021/2022

Data obtained and tabulated in Table (1) show the population fluctuation of Greenhouse Whitefly, *T.*

vaporariorum at both of the two successive locations (Giza and Qaliobyah Governorates) during successive season 2021/2022. Data obtained and tabulated at Table (1) show also mean population number of the successive insect *T. vaporariorum* infesting strawberry plants which were treatment by the successive plant hormones ; Cytokinin (CKs), Gibberellin (GAs) and Auxin (IAA) compared to control (strawberry plants which did not treat with any plant hormone). Results obtained show that the insect infestation by the successive insect *T. vaporariorum* on strawberry plants which treatment by plant hormones at both of the two successive locations were arranged ascending as follow; Cytokinin (CKs), Gibberellin (GAs) and Auxin (IAA), respectively compared to control.

Table 1: Population fluctuations of *T. vaporariorum* on strawberry plants at Giza and Qaliobyah Governorate during 2021/2022 season

Date	Giza Governorate				Qaliobyah Governorate			
	Control	CKs	GAs	IAA	Control	CKs	GAs	IAA
1/11/2021	17.5	7.5	9.5	11.5	22.5	9.5	13.3	14.2
15/11/2021	19.7	8.6	11.6	13.3	25.7	10.2	15.5	16.3
1/12/2021	20.8	9.3	12.8	14.5	26.5	12.7	16.7	17.5
15/12/2021	23.5	12.5	14.3	15.7	28.7	14.0	18.3	19.2
1/1/2022	27.4	14.3	16.5	18.5	30.5	17.2	19.8	20.7
15/1/2022	30.8	16.5	18.6	19.8	33.2	19.6	21.5	22.1
1/2/2022	33.5	18.3	20.5	21.3	35.5	21.5	24.6	25.3
15/2/2022	35.2	20.5	22.3	23.7	39.3	23.7	25.7	26.7
1/3/2022	39.3	22.7	24.8	25.4	42.8	24.1	26.8	27.4
15/3/2022	42.5	24.5	26.5	26.8	45.5	26.6	28.9	29.4
1/4/2022	40.7	21.3	23.7	25.8	43.6	22.5	25.7	26.5
15/4/2022	37.5	19.6	20.9	22.5	40.3	20.4	23.6	24.7
Total	368.4	195.6	222.0	238.8	414.0	222.0	260.4	270.0
Mean	30.7	16.3	18.5	19.9	34.5	18.5	21.7	22.5
%	-	47.1	39.8	35.2	-	46.4	37.3	34.8
F 0.05	315.66				425.21			
L.S. D	1.022				1.035			

Means within columns bearing different subscripts are significantly different ($P < 0.05$)

Whereas at Giza Governorate mean population number of *T. vaporariorum* (adults and nymphs) on strawberry plants which treated with cytokinin hormone (CKs) was 16.3 individual/leaf, mean population number of *T. vaporariorum* on strawberry plants which treated with gibberellin hormone (GAs) was 18.5 individual/leaf, mean population number of *T. vaporariorum* on strawberry plants which treated with auxin hormone (IAA) was 19.9 individual/leaf compared to control whereas mean population number of *T. vaporariorum* on strawberry plants which did not treat with any plant hormone was 30.7 individual/leaf. As the same trend data was achieved at Qaliobyah Governorate where mean population number of *T. vaporariorum* (adults and nymphs) on strawberry plants which treated with cytokinin hormone (CKs) was 18.5 individual/leaf, mean population number of *T. vaporariorum* on strawberry plants which treated with gibberellin hormone (GAs) was 21.7 individual/leaf, mean population number of *T. vaporariorum* on strawberry plants which treated with auxin hormone (IAA) was 22.5 individual/leaf compared to control whereas mean population number of *T. vaporariorum* on strawberry plants which did not treat with any plant hormone was 34.5 individual/leaf. Results obtained also at Table (1) show that the reduction percentage % in the mean population of the successive insect *T. vaporariorum* at both of strawberry

plants treatment with the successive plant hormones compared to control (strawberry plants did not treated with plant hormones). Whereas at Giza Governorate reduction percentage % in the mean population number of *T. vaporariorum* in strawberry plants which treated by cytokinin hormone (CKs) was 47.1%, reduction percentage % in the mean population number of *T. vaporariorum* in strawberry plants which treated by gibberellin hormone (GAs) was 39.8%, reduction percentage % in the mean population number of *T. vaporariorum* in strawberry plants which treated by auxin hormone (IAA) was 35.2%, while in Qaliobya Governorate reduction percentage % in the mean population number of *T. vaporariorum* in strawberry plants which treated by cytokinin hormone (CKs) was 46.4%, reduction percentage % in the mean population number of *T. vaporariorum* in strawberry plants which treated by gibberellin hormone (GAs) was 37.3%, reduction percentage % in the mean population number of *T. vaporariorum* in strawberry plants which treated by auxin hormone (IAA) was 34.8%.

Statically analysis show that were highly significant differences between mean population number of the successive insect *T. vaporariorum* infesting strawberry plants which treated by the successive plant hormones compared to control plants at both in the two successive locations (governorates) whereas F (0.05) and L.S.D values in Giza Governorate were (315.66, 1.022) respectively. While these values in Qaliobya Governorate were (425.21, 1.035) respectively.

These results agreement with those obtained by Emam and Seham (2019) [5] who indicated to that treatment cucumber seedling by cytokinin hormone (CKs) led to reduce population numbers of *Aphis gossypii* Glover and *Tetranychus urticae* Koch infesting cucumber plants. Also, Hayam (2020) [9] indicated to that when treated squash plants *Cucurbita pepo* L. by cytokinin hormone (CKs) led to decrease population number of whitefly, *Bemisia tabaci* individuals which infesting squash plants compared to control plants (squash plants did not treat by CKs hormone). Gamila and Abla (2023) [8] indicated to that treatment tomato seedlings by gibberellin hormone (GAs) before and after plating led to decrease population number of *Tuta absoluta* individuals which infesting tomato plants compared to control plants (tomato plants did not treat by GAs hormone).

Effectiveness of the successive pant hormones on the physiological adjectives of *T. vaporariorum*

Experiments were carried out to study effectiveness of treatment strawberry plants by three plant hormones cytokinin hormone (CKs), gibberellin hormone (GAs) and auxin hormone (IAA) on the physiological adjectives of *T. vaporariorum*. These physiological adjectives stimulated in two important genes and two important hormones secreted inside the successive insect *T. vaporariorum*. Whereas there were two important genes secreted inside that insect *T. vaporariorum*; sucrose gene and alpha glucosidase gene (AGLU), these two genes are involved (responsible) in osmotic pressure maintenance particularly in sap sucking insects, any damage happen in these genes affected directly on the osmotic pressure maintenance inside sucking insect and leading to death (mortality). Feeding of successive insect *T. vaporariorum* on strawberry plans treatment by plants hormones affected directly on decreasing insect

excretion and concentration of these genes whereas concentration of these important genes in insect which feeding on strawberry plants did not treatment by any plant hormone (control) were 1.5, 1.3 mg/100g respectively. Concentration of these important genes in *T. vaporariorum* insect which feeding on strawberry plants treatment by cytokinin hormone (CKs) were 1.1, 0.9 mg/100g respectively. Concentration of these important genes in *T. vaporariorum* insect which feeding on strawberry plants treatment by gibberellin hormone (GAs) were 1.2, 1.0 mg/100g respectively. Concentration of these important genes in *T. vaporariorum* insect which feeding on strawberry plants treatment by auxin hormone (IAA) were 1.3, 1.1 mg/100g respectively.

Statically analysis show that were highly significant between concentration of the important genes secreting by the successive insect *T. vaporariorum* whereas F (0.05) and L.S.D were (411.23, 1.046) respectively.

Beside studied effectiveness of the successive plant hormones Cytokinin (CKs), Gibberellin (GAs) and Auxin (IAA) on these two important genes secreted by insect *T. vaporariorum* current study also contained effectiveness of these plant hormone on two important hormones secreted inside that insect, these hormones were; juvenile hormone and molting hormone. Whereas results obtained show that feeding of the successive insect *T. vaporariorum* on strawberry plans treatment by plants hormones affected directly on decreasing these important hormones secreted by insect *T. vaporariorum* whereas concentration of these important hormones (juvenile hormone and molting hormone) in insect which feeding on strawberry plants did not treatment by any plant hormone (control) were 10.5, 7.6 mg/100g respectively. Concentration of these hormones in *T. vaporariorum* insect which feeding on strawberry plants treatment by cytokinin hormone (CKs) were 7.1, 4.5 mg/100g respectively. Concentration of these hormones in *T. vaporariorum* insect which feeding on strawberry plants treatment by gibberellin hormone (GAs) were 8.3, 5.9 mg/100g respectively. Concentration of these hormones in *T. vaporariorum* insect which feeding on strawberry plants treatment by auxin hormone (IAA) were 9.0, 6.1 mg/100g respectively.

Statically analysis show that were highly significant between concentration of these important hormones secreting by the successive insect *T. vaporariorum* whereas F (0.05) and L.S.D were (372.81, 1.031) respectively.

Results obtained were agreement with those obtained by Salem *et al.* (2023) [13] who studied effectiveness of treatment gladiolus bulbs by cytokinin hormone (CKs) on the physiological characteristics of Gladiolus Thrips, *Thrips simplex* and found that treatment gladiolus bulbs by cytokinin hormone (CKs) before planting led to negative effect on the internal substances secreted inside insect such as; total lipids, carbohydrates, total proteins, juvenile hormone, molting hormone and important enzymes such as: Lipase, Kinase, Alpha esterase, Beta esterase, Oxidation enzymes and Digestive enzymes. Gamila and Abla (2023) [8] indicated to that treatment tomato seedlings by gibberellin hormone (GAs) before and after plating led to decrease population number of *Tuta absoluta* individuals which infesting tomato plants compared to control plants (tomato plants did not treat by GAs hormone) and when treated tomato seedlings by CKs hormone led to decrease population number of *Tuta absoluta* individuals which

infesting tomato plants more than gibberellin hormone (GAs) and authors indicated also to that the two successive hormones affected on the plant healthy whereas led to positive effects on the plant healthy. Aso, Kemal and John (2009)^[11] indicated to that the plant growth hormone, auxin hormone has been recognized as a regulator of plant defense and led to positive effects on the plant healthy. Also, Elizabeth and Lucia (2018)^[4] referred to that the plant hormone auxin is a central regulator of plant growth and development because auxin hormone plays critical roles in cell division and cell expansion. David *et al.* (2013)^[3] indicated to those plant hormones beside their important role in regulating plant growth and defense they have a serious effect against pathogen, herbivore and insects attack plants, and authors indicated also to that cytokinin hormone (CKs) play a key role in plant morphology, plant defense and other vital processes and also this hormone has a serious effect against arthropods and pathogens.

Conclusion

Results obtained show that when treatment strawberry plants by cytokinin hormone (CKs) led to decrease mean population number of the successive insect *T. vaporariorum* more than when treatment these plants by gibberellin hormone (GAs) and auxin hormone (IAA) respectively. Results obtained also show that cytokinin hormone (CKs) was higher effectiveness on the physiological adjectives were examined of the successive insect *T. vaporariorum* more than both gibberellin hormone (GAs) and auxin hormone (IAA) respectively. These physiological adjectives were tested stimulated in concentration of two important genes (sucrase gene and alpha glucosidase gene AGLU) and two important hormones (juvenile hormone and molting hormone) which secreted inside the successive insect *T. vaporariorum*. Whereas results obtained indicated to that effectiveness of cytokinin hormone (CKs) was higher than both gibberellin hormone (GAs) and auxin hormone (IAA) respectively on decreasing concentration of these important genes and hormones which secreted inside the successive insect *T. vaporariorum*

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