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Predacious mites as a tool to manage spider mites *Tetranychus* spp. population on cotton cultivars

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Abstract:

A Field experiment was carried out to evaluate the role of predacious mites, which are associated with *Tetranychus* spp. infestation on their population of cotton. The susceptibility of three cotton cultivars (Mc Nair 220, Okra leaf and Giza 70) to the infestation by *Tetranychus* spp. was evaluated. The existence of three predatory mites of *Tetranychus* spp.; *Amplyseius gossipi* (El-Badry) (Acari: Phytoseiidae) , *Agistemus exertus* (Gonazlez) (Acari: Stigmaeidae) and *Tydeus californicus* (Banks) (*Acari*: Tydeidae) was also, estimated on cotton cultivars. The population dynamics of *Tetranychus* spp. and their associated predacious mites were studied along two successive cotton seasons on the three cotton cultivars. The average number of spider mites, abundant density (Expressed as the square root of the observed number +1), on each cultivar declared significant differences between all tested cultivars. The upland Mc Nair 220 cultivar was more susceptible to *Tetranychus* spp. infestation with a mean of abundant density 6.42 and 6.05 and 6.02 mites/ 10 leaves while the Egyptian cultivar Giza 70 was tolerant (3.78 and 3.69 mites/10 leaves) along with the first and the second seasons, respectively. In addition, data showed the existence of the three predator mites on all cotton cultivars during both seasons. The highest abundant density was recorded for *T. califorrnicus* followed by *A. exertus* and *A. gossipi*. Moreover, the population of *Tetranychus* spp. started to increase in June and reached its peak in September when it started to decline till October. The same trend was observed among the three spider predator mites, but they started to increase in July and reached their peaks in the first week of October. These results might be useful to determine the appropriate time to apply the other technique of control for integrated pest management of the two spotted spider mites, *Tetranychus urtica* Koch and *T. cinnabarinus* (Boisduval) (Acari: Tetranychidae) .

Introduction

Egyptian cotton is well ranked as the first of its kind globally due to its long stable and spinning quality. Cotton seed also produces a good oil quality. Unfortunately, Cotton functions as a sink crop for phytophagous pests because of its long season and its common host for pests found on adjacent short-season crops, including soybeans and corn (Barros *et al*., 2010). This instance pests pressure results in a large number of insecticide applications. The cultivated cotton is liable to be attacked by serious pests among which is the piercing-sucking pests. Phytophagous mite represents particular importance in our modern agriculture. Scarcely can we find an agriculture crop without mite population. *Tetramychus* spp. [*Tetranychus urticae* Koch and *Tetranychus cinnabarinus* (Boisduval) (Acari: Tetranychidae)] is one of the most severe phytophagous species and it is a significant pest in many cropping systems worldwide (Nauwen *et al*., 2001), such as field crops, vegetables, fruits and ornamental plants (Dermauw *et al*., 2012 and Basha *et al*., 2021). It causes many severe injuries worldwide; such as reducing yield and yield components (Wilson *et al*., 1991 and Wilson, 1993). The phytoseiidae mites are the vital group among the predatory mites on various crops (El-Badry, 1967 and Croft and McGroarty, 1977). The spider mite is a serious cosmopolitan pest that feeds on more than 1200 host plant species, 150 of them are economically significant (Migeon and Dorkeld, 2011; Azadi-Qoort *et al.*, 2019 and Najafabadi *et al*., 2019). *Amplyseius gossipi* (El-Badry) (Acari: Phytoseiidae) is the key predator for managing spider mites (Specht, 1968) in particular the two-spotted spider mites. It reproduces more quickly than the two-spotted spider mite, and feds on all of their stages.

Stigmateid mites are found in several fields, forests, and cash crops they can predate on a wide variety of harmful soft bodies and slow-moving insects and mites (Wilson, 1993). The most important predators of family Stigmatidae include genera *Agistemus* that predates on spider mite (Croft, 1994) of these genera, *Agistemus exertus* (Gonazlez), *Agistemus buntex* Chaudhri , *Agistemus pallinii* Matioli are widely diverse species (Khan *et al*., 2010 and Fouly *et al*., 2011).

Tydeus californicus (Banks) (*Acari*: Tydeidae) is considered a scavenger mite (Gerson, 1968). Reports showed that some tydeid species pray on tetranychid eggs, eriophyids (Laing and Knop, 1983). Several tydieds can act as alternative prey of phytoseiids (Knop and Hoy, 1983 and Camporese and Duso, 1995) and their presence could contribute towards maintaining phytoseiid population levels when spider mite population is low.

Spider mites' control in cotton is manly reliance on the use of chemical pesticides. These pesticides destruction of predacious mite is partially responsible for spider mites increasing population (Dittrich, 1988). As a consequence of public awareness of environmental hazards due to pesticide application, several alternative ways were developed to refine the overall integrated pest control strategy such as; host plant resistance to pests, and pest population monitoring. Biological control, evaluation economic thresholds, pesticide selectivity, minimized pesticide application rates, and application timing are commonly employ tactics (Flint and Bosch, 1981).

In the case of the cotton crop, breeders, especially in the United States of America and Egypt, have produced several cultivars and genotypes that differ in their ability to tolerate pest infestation. The property of plant resistance to insect, usually attributed to morphological as well as biochemical factors (Amr, 1993). Several investigators have found that cotton cultivars that are tolerant pest infestation differ from susceptible ones in their content of a group of chemicals known collectively as allelochemicals (Kogan, 1986) and reduction in nutrients level (Penny *et al*., 1967).

T. urticae developed resistance expeditiously as a consequence of short life cycle, heavy progeny and arrhenotokous parthenogenesis. Thus, it could be labeled as one of the most resistant species that its control became challenging in several parts globally (Van Leeuwen *et al*., 2010). The development of resistance in spider mites *Tetranychus* spp. has highlighted the need for an integrated pest management strategy. Studies of spider mites predators species that can be utilized for biological control of the *T. urtica* in Egypt are inadequate (Ibrahim , 2017 and El-Erksousy *et al*., 2016). Pest management adopts specific tactics such as; host plant susceptibility and biological control.

Therefore, the current work aimed to utilize predator mites and plant resistance tactics for integrated pest management of *Tetranychus* spp., through monitoring the population dynamics of the spider mite and their predacious mites.

Materials and methods

1. Cotton cultivars:

Two types of cotton species were selected for the study; the upland glanded species *Gossypium hirsutum*, (A medium stable) represented by Mc Nair 220 and Okra leaf cultivars and the Egyptian glanded *Gossypium barbadense*, an extra stable species demonstrated by Giza 70 one. The three cotton cultivars were obtained from the Agronomy Department, Alexandria University.

2. Field trials:

The experiment was carried out at the Experimental Station, Alexandria university at Abies, an area of about 420 m^2 was divided into four strips ($105m^2$) every strip was divided into four plots each plot ($21m^2$) was divided into four rows surrounded by non-cultivated pelt. The experiment design was Randomized Complete Blocks Design (RCBD). The experimental plot for this study was not sprayed with pesticides. The sampling of cotton leaves was started in May till the early days of November along two successive seasons. The samples were collected in the early morning at about 7 o'clock to ensure mites stability and avoid adverse climatic conditions.

3. Estimation of mite's infestation:

A sample of 10 cotton leaves was randomly collected weakly from the lower, middle and upper leaves of each plot (Petrushov and Belyaeva, 1989). Mobile stages larvae nymphs and adults were recorded weekly on ten leaves as a sub sample. Data of every four successive sub-samples were combined to make a monthly single sample. The family, genus and species levels were identified using the key developed by Krantz (1978) and Zaher (1986). Data of infestation were transformed to $\sqrt{x}$ +1 according to (Snedecor, 1961) the variance was compared using two ways ANOVA with and post hoc Student-Newman-Keuls test (Costat Statistical Software, 1990) , https://www.cohort.com.

Results and discussion

1. Susceptibility of different cotton cultivars to phytophagous mites *Tetranychus* spp. infestation:

The infestation of *Tetranychus* spp. to the three-cotton cultivar along the two seasons is present in (Figure 1 and Table 1). According to the average number of spider mites (Mobile stages) on each cultivar, the data of first season showed that, the Egyptian cotton cultivars, Giza70 was the most tolerant cultivar to *Tetranychus* spp. infestation among the tested cotton cultivars. While, Mc Nair 220 cultivar was sensitive to *Tetranychus* spp., infestation. The average number of spider mites showed a significant difference between the sensitive cultivars Mc Nair 220 and Okra leaf (6.42 and 6.11 individuals/10 leaves) on one hand and the tolerant cotton cultivar (Giza70, 3.78 individuals / 10 leaves on the other hand. The data along the second season exhibited the same trend, among the three cotton cultivars, Giza70 was the most tolerant cultivar to *Tetranychus* spp., whereas, the average number of infestation (3.69 individuals/10 leaves) followed by Okra leaf (5.57 individuals/10 leaves) and finally Mac Nair220 (6.05 individuals/10 leaves). Statistically, there were significant differences between the tested Egyptian cotton cultivar and the two American cultivars which may be due to the variation between cultivars in their morphological characters (Leaf area, or glabrous leaves), allelochemical (Gossypol) and some nutrients (Wilson and Sadras 1998).

Table (1): The accounting of spider mites *Tetranychus* spp. and their associated predators on three cotton cultivars along two successive seasons.

Season	Mite	Cotton Cultivar Mean number of mites per 10 cotton leaves*±SE			LSD (0.05) within row
		Mac Nair	Okra Leaf	Giza 70	
First	**Pest** ***Tetranychus* spp.**	6.42 ± 1.91	6.11 ± 1.48	3.78 ± 1.92	0.31
	Predator ***Amblyseius gossipi***	1.83 ± 0.42	1.27 ± 0.19	1.42 ± 0.25	0.13
	Agistemus exertus	2.01 ± 0.52	1.68 ± 0.36	1.79 ± 0.05	0.41
	Tydues californicus	2.83 ± 0.76	2.31 ± 0.54	2.94 ± 0.84	0.106
Second	**Pest** ***Tetranychus* spp.**	6.05 ± 2.42	5.57 ± 2.34	3.69 ± 1.52	0.15
	Predator ***Amblyseius gossipi***	2.19 ± 0.47	1.48 ± 0.23	3.69 ± 1.50	0.41
	Agistemus exertus	1.49 ± 0.29	1.30 ± 0.17	1.47 ± 0.56	0.11
	Tydues californicus	2.81 ± 0.88	2.51 ± 0.74	3.63 ± 1.11	0.726

*** The mean number of mites (Mobile stages) per 10 cotton leaves expressed as the square root of the obtained number plus one**.

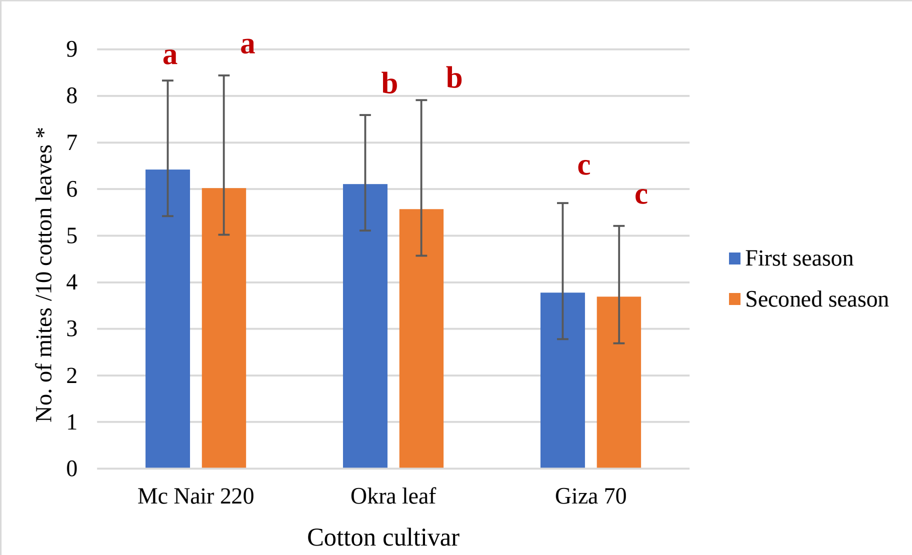


Figure (1): Susceptibility of five cotton cultivars to spider mite *Tetranychus* spp. infestation along two successive seasons.
*** The mean number of mites/ 10 cotton leaves expressed as the square root of the obtained number plus one**

This result was in accordance with the results published by Misra *et al*. (1992). They found that, the population density of *T. cinnabarinus* was in negative relation with the density of leaf hairs.

Miyazaki *et al*. (2017) mentioned that dense leaf hairs and high gossypol content are negatively affecting thrips. Since, thrips were significantly less abundant and caused less damage on diploid cotton genotypes from *Gossypium arboretum* L. than on the standard commercial *Gossypium hirsutum*.

Gentile *et al*. (1969) found that, the resistance of cotton cultivars *Solanum penellii* and *Lycopersicon hirsutum* to *T. cinnabarinus* and *T. urticae* was a consequence of that the mite became entangled in the sticky exudate of the glandular hairs of these species.

Harvey and Martin (1990) reported that, pubescent wheat was more susceptible than the glabrous wheat to the (Wheat crul) dry bulb mite *Eriophyes tulipae* Keifer (Acari : Eriophyidae).

Also, El-Halawany *et al.* (1990) found that, leaves of sultani fig variety were more susceptible to infestation with phytophagous *Tetranychus arabicus* Attiah (*Acari*: *Tetranychidae*) than the leaves of adsi variety. This might be due to differences in leaf epidermal hairs.

In contrast, several investigators mentioned that the surface hair or trichomes are the first plant organ contacted during the preliminary stages or host plant acceptance. Reed (1974) mentioned that, trichomes also existed on leaves of cotton cultivars that resist to the leafhopper *Empoasca facialis* Jacobi (Hemiptera: Cicadellidae). The current results also indicated significant differences between Mc Nair 220 (Characterized by large leaf area) and Okra leaf (Characterized by small leaf area).

Thus, the leaf area may affect the degree of *Tetranychus* spp. infestation. Gossypol in cotton cultivars had been often correlated with the resistance to insect pests (Sharma and Agarwal, 1984).

Although both cultivars Mc Nair 220 and Giza70 are contain gossypol, Mc Nair 220 was susceptible to mite infestation while Giza 70 was more tolerant. Abdou (1995) found that, Giza70 had high contents of terpenoids and aldehydes which may explain why this cultivar is spider mite tolerance. Therefore, it could be considered that gossypol is not the sole factor affecting plant resistance to infestation by *Tetranychus* spp.

2. The existence of the associated spider mite predators on the three cotton cultivars along two successive seasons:

The data in (Table 1) showed the existence of three spider mite predators on all cotton cultivars along the two seasons. The results cleared that, the predacious mite *Amplyseius gossipi* El-Badry (Acari: Phytoseiidae) had the lowest average number of mobile stages on okra leaf cultivar (1.27 and 1.48 individuals/10 leaves), within the first and the second seasons, respectively. While, it possessed the highest density on Mac Nair cultivar (1.83 individuals/10 leaves) within the first season and on Giza 70 (3.69 individuals/10 leaves) within the second season.

As regards predatory mite *Agistemus exertus* (Gonzalez) (Acari: Phytoseiidae) the results indicated that, the lowest average number was on (1.68 and 1.30 individuals/10 leaves), within the first and the second seasons, respectively.

Likewise, the highest density was recorded on Mc Nair 220 (2.01 and 1.49) and on Okra leaf (1.68 and 1.30 individuals/10 leaves), within both seasons, respectively. The third predacious mite's data cleared that, predatory mite *Tydues californicus* (Banks) (Acari:Tydeidae), ranging between 2.31 and 2.94 individuals/10 leaves on the okra leaf and Giza 70 cultivar, respectively along with the first season.

Similarly, within the second season the mean abundant *T. californicus* numbers were 2.51 and 3.63 individuals/ 10 leaves on okra leaf and G70 cultivars, respectively. Regarding the three predatory mites' species, the largest population was for *T. califorrnicus* followed by *A. exertus* and *A. gossipi*.

However, there were no significant differences in the abundance density between the three predator mites on all tested cotton cultivars. *T. californicus* has broader diets, feeding on various pest species and pollens (Croft *et al*., 1998 and Gerson *et al*., 2003).

Thus, it is considered a scavenger mite (Gerson, 1968), that can thrive by feeding on pollen, and preying on tetranychid eggs and eriophyids (Laing and Knop, 1983). This finding might explain the more significant number of *T. californicus* than *A. exertus* and *A. gossipi*. Several tydeids can act as alternative prey of phytoseiids, and their presence could contribute toward, maintaining phytoseiid population level when spider mite population is low.

The three predators mentioned before were existed all over at the same time. Thus, the combined use of these predators is considered as a control strategy. The current findings coincide with the results published by Vacacela Ajila *et al.* (2019), who stated that the combined use of Neoseius (=*Amblyseiys californicus*) and *Phytoseiuls macropilisis* considered as a control strategy. *P. macropilis* tends to disperse when the density of spider mites is low, *N. californicus* remains behind because it can feed on other food sources and it is more resistant to starvation.

The current results also agreed with Jai-Sun and Soon-Won (1985) 's findings, who stated that, *Amplyseius terminals* was the most effective biological control agent to the two-spotted spider mite but its density was highly variable with management system from one plot to another, and from year to year.

Fonseca *et al.* (2020) mentioned that the species predator *P. macropilis* and *N. californicus* are used to control the two spotted-spider mite *T. urticae*. The two predators do not avoid plants with other species as they may coexist together with their common prey. This result matches the current study, where the three predators mentioned above existed simultaneously on the same three cotton cultivars.

A.gossypi is a crucial predator for managing spider mites which specialized on two spotted spider mites, fed on all stages of the two spotted spider mite (Specht, 1968). The predation rate of *Amplyseius chiapensis* DeLeon (Acari: Phytoseiidae) was 25.6 protonymph consumed/ leaf/ day in the presence of web by *T. urticae*, while in the absence of web it was slightly higher at 29.5 protonymph consumed/ Female/ day (Do Amaral *et al*., 2020).

Also, Jai-Sun and Soon Won (1985) found that, *A. terminalis* was an effective biological control agent to the two-spotted spider mite, but its density was highly variable with the management system from one plot to another and from year to year. It seemed to be an effective predator for the phytophagous mite after August.

A relationship could be obtained between the infestation of cotton varieties by *T. urticae* and the presence of the predatory mite *T. californicus*. The current results displayed, that, the susceptible (Mc Nair 220) and moderately susceptible (Okra leaf) cultivars, had the least abundant density of *T. californicus* while, the tolerant cultivar Giza70 had the highest abundant density of *T. californicus*. Thus, this predator mite may play a role as a biological control agent.

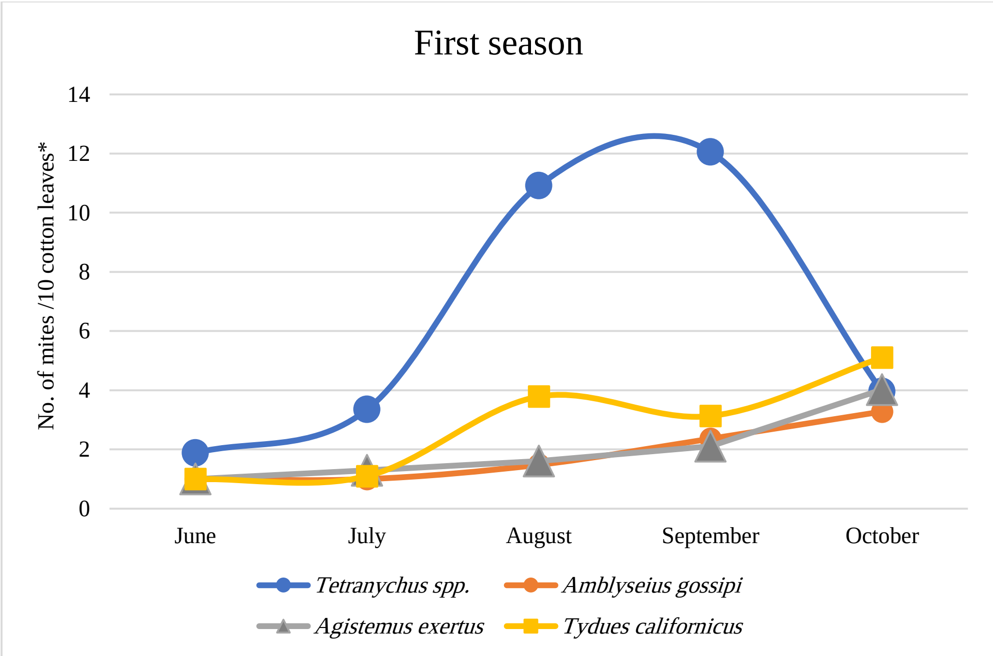
3. The population dynamics of spider mites and their predacious mite on three cotton cultivars:

This part of the research aimed to determine the adjustability of the pesticide application. The data presented in (Figures 2, 3 and 4) show *Tetranychus* spp. and its predators population dynamics on the susceptible cultivar Mac Nair 220; the moderate susceptible okra leaf and the tolerant one Giza 70 cultivars during two successive seasons.

Data of both seasons showed that, on all cultivars the spider mite started to emerge in Jun and increased gradually in numbers to reach its peak during September then starting to decline during October.

The predatory mite *A. gossipi* population size started to increase from July and reached the maximum population before the cotton harvesting. The predatory mite *A. exertus* population also increased from July and reaches their highest density during the first week of October before the cotton was harvested.

Similarly, the numbers of individuals of the predator mite *T. californicus* elevated in July and reaches the high population density in the first days of October.



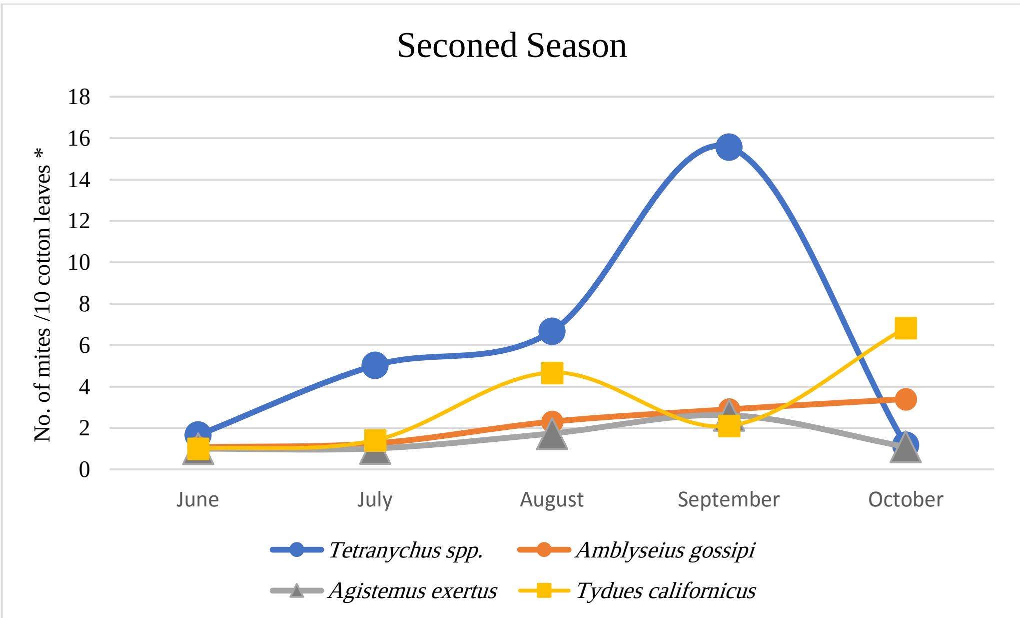
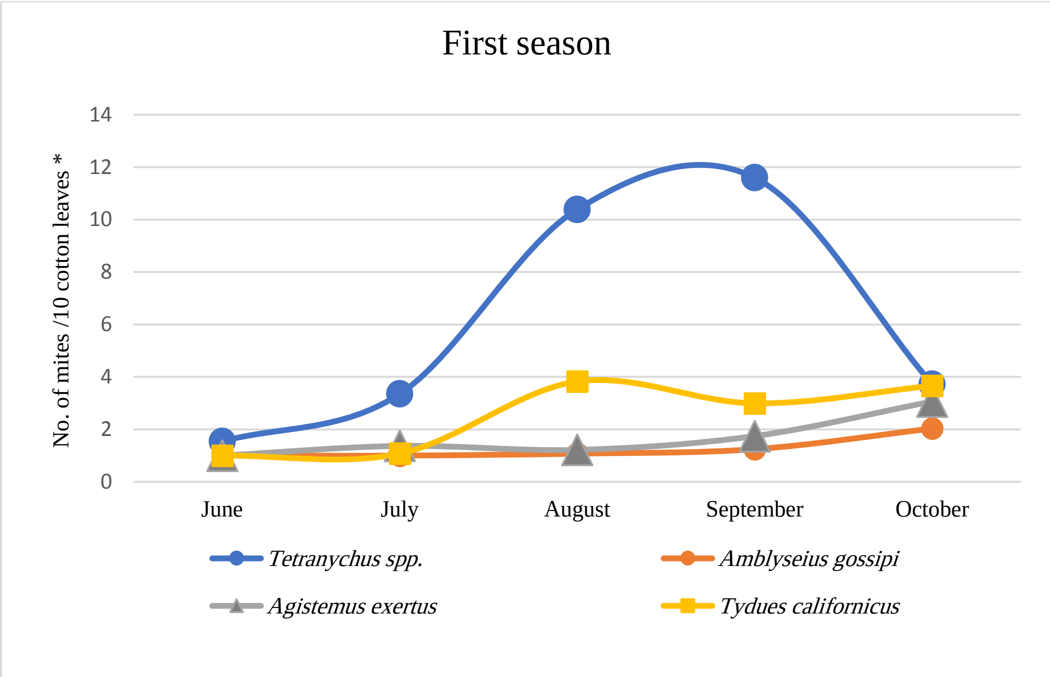


Figure (2): Population dynamics of spider mites *Tetranychus* spp. and their predacious mites on MC Nair 220 cotton cultivar along two successive seasons.
*** The mean number of mites/ 10 cotton leaves expressed as the square root of the obtained number plus one.**



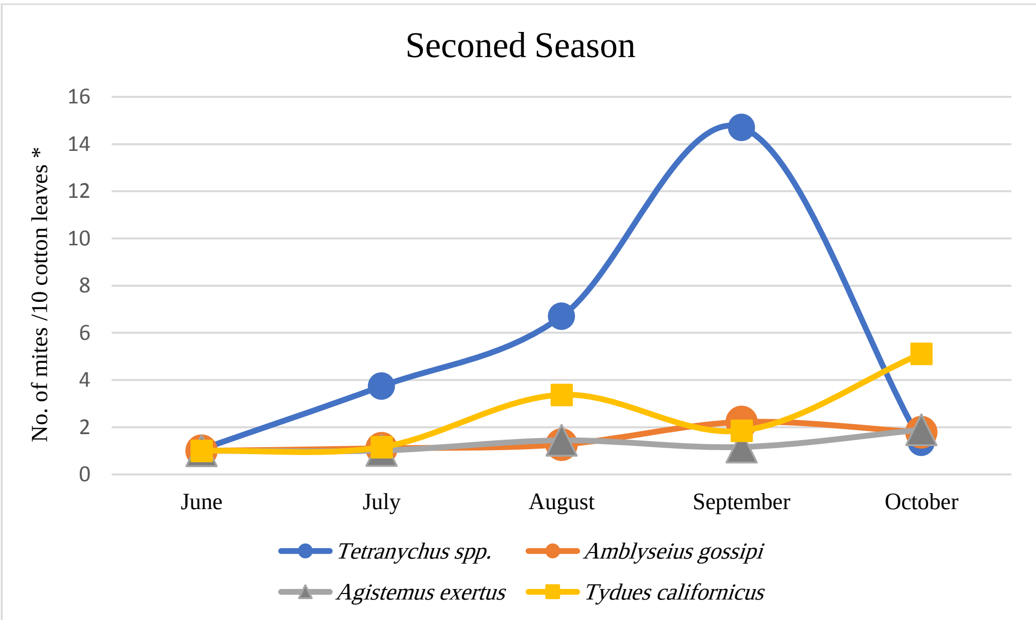
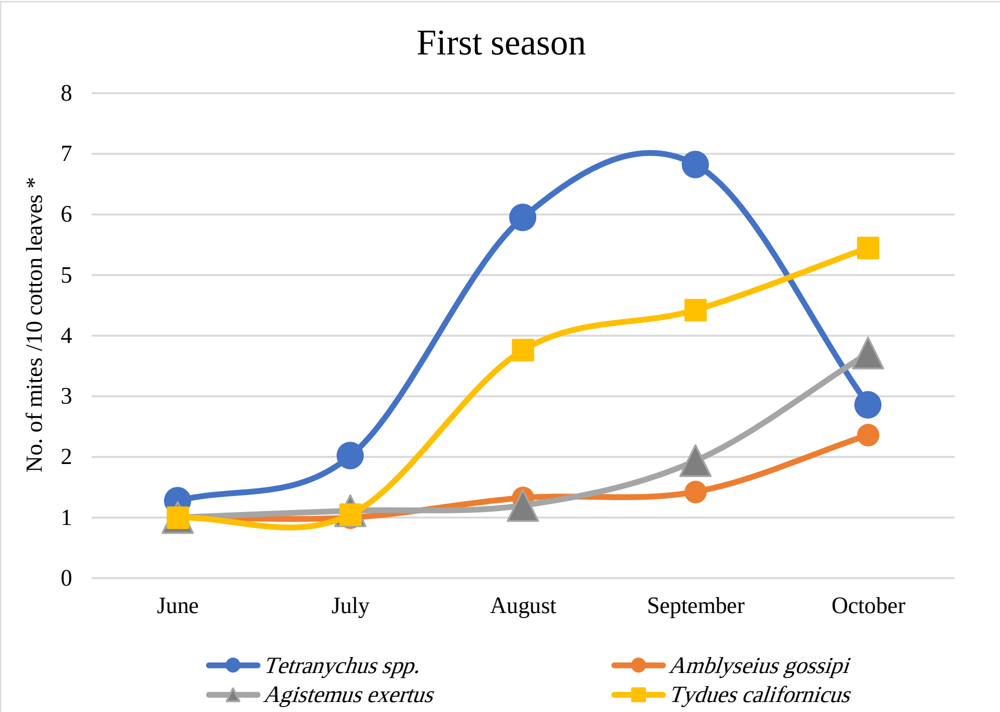


Figure (3): Population dynamics of spider mites *Tetranychus* spp. and their predacious mites on Okra leaf cotton cultivar along two successive seasons.
*** The mean number of mites/ 10 cotton leaves expressed as the square root of the obtained number plus one.**



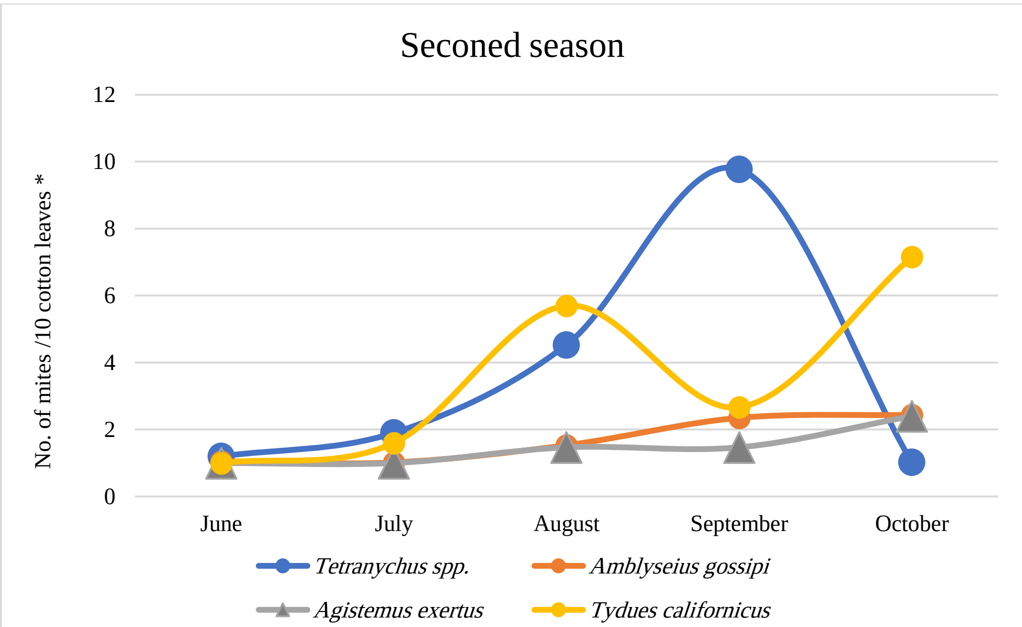


Figure (4): Population dynamics of spider mites *Tetranychus* spp. and their predacious mites on Giza 70 cotton cultivar along two successive seasons.
*** The mean number of mites/ 10 cotton leaves expressed as the square root of the obtained number plus one.**

The current results revealed that, the predacious mites were occurred on all tested cotton cultivars. In addition, the population of the predatory mites reached the maximum density before the cotton harvesting. These results agreed with the results obtained by El-Halawany and Abdel-Samad (1990), they found that the annual peak of predaceous mites appeared one month after that of the phytophagous mite *T. arabicus* resulting in a gradual decrease in the later population density. A recent study showed that the density of predators of *T. urticae* was not associated with the pest mite populations during the spring of 2015 and 2016 seasons, which is a result of the low numbers of the recorded predators in the studied area (Abo-Elmaged *et al.*, 2021). As regards of *Tetranychus* spp., the population started to increase in June and reached its peak in the second week of September then it declines till the end of September, these results agree with the results obtained by Petrushov and Belyaeva (1989), they found that the number of *T. urticae* increased intensity from the end of July till the mid-September. Margolies and Kennedy (1985) showed that, *T. urticae* on maize and groundnut outbreak coincided with the crop host's flowering and fruiting season. Shanbaky *et al.* (2016) mentioned that the population of *T. urticae* started to peak up since the fourth week of June when most of the life stages of *T. urticae* were observed on the plant leaves. They also reported that, the abundance of eggs and most movable life stages gradually increased to reach their peaks during September, the peak of *T. urticae* was followed by a decrease of the pest number at the end of the season. Apparently, the *T. urticae* population affect by temperature and humidity as, in current work, the maximum numbers of mites were recorded during the period of moderate temperature and humidity in Alexandria. Abo-Elmaged *et al.* (2021), found that, the abundance of the two spotted spider mite, *T. urticae* on cucumber in Upper Egypt has fluctuated with a peak during the middle of May when the temperature and relative humidity was moderate.

From the previous data, we can define pesticide application time to be on the second week of September to avoid pesticide application's adverse effect on the three predators. Whereas the three predations mite density was high, and the populations density of *Teytranychus* spp. was approximately low (Abd El-Rahman and Moustafa, 2002).

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