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# Diversity and abundance of spiders and other arthropods in quinoa plants treated with some chemical salts and their effects on downy mildew and yield

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**Abstract:**

Experiment was conducted at Fayoum Governorate, Egypt during two successive winter season, 2018-2019 and 2019-2020 on quinoa plants to study effects of some chemical salts on spiders, other arthropods, downy mildew and its effects on quinoa yield. Treatments used were copperal max, calcivin, potassium silicate, max. growth and mix. Spiders and other arthropods were sampled using pitfall traps. A total of 424 spiders, representing 9 families. Spider recorded the highest number with max. growth and lowest number with potassium silicate in first season. While in second season, the highest number recorded with mix. and the lowest recoded also with potassium silicate. The most abundant families were Lycosidae and Linyphiidae spiders represented 46.64, 30.49 % and 44.78, 26.87%, during the two seasons, respectively. The most abundant species were *Wadicosa fidelis* (O.Pickard-Cambridge and *Sengletus extricates* (O.Pickard-Cambridge) in two seasons. According to Shannon-Wiener and Simpson, it was found that plot treated with max. growth treatment (90 individuals) and mix. (99 individuals) included the highest number of dominant species the highest numbers of individuals decreased to 39 individuals in control. Sørensen quotient of similarity between treatment and control concluded that 66.67 and 47.62% in copperal max, 66.67 and 50% in calcivin, 81.82 and 50% in potassium silicate, 81.82 and 60% in max. growth, and 84.21 and 35% in mix in two seasons respectively. The total number of pests and predators was higher in first season (3128 individuals ) than in the second season (2676 individuals). The results obtained that the disease is caused by *Peronospor avariabilis*. Mix treatment was the lowest disease incidence and disease severity and the highest yield Kg/fed during two seasons. Statistical analysis proved that no significant differences were observed in first season and high significant differences between mix. growth treatment and other treatments.

## Introduction

Quinoa is a very recent crop was introduced to Egypt. Quinoa is considered an important crop due to it can grow and gives considerable yield in new reclaimed salty soil with salty water (1800 ppm) where wheat or many other crops cannot grow (Abd El-Moity and Ali, 2016). Edible quinoa seeds are grown in some cases and places. Green leaves are eaten as vegetables (Gee *et al.*, 2006). Recent research has focused on greater reliance on conservation and attraction of endemic natural enemies to reduce chemical inputs for management of pests (James *et al.*, 2003 and James and Price, 2004). Also, it is important to find alternative measures to control plant diseases which do not harm the environment and at the same time increase yield and improves product quality (Batish *et al.*, 2007 and Camprubí *et al.*, 2007). Nutrients are important for growth and development of plants and microorganisms, and they are important factors to reduce pests (Agrios, 2005). As predators, spiders are important biological control agents in agro-ecosystems, playing a vital role in structuring arthropod communities and thus having a significant role in the balance of nature (Nyffeler *et al.*, 1994 and Marc *et al.*, 1999). Agricultural practices affect the patterns of soil fauna abundance, richness, and diversity. Also, the presences of groups such as Araneae are related to ecological equilibrium, quality, and sustainability of the agricultural systems. (Silva *et al.*, 2018). Downy mildew is one of the limiting diseases for quinoa plants (Choi *et al.*, 2010). Most studies (Abd El-Moity and Ali, 2016) agree with our finding which indicated that the downy mildew pathogen is identification as *Peronospora farinosa* f. sp. *chenopodii*. While, certain studies indicated that the quinoa downy mildew pathogen is *Peronospora variabilis* (Choi *et al.*, 2010).

From this point of view, this is an attempt to study biodiversity of spiders and other arthropods in quinoa plants treated with some chemical salts and their effect on downy mildew and yield.

## Materials and methods

### 1. Experimental design:

Field experiments were conducted for two winter successive seasons, 2018-2019 and 2019-2020 at Ibshway; Fayoum Governorate. An area of about 200 $m^2$ was divided into 18 equal plots that received 5 treatments and control of 3 replicates each. A spilt plots design with three replicates was used. Seeds of quinoa (*Chenopodium quinoa*, Caryophyllales, Amaranthaceae) were Variety Egypt 1 planted. Plots were distributed in a complete randomized block design. All plots received the normally recommended agricultural practices except the absence of any pesticides. Soil fertilizer at the rate of 45:25: 60 N: P: K. in addition to sprays with treatments after month after farming plants and repeated each 15 day. The field experiment was under conditions of natural downy mildew infection.

### 2. Treatments used:

All treatments used were produced under Central Lab. of Organic (CLOA), Agric. Research center, Giza, Egypt. They were used at 1 liter/200-liter water . The treatments rates of spray as follow :

**Trade name:** Copperal max. **Active ingredient:** $CuSo_4$ 8% **Rate/200 Liter water:** 1Liter

**Trade name:** Calcivin **Active ingredient:** $Cacl_2$ 15 % **Rate/200 Liter water:** 1Liter

**Trade name:** Potassium silicate **Active ingredient:** $K_2Sio_3$ 15% **Rate/200 Liter water:** 1Liter
**Trade name:** Max. growth **Active ingredient:** Fe 5% + Zn 5% + Mn 5% **Rate/200 Liter water:** 1Liter
**Trade name:** Mix. (All treatments) **Active ingredient:** $CuSo_4$ + $K_2Sio_3$ + max. growth + $Cacl_2$ as alone) **Rate/200 Liter water:** 1Liter
**Control:** Water

**3. Spider abundance and diversity:**

To determine the effect of fertilizer treatments on spider abundance and diversity in the agroecosystem, spiders were sampled using pitfall traps method as described by Southwood (1978) and Slingsby and Cook (1986). Three pitfall traps were placed in each fertilizer treatment every week and three in control plot. Arthropod specimens were placed in 70% alcohol and some droplets of glycerin. Spiders were counted and sorted in the laboratory and identified to species level as much as possible.

**3.1. Frequency and abundance values:**

The frequency values of the most abundant species were classified into three classes according to the system adopted by Weis Fogh (1948); “Constant species” more than 50% of the samples, "accessory species" 25-50 % of the samples and "accidental species" less than 25%. On the other hand, the classification of dominance values were done according to Weigmann (1973) system in which the species were divided into five groups based on the values of dominance in the sample; Eudominant species (>30% individuals), dominant species (>10-30% individuals), subdominant (>5-10% individuals), recedent species (1-5% individuals) and subrecedent species (<1% individuals).

**3.2. Species diversity:**

The community structure of soil spiders was described using the species richness, Shannon-Wiener and Simpson indices "S". The Shannon-Wiener Index "H’" is one of the most common ecological indexes, it may provide an indication of community stability under the balance of nature and it may also respond differently of geographical, developmental, or physical factors. Higher number of H' indicates higher number of species, higher relative abundance and species evenness, so, it means increase in diversity. While Simpson Index "S" is more responsive to changes in the importance of most dominant species, it is a measure of dominance (i.e. The probability of two randomly selected individuals will be of the same species) (Nestle *et al.*, 1993). A community dominated by one or two species is less diverse than one in which several different species have a similar abundance. The two indices were calculated as described by Ludwig and Reynolds (1988):

$H' = -\sum (ni / n) \ln (ni/ n)$ and $S = \sum (ni/n)^2$

Where ni is the number of individuals belonging to the ith of "S" taxa in the sample and "n" is the total number of individuals in the sample

**3.3. Sørensen quotient of similarity:**

To allow a comparison of the two samplings between microhabitats of the two cultivation systems, Sørensen's quotient of similarity (Sørensen, 1948) was used to determine the similarities of spider species composition among the communities, it is: QS = 2 C / A + B

Where: A and B are the number of species in samples A and B, respectively, and C is the number of species shared by the two samples; QS is the quotient of similarity and ranges from 0 to1.

**4. Identification of the pathogen that cause downy mildew:**

The samples of infected leaves of quinoa were examined by the staff of the Mycology and Plant Disease Survey Research, Plant Pathology Research Institute. ARC

**Disease assessment:**

$$\text{Disease incidence} = \frac{\text{Number of disease plants}}{\text{Total number of inspected plants}} \times 100\ \%$$

**(Mhada *et al.*, 2015)**

$$\text{Disease severity} = \frac{\sum (\text{Rating no.} \times \text{no. of plants in each rating})}{\text{Total of plants} \times \text{highest rating}} \times 100\%$$

**(Abd El-Moity and Ali, 2016)**

Disease severity was assessed according to 0 – 5 scale (Mhada *et al.,* 2015).

**5. Statistical analysis:**

All collected data for various treatments were statistically analyzed according to the technique of analysis of variance for split-plot arranged in randomized complete block design using the InfoStat computer software package (Version, 2012). The differences among treatment means were compared by LSD as a post hoc test at ≤ 5% level of significance (Gomez and Gomez, 1984).

**Results and discussion**

**1. Spider assemblages:**

During the 2018- 2019 and 2019-2020 seasons, 424 spiders, representing 9 families, were captured with pitfall traps Tables (1 and 2). Lycosidae and Linyphiidae spiders represented 46.64, 44.78% and 30.49-26.87%, during the two seasons, respectively, of the total number of trapped spiders. These two spider families were the primary ground-dwelling predators in quinoa field. These results agree with (Abd El-Karim *et al.*, 2016; Tahir and Butt, 2009 and Rizk *et al.*, 2012) who found that most of individuals collected belong to family Lycosidae. Also, as shown in Tables (1 and 2), during first season a total number of 223 spiders were collected during this experiment; belonged to 9 families, 18 genera and 18 species. Adults comprised 69.51%, while Juvenile were 30.49%. The sex ratio was 1 ♀: 5.46 ♂. In second season, a total number of 201 spiders were collected; belonged to 9 families, 19 genera and 19 species. Adults comprised 64.68%, while Juvenile were 28.86%. The sex ratio was 1 ♀: 4.42 ♂. The 9 families found in the present study represent 21.95% of the 41 families recorded in Egypt (El-Hennawy, 2017).

These results as Ebaid and Mansour (2006) who found that spiders recorded 799 and 937 individuals for the two seasons, respectively in plot treated with mixture of some chelated microelements (Powder of; zinc 12%, mn 12%, fe 12%, cu 12% and 6% liquid boron).

**2. Under each treatment during two seasons:**

Different treatments influenced spider abundance. The effect of tested treatments on spiders inhabiting land of management is presented in Tables (1 and 2).

**2.1. Copperal max (Cuso4):**

A total of 31 and 29 individuals were collected and identified to 6 families, 11, 12 genera and 11, 12 species in two seasons respectively. Adults comprised 96.78, 96.55%, while Juvenile averaged 3.23, 3.45% respectively. The sex ratio was 1♀:3.29♂, 1♀:2.5♂ respectively. The most abundant species *Sengletus extricates* (O.Pickard-Cambridge) , Linyphidae (7 and 6 individuals) in two seasons respectively.

**2.2. Calcivin (Cacl2):**

A total of 53 and 32 individuals were collected and identified to 6 and 7 families, 11 genera and 11 species. Adults comprised 47.17, 81.25%, while Juvenile were 52.83 and 18.75% respectively. The sex ratio was 1♀:5.25♂

and 1♀:2.25♂ in two seasons respectively. The species that recorded the highest numbers were *Wadicosa fidelis* (O.Pickard-Cambridge) (27 indv.) and *Pardosa* sp. (7 individuals), Lycosidae in first season while *Pardosa* sp. (6 individuals), Lycosidae and *S. extricates*, Linyphidae (6 individuals) in second season.

**2.3. Potassium silicate (K2sio3):**

A total of 26+ (1 egg sac) and 25 individuals were collected and identified to 7 and 6 families, 12 and 10 genera and 12 and 10 species respectively. Adults comprised 84.62 and 96% while, Juvenile averaged 15.38 and 4%. The sex ratio was 1♀:10♂ and 1♀:7♂ in two seasons respectively. *S. extricates*, Linyphidae (8, 7 individuals) recorded the highest numbers in two seasons respectively.

**2.4. Max. growth (Fe + zn + mn):**

A total of 59 and 31 (+1 egg sac) individuals were collected and identified to 6 and 5 families, 12 and 11 genera and 12 and 11 species respectively. Adults comprised 47.46 and 90.32%, while Juvenile averaged 52.54 and 9.68%. The sex ratio was 1♀:8.33♂ and 1♀:4.6♂ in two seasons respectively. The most abundant species were *W. fidelis* (27 individuals), Lycosidae and *S. extricates*, Linyphidae (7 individuals) in first season while in second season, *W. fidelis* (5 individuals) and *Pardosa* sp. (5 individuals), Lycosidae and *Enoplognatha gemina* Bosmans and Van Keer, Theridiidae (5 individuals).

**2.5. Mix. (Cu+ca+k2+ fe but cacl2 as alone):**

A total of 30 (+1 egg sac) and 69 individuals were collected and identified to 5 and 6 families, 9 and 8 genera and 9 and 8 species respectively. Adults comprised 90 and 33.33%, while Juvenile averaged 10 and 66.67%. The sex ratio was 1♀:5.5♂ and 1♀:2.9♂ in two seasons respectively. The most abundant species, were *Pardosa* sp. (5 individuals), Lycosidae and *S. extricates*, Linyphidae (6 individuals) in first season while in second season, *W. fidelis* (50 indv.) and *Pardosa sp.* (5 individuals), Lycosidae and *S. extricates*, Linyphidae (9 individuals).

**3. Control:**

A total of 24 and 15 individuals were collected and identified to 5 and 6 families, 10 and 9 genera and 10 and 9 species respectively. Adults averaged 95.83 and 93.33%, while Juvenile comprised 4.17 and 6.67%. The sex ratio was 1♀:6.67♂ and 1♀:1.33♂ in two seasons respectively. the most abundant species collected *S. extricates* (6 individuals) and *Mermessus denticulatus* (Banks) , Linyphidae in first season while in second season, *S. extricates* (3 indv.), Linyphidae and *Zelotes* sp. (4 individuals)., Gnaphosidae. Ebaid and Mansour (2006) found that the mean total numbers of predators in the plots, which received mixture of some chelated microelements (Powder of; zinc 12 %, mn 12 %, fe 12 %, cu 12 % and 6 % liquid boron) were 116 and 151.5 in two successive seasons respectively and there are insignificant differences between microelements and untreated cotton plots of some predacious species (Beetles, aphid lion rove beetles and true spider). Tahir and Butt (2009) indicated that abundance and spatial distribution of a spider species significantly depend on the type of management practice in the field.

**4. Species richness:**

During the two seasons, among the total of 21 species and 9 families were collected (Tables 1 and 2 ), 13 species of 7 families were recorded in copperal max treatment, 15 species of 8 families in calcivin treatment, 13 species of 7 families Potassium silicate treatment, 13 species of 6 families were recorded in Max. growth treatment, 12 species of 8 families were recorded in mix treatment and 13 species of 7 families in control. A total of 6 species had common occurrence in all treatment during the two seasons. Family Eutichuridae was absent in treatments with Potassium silicate and control. Family Thomisidae was absent in treatments with copperal max., potassium silicate, max. growth and control. Family Dictynidae was found only in potassium silicate treatment and control. Also, during two seasons, the highest numbers of individuals recorded in the plot treated with max. growth (90 individuals) and mix (99 individuals) decreased to 39 indv. in control. These results agreement with (Siemann, 1998), who indicated that fertilizer application increases plant biomass production, supporting high numbers of herbivores as well as detritivores, thus enhancing predator abundance.

**5. Frequency and abundance values:**

Tables (3 and 4) showed spiders associated with quinoa plants as affected by different fertilizers. In first season, Family Lycosidae and Linyphididae were considered "Constant" (C) in calcivin treatment and control according to Weis Fog system which occupied 66.04 and 54.17% of the collected spiders. While considered "Accessory (ac) and Accidental (A) in the other treatments. Members of *W. fidelis* was "Eudominant" in treatments with calcivin and Max. growth according to Weigmann classification of dominance. However, in the second year, Family Lycosidae and Linyphididae were considered "Constant" (C) in treatments with Potassium silicate and mix. Whereas considered "Accessory (ac) and Accidental (A) in other treatments. Members of *W. fidelis* was "Eudominant" in treatments with mix. Similar results were reported by (Abd El-Karim *et al.*, 2016) who found that family Lycosidae was considered "constant" in Calendula treated with fertilizers with 50.32 and 59.39% in two seasons, respectively. These results agreed with the results obtained by (Shuang-Lin and Bo-Ping, 2006 and Abd El-Karim *et al.*, 2016) who indicated that members of family Lycosidae: ranged between "dominant" and "eudominant" (According to Weigmann classification of dominance).

**6. Species diversity:**

The biodiversity of spiders in the plots treated is compared using Shannon Wiener "H'" and Simpson "S" Indices of diversity (Table 5). In first season, The cover plantation of quinoa in different plots varies in their species richness; the plot treated with max. growth recorded the highest population of total number 59 individuals. Its ecosystem is made of 6 families, 12 genera and 12 species; followed by calcivin that recorded spider population of 53 individuals, belonging to 6 families, 11 genera and 11 species. While the control recorded the least species richness of 24 individuals. While in second season, the plot treated with mix recorded the highest population of total number 69 individuals of 6 families, 8 genera and 8 species. The biodiversity index calculation indicates that (Copperal max. and potassium silicate) and (Copperal max., calcivin and max. growth) were the most diverse; the species richness of spiders in different families and their equitability (Evenness) were higher in two seasons respectively. According to Simpson Index which is a measure of dominance (responsive to changes for the most dominant species), it was found that calcivin (0.30) and max. growth (0.32) in 1$^{st}$ season and mix (0.55) in 2$^{nd}$ season included the highest number of dominant species. The present results agree with Öberg (2007) who stated that organic practice may add diversity to the soil structure and increase the abundance of prey and in turn the abundance of spiders. The same results were recorded by (Schmidt *et al.*, 2005) as they found that abundance of spiders in organic fields was more than conventionally.

**7. Similarity of species**

In two seasons 2018 and 2019, community of spiders collected from control (24 and 15 individuals) was lower than those collected from copperal max. treatment (31 and 29 individuals), calcivin treatment (53 and 32 individuals), potassium silicate treatment (26 and 25 individuals), max. growth treatment (59 and 31 individuals) and mix treatment (30 and 69 individuals) respectively. Also, among the 21 species obtained, 11 and 12 species were collected from copperal max. treatment, 11 and 11 species from calcivin treatment, 12 and 10 species from potassium silicate treatment, 12 and 11 species from max. growth treatment, 9 and 8 species from mix treatment and 10 and 9 species from control in two successive seasons. To estimate spider composition of that different microhabitat, Sørensen's quotient of similarity was applied by comparing the number of species and individuals of control apparently with catch one of those treatments. It is concluded that the similarity to control compared by other treatments recorded 66.67 and 47.62% in copperal max, 66.67 and 50% in calcivin, 81.82 and 50% in potassium silicate, 81.82 and 60% in max. growth and 84.21 and 35% in mix in two seasons respectively.

**8. Total numbers, dominance and abundance degrees of arthropod pests and their natural enemies by pitfall trap:**

Tables (6 and 7) indicated a total of 3128 individuals in the 1$^{st}$ season and 2676 individuals in the 2$^{nd}$ season were counted from 9 samples on quinoa plants from seedling to maturity by using pitfall trap. The number of individuals was (539 and 490 individuals) in copperal max treatment, (520 and 432 individuals) in calcivin treatment, (660 and 400 individuals) in potassium silicate treatment, (450 and 443 indv.) in max. growth treatment, (493 and 490 individuals) in mix treatment and (466 and 421 individuals) in control in 2018 and 2019 season, respectively. The dominance and abundance degrees indicated that Collembola, Muscidae, Formicidae, and Spiders recorded the highest dominant and abundant in both seasons. Birkhofer *et al.* (2008) indicated that the application of both organic and inorganic fertilizers to ecosystems has been shown to increase the populations and diversity of soil fauna. These results documented by Salem *et al.* (2012) who found that some predators help in planning Integrated Pest Management (I.P.M.) strategies.

**9. Downy Mildew and yield:**

**9.1. Identification of the pathogen cause downy mildew:**

Symptoms of downy mildew on quinoa plants were observed on the lower leaves of plants in the form of necrotic spots on the upper surface and correspondingly grayish black conidiophores bear conidiospores of the pathogen on the lower surface (Table 8). Light microscopy revealed presence of colorless dichotomously branched sporangiophores (2 – 3.2µ width), slightly curved at the far point bearing hyaline sporangia. Spores are 1deciduous mostly avoid, 11.0 – 15.6µ 20.0 – 25.5µ.

dark brownish oospores were observed embedded into leaf tissues. The disease is caused by *peronospor avariabilis* Gaum, formerly *peronospora farinose* F. sp. *chenopodii Byford* (Choi *et al.*, 2010).

**9.2. Disease assessment and grain yield:**

From Table (8) all treatments were affected by disease incidence where max. growth considered the higher value 43.3 and 41.3% during 2019 and 2020 respectively compared to other treatments. The lowest values occurred with mix treatment where recorded 6.67 and 6.0% during 2019 and 2020 season. Also, the same results were found with disease severity where max. growth 15.23 and 17.67% during 2019 and 2020 respectively and mix recorded 2.47 and 2.63%. Significantly differences between all treatments were occurred. Results indicated that The highest value of yield Kg/fed was evident with treatment mix 1711.67 and 1692.67 Kg/fed. while the lowest value recorded in control with 619.33 and 703 Kg/fed. in 2019 and 2020 respectively. Significant differences between all treatments were occurred. These results agreement with Danielsen *et al.* (2003), who found that the most significant disease affecting quinoa cultivation in South America, is downy mildew and reducing the yield up to 33-58% and even up to 99% in some quinoa fields.

10. Statistical analysis :

Statistical analysis proved that no significant differences were observed between means of treatments in first season and high significant differences between mix treatment and other treatments. These results showed the application on chemicals salts effect of biodiversity of spiders and arthropods. From former results we can conclude that application of chemical salts improves spiders biodiversity and at the same time reduce incidence and severity of downy mildew and increase quinoa yield. These obtained data indicate that use of nutrients can conserve biodiversity in agro ecosystem. These agree with Attwood *et al*. (2008) and Whittingham (2011) who revealed that programmes in numerous countries have attempted to reduce the severity of agriculture's negative influence on biodiversity by paying farmers to reduce management intensity through reduced pesticide and synthetic fertilizer inputs or by converting farms to organic practices.

**Table (1) Richness of spider species inhabiting quinoa plants under effects of different fertilizer treatments in 2018-2019 season**

| Families & taxa names | copperal Max | | | Calcivin | | | Potassium silicate | | | Max. growth | | | Mix | | | Control | | | Σ | | | Σ | Total | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ♂ | ♀ | j | ♂ | ♀ | j | ♂ | ♀ | j | ♂ | ♀ | j | ♂ | ♀ | j | ♂ | ♀ | j | ♂ | ♀ | j | | | |
| **Lycosidae** | | | | | | | | | | | | | | | | | | | | | | | **104** | **46.64** |
| *Wadicosa fidelis* | 3 | 3 | | | 2 | 25 | | 1+1▲ | | 1 | 1 | 30 | 1 | 1+1▲ | 2 | | 1 | | 5 | 9+2▲ | 57 | **71** | | |
| *Pardosa sp.* | 1 | | | 6 | | 1 | 4 | | | 4 | | | 5 | | | 3 | | | 23 | 0 | 1 | **24** | | |
| *Hogna ferox* | 2 | | | 1 | | | 1 | | | 1 | | | 2 | | | 2 | | | 9 | 0 | 0 | **9** | | |
| **Theridiidae** | | | | | | | | | | | | | | | | | | | | | | | **28** | **12.56** |
| *Enoplognatha gemina* | 5 | | | 5 | | | 2 | | | 5 | | | 3 | | | 1 | | | 21 | 0 | 0 | **21** | | |
| *Kochiura aulica* | | 3 | | 1 | | | | | | | 1 | | | 1 | | | | | 1 | 5 | 0 | **6** | | |
| *Eyryopis sp.* | | | | 1 | | | | | | | | | | | | | | | 1 | 0 | 0 | **1** | | |
| *Theridion sp.* | | | | | | | | | | | | | | | | | | | | | | | | |
| **Philodromidae** | | | | | | | | | | | | | | | | | | | | | | | **5** | **2.24** |
| *Thanatus albini* | | | | | | | | 1 | | | | | | 1 | | 3 | | | 3 | 2 | 0 | **5** | | |
| **Linyphidae** | | | | | | | | | | | | | | | | | | | | | | | **68** | **30.49** |
| *Mermessus denticulatus* | 2 | | | 2 | 1 | | 3 | | 1 | 2 | | | 4 | 2 | | 3 | 1 | 1 | 16 | 4 | 2 | **22** | | |
| *Prinerigone vagans* | 1 | | | | | | 1 | | | 2 | | | | | | 1 | | | 5 | 0 | 0 | **5** | | |
| *Erigone sp.* | | | | | | | | | | 2 | | | | | | 1 | | | 3 | 0 | 0 | **3** | | |
| *Sengletus extricatus* | 7 | | | 4 | | | 7 | | 1 | 5 | 1 | 1 | 5 | | 1 | 5 | 1 | | 33 | 2 | 3 | **38** | | |
| **Gnaphosidae** | | | | | | | | | | | | | | | | | | | | | | | **7** | **3.14** |
| *Zelotes sp.* | | 1 | | | | | | | | | | | | | | | | | 0 | 1 | 0 | **1** | | |
| *Micaria dives* | | | | | | | | | | | | | | | | | | | | | | **0** | | |
| *Drassodes pubescens* | | | | | | 1 | | | 1 | 1 | | | 2 | | | 1 | | | 4 | 0 | 2 | **6** | | |
| **Eutichuridae** | | | | | | | | | | | | | | | | | | | | | | | **2** | **0.90** |
| *Cheiracanthium isiacum* | | | 1 | | | | | | | 1 | | | | | | | | | 1 | 0 | 1 | **2** | | |
| **Salticidae** | | | | | | | | | | | | | | | | | | | | | | | **7** | **3.14** |
| *Phlegra flavipes* | 2 | | | | 1 | 1 | 1 | | | 1 | | | | | | | | | 4 | 1 | 1 | **6** | | |
| *Pellenes sp.* | | | | | | | | | | | | | | | | | | | | | | **0** | | |
| *Heliphannes sp.* | | | | | | | 1 | | | | | | | | | | | | 1 | 0 | 0 | **1** | | |
| **Thomisidae** | | | | | | | | | | | | | | | | | | | | | | | **1** | **0.45** |
| *Xysticus sp.* | | | | 1 | | | | | | | | | | | | | | | 1 | 0 | 0 | **1** | | |
| **Dictynidae** | | | | | | | | | | | | | | | | | | | 0 | 0 | 0 | **0** | **1** | **0.45** |
| *Lathys sp.* | | | | | | | | | 1 | | | | | | | | | | 0 | 0 | 1 | **1** | | |
| **Total** | 23 | 7 | 1 | 21 | 4 | 28 | 20 | 2 | 4 | 25 | 3 | 31 | 22 | 5 | 3 | 20 | 3 | 1 | 131 | 24 | 68 | **223** | | |
| | **31** | | | **53** | | | **26 + 1 Egg Sac** | | | **59** | | | **30 + 1 Egg Sac** | | | **24** | | | **223** | | | | | |

**▲ = Egg sac**

**Table (2) Richness of spider species inhabiting quinoa plants under effects of different fertilizer treatments in 2019-2020 season**

| Families &taxa names | copperal Max | | | Calcivin | | | Potassium silicate | | | Max. growth | | | Mix | | | Control | | | Σ | | | Σ | Total | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ♂ | ♀ | *j* | ♂ | ♀ | *j* | ♂ | ♀ | *j* | ♂ | ♀ | *j* | ♂ | ♀ | *j* | ♂ | ♀ | *j* | ♂ | ♀ | *j* | | | |
| **Lycosidae** | | | | | | | | | | | | | | | | | | | | | | | 90 | **44.78** |
| *Wadicosa fidelis* | 1 | 2 | | 1 | 2 | | 2 | 2 | | 1 | 3+1▲ | 1 | 1 | 4 | 45 | | | | 6 | 13+1▲ | 46 | 65 | | |
| *Pardosa sp.* | 3 | | | 6 | | | 2 | | | 5 | | | 3 | | | 1 | | | 20 | 0 | 0 | 20 | | |
| *Hogna ferox* | 1 | | | | | | 2 | | | 1 | | | | | | | 1 | | 4 | 1 | 0 | 5 | | |
| **Theridiidae** | | | | | | | | | | | | | | | | | | | | | | | 22 | **10.95** |
| *Enoplognatha gemina* | 4 | | | 3 | | | 5 | | | 5 | | | 2 | | | | | | 19 | 0 | 0 | 19 | | |
| *Kochiura aulica* | | 1 | | | | | 1 | | | | | | | | | | | | 1 | 1 | 0 | 2 | | |
| *Eyryopis sp.* | | | | | | | | | | | | | | | | | | | | | | 0 | | |
| *Theridion sp.* | | 1 | | | | | | | | | | | | | | | | | 0 | 1 | 0 | 1 | | |
| **Philodromidae** | | | | | | | | | | | | | | | | | | | | | | | 7 | **3.48** |
| *Thanatus albini* | 3 | 1 | | 1 | | | 1 | | | | | | | | | 1 | | | 6 | 1 | 0 | 7 | | |
| **Linyphidae** | | | | | | | | | | | | | | | | | | | | | | | 54 | **26.87** |
| *Mermessus denticulatus* | 1 | 2 | | 2 | 2 | | | | | 3 | | 1 | 2 | | | 1 | | | 9 | 4 | 1 | 14 | | |
| *Prinerigone vagans* | | 1 | | 2 | 1 | | 1 | | | 1 | | | | | | | | | 4 | 2 | 0 | 6 | | |
| *Erigone sp.* | | | | | | | | | | 1 | | | | | | | | | 1 | 0 | 0 | 1 | | |
| *Sengletus extricatus* | 5 | | 1 | 1 | 3 | 2 | 6 | 1 | | 2 | | | 7 | 2 | | 2 | 1 | | 23 | 7 | 3 | 33 | | |
| **Gnaphosidae** | | | | | | | | | | | | | | | | | | | | | | | 15 | **7.46** |
| *Zelotes sp.* | | | | | | | | | | 2 | | | | | | 3 | 1 | | 5 | 1 | 0 | 6 | | |
| *Micaria dives* | | | | | | 1 | | | | | | | | | | | | | 0 | 0 | 1 | 1 | | |
| *Drassodes pubescens* | | | | 2 | | | | | 1 | 1 | 2 | | | | | | 1 | 1 | 3 | 3 | 2 | 8 | | |
| **Eutichuridae** | | | | | | | | | | | | | | | | | | | | | | | 6 | **2.99** |
| *Cheiracanthium isiacum* | 1 | | | | | 2 | | | | 1 | | 1 | | | 1 | | | | 2 | 0 | 4 | 6 | | |
| **Salticidae** | | | | | | | | | | | | | | | | | | | | | | | 5 | **2.49** |
| *Phlegra flavipes* | 1 | | | | | 1 | 1 | | | | | | 1 | | | | | | 3 | 0 | 1 | 4 | | |
| *Pellenes sp.* | | | | | | | | | | | | | | | | | 1 | | 0 | 1 | 0 | 1 | | |
| *Heliphannes sp.* | | | | | | | | | | | | | | | | | | | | | | 0 | | |
| **Thomisidae** | | | | | | | | | | | | | | | | | | | | | | | 1 | **0.50** |
| *Xysticus sp.* | | | | | | | | | | | | | | 1 | | | | | 0 | 1 | 0 | 1 | | |
| **Dictynidae** | | | | | | | | | | | | | | | | | | | | | | | 1 | **0.50** |
| *Lathys sp.* | | | | | | | | | | | | | | | | | 1 | | 0 | 1 | 0 | 1 | | |
| **Total** | **20** | **8** | **1** | **18** | **8** | **6** | **21** | **3** | **1** | **23** | **5** | **3** | **16** | **7** | **46** | **8** | **6** | **1** | **106** | **24** | **58** | **201** | | |
| | **29** | | | **32** | | | **25** | | | **31+1▲** | | | **69** | | | **15** | | | **201** | | | | | |

**▲ = Egg sac**

**Table (3) Dominance-frequency relationship of spider communities associated with quinoa plants affected by different fertilizers durig 2018-2019**

| Families &taxa names | copperal Max | | | | | Calcivin | | | | | Potassium silicate | | | | | Max. growth | | | | | Mix | | | | | Control | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | Sp% | Dom. | F.% | Frq. | Total | Sp% | Dom. | F.% | Frq. | Total | Sp% | Dom. | F.% | Frq. | Total | Sp% | Dom. | F.% | Frq. | Total | Sp% | Dom. | F.% | Frq. | Total | Sp% | Dom. | F.% | Frq. |
| **Lycosidae** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Wadicosa fidelis* | 6 | 19.35 | D | 29.03 | ac | 27 | 50.94 | E | 66.04 | C | 1 | 3.85 | R | 23.08 | A | 32 | 54.2 | E | 62.71 | E | 4 | 13.3 | D | 36.7 | ac | 1 | 4.17 | R | 25 | ac |
| *Pardosa sp.* | 1 | 3.23 | R | | | 7 | 13.21 | D | | | 4 | 15.4 | D | | | 4 | 6.78 | sd | | | 5 | 16.7 | D | | | 3 | 12.5 | D | | |
| *Hogna ferox* | 2 | 6.45 | sd | | | 1 | 1.89 | R | | | 1 | 3.85 | R | | | 1 | 1.69 | R | | | 2 | 6.67 | R | | | 2 | 8.33 | sd | | |
| **Theridiidae** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Enoplognatha gemina* | 5 | 16.13 | D | | | 5 | 9.43 | sd | | | 2 | 7.69 | sd | | | 5 | 8.47 | sd | | | 3 | 10 | sd | | | 1 | 4.17 | R | | |
| *Kochiura aulica* | 3 | 9.68 | sd | 25.81 | ac | 1 | 1.89 | R | 9.43 | A | | | | 7.69 | A | 1 | 1.69 | R | 10.17 | A | 1 | 3.33 | | 13.33 | | | | | 4.17 | A |
| *Eyryopis sp.* | | | | | | 1 | 1.89 | R | | | | | | | | | | | | | | | | | | | | | | |
| *Theridion sp.* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Philodromidae** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Thanatus albini* | | | | | | | | | | | 1 | 3.85 | R | 3.85 | A | | | | | | 1 | 3.33 | sd | 3.33 | ac | 3 | 12.5 | D | 12.50 | A |
| **Linyphidae** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Mermessus denticulatus* | 2 | 6.45 | sd | | | 3 | 5.66 | sd | | | 4 | 15.4 | D | | | 2 | 3.39 | R | | | 6 | 20 | D | | | 5 | 20.8 | D | | |
| *Prinerigone vagans* | 1 | 3.23 | R | 32.26 | ac | | | | 22.64 | A | 1 | 3.85 | R | 50.00 | ac | 2 | 3.39 | R | 22.03 | A | | | | 40.00 | C | 1 | 4.17 | R | 54.17 | C |
| *Erigone sp.* | | | | | | | | | | | | | | | | 2 | 3.39 | R | | | | | | | | 1 | 4.17 | R | | |
| *Sengletus extricatus* | 7 | 22.58 | D | | | 4 | 7.55 | sd | | | 8 | 30.77 | E | | | 7 | 11.9 | D | | | 6 | 20 | R | | | 6 | 25 | D | | |
| **Gnaphosidae** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Zelotes sp.* | 1 | 3.23 | R | 3.23 | A | | | | 1.89 | A | | | | 3.85 | | | | | 1.69 | A | | | | 6.67 | A | | | | 4.17 | A |
| *Micaria dives* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Drassodes pubescens* | | | | | | 1 | 1.89 | R | | | 1 | 3.85 | R | | | 1 | 1.69 | R | | | 2 | 6.67 | sd | | | 1 | 4.17 | R | | |
| **Eutichuridae** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Cheiracanthium sp.* | 1 | 3.23 | R | 3.23 | A | | | | | | | | | | | 1 | 1.69 | R | 1.69 | A | | | | | | | | | | |
| **Salticidae** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Phlegra flavipes* | 2 | 6.45 | sd | 6.45 | A | | | | 3.77 | A | 1 | 3.85 | R | 3.85 | A | 1 | 1.69 | R | 1.69 | A | | | | | | | | | | |
| *Pellenes sp.* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Heliphannes sp.* | | | | | | 2 | 3.77 | R | | | 1 | 3.85 | R | | | | | | | | | | | | | | | | | |
| **Thomisidae** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Xysticus sp.* | | | | | | 1 | 1.89 | R | 1.89 | A | | | | | | | | | | | | | | | | | | | | |
| **Dictynidae** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Lathys sp.* | | | | | | | | | | | 1 | 3.85 | R | 3.85 | A | | | | | | | | | | | | | | | |
| **Total** | 31 | | | | | 53 | | | | | 26 | | | | | 59 | | | | | 30 | | | | | 24 | | | | |

**Frequency (abundance), by Weis Fog**
> 50 % = Constant ( C )
25 - 50 % = Accessory ( ac )
> 25 % = Accidental ( A)

**Dominance, by Weigmann**
> 30 % = Eudominant ( E )
10 - 30 % = Dominant ( D )
5 - 10 % = Subdominant ( sd )
1 - 5 %= Recedent ( R )
> 1 % = Subrecedent ( Sr )

**Table (4) Dominance-frequency relationship of spider communities associated with quinoa plants affected by different fertilizers durig 2019-2020**

| Families &taxa names | Copperal Max | | | | | Calcivin | | | | | Potassium silicate | | | | | Max. growth | | | | | Mix | | | | | Control | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | Sp% | Dom. | F.% | Frq. | Total | Sp% | Dom. | F.% | Frq. | Total | Sp% | Dom. | F.% | Frq. | Total | Sp% | Dom. | F.% | Frq. | Total | Sp% | Dom. | F.% | Frq. | Total | Sp% | Dom. | F.% | Frq. |
| **Lycosidae** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Wadicosa fidelis* | 3 | 10.34 | **D** | 24.14 | **A** | 3 | 9.38 | **sd** | 28.13 | **as** | 4 | 16 | **R** | 32.00 | **ac** | 5 | 16.1 | **D** | 35.48 | **ac** | 50 | 72.5 | **E** | 76.81 | **C** | | | | 13.33 | **A** |
| *Pardosa sp.* | 3 | 10.34 | **D** | | | 6 | 18.75 | **D** | | | 2 | 8 | **sd** | | | 5 | 16.1 | **D** | | | 3 | 4.35 | **R** | | | 1 | 6.67 | **sd** | | |
| *Hogna ferox* | 1 | 3.45 | **R** | | | | | | | | 2 | 8 | **sd** | | | 1 | 3.23 | **R** | | | | | | | | 1 | 6.67 | **sd** | | |
| **Theridiidae** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Enoplognatha gemina* | 4 | 13.79 | **D** | | | 3 | 9.38 | **sd** | | | 5 | 20 | **D** | | | 5 | 16.1 | **D** | | | 2 | 2.9 | **R** | | | | | | | |
| *Kochiura aulica* | 1 | 3.45 | **R** | 20.69 | **A** | | | | 9.38 | **A** | 1 | 4 | **R** | 24.00 | **A** | | | | 16.13 | **A** | | | | 2.90 | **A** | | | | | |
| *Eyryopis sp.* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Theridion sp.* | 1 | 3.45 | **R** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Philodromidae** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Thanatus albini* | 4 | 13.79 | **D** | 13.79 | **A** | 1 | 3.13 | **R** | 3.13 | **A** | 1 | 4 | **R** | 4.00 | **A** | | | | | | | | | | | 1 | 6.67 | **sd** | 6.67 | **A** |
| **Linyphidae** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Mermessus denticulatus* | 3 | 10.34 | **D** | | | 4 | 12.50 | **D** | | | | | | | | 4 | 12.9 | **D** | | | 2 | 2.9 | **R** | | | 1 | 6.67 | **sd** | | |
| *Prinerigone vagans* | 1 | 3.45 | **R** | 34.48 | **ac** | 3 | 9.38 | **sd** | 40.63 | **ac** | 1 | 4 | **R** | 32.00 | **C** | 1 | 3.23 | **R** | 25.81 | **ac** | | | | 15.94 | **A** | | | | 26.67 | **ac** |
| *Erigone sp.* | | | | | | | | | | | | | | | | 1 | 3.23 | **R** | | | | | | | | | | | | |
| *Sengletus extricatus* | 6 | 20.69 | **D** | | | 6 | 18.75 | **D** | | | 7 | 28 | **D** | | | 2 | 6.45 | **sd** | | | 9 | 13 | **D** | | | 3 | 20 | **D** | | |
| **Gnaphosidae** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Zelotes sp.* | | | | | | | | | 9.38 | **A** | | | | 4.00 | **A** | 2 | 6.45 | **sd** | 16.13 | **A** | | | | | | 4 | 26.7 | **D** | 40.00 | **ac** |
| *Micaria dives* | | | | | | 1 | 3.13 | **R** | | | | | | | | | | | | | | | | | | | | | | |
| *Drassodes pubescens* | | | | | | 2 | 6.25 | **sd** | | | 1 | 4 | **R** | | | 3 | 9.68 | **sd** | | | | | | | | 2 | 13.3 | **D** | | |
| **Eutichuridae** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Cheiracanthium sp.* | 1 | 3.45 | **R** | 3.45 | **A** | 2 | 6.25 | **sd** | 6.25 | **A** | | | | | | 2 | 6.45 | **sd** | 6.45 | **A** | 1 | 1.45 | **R** | 1.45 | **A** | | | | | |
| **Salticidae** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Phlegra flavipes* | 1 | 3.45 | **R** | 3.45 | **A** | 1 | 3.13 | **R** | 3.13 | **A** | 1 | 4 | **R** | 4.00 | **A** | | | | | | 1 | 1.45 | **R** | 1.45 | **A** | | | | 6.67 | **A** |
| *Pellenes sp.* | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 6.67 | **sd** | | |
| *Heliphannes sp.* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Thomisidae** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Xysticus sp.* | | | | | | | | | | | | | | | | | | | | | 1 | 1.45 | **R** | 1.45 | **A** | | | | | |
| **Dictynidae** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Lathys sp.* | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 6.67 | **sd** | 6.67 | **A** |
| **Total** | **29** | | | | | **32** | | | | | **25** | | | | | **31** | | | | | **69** | | | | | **15** | | | | |

**Frequency (abundance), by Weis Fog**
**> 50 % = Constant ( C )**
**25 - 50 % = Accessory ( ac )**
**> 25 % = Accidental ( A)**

**Dominance, by Weigmann**
**> 30 % = Eudominant ( E )  1 - 5 % Recedent ( R )**
**10 - 30 % = Dominant ( D )  > 1 % = Subrecedent ( Sr )**
**5 - 10 % = Subdominant ( sd )**

**Table (5): Estimation of Shannon-Wiener and Simpson Indices of spider diversity two seasons**

| | Copperal Max | Calcivin | Potassium silicate | Max. growth | Mix | Control |
|---|---|---|---|---|---|---|
| **First Season, 2018-2019** | | | | | | |
| **Shannon-Wiener Index** | 2.15 | 1.69 | 2.14 | 1.67 | 2.03 | 2.06 |
| **Simpson Index** | 0.14 | 0.30 | 0.16 | 0.32 | 0.15 | 0.15 |
| **Second season, 2019-2020** | | | | | | |
| **Shannon-Wiener Index** | 2.27 | 2.22 | 2.02 | 2.24 | 1.02 | 2.03 |
| **Simpson Index** | 0.12 | 0.12 | 0.16 | 0.12 | 0.55 | 0.16 |

**Table (6) Dominance and abundance (D & A) of arthropod pests and their natural enemies collected from quinoa plantation using pitfall traps during 2018-2019 season, Fayoum Governorate.**

| Order | Family | Copperal Max | | | Calcivin | | | Potassium silicate | | | Max. growth | | | Mix | | | Control | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | D% | A% | | D% | A% | | D% | A% | | D% | A% | | D% | A% | | D% | A% | |
| Coleoptera | Carabidae | 9 | 1.67 | 44.44 | 8 | 1.54 | 66.67 | 10 | 1.52 | 44.44 | 11 | 2.44 | 66.67 | 9 | 1.83 | 55.56 | 7 | 1.50 | 66.67 | **54** |
| | Staphylinidae | 2 | 0.37 | 11.11 | 3 | 0.58 | 22.22 | 4 | 0.61 | 22.22 | 4 | 0.89 | 33.33 | 1 | 0.20 | 11.11 | 1 | 0.21 | 11.11 | **15** |
| | Coccinellidae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0.20 | 11.11 | 0 | 0 | 0 | **1** |
| Collembola | Collembola | 74 | 13.73 | 100 | 97 | 18.65 | 100 | 106 | 16.06 | 100 | 99 | 22.00 | 100 | 72 | 14.60 | 100 | 107 | 22.96 | 100 | **555** |
| Diptera | Muscidae | 141 | 26.16 | 88.89 | 122 | 23.46 | 77.78 | 98 | 14.85 | 66.67 | 79 | 17.56 | 66.67 | 104 | 21.10 | 66.67 | 78 | 16.74 | 100 | **622** |
| Heteroptera | Miridae | 0 | 0 | 0 | 1 | 0.19 | 11.11 | 0 | 0 | 0 | 1 | 0.22 | 11.11 | 0 | 0 | 0 | 0 | 0 | 0 | **2** |
| Homoptera | Aleyrodidae | 1 | 0.19 | 11.11 | 0 | 0.00 | 0.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0.21 | 11.11 | **2** |
| | Aphididae | 13 | 2.41 | 55.56 | 24 | 4.62 | 77.78 | 29 | 4.39 | 77.78 | 8 | 1.78 | 33.33 | 11 | 2.23 | 44.44 | 9 | 1.93 | 44.44 | **94** |
| | Cicadellidae | 3 | 0.56 | 33.33 | 5 | 0.96 | 33.33 | 3 | 0.45 | 33.33 | 9 | 2.00 | 44.44 | 1 | 0.20 | 11.11 | 6 | 1.29 | 33.33 | **27** |
| Hymenoptera | Formicidae | 238 | 44.16 | 100 | 191 | 36.73 | 100 | 359 | 54.39 | 100 | 153 | 34.00 | 100 | 246 | 49.90 | 100 | 208 | 44.64 | 88.89 | **1395** |
| | Insect parasitoids | 5 | 0.93 | 33.33 | 6 | 1.15 | 44.44 | 8 | 1.21 | 44.44 | 7 | 1.56 | 55.56 | 6 | 1.22 | 33.33 | 7 | 1.50 | 33.33 | **39** |
| | Parasitoid wasps | 1 | 0.19 | 11.11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Orthoptera | Acrididae | 2 | 0.37 | 22.22 | 0 | 0.00 | 0.00 | 1 | 0.15 | 11.11 | 1 | 0.22 | 11.11 | 0 | 0 | 0 | 1 | 0.21 | 0.041 | **5** |
| | Gryllidae | 1 | 0.19 | 11.11 | 1 | 0.19 | 11.11 | 3 | 0.45 | 11.11 | 0 | 0.00 | 0.00 | 0 | 0 | 0 | 0 | 0 | 0 | **5** |
| Thysanoptera | Thripidae | 3 | 0.56 | 33.33 | 3 | 0.58 | 11.11 | 3 | 0.45 | 22.22 | 6 | 1.33 | 44.44 | 1 | 0.20 | 11.11 | 8 | 1.72 | 44.44 | **24** |
| Dermapter | Labiduridae | 2 | 0.37 | 22.22 | 1 | 0.19 | 11.11 | 1 | 0.15 | 11.11 | 1 | 0.22 | 11.11 | 1 | 0.20 | 11.11 | 1 | 0.21 | 11.11 | **7** |
| Lepidoptera | | 4 | 0.74 | 33.33 | 0 | 0 | 0 | 4 | 0.61 | 22.22 | 7 | 1.56 | 33.33 | 2 | 0.41 | 22.22 | 6 | 1.29 | 22.22 | **23** |
| Isopoda | | 0 | 0 | 0 | 2 | 0.38 | 22.22 | 0 | 0 | 0 | 1 | 0.22 | 11.11 | 1 | 0.20 | 11.11 | 1 | 0.21 | 11.11 | **5** |
| Myriapoda | | 8 | 1.48 | 33.33 | 3 | 0.58 | 22.22 | 5 | 0.76 | 33.33 | 4 | 0.89 | 33.33 | 7 | 1.42 | 44.44 | 1 | 0.21 | 11.11 | **28** |
| Spiders | | 31 | 5.75 | 88.89 | 53 | 10.19 | 100 | 26 | 3.94 | 77.78 | 59 | 13.11 | 100 | 30 | 6.09 | 88.89 | 24 | 5.15 | 77.78 | **223** |
| Snails | | 1 | 0.19 | 11.11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| **Total** | | **539** | | | **520** | | | **660** | | | **450** | | | **493** | | | **466** | | | **3128** |

**Table (7) Dominance and abundance (D & A) of arthropod pests and their natural enemies collected from quinoa plantation using pitfall traps during 2019-2020 season, Fayoum Governorate.**

| Order | Family | Copperal Max | | | Calcivin | | | Potassium silicate | | | Max. growth | | | Mix | | | Control | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | D % | A % | | D % | A % | | D % | A % | | D % | A % | | D % | A % | | D % | A % | |
| Coleoptera | Carabidae | 11 | 2.24 | 44.44 | 8 | 1.85 | 55.56 | 13 | 3.25 | 88.89 | 9 | 2.03 | 55.56 | 15 | 3.06 | 66.67 | 13 | 3.09 | 55.56 | **69** |
| | Staphylinidae | 6 | 1.22 | 33.33 | 2 | 0.46 | 22.22 | 1 | 0.25 | 11.11 | 5 | 1.13 | 33.33 | 3 | 0.61 | 22.22 | 1 | 0.24 | 11.11 | **18** |
| | Coccinellidae | 3 | 0.61 | 22.22 | 1 | 0.23 | 11.11 | 1 | 0.25 | 11.11 | 6 | 1.35 | 33.33 | 1 | 0.20 | 11.11 | 3 | 0.71 | 11.11 | **15** |
| Collembola | Collembola | 78 | 15.92 | 100 | 113 | 26.16 | 100 | 79 | 19.75 | 100 | 111 | 25.06 | 33.33 | 81 | 16.53 | 100 | 105 | 24.94 | 100 | **567** |
| Diptera | Muscidae | 163 | 33.27 | 88.89 | 91 | 21.06 | 66.67 | 128 | 32.00 | 33.33 | 46 | 10.38 | 88.89 | 119 | 24.29 | 77.78 | 16 | 3.80 | 66.67 | **563** |
| Heteroptera | Miridae | 0 | 0 | 0 | 1 | 0.23 | 11.11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0.24 | 11.11 | **2** |
| Homoptera | Aleyrodidae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0** |
| | Aphididae | 6 | 1.22 | 33.33 | 8 | 1.85 | 33.33 | 3 | 0.75 | 33.33 | 10 | 2.26 | 55.56 | 12 | 2.45 | 55.56 | 4 | 0.95 | 22.22 | **43** |
| | Cicadellidae | 3 | 0.61 | 22.22 | 5 | 1.16 | 22.22 | 2 | 0.50 | 22.22 | 4 | 0.90 | 44.44 | 1 | 0.20 | 11.11 | 2 | 0.48 | 22.22 | **17** |
| Hymenoptera | Formicidae | 159 | 32.45 | 100 | 129 | 29.86 | 88.89 | 137 | 34.25 | 100 | 187 | 42.21 | 88.89 | 163 | 33.27 | 100 | 226 | 53.68 | 100 | **1001** |
| | Insect parasitoids | 10 | 2.04 | 55.56 | 9 | 2.08 | 33.33 | 5 | 1.25 | 33.33 | 7 | 1.58 | 66.67 | 5 | 1.02 | 33.33 | 6 | 1.43 | 44.44 | **42** |
| | Parasitoid wasps | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0** |
| Orthoptera | Acrididae | 0 | 0 | 0 | 2 | 0.46 | 11.11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **2** |
| | Gryllidae | 1 | 0.20 | 11.11 | 1 | 0.23 | 11.11 | 0 | 0 | 0 | 1 | 0.23 | 11.11 | 0 | 0.00 | 0.00 | 1 | 0.24 | 11.11 | **4** |
| Thysanoptera | Thripidae | 4 | 0.82 | 33.33 | 7 | 1.62 | 44.44 | 0 | 0 | 0 | 10 | 2.26 | 22.22 | 4 | 0.82 | 33.33 | 3 | 0.71 | 22.22 | **28** |
| Dermapter | Labiduridae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0.45 | 11.11 | 0 | 0 | 0 | 4 | 0.95 | 33.33 | **6** |
| Lepidoptera | | 5 | 1.02 | 33.33 | 9 | 2.08 | 44.44 | 1 | 0.25 | 11.11 | 4 | 0.90 | 33.33 | 5 | 1.02 | 22.22 | 9 | 2.14 | 44.44 | **33** |
| Isopoda | | 0 | 0.00 | 0.00 | 2 | 0.46 | 22.22 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0.41 | 22.22 | 1 | 0.24 | 11.11 | **5** |
| Myriapoda | | 9 | 1.84 | 44.44 | 10 | 2.31 | 55.56 | 5 | 1.25 | 22.22 | 10 | 2.26 | 55.56 | 6 | 1.22 | 55.56 | 11 | 2.61 | 33.33 | **51** |
| Spiders | | 29 | 5.92 | 100 | 32 | 7.41 | 100 | 25 | 6.25 | 100 | 31 | 7.00 | 88.89 | 69 | 14.08 | 66.67 | 15 | 3.56 | 77.78 | **201** |
| Snails | | 3 | 0.61 | 11.11 | 2 | 0.46 | 22.22 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0.82 | 11.11 | 0 | 0 | 0 | **9** |
| **Total** | | **490** | | | **432** | | | **400** | | | **443** | | | **490** | | | **421** | | | **2676** |

**Table (8): effect of treatments on incidence and severity of downy mildew, biodiversity of spiders and grain yield of quinoa plants**

| Treatments | Spider | | Grain yield | | Assessment of diseases | | | | % Reduction | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Disease incidence % | | Disease severity % | | | |
| | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| **Copperal Max** | 3.56a | 3.22b | 1564b | 1613.33b | 11.67e | 14.33e | 3d | 4e | **88.33** | **85.67** |
| **Calcivin** | 6.22a | 3.56ab | 1402e | 1491.67e | 31.67c | 35c | 7.13c | 12.07c | **68.33** | **65.00** |
| **Potassium silicate** | 2.78a | 2.78b | 1518.33c | 1581.33c | 20.33d | 24.67d | 4.60d | 6.47d | **79.67** | **75.33** |
| **Max. growth** | 6.67a | 3.22b | 1433d | 1502.67d | 43.33b | 41.33b | 15.23b | 17.67b | **56.67** | **58.67** |
| **Mix. (all treatments)** | 2.89a | 7.67a | 1711.67a | 1692.67a | 6.67f | 6f | 2.47d | 2.63e | **93.33** | **94.00** |
| **Control** | 2.67 | 1.89b | 619.33f | 703f | 100a | 100a | 68a | 72.17a | **0.00** | **0.00** |
| **LSD (5%)** | **5.12** | **4.24** | **5.01** | **2.52** | **2.34** | **2.34** | **2.2** | **1.52** | | |

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