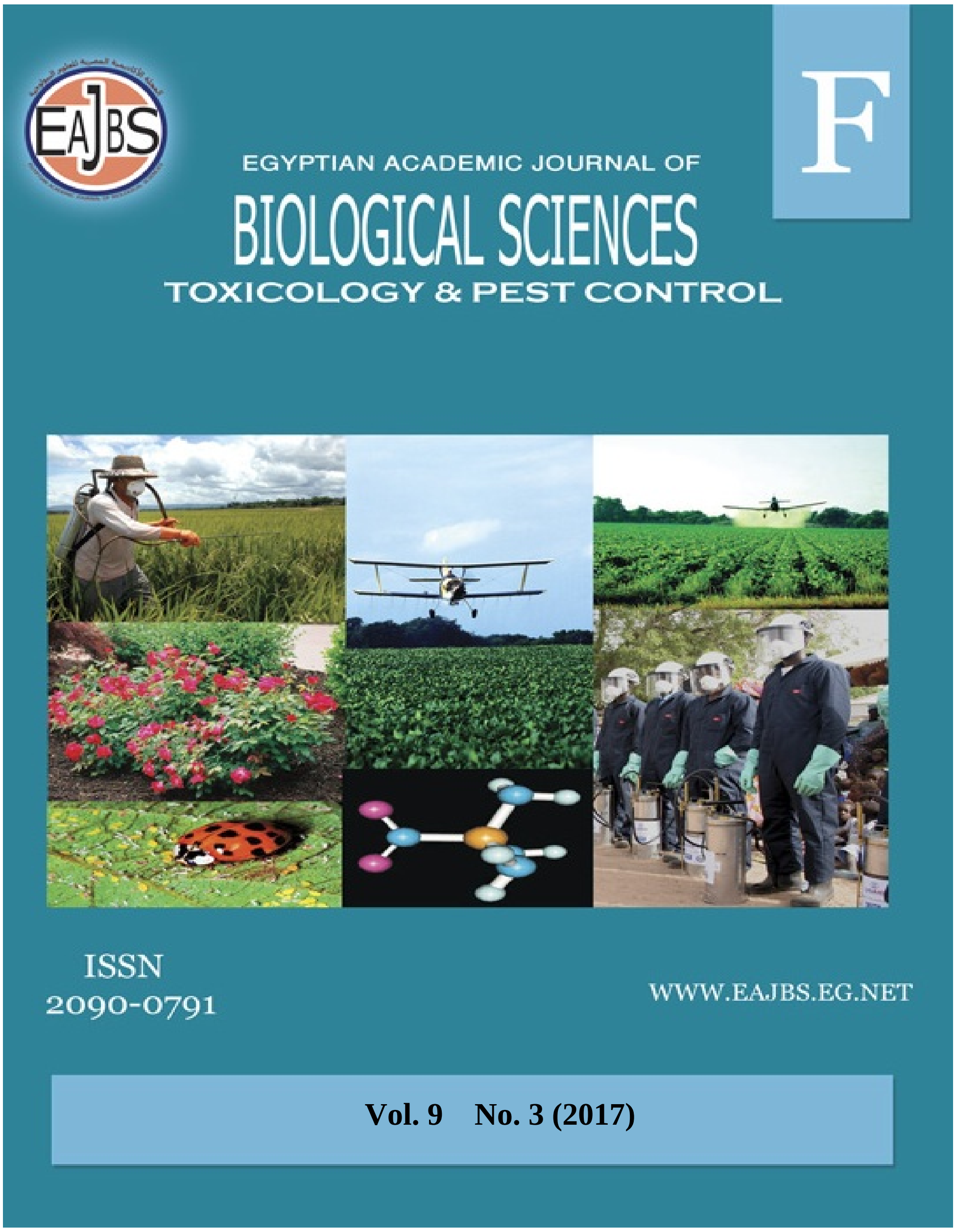

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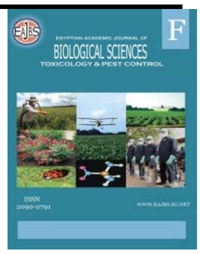

Internet of Things (IoT) To Control The Two-Spotted Spider Mite, *Tetranychus urticae* Koch in Green houses

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ABSTRACT

Internet of things (IoT) technology declared its effects in agriculture generally and for pests' control specifically. IoT is able to do many tasks in greenhouses which were infested with the two-spotted spider mite, *Tetranychus urticae*. The full automated system depended on the wireless protocol that used sensors, Arduino, geographic information system (GIS), global system for mobile communication (GSM), etc., for data collection, processing, and others. It could be effective for pest monitoring, then data transference and finally decisions related to the activation of the distinctive procedure automatically. Such technology can direct even light or sound or both to let particular predator come and victual its prey with little efforts than occurred in control. Drone with light emitting diodes (LEDs) caused more than 90% reduction of infestation with most used colors by attracting specific predators to both exposed types, green and red, of *T. urticae*. Also but with little difference, recorded voices of adult females of *T. urticae*in the case of high infestations, showed their effectiveness to attract predators to cause reduction with about 80%. In other words, the precision agricultural system is so close for being applied to control mites through IoT as an advanced technology in both open fields and greenhouses successfully.

INTRODUCTION

The Internet of Things (IoT) is the mix of the progressed and physical world. It is the arrangement of physical things embedded with electronic circuits, sensors, programming, and system affiliation which engages these issues to exchange data with each other. In a universe of IoT, a huge number of things or gadgets will be interconnected and interestingly recognized on the Internet. IoT enables items to be detected and controlled remotely crosswise over existing system foundation, making open doors for more straightforward reconciliation between the physical world and PC based frameworks, and bringing about enhanced proficiency, precision, what's more, monetary advantage (Marković *et al*. 2015).

IoT presents an innovated creation view to customary farming, and it is situated to the data organize including computerization, utilization of insightful gadgets and their systems administration during the agrarian operations.

The platform of IoT empowers greenhouses to track any infestation and its control with performance monitoring (pressure, temperature, fertilization, et cetera) on a real-time basis. This will empower them to do preventive support and recognize any variations from the norm in the framework (Shahzadi *et al*. 2016).

IoT framework is mainly depended on the full electronic system. It consists of both programmed Raspberry Pi and Arduino.

The stage incorporates executives, specialists, and normal guests. Through PCs, cell phones, etc., they can log in the remote server and view the ongoing information, chronicled information and remote parameter setting that collected by the checking detecting layer; horticultural specialists can investigate the gathered information and construct a specialist database. The data stage of infection and pests monitor based on IOT would be a coordinated framework that incorporates a wide range of data which incorporates the agrarian administration learning, buy, warehousing, conveyance and retail and understands the data trade between various stages. The center capacity is quick obtaining, consistent association, solid transmission and in-time inquiry and trackback of data (Shi *et al*. 2015).

In light of the qualities of exact recognition, proficient transmission and smart the combination of Internet of Things and Distributed Computing, the framework would be able to obtain ongoing ecological data for trim development and after that be transmitted. The framework can screen an assortment of ecological parameters in nursery adequately and meet the real farming generation necessities.

Gadgets, for example, temperature sensor, light sensor, relative mugginess sensor and soil dampness sensor are incorporated to show the proposed framework. This exploration concentrates on building up a framework that can naturally gauge and screen changes of temperature, light, Humidity, and moisture level in the nursery. The amount and nature of creation in nurseries can be expanded. The strategy utilized as a part of our framework gives the proprietor the subtle elements on the web independent of their nearness on location. The fundamental framework gathers environmental parameters inside nursery burrow like clockwork. The parameters that are gathered by a system of sensors are being logged and put away web based utilizing distributed computing and Internet of Things (IoT) together called as Cloud IoT (Patil *et al.* 2012). IoT can automatically connected with cloud and then no need to human conjugation.

Through IoT system, there are many tools can be controlled to do some tasks in the greenhouse and certainly as presented at this paper both light emitting diodes (LEDs) and bioacoustics of both pest and predator. IoT could operate each tool separately or together as required. LEDs emphasized their role against wide spectrum of agricultural pests with extraordinary outcomes which represented a remarkable mode of action in comparable with frequent used pesticides (Abd El-Wahab 2015; Abd El-Wahab and Abouhatab 2014).Beside so, bioacoustics were used in some issues related mainly to survey, prediction and control operations against some orders such as.

The point of this work was to display the IoT idea in the observing and control framework display connected to cultivate creation forms under greenhouses. In addition, the principle concentrate is on meanings of IoT gadgets and acknowledge by accessible microcontroller stages, with shields and suitable sensors to control mites.

MATERIALS AND METHODS

Designed IOT System with both LEDs and bioacoustics:

The main system was depending on Arduino Leonardo that can be stimulated when connected to the usual USB of a computer \ Raspberry pi \ phone or tablet on Android through an OTG connector. Beside NodeMCU-ESP8266 can make connection among electronics with internet through wireless protocols. Therefore, geographic information system (GIS), global system for mobile communication (GSM), Global Positioning System (GPS) and others, were gained through specific modules (Atzori *et al*. 2010). Besides, innovated bioacoustics device which consisted of microphone and piezoelectric stimulator modules were connected to such platform, like Radio frequency identification (RFID) module: The remote non-contact utilization of radio frequency electromagnetic fields to exchange information, for the motivations behind consequently recognizing and following labels connected to objects (Welbourne *et al*. 2009). Moreover, LEDs with two colors, white (BSWL, 420-680 nm) and blue (460 nm), were connected to the Arduino system which powered by solar energy. Ultra-directional microphones were also conjugated to the full system with innovated module could pick and then record required bioacoustics successfully with no noises interaction.

Used Innovated instruments:

Both innovated instruments were gained about 21 international prizes from many countries all over the world and proved their effectiveness against agricultural pests through personal research from 2010 till now.

Stable Instrument:

10Watt monocrystalline solar panel - 14" X 12", 20-ft/18-gauge cables, 12V/3aH 20-hr battery, solar charge controller to protect battery from overcharge / over discharge and Light Emitting Diodes (LEDs) were used to make the full required system. LEDs with two colors, powered by solar energy were used effectively. LEDs provided 12 h light/12 h dark photoperiod at the duration of exposure. Treatments were done under two different light colors, while control was under normal fluorescent light (Abd El-Wahab and Bursic 2014). 6 LEDs were used as 3 LEDs per each color. Two colors, white and blue were used and controlled by Arduino Uno. C++ language was used in the programming to On/Off lights automatically. Principally, all basically mentioned modules were joined the full system and bioacoustics modules were also conjugated in the full system and then info and decisions were send and received to computing cloud.

The Drone:

The drone is relying upon 4 engines, RC remote, ESC, flight controller, and rechargeable battery. LEDs were included with their controller and the entire framework is relying upon solar energy. Drone was with wireless control and LEDs colors were easily changed depending on the infested plant, pest, place and required mode of action of LEDs. Also, full voice system was conjugated in the drone and operated through IoT system automatically. Moreover, the fixed camera on the drone was able to take a full image of the status at the greenhouses each 30 minutes and sent it to the system which decided if LEDs, bioacoustics or both would be used. Fundamentally, used modules to specify position of flight and also infestation with mites, were certainly joined the drone. Results also were being received and analyzed immediately.

Crops in Greenhouses:

Greenhouses of strawberry and cowpea were used to examine IoT system with all of its applications through both used tools, the stable set and the drone. Main used LEDs with two colors and recorded bioacoustics' systems were used against both forms of *Tetranych usurticae*. Four greenhouses were used in this research, and each one was constructed on 1000m². Both predators, *Sethorusp unctillium* and *Scolothrips sexmaculatus*, were released after the infestations occurred within one week. Separators were placed among treatments in the greenhouses to prevent interaction among them.

Data Analysis:

SPSS (V.16) was utilized to demonstrate contrasts among treatments and test significance among different groups which even exposed to LEDs, bioacoustics, or both in comparable with control in the present research.

RESULTS AND DISCUSSION

The platform and usage of an electronic framework implemented and based on GSM (Global System for Mobile correspondence), cloud registering and Internet of Things (IoT) for detecting and controlling mites were presented in this paper with a simple technique which suitable for Egyptian economic circumstances.

Light emitting diodes (LEDs) demonstrated their ability against mites as shown in Table (1). LEDs were combined and controlled by internet of things (IoT) system that showed at stable unit of LEDs, then new identification is released, internet of robotic things (IoRT) which appeared in LEDs'drone.

Table (1) indicated to the direct effect of LEDs on *Tetranychus* forms infested greenhouses'crops. White LEDs caused higher mortality percentages when exposure was done by drone (90.78 and 79.97 %) than stable unit (97.24 and 92.74 %) against both green and red forms of *Tetranychus urticae*, respectively. In the same trend but with lower mortality percentages than got from white LEDs, drone with blue LEDs resulted in 91.20 and 96.55% in comparable with stable unit (84.11and 89.26 %) against both green and red forms of *T. urticae*, respectively.

Nonetheless, there was another response which appeared in escaping or keeping quiescent and the highest percentage was in case of red form of *T. urticae* infested strawberry and exposed to blue LEDs of the drone. Also, such mentioned response was the result of exposure to LEDs through IoT system.

Non Parametric Tests were used to affirm the relation between LEDs'exposure and mortality of Tetranychus mites under the full IoT system. Significance was assured at the 0.01 level (2-tailed) of K-related samples through both Friedman Test (Chi-Square =36.144**) and Kendall's Coefficient of Concordance (Kendall's Wa) = 723**. In the same trend, one way anova test showed that used tools (F=6.300**) have a significant effect on mortality (F=148.395**) and also other response (F=56.695**).

Table 1: Direct effects of light emitting diodes (LEDs) of stable unit and drone through IoT system against *Tetranychus urticae*

Pests	The Crop	Used Tool	LEDs Colors	% Mortality	% Other Response
Tetranychus urticae Green Form	Cowpea	Stable Set	White	90.78	65.39
			Blue	84.11	56.01
		LEDs Drone	White	97.24	72.72
			Blue	91.20	63.28
		Control		10.15	1.88
Tetranychus urticae Red Form	Strawberry	Stable Set	White	79.97	52.67
			Blue	89.26	68.26
		LEDs Drone	White	92.74	65.51
			Blue	96.55	74.20
		Control		10.68	2.47

Moreover, pearson correlation was significant at the 0.05 level (2-tailed) of mortality and tools =-.723* and correlation between LEDs colors and tools=.643* at the 0.01 level (2-tailed). While, correlation is significant at the 0.01 level (2-tailed) of mites and crops=1** and the same of LEDs and mortality=-.792** .

In addition, LEDs were able to contribute in biological control of mites as well as physical control. Certain colors of LEDs which conjugated in the drone were able to control the two forms of *T. urticae* by attracting specific predator to each form as showed at Table (2). Voracity was recorded 100% for *S. punctillium* on green form of *T. urticae* which infested cowpea and exposed to white LEDs and also for *S. sexmaculatus* on red form of *T. urticae* which infested strawberry and exposed to blue LEDs (Table 2). About olfaction, the highest percentage was detected for *S. punctillium* on green form of *T. urticae* which infested cowpea and exposed to white LEDs (Table 2).

Highly significant results showed that voracity was depended mainly on LEDs colors and they were confirmed by Friedman Test which showed Chi-Square=54.873** and Kendall's Coefficient of Concordance (Kendall's Wa =.915** with Chi-Square= 54.873 **).

While, Kruskal-Wallis Test showed that voracity chi-square=4.083* at 5% depending on LEDs colors and the same result was confirmed by Std. Deviation of Jonckheere-Terpstra Statistic Test (3.464*).

Table 2: Indirect effects of light emitting diodes (LEDs) of drone through IoT system on voracity and olfaction of predators against *Tetranychus urticae*

Pests	Predator	LEDs	Crop	% Voracity	% Olfaction
***Tetranychus urticae* Green Form**	*Sethorusp unctillium*	Blue White	Cowpea	92.45 100	95.04 100
	Scolothrips sexmaculatus	Blue White		70.08 90.27	84.09 70.85
	Sethorusp unctillium	Control		52.88	59.57
	Scolothrips sexmaculatus			39.77	43.89
***Tetranychus urticae* Red Form**	*Sethoruspunctillium*	Blue White	Strawberry	68.01 79.67	75.28 83.49
	Scolothrips sexmaculatus	Blue White		100 91.87	97.04 94.91
	Sethorus punctillium	Control		57.38	66.27
	Scolothrips sexmaculatus			42.87	51.05

Substantially, bioacoustics was played an important role to control the two forms of *T. urticae* but indirectly (Table 3).

Drone with bioacoustics modules were more effective to emit required voices vastly than stable unit. So the drone with recorded voices were able to attract predators which showed the highest percentage of voracity for *S. sexmaculatus* on red form of *T. urticae* that in fisted strawberry and exposed to predators' voices (84.17 %). Concerning 100% olfaction, it was recorded for *S. punctillium* on green form of *T. urticae* which infested cowpea and exposed to predators' voices (Table 3). Kendall's Coefficient of Concordance recorded (Kendall's Wa= .823** with Chi-Square= 49.351**) with high significant difference at 1%.

Two related samples test was done of voices-voracity was tested specifically through Wilcoxon Signed Ranks Test .The highest significant result recorded (Z=-3.059**) with Std. Deviation of Marginal Homogeneity Statistic= 108.162**.With also significant difference but little than occurred at the previous relation, two related samples test of voices-olfaction, Z=-3.059* but with high significant Std. Deviation of Marginal Homogeneity Statistic= 125.036**.

Table 3: Effect of emitted bioacoustics by drone through IOT system on voracity and olfaction of predators against both forms of *Tetranychus urticae*

Pests	Predator	Bioacoustics	Crop	% Voracity	% Olfaction
***T. urticae* Green Form**	*Sethorusp unctillium*	Pests	Cowpea	77.14	90.24
		Predators		85.39	100
	Scolothrips sexmaculatus	Pests		56.27	62.02
		Predators		80.21	74.27
	Sethorusp unctillium	Control		47.04	61.12
	Scolothrips sexmaculatus			33.48	54.07
***T. urticae* Red Form**	*Sethorusp unctillium*	Pests	Strawberry	63.24	78.17
		Predators		72.51	81.69
	Scolothrips exmaculatus	Pests		60.41	71.07
		Predators		84.17	92.72
	Sethorusp unctillium	Control		39.90	47.90
	Scolothrips sexmaculatus			40.87	52.77

Moreover, one way test showed both significant olfaction and voracity differences (F=11.870* and 13.414*), respectively. With grouping variable: LEDs, both Jonckheere-Terpstra Test, showed that voracity differences were significant (Std. Deviation of J-T Statistic =3.464*) and Kruskal Wallis Test recorded Chi-Square=4.083*.

Consequently, both joint actions of both bioacoustics and LED scould increase the expectation of higher voracity and olfaction percentages than used separately from each other.

Table (4) showed the effect of using pests' voices plus certain colors of LEDs through IoT system to investigate voracity and olfaction of predators against the two forms of *T. urticae*.

Data revealed that drone with its modules was able to do its tasks more successfully than the stable unit on both crops. Treatments which caused 100% mortality were by drone mainly for *S. punctillium* on green form of *T. urticae* that infested cowpea and exposed to white LEDs and also in case of *S. sexmaculatus* on red form of *T. urticae* which in fested strawberry and exposed to blue LEDs.

Concerning olfaction percentages, the highest was recorded by drone for *S. sexmaculatu s*on green form of *T. urticae* which infested cowpea and exposed to blue LEDs (98.98%) and the lowest was declared by stable unit for *S. punctillium* on red form of *T. urticae* which infested cowpea and exposed to white LEDs (63.27%).Besides, control variables for both estimated voracity and olfaction percentages for predators were recorded frequently lower values. Nonparametric tests showed that high significant differences were recorded in case of use both pests' voices and LEDs colors together. Friedman Test (Chi-Square=116.151**) and Kendall's Coefficient of Concordance =.807** (Chi-Square=116.151).

Alongside, Kolmogorov-Smirnov Z =2** was high significant at 1% for both sets and predators which means that the difference of responses was relate to the used instrument which able to attract specific predator to each pest on certain crop efficiently. Same results were gained by Moses Test through both Observed and trimmed Control Group Span and then outliers trimmed from each end (Sig. (1-tailed). Moreover, both voracity and olfaction variations were highly significant at 1% at Mann-Whitney U (28.500 and 31.000) and Wilcoxon W (64.500 and 67.000), resp. and all of mentioned differences were upon certain used sets to attract specific predators. Additionally, Cronbach's Alpha through Reliability Statistics recorded 485**.

On the premise of the data got, cultivators can respond in an auspicious way and apply fitting measures. Information on the operation of farming apparatus is acquired utilizing sensors, which empower administrators to modify machine operation to working conditions so as to accomplish higher adequacy and nature of the creation procedure. Shi *et al.* (2015) introduced IoT concept that utilized as a part of controlling plant ailments and pests, which comprise of a checking framework to gather data about required items, utilizing sensor hubs and segments of data processing.

Table 4: Indirect effects of joint action of both pests bioacoustics and light emitting diodes (LEDs) through IOT system against *Tetranychusurticae*

Pests	Predator	Pests' Voices+ LEDs Colors	Used Sets	Crop	% Voracity	% Olfaction
***T.urticae* Green Form**	*Sethorusp unctillium*	White	Stable	Cowpea	98.14	95.34
	Scolothrips sexmaculatus				92.04	78.60
	Sethorusp unctillium		Drone		100	97.14
	Scolothrips sexmaculatus				96.11	90.77
	Sethorusp unctillium	Control			75.27	41.34
	Scolothrips sexmaculatus				61.20	30.82
***T.urticae* Red Form**	*Sethorusp unctillium*	White	Stable	Strawberry	96.15	63.27
	Scolothrips sexmaculatus				93.38	85.01
	Sethorusp unctillium		Drone		99.07	92.08
	Scolothrips sexmaculatus				97.30	88.31
	Sethorusp unctillium	Control			70.01	45.67
	Scolothrips sexmaculatus				52.07	50.27
***T.urticae* Green Form**	*Sethorusp unctillium*	Blue	Stable	Cowpea	93.91	79.11
	Scolothripssexmaculatus				98.44	80.73
	Sethorusp unctillium		Drone		95.17	75.09
	Scolothrips sexmaculatus				96.39	98.98
	Sethorusp unctillium	Control			67.94	52.12
	Scolothrips sexmaculatus				80.49	73.96
***T.urticae* Red Form**	*Sethorusp unctillium*	Blue	Stable	Strawberry	95.71	83.41
	Scolothrips sexmaculatus				98.24	88.09
	Sethorusp unctillium		Drone		98.54	88.14
	Scolothrips sexmaculatus				100	98.25
	Sethorusp unctillium	Control			77.98	70.21
	Scolothrips sexmaculatus				80.01	60.78

Obtained results could be clarified upon the main mode of action of LEDs against mites which was relying on Mono Amine Oxidases (MAO).The enzyme activity turned lower in the exposed pests to LEDs colors than untreated. So the more accumulation of biogenic amines occurred and then attraction of the predator increased as a result. The same outcome was proved against mites and insects (Abd El-Wahab *et al.* 2015; Abd

El-Wahab and Abouhatab 2015), effectively.

MAO activity was lower in LEDs treatments *Phenacoccus solenopsis* Tinsleythan control.

Cool White and super blue LEDs affected MAO activity with 1.04 and 1.87 mOD min-1 mg-1 proteins. On the other hand, all controls even positive or negative recorded the highest values of MAO specific activity (3.61 and 2.55 mOD min-1 mg-1 proteins), respectively.

Moreover, voracity values of *Propyleaquatuor decimpunctata* L. on *Phenacoccus solenopsis* under cool white and super blue LEDs were increased than control with 90% and 77.78%, of the same arrangement, than both positive control (1.11%) and negative control (0%) as estimated by Abd El-Wahab and Abouhatab (2015). Concerning the attraction of predators to the exposed mites to LEDs colors, phototactic conduct of two predators, *Stethorusp unctillum* and *Scolothrips sexmaculatus* was unequivocally influenced by LEDs to the two types of *Tetranychus urticae* (Abd El-Wahab and Abouhatab 2014). The most noteworthy fascination of attraction ratio estimations of *S. punctillium*to *T. urticae*green type presented to white LED while it was recognized with *S. sexmaculatus* gone after red shape presented to blue LED. Concerning ravenousness, it was recorded 100 % if there should arise an occurrence of predation on the green and red types of *T. urticae* presented to white and blue LEDs by *S. punctillum* and *S. sexmaculatus*, resp. Results demonstrated that there were altogether contrasts of insect predators' phototactic conduct which back predominantly to LEDs colors.

Additionally, light emitting diodes (LEDs) with two certain colors, white and blue, demonstrated effectively its immediate impacts on the two types of *Tetranychus urticae* even they were used separately or with pesticide. The cooperation of Vertimec and LEDs constantly recorded the most elevated direct impact, 100% mortality, against females of the two types even by the assurance of mortality rates or translaminar impacts taken after by others. Plus, LEDs had an adequate translaminar impact more than Vertimec, fundamentally. White LEDs were more compelling against the green frame in all treatments while Blue LEDs were more viable against the red shape. Treatments caused hindrance of the catalyst, however, White LEDs and Blue LEDs joined with Vertimec LC_{50} diminished the protein movement of the green sort of *T. urticae* (0.09 and 0.13 mOD min-1 mg-1 proteins, resp.) more than the red sort (0.1 and 0.17 mOD min-1 mg-1 proteins, resp.). Taking everything into account, there was a nearby unique positive connection among a collection of biogenic amines and proportion of mortality which was influenced principally by LEDs colors (Abd El-Wahab 2015).

Bioacoustics of both mites and predators were contributed successfully in biological control of the target pests. Even though there are no many studies which tried to depend mainly on voices to control tiny agricultural pests such as mites. But through IoT, recording and then emitting voices, new system could be done easily and got efficient dominance against pests. Additionally, in this paper voices of both pests and predators were recorded to estimate their effects on percentages of voracity and olfaction of the predators. Data confirmed the useful use of bioacoustics to control mites biologically. Furthermore, bioacoustics' outflows of stored grain insects, created by moving, bolstering, ovipositing and so forth can be utilized for recognition purposes as well as detection and identification of species and population density beside predication of infestation through the framework as detected under laboratory conditions by Eliopoulos *et al*. (2013).

Advantages of IoT applications in horticulture incorporate change in the utilization productivity of info sources, for example, soil, water, pesticides, and so on., lessened cost of creation, expanded benefit, supportability, sustenance wellbeing, natural insurance (Patil *et al.* 2012). Through IoT, agriculturists can convey their yields to clients on a wide scale. This can change the inventory network in the best approach to give a more coordinated and shorter chain from the purpose of creation to the customer.

In the most recent decade, changes of technological systems have additionally influenced rural yield creation and ranching. Using different sensors and remote gadgets, agriculturists can get data about soil dampness (Zhang *et al.* 2013), nutrients status (Galande et al. 2015), or plant ailments and pests' prominence in plants (Dang et al. 2013).So all required agricultural operations especially pests' control will be done totally upon advanced technology with no need to pesticides because IoT will take proactive and preventive activities to limit the plagues of diseases and pests (Shahzadi *et al.* 2016).

IoT is being a new trend in the infotronic agricultural systems with unique advantages to go in the same target with UN sustainable development goals (SDGs). IoT system could be distributed especially in low income countries to offer a chance of work and training for youth, women and refugees.

CONCOLUSION

Internet of things (IoT) with all of its attachments and applications will be able to control mites successfully under greenhouses even with automatically used LEDs, bioacoustics or both. No need for more human interaction in such activities because all of the system is connected directly with computing cloud which can send and receive data and decisions, respectively depending on many factor related to the target pest, attractant predator and the infested plant.

REFERENCES

Abd El-Wahab, R. (2015). Direct Effects of Light Emitting Diodes (LEDs) on The Two Spotted Spider Mite, *Tetranychus urticae*. Int. J. Scient. Res. Agric. Sci., 2 (Proceedings), pp.79-85.

Abd El-Wahab, R. Anwar, E. M., Abouhatab, E. E. and Li, X. (2015). The Indirect Role of Solar Energy in Controlling Cotton Leafworm, *Spodoptera littoralis* (Bosid) (Lepidoptera: Noctuidae). Int. J. Chem. Biol. Sci. 1 (8): 1-8.

Abd El-Wahab, R.A. and Abouhatab, E. E. (2015). Phototactic Effects of Solar Energy and Light Emitting Diodes (LEDs) on *Propyleaqua-tuordecimpunctata* L. against *Phenacoccus solenopsis* Tinsley. Int. J. Sci. Res. Agricul. Sci., 93(5A):1-14.

Abd El-Wahab, R. A. and Abouhatab, E. E. (2014). Effects of Light Emitting Diodes (LEDs) On the Insect Predators Behavior against the Two Forms of *Tetranychus urticae* Koch. Int. J. Chem. Biol. Sci. (IJCBS) 1 (4): 36-45.

Abd El-Wahab, R. A. and Bursic, V. (2014). Light Emitting Diodes (LEDs) Reduce Vertimec, Resistance in *Tetranychus urticae* (Koch). Int J. Chem Biol. Sci. (IJCBS), 1(3): 28-40.

Atzori, L., Iera, A. and Morabito, G. (2010). The Internet of Things: A Survey. Computer Networks, 54: 2787-2805.

Dang, K., Sun, H., Chanet, J. P., Garcia-Vidal, J., Barcelo-Ordinas, J. M., Shi, H.L., and Hou, K. M. (2013). Wireless multimedia sensor network for plant disease detections. NICST'2103 New Information Communication Science and Technology for Sustainable Development: France-China International Workshop, Clermont-Ferrand, France, 6.

Eliopoulos, P. A., Givropoulou, E. G., Potamitis, E., and Kontodimas, D. C. (2013). Bioacoustic detection and estimation of population density of insect pests in stored grain. 15th Panhellenic Entomological Congress. Session 13: Insects of Medical Importance-Stored Product Pests. 22-25 Oct., 2013. Hellenic Entomological Society, Kavala, Greece.

Galande, S. G., Agrawal, G.H., and Dighe, S. B. (2015). Greenhouse Microclimatic Real-Time Monitoring with the Help of NPK Sensor. International Journal of Emerging Trends in Science and Technology, 2(5): 2511-2515.

Marković, D., Koprivica, R., Pešović, U., andRanđić, S. (2015). Application of IoT in monitoring and controlling agricultural production. Acta Agriculturae Serbica, Vol. XX, 40:145-1531.

Patil, V. C., Al-Gaadi, K. A., Biradar, D. P. and Rangaswamy, M. (2012). Internet of things (IoT) and cloud computing for agriculture: An overview. Proceedings of Agro-Informatics and Precision Agriculture (AIPA 2012), India, 292-296.

Shahzadi, R., Tausif, M., Ferzund, J., and Suryani, M. A. (2016). Internet of Things based Expert System for Smart Agriculture. (IJACSA) International Journal of Advanced Computer Science and Applications, 7(9):341-350.

Shi, Y., Wang, Z., Wang, X. and Zhang, S. (2015). Internet of Things Application to Monitoring Plant Disease and Insect Pests. International Conference on Applied Science and Engineering Innovation (ASEI 2015), 31-34.

Welbourne, E., Battle, L., and Cole, G. (2009). Building the Internet of Things using RFID. IEEE Internet Computing, 13(3):48-55.

Zhang, M., Li, M., Wang, W., Liu, C., and Gao, H. (2013). Temporal and spatial variability of soil moisture based on WSN. Mathematical and Computer Modelling, 58(3-4): 826–833.

ARABIC SUMMERY

إنترنت الأشياء (IoT) لمكافحة العنكبوت ذو البقعتين ***Tetranychus urticae*** **Koch** فى الصوب الزراعية

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أظهرت تكنولوجيا إنترنت الأشياء (IoT) تأثيراتها في الزراعة عموما وفى مكافحة الآفات على وجه التحديد. إنترنت الأشياء قادرة على القيام بالعديد من المهام في الصوب الزراعية المصابة بالعنكبوت ذو البقعتين *Tetranychusurticae*. ويعتمد النظام الآلي الكامل على البروتوكول اللاسلكي الذي يستخدم أجهزة الاستشعار، ونظام الأردوينو، ونظام المعلومات الجغرافية (GIS) والنظام العالمي للاتصالات المتنقلة (GSM) وغيرها، وذلك لجمع البيانات وتجهيزها وغيرها من العمليات. ويمكن أن تكون فعالة لمراقبة الآفات، ثم نقل البيانات وأخيرا القرارات المتعلقة بتفعيل القرار اللازم تلقائيا. هذه التكنولوجيا يمكن أن توجه حتى الضوء أو الصوت أو كليهما للسماح لمفترس معين للحضور والفوز بفريستهبجهد أقل مقارنة بالكنترول. الطائرات بدون طيار المزودة الثنائيات الباعثة للضوء (LEDs) في خفض أكثر من ٩٠٪ من الإصابة معأكثر الألوان استخداما من خلال جذب المفترسات لكلا الشكلين المعرضين ، الأخضر والأحمر، من *T. urticae*. أيضا ولكن مع اختلاف بسيط، تم تسجيل أصوات الإناث البالغات من *T. urticae* في حالة الإصابة العالية والتى أظهرت فعاليتها فى جذب المفترسات للحد من الاصابةبنسبة ٨٠٪ تقريبا. وبعبارة أخرى، فإن النظام الزراعي الدقيق قريب جدا للتطبيق وذلك لمكافحة الأكاروسات من خلال تكنولوجيا إنترنت الأشياء (IoT) كتقنية متقدمة في كل من الحقول المفتوحة و الصوب الزراعية بنجاح.

الكلمات المفتاحية: انترنت الأشياء،*Tetranychus*،الأردينو،الدايودات،الأصوات،المفترسات.