https://dx.doi.org/10.4314/ejppri.v7i3.2

Egypt. J. Plant Prot. Res. Inst. (2024), 7 (3): 288–294

Egyptian Journal of Plant Protection Research Institute

www.ejppri.eg.net

Efficiency of gibberellic acid on feeding, biological and biochemical parameters of *Spodoptera littoralis* (Lepidoptera: Noctuidae) on tomato *Solanum lycopersicum*

Anwaar, M. Abaza; Salem, M.M. Hagar and Ayat, I. El-Kholy

Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza, Egypt.

ARTICLE INFO

Article History

Received:5 /7/2024

Accepted:1 /9/2024

Keywords

Gibberellic acid, *Spodoptera littoralis*, feeding inhibition, biological parameters, biochemical parameters, and *Solanum lycopersicum.*

Abstract

The plant growth regulators (PGRs), such as gibberellic acid (GA_3), are used to improve the quality and quantity of the tomato crop, *Solanum lycopersicum*. The effect of different concentrations of GA_3 on feeding, biological, and biochemical parameters of *Spodoptera littoralis* (Boisduval) (Lepidoptera: Noctuidae) larvae was studied. After foliar spray of GA_3 concentrations on *S. lycopersicum* plants, the treated leaves were brought to the laboratory for this study. The larvae fed on treated leaves with GA_3 exhibited feeding inhibition, where feeding inhibition indices (FII) increased as the concentration increased and days post-treatment. The calculated sub-lethal concentration (LC_{50}) of GA_3 caused disturbance in the biological parameters of *S. littoralis*; it prolonged larval and pupal periods. The pupation (68.75%) and emergence (80%) percentages were decreased for treated larvae. The reduction in larvae weights can only result from insufficient feeding caused by the anti-feeding activity, which appears from the results of FII indices. Some malformations were observed when larvae reached the pupation stage, these malformations may be responsible for mortality and decreasing in pupation percentage. The LC_{50} of GA_3 decreased the phenoloxidase and protease enzyme activities relative to control larvae by (-20.79%) and (-60.16%), respectively. It slightly increased the activity of α-and β-esterase enzymes by 3.74 and 20.18%, respectively. It also decreased the amount of total carbohydrates in treated larvae by (-25.26%) compared with control ones. This study supported the idea that plant growth regulator GA_3 can be used as a potential insecticide against *S. littoralis* larvae. GA_3 treatment caused feeding inhibition and disturbance in both biological and biochemical parameters of *S. littoralis* larvae.

Introduction

Tomato *Solanum lycopersicum* L. (Solanaceae), is an economically and nutritionally important fruit grown worldwide under open fields and protected cultivation. The cotton

leafworm, *Spodoptera littoralis* (Boisduval) (Lepidoprera: Noctuidae), is a destructive polyphagous pest. The larvae can feed on the most economically viable plant species (Brown and Dewhurst, 1975). New approaches for using natural compounds for insect control can reduce the population of insects and increase food production. The use of natural compounds can interfere with the reproduction and development of target insects (Isman and Machial, 2006). Plant growth regulators (PGRs) are natural compounds that are used to increase the quality of products, crop yield, and increase or reduce plant growth rate. Application of PGRs induces the defense of plants against several biotic and abiotic stresses, they interfere with the biological parameters of insects, thus reducing their growth and development (Prado and Frank, 2013 and Keskin, 2016). Gibberllic acid (GA_3) belongs to the plant growth regulators that play an important role in the growth and development mechanisms of plants that are used to improve the quality and quantity of tomato crops (Gelmesa *et al.*, 2012 and Ning and Subroto, 2018). The PGRs affect directly and indirectly the growth and reproduction of phytophagous insects (Kaur and Rup, 2003; Abdellaoui *et al*., 2009 and Altuntas *et al.*, 2012).

The present study attempts to evaluate the effect of GA3, as a plant growth regulator, on feeding inhibition, biology, and the biochemical content of S. littoralis larvae.

Materials and methods

1. Insect:

The *S. littoralis* strain used in the present study was reared under laboratory conditions. The culture was kept under optimum conditions 25±2 ºC, 75±5% R.H, and 16 hrs. light: 8 hrs. dark photoperiod (El-Defrawi *et al.*, 1964). The 4th instar larvae were selected for the experiments.

2. Treatments:

Pure GA_3 used in this experiment was dissolved in distilled water, while in the control, the larvae received the same amounts of distilled water. For the foliar application of GA_3, five concentrations (12.5, 25, 50, 100, and 200 ppm) were sprayed on tomato plants, *S. lycopersicum* on a tomato farm in Ismailia Governorate.

3. Feeding inhibition activity:

The activity of GA_3 on food consumption of *S. littoralis* larvae was investigated under laboratory conditions; the freshly molted 4th instar larvae (n = 30 for each concentration) were selected and starved for 4-5 hrs. prior to assay. *S. lycopersicum* larvae which were sprayed with GA_3 concentrations in the field were brought to the laboratory. The leaves were weighed and offered to starved larvae in the laboratory for 48 hrs. only, then transferred to feed on untreated and weighed leaves. Uneaten food was separated from the feces and weighed daily. Feeding inhibition index (FII) = $100[(C_v\text{-}T/C_v)]$ was calculated; T: Treated larvae; C = Control larvae. This index evaluates the efficiency of the substance to inhibit the feeding of treated larvae (Bentley *et al.*, 1984 and Nelson *et al.*, 2009). The mortality percentages were recorded daily and corrected (Abbott, 1925). The sublethal concentration was calculated.

4. Latent activity on biological parameters:

To study the latent activity of GA_3, newly molted 4th instar larvae of *S. littoralis* fed on *S. lycopersicum* leaves were treated with the determined sub-lethal concentration (LC_{50}) of GA_3 for 48 hrs. Then the surviving larvae were transferred to feed on untreated leaves till pupation occurred. Other larvae were fed on untreated leaves for the same period as a control. The

biological parameters such as larval weight, larval period, pupation percentages, pupal weight, pupal period, and emergence percentages were recorded. The change in these biological parameters was calculated.

5. Biochemical parameters:

The larvae were fed on tomato leaves treated with the determined LC_{50} of GA_3; the biochemical activity of phenoloxidase (Ishaaya, 1971), chitinase (Ishaaya and Casida, 1974), protease (Tachell *et al*., 1972), Alpha esterase, beta esterase (Van Asperen, 1962), and total carbohydrate (Dubois *et al.,* 1956 and Crompton and Birt, 1967) were evaluated.

Results and discussion

1. Feeding inhibition activity of gibberellic acid:

The Feeding Inhibition Index (FII) was calculated to evaluate the efficiency of GA_3 to inhibit feeding of 4th instar larvae of *S. littoralis* in the laboratory. From this experiment, GA_3 treatment inhibits the feeding of the treated larvae. FII indices increased as the concentration increased and days post-treatment, where the maximum values of the FII index were recorded with the highest concentration 200 ppm. After 6 days, the anti-feeding activity (FII) of GA_3 increased by 37.86, 48.66, 58.08, 72.42, and 76.71%, respectively, since 12.5, 25, 50, 100, and 200 ppm (Table 1). These results showed that GA_3 had a toxic effect on treated larvae. Abdellaoui *et al.* (2009) reported that GA_3 caused high mortality in *S. littoralis* and *Locusta migratoria* (L.) (Orthoptera: Acrididae) larvae under laboratory conditions.

Table (1): Anti-feeding activity of GA_3 concentrations on *Spodoptera littoralis* larvae.

Concentration	Feeding Inhibition Index		
	2 Days	4 Days	6 Days
12.5	14.55	31.10	37.86
25	30.12	36.36	48.66
50	36.14	53.47	58.08
100	53.01	65.24	72.42
200	62.65	66.31	76.10

Feeding Inhibition Index (FII)=100[(C_v-T/C_v)]; T: Treated larvae; C= Control larvae.

2.Latent activity on biological parameters:

Table (2) shows that the sub-lethal concentration (LC_{50}) of GA_3 decreased the weight of treated larvae, where the larval weights are 0.272±0.005 and 0.338±0.002 g, respectively, for treated and control larvae. These results show that a reduction in larvae weight may be a result of insufficient feeding caused by anti-feeding activity, which appears in the results shown in FII indices. The LC_{50} concentration prolonged the larval period till pupation occurred; the larval periods were 10.86±0.254 and 11.25±0.302 days, respectively, for control and treated larvae. We observed some malformations occurred when larvae reached the pupation stage. These malformations may be responsible for mortality and decreasing pupation percentage 68.75% compared with control larvae. The sub-lethal concentration caused disturbance for the pupal stage; the weight of emerged pupae was 0.193±0.0124 g while 0.302±0.005 g for control ones. It prolonged the pupal period 12.9±0.378 days compared with control 11.73±0.251 days. The surviving pupae emerged with an 80% percentage when compared with the control ones.

Table (2): Latent activity of sub-lethal concentrations of gibberellic acid on biological parameters of *Spodoptera littoralis* larvae.

Treatment	Larval weight (gm)	Larval duration days	Pupation %	Pupal weight (gm)	Pupal duration (days)	Emergence%
Control	0.338±0.002	10.86±0.254	68.75	0.302±0.005	11.73±0.251	80
LC_{50} of GA_3	0.272±0.005	11.25±0.302		0.193±0.0124	12.9±0.378	

3. Biochemical parameters:

The activity of some enzymes was evaluated for surviving larvae after treatment with LC_{50} of GA_3.The results are in Table (3). Show that the LC_{50} of GA_3 caused a decrease in phenoloxidase enzyme activity relative to control larvae by (-20.79%).

Table (3): Biochemical parameters of *Spodoptera littoralis* larvae.

Parameters	Gibberellic acid	Control	Chang%
Phenoloxidase O.D unit x10^3 /min./gb.wt	10.82±0.62	13.66±02.88	-20.79
Protease µg alanin/min./g b. wt	176.67±8.0.	443.51±18.41	- 60.16
α-acetate µg α-naphthol released/min./mg protein	18.01±0.23	17.36±0.13	3.74
β-acetate µg β-naphthol released/min./mg protein	38.58±0.7	32.1±0.4	20.18
Total carbohydrates	8.34±0.11	11.16±0.01	- 25.26

The structures of PGRs and insect juvenile hormone (JH) are similar, it reflects that their modes of action may be the same. The similarity in their structures shows the inhibitory effect on phenoloxidase activity (Rolff and Siva-Jothy, 2002 and Rantala *et al.*, 2003). The activity of the protease enzyme decreased sharply by (-60.16%), the observed decrease in enzyme activity may be due to the feeding inhibition activity of GA_3. The production of protease enzymes is related to feeding behavior and the amount of food that passes through the alimentary canal (Chapman, 1985). GA_3 treatment slightly increases the activity of α-and β-esterase enzymes by 3.74 and 20.18%, respectively. Esterase enzymes are detoxifying enzymes that hydrolyze esoteric bonds of chemical compounds (Hemingway and Karunaratne, 1998). It was observed decrease in the amount of total carbohydrates in treated larvae was observed by (-25.26%) compared with control ones. The phenoloxidase and esterase enzymes work together as an insect defense system, they work to deactivate and get rid of toxic compounds, as reported by Hemingway and Karunaratne (1998), Zibaee and Bandani (2010), Aslanturk *et al*. (2011), and Valizadeh *et al*. (2013). The following study supported that the plant growth regulators (PGRs) as GA_3, can be used as potential insecticides against *S. littoralis* larvae. GA_3 treatment caused feeding inhibition and disturbance in both biological parameters and enzyme activities of *S. littoralis* larvae.

References

Abbott, W.S. (1925): A method of computing the effectiveness of an insecticide. J. Econ. Entomol., 18: 265-267.

Abdellaoui, K.; Halima-Kamal, M.B.; Hamouda, M.H.B. (2009): Insecticidal activity of

gibberellic acid against *Spodoptera littoralis* (Lepidoptera: Noctuidae) and *Locusta migratoria* (Orthoptera: Acrididae). Pes. Technol. 3: 28-33.

Altuntas, H.; Kilic, A.; Uckan, F. and Ergin, E. (2012): Effects of gibberellic acid on Hemocytes of *Galleria mellonella* L. (Lepidoptera: Pyralidae). Environ. Entomol., 41: 688-696. Doi: 10.1603/EN11307.

Aslanturk, A.; Kalender, S.; Uzunhisarciki, M. and Kalender, Y. (2011): Effects of methidathion on antioxidant enzyme activities and malondialdehyde level in midgut tissues of *Lymantria dispar* (Lepidoptera) larvae. J. Entomol. Res. Soc., 13: 27. DOI:10.5072/ZENODO.30856.

Bentley, M.; Leonard, D.; Stoddard, W. and Zalkow, L. (1984): Pyrrolizidine alkaloids as larval feeding deterrents for spruce budworm *Choristoneura fumiferana* (Lepidoptera: Tortricidae). Annals of the Entomolgical Society of America, 77: 393-397. DOI:10.1093/AESA/77.4.393.

Brown, E.S. and Dewhurst, C.F. (1975): The genus *Spodoptera* (Lepidoptera: Noctuidae) in Africa and the Near East. Bull. Entomol., Res., 65: 221-261. DOI:10.1017/S0007485300005939.

Chapman, R. F. (1985): Structure of the digestive system. In: G.A. Kerkut and L.I. Gilbert (editors): Comprehensive Insect Physiology, Biochemistry and Pharmacology. Vol. 4. Pergamon Press, Oxoford, 165-211.

Crompton, M. and Birt. (1967): Change in the amount of carbohydrates, phosphagen, and related compounds during the metamorphosis of the blowfly *Lucilia cuprina*. J. Insec. Physiol., 13: 1575-1595.https://doi.org/10.1016/0022-1910(67)90180-1.

Dubois, M.; Gilles, K.A.; Rebers, P.A. and Smith, F. (1956): Colorimetric method for determination of sugars and related substance. J. Analy. Chem., 28:350-356.

El-Defrawi, M.E.; Toppozada, A.; Mansour, N. and Zeid, M. (1964): Toxicological studies on the Egyptian cotton leafworm, *Prodenia litura* (F.) susceptibility of different larval instars of *Prodenia* to insecticides. J. Econ. Entomol., 57: 591-593. DOI:10.1093/JEE/57.4.591.

Gelmesa, D.; Abebie, B. and Desalegn, B. (2012): Regulation of tomato (*Lycopersicon esculentum* Mill.) fruit setting and earliness by gibberellic acid and 2, 4-dichlorophenoxy acetic acid application. Afr. J. Biotechnology., 11: 11200-11206. DOI:10.5897/AJB11.2928.

Hemingway, J. and Karunaratne, S. (1998): Mosquito carboxylesterases: a review of the molecular biology and biochemistry of a major insecticide resistance mechanism. Med. Vet. Entomol., 12: 1-12.DOI: 10.1046/j.1365-2915.1998.00082.x.

Ishaaya, I. (1971): Observation on the phenoloxidase system in the armored scales *Aonidiella aurantii* and *Chrysomphalus aonidum*. Pestic. Biochem. Physiol., 39: 935-943.

https://doi.org/10.1016/0305-0491(71)90117-9.

Ishaaya, I. and Casida, J. E. (1974): Dietry TH 6040 alters composition and enzyme activity of housefly larval cuticle. Pestic. Biochem. Physiol., 4: 484-490. https://doi.org/10.1016/0048-3575(74)90073-X.

Isman, M. B. and Machial, C. M. (2006): Pesticides based on plant essential oils: from traditional practice to commercialization. In M. Rai and M.C. Carpinella (eds.), Naturally Bioactive Compounds, Elsevier, BV, 29-44.

Kaur, R. and Rup, P.J. (2003): Influence of some plant growth regulators (PGRs) on biochemical profile in the larvae of melon fruit fly *Bactrocera cucurbitae* (Coquillett) (Diptera: Trypetidae). Entomon. Trivandrum, 28: 89-96. DOI:10.1017/S1742758400020336.

Keskin, M. (2016): Influence of abscisic acid on the biology and hemocytes of the model insect *Galleria mellonella* (Lepidoptera: Pyralidae). Ann. Entomol Soc Am., 109: 244-251. https://doi.org/10.1093/aesa/sav122.

Nelson, Z.; Budia, F.; Vinuela, E. and Medina, P. (2009): Antifeedant and growth inhibitory effects of extracts and drimanes of *Drrimys winteri* stem bark against *Spodoptera littoralis*. Industerial Crops and Products., 30: 119-125. https://doi.org/10.1016/j.indcrop.2009.02.009.

Ning, H.T. and Subroto, G. (2018): Effect of hormone concentration and frequency of administration of gibberellins on growth and yield of tomato fruit. Agri. Rural Sci., 1: 104-115.

Prado, S. G. and Frank, S.D. (2013): Tritrophic effects of plant growth regulators in an aphid-parasitoid system. Biol. Control, 66: 72-76. https://doi.org/10.1016/j. biocontrol.2013.03.019.

Rantala, M. J.; Vainikka, A. and Kortet, R. (2003): The role of juvenile hormone in immune function and pheromone production trade-offs: a test of the immune competence handicap principle. Proc. Royal Soc. London B. Biol. Sci., 270: 2257-2261. doi:10.1098/rspb.2003.2472

Rolff, J. and Siva-Jothy, M.T. (2002): Copulation corrupts immunity: a mechanism for a cost of mating in insects. Proc. Natl. Acad. Sci., 99: 9916-9918. doi: 10.1073/pnas.152271999.

Tachell, R. J.; Arman, S. F. and Boctor, F. N. (1972): Biochemical and physiological studies of certain Ticks. (Ixodoidea). Z. Parsitenk, 9:345-350.

Valizadeh, B.; Sendi, J.J.; Zibaee, A. and Oftadeh, M. (2013): Effect of Neem based insecticide Achook® on mortality, biological and biochemical parameters of elm leaf beetle *Xanthogaleruca luteola* Mull (Col: Chrysomelidae). J. Crop Prot., 2: 319-330.

Van Asperen, K. (1962): A study of housefly esterase by means of sensitive colourimetric method. J. Insect. Physiol., 8: 401-416. https://doi.org/10.1016/0022-

1910(62)90074-4.

Zibaee, A. and Bandani, A.R.A. (2010): Study on the toxicity of the medicinal plant, *Artemisia annua* L. (Astracea) extracts the sunn pest, *Eurygaster integriceps* Puton (Heteroptera: Scutelleridae). J. Plant Prot. Res., 50P: 48-54. DOI:10.2478/v10045-010-0014-4.