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PEST MANAGEMENT

Impact of Chemical, Organic and Bio-Fertilizers Application on Bell Pepper, *Capsicum annuum* L. and Biological Parameters of *Myzus persicae* (Sulzer) (Hem.: Aphididae)

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Abstract

Myzus persicae (Sulzer) is a polyphagous aphid that causes chlorosis, necrosis, stunting, and reduce growth rate of the host plants. In this research, the effects of Zinc sulfate and vermicompost (30%), *Bacillus subtilis*, *Pseudomonas fluorescens*, *Glomus intraradices*, *G. intraradices* × *B. subtilis*, and *G. intraradices* × *P. fluorescens* compared to control was investigated on the growth characters of *Capsicum annuum* L. and biological parameters of *M. persicae.* Different fertilizers caused a significant effect on growth characters of *C. annuum* and biological parameters of *M. persicae*. The highest plant growth was observed on Zinc sulfate and *B. subtilis* treated plants, and the lowest was on control. Increase in the amount of specific leaf area (SLA) (0.502 mm^2 mg^{-1}) was significantly higher in the *B. subtilis* than other fertilizer treatments. The longest (10.3 days) and the shortest (5.3 days) developmental times of *M. persicae* nymphs were observed on 30% vermicompost and Zinc sulfate treatments, respectively. The lowest adult longevity periods of *M. persicae* (11.2 and 11.3 days) were observed on *G. intraradices* × *B. subtilis* and 30% vermicompost treatments, respectively, and the longest ones (16.4 days) on Zinc sulfate. The highest rate of nymphal mortality and the lowest amount of nymphal growth index (NGI) were recorded on 30% vermicompost. The nymphs reared on Zinc sulfate treatment had the lowest rate of nymphal mortality and the highest amount of NGI. Thus, amending the soil with 30% vermicompost had a significantly negative effect on the biological parameters of *M. persicae* that can be used as an ecological control tactic for this pest.

Introduction

Bell pepper, *Capsicum annuum* L., is an important vegetable crop with a good source of nutrients, vitamins A, C, K, and B6, calcium, iron, zinc, fiber natural pigments, and antioxidant compounds important for human health (Greenleaf 1986, Deepa *et al* 2007, Howard *et al* 2000). A variety of insects damage the bell pepper during its growth including the green peach aphid, *Myzus persicae* (Sulzer) (Hem.: Aphididae). It is a polyphagous and a holocyclic aphid that causes chlorosis, necrosis, stunting, flower and fruit abortion, leaf distortion, defoliation, wilting, and reduced growth rate of the plant (Blackman & Eastop 2000, Frantz *et al* 2004). This aphid is also a vector of potato leaf roll virus (PLRV), potato Y virus (PVY), pepper mottle virus (Pep MoV), tobacco etch virus (TEV), and cucumber mosaic virus (CMV) (Robert *et al* 2000, Palukaitis & Garcia-Arenal 2003, Fenton *et al* 2010). Currently, the population of *M. persicae* is mostly managed with synthetic insecticides. However, after repeated control of the aphid populations with synthetic insecticides, resistant populations are developed through a strong selective pressure (Foster *et al* 1998, Bolandandam *et al* 2004). Therefore, other nonchemical control methods need to be integrated for effective control of this aphid. Using organic and bio-fertilizers may prove to be a complementary ecological control method for this pest.

Amending the soil with chemical fertilizer may affect the nutritional quality of plants, which in turn may affect herbivory (van de Rive *et al* 1972, Bentz *et al* 1995). Potassium, which is commonly in higher concentration in vermicomposts, might affect the interaction of plant-insect differently. High levels of K have a negative influence on insects such as white backed plant hopper, *Sogatella furcifera* (Horváth) (Salim 2002), brown plant hopper (BPH), *Nilaparvata lugens* (Stål) (Samiayyan & Janarathanan 1990), and other leaf hoppers and mites (Parihar & Upadhyay 2001). The negative influence of high levels of K on insect populations is assumed to be related to a reduced carbohydrates and amino acids concentrations (Baskaran *et al* 1985), and increased silica content and sclerenchyma's layer in plant (Dale 1988). On the other hand, populations of many insect species have been reported to increase significantly with the increased use of nitrogen and phosphorus fertilizers (Urabe & Sterner 2001, Schade *et al* 2003, Throop & Lerdau 2004, Hogendorp *et al* 2006). This might be due to decrease in soluble protein and free sugar content in plants. Patriquin *et al* (1995) noted that various forms of organic fertilizer applied to the soils may decrease populations of arthropod pests and resultant crop damage.

Vermicompost is a nutrient-rich, microbiologically active organic amendment that equilibrates the release of nutritional components such as nitrogen, soluble potassium, exchangeable calcium, magnesium, and phosphorous that affects quality and yield of crops (Yardim *et al* 2006). Meanwhile, vermicompost amendment of the soil has shown some negative effects on some phytophagous insects such as *Heteropsylla cubana* Crawford (Biradar *et al* 1998); *Aproaerema modicella* (Deventer) (Ramesh 2000); *Manduca quinqemaculata* (Haworth) (Yardim *et al* 2006); *M. persicae* and *Aphis gossypii* Glover, *Acalymma vittatum* (Fabricius) and *Diabotrica undecimpunctata* Howardi, *Tetranychus urticae* Koch, and *Pseudococcus* sp. (Rao 2002, Arancon *et al* 2006, Edwards *et al* 2009, Razmjou *et al* 2011).

Plant growth promoting rhizobacteria (PGPR) that are used as biofertilizater, phytostimulant, and biocontrol (Bloemberg & Lugtenberg 2001) also might induce systemic resistance (ISR) or systemic acquired resistance (SAR) in crop plants against different pathogens and some insect pests (Hammerschmidt & Kuc 1995, Vidhyasekaran & Muthamilan 1999). The use of PGPR has increased corn resistance to the corn earworm, *Helicoverpa zea* (Hübner) (Bong & Sikorowski 1991), cucumber beetles (Zehnder *et al* 1997), and cotton bollworm *Helicoverpa armigera* (Hübner) (Qingwen *et al* 1998).

Arbuscular mycorrhizal (AM) fungi are widespread micro-organisms associated symbiotically with the roots of more than 80% of terrestrial plants (Smith & Read 2008). *Glomus intraradices* is a member of the AM fungus that is used as a soil inoculant in agriculture and horticulture (Schuessler & Walker 2010). Mycorrhizal fungi increase the host plant's ability to absorb the mineral elements from the soil, especially phosphorus and non-sources available to them (Kristek *et al* 2005).

Our objective was to evaluate the effects of some chemical, organic, and bio-fertilizers on the life table parameters of *M. persicae* under the laboratory conditions. The results could be used as a complementary ecological pest management program for *M. persicae* on the bell pepper.

Material and Methods

This research was conducted during 2014 in the greenhouse and laboratory of the Department of Plant Protection, College of Agriculture and Natural Resources, University of Mohaghegh Ardabili, Ardabil, Iran. The sandy loam soil which used to grow plants was collected from a fallow potato field in Ardabil plain. The chemical and bio-fertilizers were obtained from the Iranian Soil and Water Research Institute in Karaj. The cattle manure vermicompost was obtained from the Pars Koud Company, Gorgan, Iran.

Plant and insect sources

Seeds of bell pepper, *C. annuum* (cv. California Wonder), were grown in 3-L-volume pots in an aphid-free greenhouse set at 25 ± 5°C, 60 ± 5% RH and 14:10 h (L:D), and when the plants reached 4–6 leaf stage, they were used in the experiment. A colony of *M. persicae*, was collected from a tomato field in Meshkin-Shahr (Ardabil province) and transferred to the potted plants raised in the greenhouse under the above mentioned conditions. To maintain a suitable aphid colony, every week some aphids were transferred from infected plants to new young plants. After rearing the aphid for three generations on the pepper plant, they were used in the experiments.

Greenhouse experiments

The experiment was conducted in the greenhouse under the above stated conditions with seven treatments in a completely randomized design experiment. Treatments were (1) bell pepper plants grown in the field collected soil and then sprayed with Zinc sulfate fertilizer at the concentration of 0.001 at 4–6 expanded leaves stages; (2) bell pepper plants grown in the same soil amended with 30% vermicompost (which contained 1.8% N, 3.9 mg/kg P, pH = 7.3, and EC = 2.2 ds/m) before planting; (3) bell pepper seeds treated with *Pseudomonas fluorescens* strain 187 as

PGPR treatments (1 mL/seed) with the rate of 1 × 10^7 CFU/mL; (4) bell pepper seeds treated with *Bacillus subtilis*, as PGPR treatments (1 mL/seed) with the rate of 1 × 10^7 CFU/mL and planted in pots containing the field collected soil; (5) bell pepper seeds treated with *G. intraradices* (5 g/seed) with 250 propagul/g and planted in pots containing the field collected soil; (6) bell pepper seeds treated with the combination of *G. intraradices* and *P. fluorescens* fertilizers; and (7) bell pepper seeds treated with the combination of *G. intraradices* and *B. subtilis*. Control plants were planted in pots containing only the field collected soil without adding any fertilizer.

Measurement of growth characters of C. annuum

For evaluating the effect of different fertilizer treatments on plant growth, indices such as plant height, leaf area, and leaf dry weight of bell pepper were measured at the flower stages on two randomly selected plants per treatment. Individual leaf area was measured with a leaf area meter AM300 (AM300 portable leaf area meter, ADC Bioscientific Ltd., Hoddesdon, UK). Leaf dry weights (DWs) were determined after they dried at 60°C for 3 days until constant weight was obtained. Specific leaf area (SLA) was calculated from leaf area and leaf dry weights determinations as follows (Evans 1972): SLA = leaf area per plant/leaf DWs per plant

In this study, also leaf chlorophyll was determined twice a week over the season on the eighth leaves per plot using a chlorophyll meter (SPAD-502, Minolta, Japan).

Determination of the life table parameters of M. persicae

Developmental time, survivorship of immature stages, fecundity, and longevity of the resultant adults were studied on 50 wigless adult aphids per treatment that were randomly chosen from the original greenhouse colony. Each adult aphid was confined in a clip cage (2 cm diameter × 1 cm height) on a leaf surface) the first fully expanded leaf from the top of the plant) with a suitable ventilation in a growth chamber that was set at 25 ± 2°C, 65 ± 5% RH, and 16:8 (L:D) h. They were permitted to produce nymphs for 24 h, and then the adult aphids were eliminated from the leaf clip cages. Each plant received one aphid nymph that was confined to the first true leaf. These nymphs were monitored daily to assess the aphid's performance on different treatments. After maturity and when the reproduction started, adult fecundity and mortality were recorded daily, and the offsprings were removed from each leaf cage until the death of all adult aphids. The mortality parameters including entropy (H) and life expectancy (e_x) were calculated according to Carey (2001):

$$H = \frac{\sum_{x=0}^{w} e_x d_x}{e_0}$$

Also the reproduction parameters of *M. persicae* including gross fecundity rate (GFR), net fertility rate (NFrR), and the mean number of nymphs produced per female per day were calculated for the treatments (Carey 1993):

$$\mathrm{GFR} = \sum_{\alpha}^{\beta} M_x$$
$$\mathrm{NFrR} = \sum_{\alpha}^{\beta} l_x M_x$$

Mean number of nymphs produced per female per day = $\frac{\sum_{\alpha}^{\beta} M_x}{(\varepsilon-\omega)}$, where l_x is the days lived in interval x and $x + 1$; M_x is the average number of offsprings produced by female at age x; α is the age of female at the first nymph; β is the age of female at the production of the last nymph; and $\varepsilon - \omega$ is the female longevity.

The nymphal growth index (NGI) was calculated by dividing the survival rate of the immature stage (l_x) by the period of each immature stage (T) (Setamou *et al* 1999):

$$\mathrm{NGI} = \frac{l_x}{T}$$

Data analysis

All data were tested for normality by Kolmogorov-Smirnov method before analysis. The data were subjected to the one-way analysis of variance (ANOVA) using the statistical software of Minitab 16.0 (Minitab Inc. 1994). Statistical differences among means were compared using the Tukey post hoc Honestly Significant Difference (HSD) test at $P < 0.05$. Difference in each parameter value on fertilizer treatments were tested for significance by estimating variances through the jackknife procedure (Sokal & Rohlf 1981, Meyer *et al* 1986).

Results

Treatment effects on growth characters and chlorophyll content of C. annuum

The results showed that the plant growth significantly increased in all fertilizer treatments, but there were significant differences across treatments (Fig 1). The highest plant height was observed on Zinc sulfate (18.9 cm) and on *B. subtilis* (18.55 cm) treatments, respectively, and the lowest plant height (10.3 cm) was observed on control plant ($F = 24.2$; df = 7, 31; $P < 0.01$) (Fig 1A). Also, different fertilizer treatments affected the leaf area of the bell pepper differently ($F = 7.9$; df = 7, 31; $P < 0.01$). The highest leaf area was observed on treatments *G. intraradices* × *P. fluorescens* (349.8 mm^2/plant) and *G. intraradices* × *B. subtilis* (329.1 mm^2/plant), respectively, while the lowest leaf area (170.4 mm^2/plant) belonged to the control plant (Fig 1B).

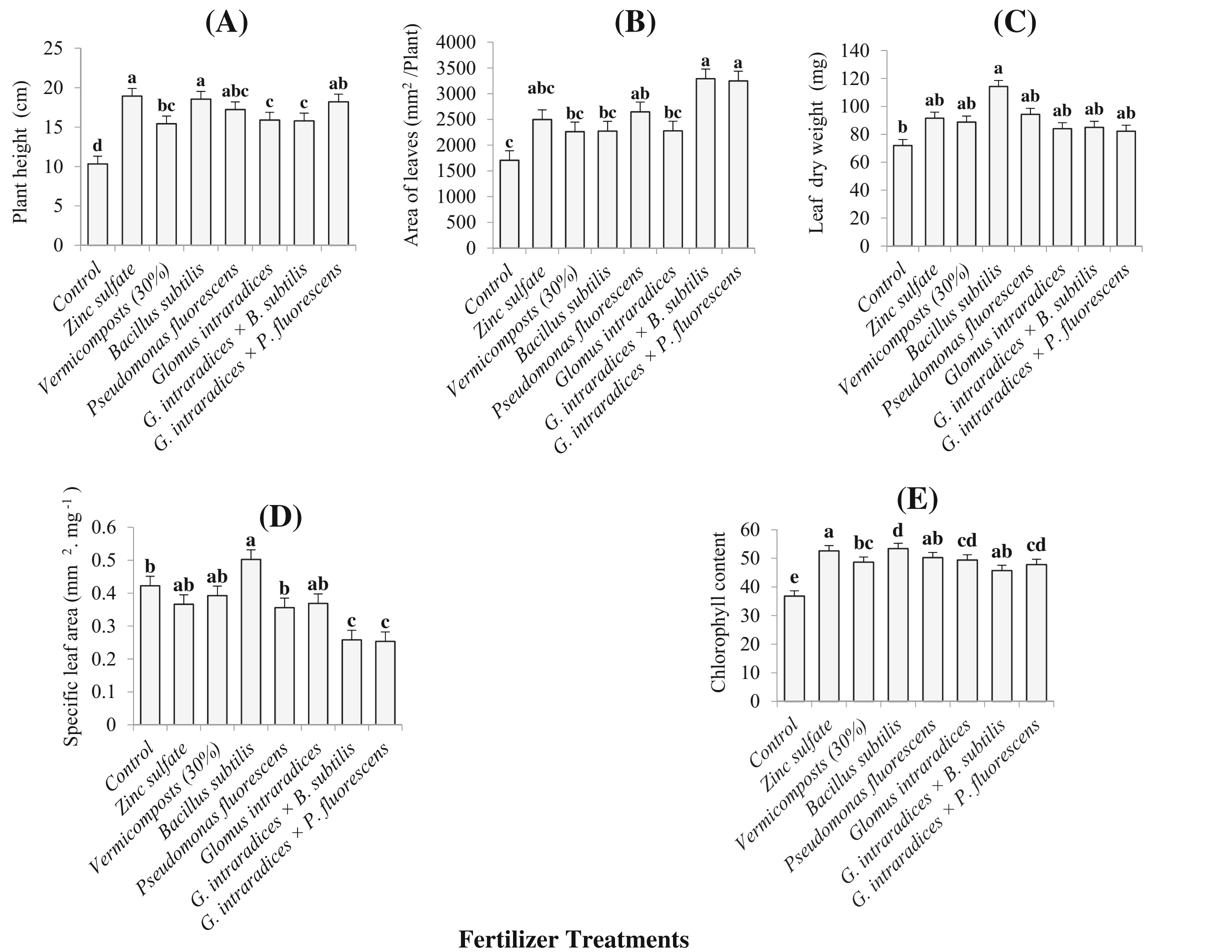

Fig 1 The effect of different fertilizer treatments on plant height (**A**), leaf area (**B**), leaf dry weight (**C**), specific leaf weight (**D**), and chlorophyll contents (**E**) of bell pepper under the greenhouse conditions (25 ± 5°°C, 60 ± 5% RH, and 14:10 h (L:D)) [$P < 0.01$, Tukey (HSD)].

Different fertilizer treatments significantly affected the leaf dry weight of *C. annuum* (F = 4.2; df = 7, 31; $P < 0.01$). The highest leaf dry weight (114.2 mg) occured on *B. subtilis* treatment, while the lowest amount (72.0 mg) was observed on control treatment. Also, different fertilizer treatments significantly affected the SLA (F = 61.46; df = 7, 31; $P < 0.01$) (Fig 1C). *Bacillus subtilis* treatment significantly increased the amount of SLA (0.502 mm^2 mg^{-1}) than the other treatments, and the lowest amount of SLA was observed on treatments *G. intraradices* × *P. fluorescens* and *G. intraradices* × *B. subtilis* (0.258 and 0.253 mm^2 mg^{-1}, respectively) (Fig 1D). Chlorophyll content of the leaves of bell pepper was affected differently with different fertilizer treatments (F = 16.9; df = 7, 31; $P < 0.01$). The highest (53.4) and the lowest (36.8) chlorophyll reading were obtained on *B. subtilis* and control treatments, respectively (Fig 1E).

Treatment effects on biology of M. persicae

Developmental time of immature stages of *M. persicae* was significantly affected by different fertilizer treatments (Table 1). There were significant differences among developmental time of nymph on different treatments (F = 25.0; df = 7, 193; $P < 0.01$). The longest (10.3 days) and the shortest (5.3 days) developmental times of *M. persicae* nymph were observed on vermicompost and Zinc sulfate treated plants, respectively. Also, there were significant differences among adult longevity of *M. persicae* on different fertilizer treatments (F = 2.6; df = 7, 195; $P < 0.01$). The shortest (11.2 and 11.3 days) and the longest (16.4 days) adult longevity period of *M. persicae* were observed on the *G. intraradices* × *B. subtilis* and vermicompost, respectively, and Zinc sulfate treated plants, respectively (Table 1).

Entropy

The entropy (*H*) of *M. persicae* on control, *B. subtilis*, vermicompost, *P. fluorescens*, Zinc sulfate, *G. intraradices*, *G. intraradices* × *P. fluorescens*, and *G. intraradices* × *B. subtilis* treatments treated plants were 0.48, 0.45, 0.43, 0.42, 0.41, 0.41, 0.40, and 0.32, respectively.

Table 1 Developmental time and fecundity of the green peach aphid, *Myzus persicae* reared on bell pepper plants treated with different fertilizer under the laboratory conditions.

Fertilizer treatments	Statistic (Mean ± SE)				
	Developmental time	Adult longevity	Life span	NGI	Nymphal mortality (%)
Control	8.4 ± 0.34b	14.0 ± 1.26abc	23.3 ± 1.42a	7.1	41
Zinc sulfate	5.3 ± 0.24e	16.4 ± 1.24a	21.2 ± 1.21a	11.3	40
Vermicompost (30%)	10.3 ± 0.52a	11.3 ± 0.75c	21.5 ± 1.16a	3.8	60
Bacillus subtilis	8.4 ± 0.27b	15.1 ± 1.33ab	22.6 ± 1.21a	6.1	48
Pseudomonas fluorescens	7.3 ± 0.25c	12.7 ± 0.93bc	20.2 ± 1.01a	7.4	46
Glomus intraradices	6.4 ± 0.15d	13.8 ± 0.92abc	20.1 ± 0.90a	9.1	42
G. intraradices × B. subtilis	9.0 ± 0.43b	11.2 ± 0.79c	20.2 ± 0.94a	5.5	50
G. intraradices × P. fluorescens	8.5 ± 0.22b	13.7 ± 0.95abc	22.3 ± 1.03a	6.1	48

The means followed by different letters in the same columns are significantly different ($P < 0.01$, Tukey HSD)

NGI nymphal growth index

Life expectancy

Life expectancies (e_x) of *M. persicae* reared on various fertilizer treated plants are given on Fig 2. The life expectancy of *M. persicae* at the first days was 17.3, 17.0, 16.9, 16.7, 15.9, 15.6, 15.2, and 14.5 on *G. intraradices × P. fluorescens*, *G. intraradices × B. subtilis*, control, Zinc sulfate, *P. fluorescens*, *B. subtilis*, *G. intraradices*, and vermicompost (30%) treated plants, respectively. The lowest and the highest e_x belonged to the vermicompost and Zinc sulfate treated plants, respectively.

Treatment effects on population growth parameters of M. persicae

There were significant differences on the number of offspring produced per female per day on different fertilizer treated plants ($F = 40.6$; df = 7, 188; $P < 0.01$). The lowest number of offspring/reproduction/day (0.30) was observed on vermicompost and no significant difference between *G. intraradices × B. subtilis* and *G. intraradices × P. fluorescens*, respectively, while the highest (1.1) was observed on Zinc sulfate and control treated plants. There were also significant differences among GFR of *M. persicae* on different fertilizer treatments ($F = 9.5$; df = 7, 188; $P < 0.01$). The lowest GFR (11.5) was observed on vermicompost treatments, and there were no significant difference among *G. intraradices*, *B. subtilis*, *G. intraradices × B. subtilis*, and *G. intraradices × P. fluorescens* treated plants. Also, the highest GFR (30.3) of *M. persicae* was observed on Zinc sulfate treated plants, and there were no significant difference between control and *P. fluorescens*. There were significant differences among NFrR of *M. persicae* on different fertilizer treated plants ($F = 30.7$; df = 7, 188; $P < 0.01$). The lowest NFrR (5.0) was observed on 30% vermicompost treatments, but there were no significant difference between *G. intraradices × B. subtilis* and *G. intraradices × P. fluorescens* treated plants. The highest value of NFrR (21.3) was observed on Zinc sulfate treated plants. The highest rate of nymphal mortality (60.0%) and the lowest amount of NGI (3.8) was recorded on vermicompost treated plants. Also, the nymphs reared on Zinc sulfate treated plants had the lowest rate of nymphal mortality (40.0%) and the highest amount of NGI (11.3) (Table 2).

Discussion

Currently, healthy and safe food free from toxic residues is demanded by consumers, especially with respect to freshly consumed vegetables like *C. annuum*. Therefore, to avoid hazardous chemicals against insect pests of such crops, certain protective or curative procedures could be implied using different non-chemical methods to reduce the pest population and resultant damage. According to the results obtained in this research, the different fertilizer treatments varied in their effects on the growth characters and leaf chlorophyll of *C. annuum* as well as the biological parameters of *M. persicae*.

We found that when the foliage of *C. annuum* treated with Zinc sulfate or when the soil is amended with *B. subtilis* treatments, plant growth was improved compared to the control. Zinc is an essential element for the functioning of many enzymes, as well as for the synthesis of tryptophan, a precursor of indole acetic acid (IAA) in plants, and Zinc deficiency causes a reduction in RNA synthesis and ribosome stability (Spiegel-Roy & Goldschmidt 2008). Also, Zinc deficiency is one of the most widespread mineral nutritional problems that affect normal development of plants (Pinton *et al* 1993, Mullins *et al* 1992). *Bacillus* sp. grows very rapidly

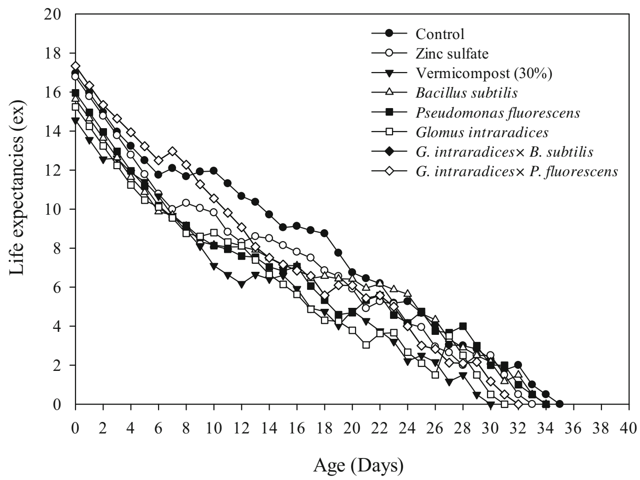

Fig 2 Life expectancies (e_x) of the green peach aphid, *Myzus persicae*, reared on different fertilizer treatments under the laboratory conditions.

and occupies the court of infection preventing pathogen spores to reach susceptible tissues in competition for spaces (Wolk & Sarkar 1994). This might be due to the induction of systemic resistance as the main mechanism of activity on the plant (Ramamoorthy *et al* 2001, Xing *et al* 2003, Abdel-Kader *et al* 2012). Thus, increasing plant growth of *C. annuum* on Zinc sulfate and *B. subtilis* treatments can be positively correlated with the amount of nutrient matter in the soil.

In this research, the highest leaf chlorophyll reading was observed on plants treated with *B. subtilis*, and the lowest reading was observed on control plant. The results of the correlation analysis revealed significant relationships between *B. subtilis* treatment in the soil and total chlorophyll content and plant height. The increased level of the total chlorophyll concentration in the leaves of the *B. subtilis* treated plants might be due to the increase of growth retardant on delaying leaf senescence and hence keeping the green pigment from degradation (Wafsy & El-Din 1995). Thus, bio-fertilizers are more effective than chemical fertilizer in improving plant growth and leaf chlorophyll content of *C. annuum*. It has been shown that conventional fertilizers (NPK) significantly increase the plant growth characters of pepper plant compared to all sources of organic manure and control (Gopinath *et al* 2009, Olaniyi & Ojetayo 2010, Abu-Zahra 2012).

Different studies have shown that fertilizer can have contradictive effects on growth, reproduction, and survival of insects feeding on the treated plants. Meyer (2000) proposed that soil nutrient availability not only affects the amount of damage that plants receive from herbivores but also enhances the ability of plants to recover from herbivores. Chau & Heong (2005) reported that organic fertilizers have positive effects on rice plant growth and the population of stem borer (SB) and leaf folder (LF) were reduced more on rice plants treated with chicken and hog manure compost and organic fertilizer compared to rice plants treated with chemical fertilizer. Also, Ramesh *et al* (2005) concluded that organic crops are more tolerant to insect attacks compared to non-organic plants. Organic rice is reported to have a thicker cell wall and lower levels of free amino acid than conventional rice. Our results indicated that the developmental time of nymph of *M. persicae* on vermicompost treated plants was higher than Zinc sulfate treated plants. van Lenteren & Noldus (1990) noted that the longer developmental time of an insect on a host is an indicative of its unsuitability for the insect. This could be due to increased secondary compounds (such as flavonoids, anthocyanin, and total phenol) on the leaves of *C. annuum*. In our experiments, the level of secondary compounds in the leaves of *C. annuum* increased significantly on vermicompost versus Zinc sulfate treatments (Mardani-Talaee *et al* 2016b). Edwards *et al* (2009) reported that phenolic substance contents of vermicompost cause change in feeding response of pests. The phenolic compounds from the wild ground nut, *Arachis hypogaea* L., retard the developmental rate of *Spodoptera litura* Hübner (Stevenson *et al* 1993). Also, the

Table 2 The reproduction of the green peach aphid, *Myzus persicae* reared on bell pepper plants treated with different fertilizer under the laboratory conditions.

Fertilizer treatments	Statistic (Mean ± SE)		
	Daily nymph production (nymph/female/day)	GFR	NFrR
Control	1.10 ± 0.04a	29.5 ± 2.70a	15.8 ± 0.80b
Zinc sulfate	1.10 ± 0.06a	30.3 ± 1.70a	21.3 ± 1.50a
Vermicompost (30%)	0.30 ± 0.04c	11.5 ± 1.71b	5.0 ± 0.70e
Bacillus subtilis	0.59 ± 0.04b	18.7 ± 2.39b	10.7 ± 0.78 cd
Pseudomonas fluorescens	0.60 ± 0.05b	28.2 ± 5.60a	10.7 ± 1.09 cd
Glomus intraradices	0.66 ± 0.05b	15.5 ± 1.59 b	11.8 ± 0.86c
G. intraradices × B. subtilis	0.42 ± 0.03c	14.2 ± 2.32b	7.7 ± 0.68e
G. intraradices × P. fluorescens	0.42 ± 0.02c	11.5 ± 1.36 b	8.3 ± 0.63de

The means followed by different letters in the same columns are significantly different ($P < 0.01$, Tukey HSD)

GFR gross fecundity rate, *NFrR* net fertility rate phenolics in plant tissues decrease the consumption rates of tissues by a geometrid caterpillar, *Epirrita autumnata* Borkhausen (Haukioja *et al* 2002).

The growth index (GI) depicts the effect of food quality on both survival rate and developmental time of an insect (Setamou *et al* 1999). NGI of *M. persicae* was lower on vermicompost treatment compared to Zinc sulfate treatment. Also, the highest and the lowest rates of nymphal mortality were recorded on vermicompost and Zinc sulfate treatments, respectively. Results of other studies have demonstrated that fertilizer treatment affect fecundity, life table parameters, and physiological performance of herbivorous insects (Edwards *et al* 2009), especially sap-sucking insects (Oliveira *et al* 2014, Mardani-Talaee *et al* 2016a). Amending the soil with fertilizers increases the level of organic matters of the soil and increased biological interactions lead to relative host plant resistance to pest damages (Luong & Heong 2005). Reduced NGI and increased mortality rate on vermicompost treated plants may be the result of lower suitability of vermicompost treated plants to *M. persicae* that can have negative effects on growth and survival, as well as the rate of ovipositon days of *M. persicae.*

Field studies have shown that the addition of vermicompost to soil significantly reduces the populations of the psyllid, *Heteropsylla. cubana Crawford* (Biradar *et al* 1998), the sucking insect *Aproaerema modicella Deventer* (Ramesh 2000), beetles (*Acalymma vittatum (F.)* and *Diabrotica undecimpunctata Howardii*), spider mites (*T. urticae*), mealybugs (*Pseudococcus* sp.), and aphids (*M. persicae (Sulzer)* and *Myzus quinquemaculata (Haworth)*) on several crops (Rao 2002, Yardim *et al* 2006, Arancon *et al* 2006).

In our studies, the lowest net fecundity of aphid was observed on vermicompost treated plants. Kale *et al* (1992) found that amending the soil with vermicompost may result in a significant increase in the abundance of N-fixers actinomycetes and other spore forming fungi compared to the soil supplemented with inorganic fertilizers. Soil enzyme activity is also significantly increased by vermicompost addition as compared to equivalent rates of mineral fertilizers (Marinari *et al* 2000, Arancon *et al* 2006, Saha *et al* 2008).

The entropy parameter provides a practical summary measure for characterizing differences in shapes of life to small changes in mortality rate among the different age group among cohorts (Carey 1993). The results showed that the survival schedules of *M. persicae* were convex on different fertilizer treatments ($H < 0.5$), suggesting that the probability of dying was higher in late ages as compared with early ones.

In summary, significant differences were observed on the life history parameters of *M. persicae* fed *C. annuum* cultivated in amended soil with bio-fertilizers. Amending the soil with vermicompost was more effective than chemical fertilizer in inducing antibiosis to green peach aphid. The observed effects were decreasing gross and net fecundity, increased developmental time and mortality rate, decreased adult longevity and NGI index, as well as life expectancies (e_x). These findings revealed that amending the soil with vermicompost at the rate of 30% under the greenhouse conditions can reduce aphid damage and can be helpful in ecological management of the pest in combination with other control tactics.

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