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ORIGINAL RESEARCH

# Effect of cow vermicompost on growth, fruit yield, and quality of hot pepper (*Capsicum annuum* var. Red chili)

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## Abstract

**Purpose** This study evaluated the response of hot pepper (*Capsicum annuum* var. Red chili) towards cow vermicompost application under field conditions.

**Method** Cow vermicompost was supplied in four levels (0, 5, 10, and 15 t $ha^{-1}$) across the two growing seasons in 2017 and 2018.

**Results** Vermicompost application significantly increased the plant height, internode distance, and number of lateral branches in both seasons. It was noticed that manuring with 15 t $ha^{-1}$ of cow vermicompost resulted with enhancedchlorophyll contents, fruit yield, and fruit number in both years. In both seasons, the highest leaf number, fruit weight, and total soluble solids are related to the third treatment (10 t $ha^{-1}$ of cow vermicompost). The results showed that 1000-seed weight and vitamin C content were affected by cow vermicompost. Data showed that manuring with vermicompost (5 t $ha^{-1}$) caused the best quality components in 2017 and 2018.

**Conclusion** the results showed that vermicompost had a significant impact on vegetative and reproductive growth and fruit quality of hot pepper.

**Keywords** Chlorophyll, Fruit yield, Organic fertilizers, Plant height, Vitamin C

## Introduction

The chili known as hot pepper (*Capsicum annum* L.) is an inevitable condiment and vegetable grown extensively throughout the world. It is a member of the nightshade family, Solanaceae. Chili plays a significant role in the Indian diet and is used as a condiment in various foodstuffs like curries, sauces, soups, and chutney to add spicy flavor and is also widely used in the preparation of curry powder. Green chili fruits are eaten raw as salad, and powder of dry chilies is an indispensable spice of every kitchen throughout India. Dried chili fruits constitute a significant share of the spices consumed per head (Koshale et al. 2018). In the Indian subcontinent, chili is cultivated over 844 thousand ha with an annual production of 2106 thousand metric tons (Anonymous 2018). While as in Jammu and Kashmir, it grabs an area of 0.60 thousand hectares with an annual yield of 0.40 thousand metric tons (Anonymous 2017). Chilies are grown in almost all the states throughout the year.

Vermicomposting is a supportable method to convert organic wastes into a nutrient-rich humus-like product through the joint action of microorganisms and earthworms under aerobic conditions (John 2010; Pattnaik and Reddy 2013; Gong et al. 2017). It includes numerous essential nutrients that play an essential role in physical, biological, and chemical improvement, as well as the yield and growth of chili (Pezeshkpour et al. 2014). Also, previous studies have remarked that vermicompost appears to affect plant growth in ways that cannot directly link to chemical or physical properties (Bachman and Metzger 2008). Organic manures provide macro, micro, secondary nutrients and enhance the soil's biological, physical, and chemical properties. Organic fertilizers are released slowly, so they are less vulnerable than mineral fertilizers, which in turn minimizes soil, water, and air pollution (Bade et al. 2017). Numerous recent reviews explained the

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benefits of vermicompost widely when applied as a source of nutrients in organic agriculture (Mistry 2015; Vennila et al. 2012). The most significant influence of vermicompost even at low concentrations is plant growth- increasing (Edwards and Arancon 2004; Singh et al. 2008). Application of vermicompost incremented leaves number, dry leaf weight, stem height, total yield, fruits number plant$^{-1}$, chlorophyll contents, pH and TSS of juice, and developed the quality of the fruit and seeds (Joshi et al. 2015). Similar research was conducted by Khandaker et al. (2017) using the chicken manure, peat moss, cow dung, vermicompost, and fish tonic for *Capsicum annuum* and found out that vermicompost gave the highest values for the number of leaves and flower buds, stomatal conductance, chlorophyll content, and plant height. Studies done on the effects of chemical fertilizer and vermicompost on the hyacinth beans (*Lablab purpureas*) detected that flower appearance growth was significantly higher in those plots, which takes vermicompost either in combination with chemicals or alone. Vermicompost incremented plant growth of Chinese cabbage, spinach, strawberries, lettuce, and tomatoes (Adhikary 2012). Joshi and Vig (2010) as well described an improvement in plant growth factors (dry plant biomass, plant height, and leaves number) with 45% vermicompost (cattle fertilizer) improved treatment in *L. esculentum*. To form the best view of the potential of several organic fertilizers, we studied the result of cow vermicompost on the growth, fruit yield, and quality of hot pepper.

## Materials and methods

This study was performed at the experimental farm of the Agricultural Faculty, Ferdowsi University of Mashhad, Iran (longitude 59° 35′ E, latitude 36° 17’ N, and 985 m elevation) during the 2017- 2018 growing seasons. This location represents the range of dry conditions, the temperature in the experimental period ranges from 16 to 39.18 °C. Annual rainfall ranges are between 91 and 120 mm, and the average annual relative humidity is 37%. A sample of soil (0-30 cm depth) was taken with a drill before land preparation and anlaysed for for chemical and physical attributes using standard laboratory methods, as explained by Mylavarapu and Kennelley (2002). The details of the sol are in Table 1. The experimental field was cleared, plowed, harrowed, and divided into plots. Pepper seeds (*Capsicum annuum* var. Red chili) were placed in large trays with a 1:1 mixture of sand and peat (1:1 v/v) within a greenhouse. Seven-week-old hot pepper plants were hand-transplanted into well-prepared beds on the farm. The plants had spaced at 50 and field 35 cm (respectively) between rows and plant on the row. Irrigation was performed after sowing via drip irrigation when required. . There were no fungicide and insecticide application in experiments. Weeds were controlled by hand. All essential cultural practices and plant conservation measures were followed uniformly for all the plots in the whole period of the experiment. Cow vermicompost was prepared from Mashhad Municipality Recycling Factory. Cow vermicompost was applied at four levels (treatments): VC 0= 0, VC 1= 5, VC 2= 10, and VC 3= 15 t ha$^{-1}$. Cow vermicompost was applied and mixed with soil from the top 15 cm layer to form experimental beds (3 weeks before planting). Vermicompost characteristics had shown in Table 2. The four experiment treatments were regulated in a completely randomized block design (CRBD) with three replications.. Hot pepper fruits were reaped at the red mature phase. There were three plots per treatment and three replicates per plot obtained. Every replicates contained twenty peppers which, were harvested from ten various randomly selected plants.

To measure the length of the main stem, the length of the lateral stems, and internodes distance a metal ruler was used. A digital caliper was used to measure the stem diameter at the end of the growing period. At the end of the experiment, three plants of each replication were selected randomly, and the number of branches and nodes were measured. The leaf area was estimated by using a specialized device (Model Leaf Area AM 200). Leaf chlorophyll contents were measured by a chlorophyll meter (Model SPAD-502-Minolto). The digital weighing scale with an accuracy of 0.001 was used to measure the fresh and dry weight of mature leaves.

Mature fruits were harvested weekly and weighed by using digital scale. The total fruit yield per plant during the growing season (June to October) was analyzed statistically. After forming the fruit on the bush and picking them, the fruit number was counted. In statistical calculations, the total fruits produced per plant during the growing season (June to October) was registered.

Fruit diameter and length were evaluated using a digital caliper. The digital weighing scale with an accuracy of 0.001 was used to measure the fresh and dry weight of mature fruit. The digital weighing scale with an accuracy of 0.001 was used to measure a thousand seeds' weight. At the end of the experiment, three fruits from each replication had randomly selected to count there.

Fruits of hot pepper from every treatment were cut into small slices and pooled. Samples had homogenized in a blender, and portions of the homogenate were utilized to define the fruit quality. Titratable acidity (Ta) was measured by titration with 0.1 N NaOH until pH= 8.1 had reached and described as g $L^{-1}$ of citric acid fresh weight utilizing citric acid as a control (Horwitz 2000). The pH amount of the fruit had determined at 20 °C with a pH meter. Total soluble solids contents (TSS) were specified with a refractometer at 20 °C and described as °Brix. Ascorbic acid or vitamin C contents were evaluated by the classical titration method using 2, 6-dichlorophenol indophenol solution and reported as mg 100 $g^{-1}$ fresh weight (Miller 1998). Data were evaluated with SAS (SAS Institute 2000), and means had compared through Duncan's multiple range test (DMRT) at a 5% level of confidence.

**Table 1** Soil characteristics of the experimental farm

| N (%) | P (ppm) | K (ppm) | Fe (ppm) | Cu (ppm) | Mn (ppm) | Zn (ppm) | pH | OM (%) | Silt (%) | Sand (%) | Clay (%) | Texture |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.101 | 15.7 | 184 | 4.42 | 1.06 | 17.0 | 1.02 | 7.68 | 1.46 | 53 | 25 | 22 | Silty loam |

**Table 2** Vermicompost characteristics

| N (%) | P (%) | K (%) | Fe (%) | Cu (ppm) | Mn (ppm) | Zn (ppm) | OC (%) | pH | Ec (ds/m) |
|---|---|---|---|---|---|---|---|---|---|
| 1.45 | 1.75 | 1.11 | 1.76 | 92 | 660 | 350 | 19.6 | 8.25 | 5.05 |

## Results and discussion

### Vegetative traits of the plant

### Plant height

Cow vermicompost application increased plant height in both years. The treatments with cow vermicompost resulted in higher plant height than the control in 2017. Plant height in cow vermicompost (15 t $ha^{-1}$) shows the highest plant height (29.33 cm) while control, with no organic fertilizer application, gives the shortest (23.33 cm) chili plant in 2018 (Table 3).The above results are similar to (Joshi and Vig 2010) and (Narkhede et al. 2011), who reported that vermicompost incremented height of plant significantly, as compared to control in chili and tomato (respectively). In this regard, the researchers showed that the application of 6 t $ha^{-1}$ of vermicompost significantly incremented the canary grass plant height compared to the control (Ghandali et al. 2016). Similarly, the lowest plant height was related to the treatment of non-application of vermicompost, and the highest plant height to the use of 10 t $ha^{-1}$ of vermicompost (Khalesro and Malekian 2017). So, vermicompost has a positive effect on the rate of photosynthesis and biomass production. Through the high power of water absorption and the desired solubility of macro and micronutrients and has improved the height of the plant (Tasdighi et al. 2015).

### Lateral stem length

The influences of cow vermicompost on the lateral stem length of hot pepper were not significant in both years (Table 3). The highest lateral stem length was obtained from 5 t $ha^{-1}$ cow vermicompost applications in 2017 20.61 (cm) and 2018 (20.16 cm).

### Internode distance

The plant internode distance of pepper was significantly influenced by cow vermicompost applications in 2017 and 2018. The treatments of 5 and 10 t $ha^{-1}$ in the first season (1.50 and 1.44 mm, respectively) and 5 t $ha^{-1}$ in the second season (2.50 mm) had the highest plant internode distance (Table 3).The physical and chemical attributes of humic acid in vermicompost and its extract by increasing nutrients storage capacity and increasing growth regulation hormones increase, nitrogen accumulation by plants. As nitrogen increases, plant growth factors such as internode distance will increase (Arancon et al. 2005; Tomati et al. 1983). On the other hand, Muscolo et al. (1999) reported that vermicompost has growth regulators such as cytokines that could be a reason to absorb more potassium. Since the element of potassium is one of the main factors in the growth of interstices. It can be concluded that the high amount of potassium in the extract extracted from vermicompost is the reason for increasing the distance between the internode by increasing the concentration of the vermicompost.

### Main stem diameter

The results indicated that organic manure treatment impact on the primary stem diameter in hot pepper was not significant in both seasons (Table 3). The application of vermicompost (10 t ha$^{-1}$) in the first season and vermicompost (15 t ha$^{-1}$) in the second season had the highest main stem diameter.

### Number of lateral branches

According to Table 3, manure treatments significantly influenced the lateral branches number of hot pepper in both years. The results showed that cow manure at all levels incremented the number of lateral branches except in 5 t ha$^{-1}$ cow vermicompost treatment. Of course, 15 t ha$^{-1}$ of cow vermicompost fertilizer (22.44 number) had played a more effective role in increasing the lateral branches number than the other treatments in the first year. The maximum lateral branch number was related to the 10 t ha$^{-1}$ cow vermicompost fertilizer with 28.00 numbers. However, the minimum was shown to the control treatment with 23.83 numbers in the second year.

Khan et al. (2019) reported that vermicompost treatments showed a significant difference in the number of branches. Singh et al. (2014) had realized that vermicompost had a positive result on vegetative growth in terms of the branch number in chili crops. The mixture of vermicompost and soil at a level of 75% led to an increase in the number of lateral branches; the researchers attribute the rise in soil minerals such as phosphorus, potassium, calcium, and magnesium to the use of this fertilizer (Beyk Khurmizi et al. 2010). An increment in the branch number per plant could be due to the regular supply of nutrients combined with vermicompost that improved vegetative growth. But lack of nutrients is resulting in poor growth (Khan et al. 2019).

### Number of nodes

The treatments with cow vermicompost resulted in more nodes than the control in 2017 and 2018. So that, the results were presented that the high node number with 46.22 and 61.50 number was obtained at 10 t ha$^{-1}$ of cow vermicompost (respectively), and the lowest amount (41.88 and 52.00 number, respectively) was in the control treatment in both seasons (Table 3).

**Table 3** The influence of cow vermicompost on the vegetative traits in hot pepper (Red Chili cultivar) in 2017-2018

| Year | Treatments | Plant height (cm) | Lateral stem length (cm) | Internode distance (mm) | Diameter of main stem (mm) | Number of lateral branches (number) | Number of nodes (number) |
|---|---|---|---|---|---|---|---|
| 2017 | VC 0 (Control) | 27.00$^{b}$ | 17.44$^{a}$ | 1.08$^{b}$ | 5.72$^{a}$ | 18.00$^{b}$ | 41.88$^{b}$ |
| | VC 1 (5 t ha$^{-1}$) | 33.83$^{a}$ | 20.61$^{a}$ | 1.50$^{a}$ | 6.96$^{a}$ | 19.22$^{b}$ | 43.00$^{ab}$ |
| | VC 2 (10 t ha$^{-1}$) | 36.55$^{a}$ | 19.44$^{a}$ | 1.44$^{a}$ | 7.02$^{a}$ | 23.77$^{a}$ | 46.22$^{a}$ |
| | VC 3 (15 t ha$^{-1}$) | 33.91$^{a}$ | 18.27$^{a}$ | 1.18$^{ab}$ | 6.92$^{a}$ | 22.44$^{a}$ | 45.00$^{ab}$ |
| 2018 | VC 0 (Control) | 23.33$^{b}$ | 18.083$^{a}$ | 1.77$^{b}$ | 5.95$^{a}$ | 23.83$^{c}$ | 52.00$^{b}$ |
| | VC 1 (5 t ha$^{-1}$) | 24.00$^{b}$ | 20.166$^{a}$ | 2.50$^{a}$ | 6.48$^{a}$ | 25.16$^{bc}$ | 56.83$^{ab}$ |
| | VC 2 (10 t ha$^{-1}$) | 26.25$^{ab}$ | 19.416$^{a}$ | 2.25$^{ab}$ | 5.75$^{a}$ | 28.00$^{a}$ | 61.50$^{a}$ |
| | VC 3 (15 t ha$^{-1}$) | 29.33$^{a}$ | 18.666$^{a}$ | 1.83$^{b}$ | 6.70$^{a}$ | 27.16$^{ab}$ | 59.16$^{a}$ |

Different letters within columns in each year indicate significant differences among treatments ($P \leq 0.05$).

The physical and chemical attributes of humic acid in vermicompost and its extract by increasing the storage capacity of nutrients and increasing growth regulatory hormones increase nitrogen accumulation by plants. As nitrogen increases, plant growth factors such as the nodes number will increase (Arancon et al. 2005; Tomati et al. 1983). Alam et al. (2007) stated that high consumption of vermicompost and decrease of chemical manure use due to the availability of macro and microelements necessary for the potato plant due to the presence of vermicompost, increase the number of nodes in the plant. As the amount of nitrogen increased, the node number in the lemon balm and basils main stem increased (Wahab and Larson 2002).

### Leaf area

The results of Table 4 showed that the effect of cow vermicompost treatments on the hot pepper leaf area was not significant in both years. Vermicompost treatment (10 t $ha^{-1}$) and (5 t $ha^{-1}$) registered maximum leaf area (11.33 and 7.20 $cm^2$, in 2017 and 2018, respectively) compared to control treatment which recorded minimum leaf area (10.77 and 6.80 $cm^2$, in 2017 and 2018, respectively).

Leaf area of sorghum (*Sorghum bicolor*) (Reddy and Ohkura 2004), pak choi (*Brassica rapa*) (Pant et al. 2009), groundnut (*Arachis hypogaea*) (Mycin et al. 2010), and strawberry (*Fragaria × ananassa*) (Singh et al. 2008) increased on applying vermicompost. Also, Paul and Metzger (2005) reported that pepper transplants grown in vermicompost resulted in a greater leaf area, which did not match our results.

### Chlorophyll leaf

The results were showed that cow vermicompost treatments on chlorophyll contents of hot pepper leaf were significant in the 2017 and 2018 growing seasons. Results demonstrated the lowest leaf chlorophyll contents by control plants, while the highest was to the 15 t $ha^{-1}$ of cow vermicompost fertilizer in both years (Table 4).

Sanwal et al. (2007) reported that the chlorophyll contents in the leaves of turmeric crops significantly improved with organic and inorganic sources of nutrients. Like the results of enhancement in chlorophyll contents due to the addition of organic fertilizers have also been obtained by Singh et al. (2014) and Narkhede et al. (2011). In this regard, Ali et al. (2007) announced in a study that vermicompost use had increased the chlorophyll contents of lettuce leaves. More chlorophyll contents in leaves might be due to macro and micronutrients were supplied by vermicompost, an important essential of chlorophyll (Jabeen et al. 2018).

### Fresh and dry leaf weight

The results showed that the effect of different levels of cow vermicompost on the fresh, dry weight of the chili pepper leaves was significant. The results showed that fresh and dry leaf weights were highest in 10 t $ha^{-1}$ (0.47 g and 0.10 g), and the lowest amount was in 5 t $ha^{-1}$ of cow vermicompost (0.32 g) and control treatment (0.07 g) in the first year (respectively). Also, the maximum fresh leaf weight (0.31 g) was observed in 15 t $ha^{-1}$ of cow vermicompost treatment, and the minimum value was in the control treatment (0.24 g) in the second year (Table 4).

The results of some studies have shown that increasing the fresh and dry weight of plants in the vermicompost bed can be due to the gradual release of elements of organic manures (Bachman and Metzger 2008). The positive effects of vermicompost use in cultivated substrates on the increased dry weight of shoots in strawberry (Arancon et al. 2004a) and potato (Yourtchi et al. 2013) plants were described that consistent with the results.

### Leaves number

All cow vermicompost applications significantly affected the leaf number in both growing seasons. The highest leaf number was observed in 10 t $ha^{-1}$ (183.64 and 90.50 number), while the least leaf number was reported at the control (145.00 and 77.50 number) in both years (Table 4).

Vermicompost with improving the physical properties of the environment, increasing the activity of microorganisms, and increasing the water holding capacity during drought stress, led to a significant increase in traits such as the leaves number in tomatoes (Özenç 2008). In another study on strawberries, the researchers attributed the increase in the leaves number in vermicompost use to the increase in the microbial population in the vermicompost (Arancon et al. 2004a). These results agree with the results of Suthar (2009) on garlic and EL-Bassiony et al. (2010) on sweet pepper based on the positive effect of vermicompost on this trait.

**Table 4** The effect of cow vermicompost on the leaf traits in hot pepper (Red Chili cultivar) in 2017-2018

| Year | Treatments | Leaf area ($cm^2$) | Chlorophyll (Speed) | Leaf fresh weight (g $plant^{-1}$) | Leaf dry weight (g $plant^{-1}$) | Leaves number (number) |
|---|---|---|---|---|---|---|
| 2017 | VC 0 (Control) | 10.77$^a$ | 64.53$^b$ | 0.35$^b$ | 0.07$^b$ | 145.00$^b$ |
| | VC 1 (5 t $ha^{-1}$) | 11.00$^a$ | 65.85$^b$ | 0.32$^b$ | 0.07$^b$ | 159.44$^{ab}$ |
| | VC 2 (10 t $ha^{-1}$) | 11.33$^a$ | 68.45$^{ab}$ | 0.47$^a$ | 0.10$^a$ | 183.64$^a$ |
| | VC 3 (15 t $ha^{-1}$) | 11.00$^a$ | 70.85$^a$ | 0.38$^{ab}$ | 0.09$^{ab}$ | 179.78$^a$ |
| 2018 | VC 0 (Control) | 6.80$^a$ | 66.13$^b$ | 0.24$^b$ | 0.04$^a$ | 77.50$^b$ |
| | VC 1 (5 t $ha^{-1}$) | 7.20$^a$ | 67.18$^b$ | 0.25$^b$ | 0.05$^a$ | 82.33$^{ab}$ |
| | VC 2 (10 t $ha^{-1}$) | 7.16$^a$ | 71.28$^{ab}$ | 0.28$^{ab}$ | 0.05$^a$ | 90.50$^a$ |
| | VC 3 (15 t $ha^{-1}$) | 7.01$^a$ | 73.61$^a$ | 0.31$^a$ | 0.06$^a$ | 86.50$^{ab}$ |

Different letters within columns in each year indicate significant differences among treatments ($P \leq 0.05$).

## Plant reproductive traits

### Fruit yield per plant

The effect of the cow vermicompost fertilizer level on pepper yield was significant in both seasons. The maximum yield in the plant was found as 527.83 (g) after the usage of 15 t $ha^{-1}$, and the minimum yield was reported as 347.56 (g) in the zero cow vermicompost application in 2017. Besides, the maximum yield was obtained (574.85 g $plant^{-1}$) in 10 t $ha^{-1}$ of cow vermicompost and its minimum (349.00 g $plant^{-1}$) in the control treatment in 2018 (Table 5).

Previous work has presented an increment in pepper yield under organic manure (Chellemi and Rosskopf 2004). These consequences are like that of Arancon et al. (2004b), who explained that pepper produced greater fruit yield with vermicompost. Singh et al. (1997) showed higher fruit yield $plant^{-1}$ in chili using vermicompost @ 10 t $ha^{-1}$. The positive result of adding vermicompost on yield performance has been reported in bell peppers (El-Bassiony et al. 2010), strawberries (Singh et al. 2008), eggplants (Moraditochaee et al. 2011), and tomatoes (Zaller 2007), which is consistent with our results. The reason could be that vermicompost, which is a rich source of macro and micronutrients, enzymes, and growth hormones that improved the growth of the plant, and fruit yield (Khan et al. 2019).

### Fruits number per plant

The effects of cow vermicompost fertilizer level on fruit numbers were significant in both years. The level of 15 t $ha^{-1}$ fertilizer created the most flower and fruit number with (95.78 and 122.33 number, respectively), while the least these variables were related to control treatment with (70.77 and 81.67 number, respectively) in 2017 and 2018 seasons (Table 5).

Vermicompost use in plant substrates increases the yield due to the supply of required nutrients. In other words, proper amounts of vermicompost by improving soil microbial activity and production of plant growth regulators by these organisms, as well as increasing the absorption of nutrients, have increased the amount of photosynthesis and plant dry matter, which ultimately leads to increased flowering and yield it ends. These results are similar to the studies of Moraditochaee et al. (2011) on the eggplant (*Solanum melongena* L.) as well as Khurshid et al. (2021) on the Chili (*Capsicum annum* L.).

## Appearance traits of fruit

### Fruit length and diameter

It was found out that cow vermicompost applications had a significant effect on the length of fruit in both years. The highest and lowest length fruit was obtained at 10 t $ha^{-1}$ with 88.40 and 82.83 mm (respectively) and control with 71.67 and 75.25 mm (respectively) in both years (Table 6).

Fruit diameter was affected by cow vermicompost in both seasons. The highest fruit diameter was in the highest cow vermicompost (15 t $ha^{-1}$) with 14.80 and 14.39 mm (respectively). However, the lowest fruit diameter was in the control treatment with 12.61 and 11.47 mm (respectively) in the 2017 and 2018 seasons. While the differences among cow vermicompost treatments were not substantial in three treatments in the second year (Table 6).

The above results are similar to (Joshi and Vig 2010) and (Narkhede et al. 2011), who reported that vermicompost increased fruit length significantly, as contrasted with control treatment in chili and tomato (respectively). Also, Khan et al. (2019) indicated that chili fruit length was substantially influenced by numerous vermicompost levels. An increment in fruit length with increasing vermicompost levels could be due to the existence of essential plant nutrients such as phosphorous, potassium, and nitrogen (Khan et al. 2019). These results confirm with Theunissen et al. (2010), who described that vermicompost contains macronutrients such as exchangeable calcium, soluble potassium, and phosphates with a sufficient quantity of vitamins, hormones, and microorganisms which, incremented the yield and growth of plants.

### Fruit-fresh and dry weight

Results obtained indicated that 10 t $ha^{-1}$ of cow vermicompost fertilizer had produced the highest fruit-fresh weight. However, the lowest fruit-fresh weight was related to the control treatment in both seasons. However, the difference among 10 and 15 t $ha^{-1}$ of cow vermicompost treatments was not statistically significant at fruit-fresh weight in 2018. However, cow vermicompost dry fruit weight was not affected in the 2017 and 2018 growing seasons (Table 6).

These results are similar to Pavan (2013) previous works and khan et al. (2019), who described that chili fruit weight incremented with the increasing quantity of vermicompost. An increment in fruit weight with an increment in vermicompost level was due to more readily available macro and micronutrients in the root zone, resulting in maximum production and better plant growth (Khan et al. 2019).

### Thousand seeds weight

It was observed that cow vermicompost manure had a remarkable influence on a thousand seeds' weight in both years. The maximum thousand seeds weight (5.01 and 5.50 g) was observed in the 5 t $ha^{-1}$ of cow vermicompost fertilizer. In addition, the minimum thousand seeds weight was recorded in the control treatment in both seasons, respectively (Table 6).

The application of 8 t $ha^{-1}$ of vermicompost compared with 4 t $ha^{-1}$ of vermicompost and control treatment increased the weight of a thousand fennel seeds (Gholami et al. 2015). Also, increase the amount of vermicompost by affecting the high absorption, storage, and preparation capacity of moisture and nutrient elements such as nitrogen, phosphorus, and potash was affected increasing the yield of fennel, such as the thousand seeds weight, and improved the seeds yield (Darzi et al. 2007). An experiment found that vermicompost fertilizer led to an increase in yield characteristics, such as the seed's weight in the beech plant (Atik 2013). The beneficial effects of vermicompost can increase soil water holding capacity and soil porosity and prevent soil acidity and release the plant's nutrients. That is increases the absorption of nutrients by the plant and increases its production capacity, and ultimately, the performance components, especially the weight of thousands of seeds (Mohammad Khani and Roozbahani 2015).

### Number of fruit seeds

Cow vermicompost fertilizer application affected the number of fruit seeds in 2017. The 5 and 10 t $ha^{-1}$ had formed the highest fruit seeds number and the lowest fruit seeds number produced in 15 t $ha^{-1}$. Nevertheless, no substantial difference was reported among the three treatments: 5, 10, and 15 t $ha^{-1}$ in 2018 (Table 6).

An experiment found that vermicompost fertilizer led to an increment in yield characteristics, such as the number of seeds in the beech plant (Atik 2013). In this regard, the researchers stated that the application of 10 t $ha^{-1}$ of vermicompost showed the highest seeds number in wheat spike (Shahbazi et al. 2015). Also, the highest average seeds number in safflower had attained in the treatment of 9 t $ha^{-1}$ of vermicompost, which increased by 8.29% compared to the control treatment. However, there was no significant difference between the levels 6 and 9 t $ha^{-1}$ of vermicompost (Hajghani et al. 2017).

**Table 5** The influence of cow vermicompost on the plant yield components in hot pepper (Red Chili cultivar) in 2017-2018

| Year | Treatments | Fruit yield per plant (g plant$^{-1}$) | Number of fruits per plant (number) |
|---|---|---|---|
| 2017 | VC 0 (Control) | 347.56$^{c}$ | 70.77$^{b}$ |
| | VC 1 (5 t ha$^{-1}$) | 404.70$^{bc}$ | 77.55$^{ab}$ |
| | VC 2 (10 t ha$^{-1}$) | 497.59$^{ab}$ | 89.77$^{ab}$ |
| | VC 3 (15 t ha$^{-1}$) | 527.83$^{a}$ | 95.78$^{a}$ |
| 2018 | VC 0 (Control) | 349.00$^{b}$ | 81.67$^{b}$ |
| | VC 1 (5 t ha$^{-1}$) | 412.86$^{b}$ | 90.83$^{b}$ |
| | VC 2 (10 t ha$^{-1}$) | 574.85$^{a}$ | 104.33$^{ab}$ |
| | VC 3 (15 t ha$^{-1}$) | 473.12$^{ab}$ | 122.33$^{a}$ |

Different letters within columns in each year indicate significant differences among treatments ($P \leq 0.05$).

**Table 6** The effect of cow vermicompost on the appearance of fruit in hot pepper (Red Chili cultivar) in 2017-2018

| Year | Treatments | Fruit length (mm) | Fruit diameter (mm) | Fruit-fresh weight (g) | Fruit dry weight (g) | Thousand seeds weight (g) | Number of fruit seeds (number) |
|---|---|---|---|---|---|---|---|
| 2017 | VC 0 (Control) | 71.67$^{b}$ | 12.61$^{b}$ | 5.93$^{b}$ | 0.80$^{a}$ | 4.13$^{b}$ | 121.00$^{ab}$ |
| | VC 1 (5 t ha$^{-1}$) | 77.25$^{b}$ | 12.99$^{b}$ | 6.74$^{ab}$ | 0.98$^{a}$ | 5.01$^{a}$ | 142.00$^{a}$ |
| | VC 2 (10 t ha$^{-1}$) | 88.40$^{a}$ | 14.00$^{ab}$ | 7.96$^{a}$ | 0.98$^{a}$ | 4.48$^{ab}$ | 136.00$^{a}$ |
| | VC 3 (15 t ha$^{-1}$) | 82.50$^{ab}$ | 14.80$^{a}$ | 7.29$^{ab}$ | 1.35$^{a}$ | 4.18$^{b}$ | 90.67$^{b}$ |
| 2018 | VC 0 (Control) | 75.25$^{b}$ | 11.47$^{b}$ | 4.92$^{b}$ | 1.20$^{a}$ | 5.00$^{b}$ | 90.66$^{a}$ |
| | VC 1 (5 t ha$^{-1}$) | 76.16$^{b}$ | 13.84$^{a}$ | 5.43$^{b}$ | 1.24$^{a}$ | 5.50$^{a}$ | 105.50$^{a}$ |
| | VC 2 (10 t ha$^{-1}$) | 82.83$^{a}$ | 14.39$^{a}$ | 7.11$^{a}$ | 1.51$^{a}$ | 5.25$^{ab}$ | 98.33$^{a}$ |
| | VC 3 (15 t ha$^{-1}$) | 80.33$^{ab}$ | 14.39$^{a}$ | 6.68$^{a}$ | 1.78$^{a}$ | 5.05$^{b}$ | 89.33$^{a}$ |

Different letters within columns in each year indicate significant differences among treatments ($P \leq 0.05$).

## Qualitative traits

### pH of fruit

Fruit pH was not significantly affected by cow vermicompost treatments used in both seasons, as presented in Table 7. Comparison of mean between vermicompost application levels showed that the highest pH of fruit with 5.44 in the 2017 year and 4.95 in the 2018 year were obtained from 10 t ha$^{-1}$ treatment.

Azarmi et al. (2009) in cucumber (*Cucumis sativus*) and Singh et al. (2008) in strawberry (*Fragaria* × *ananassa*) showed that the pH was enhanced by vermicompost application, which did not match our results.

### Titratable acidity

Results were existed in Table 7 demonstrate that cow vermicompost treatments significantly influenced the titratable acidity of fruit in both years. Among cow vermicompost treatments, the lowest titratable acidity was produced at treatment with 15 t ha$^{-1}$ of cow vermicompost (25.90 and 57.40 g L$^{-1}$). However, the highest titratable acidity was in control with 33.66 and 31.85 g L$^{-1}$ in 2017 and 2018 years (respectively). But the difference between control and 5 t ha$^{-1}$ of cow vermicompost treatments was not statistically significant at titratable acidity in the second year (Table 7).

Shehata et al. (2011) and Singh et al. (2010) described in separate experiments that vermicompost fertilizers did not significantly influence the acidity of the strawberry fruit, which did not agree with our results.

### Total soluble solids

The total soluble solids in the cow vermicompost treatments were significant in both seasons. The highest total soluble solids were in the 10 t ha$^{-1}$ level of cow vermicompost treatment. However, the lowest value occurred in control in the 2017 and 2018 growing seasons. However, no significant difference was observed between the two treatments: 10 and 15 t ha$^{-1}$ levels of cow vermicompost in 2018 (Table 7).

Shehata et al. (2011) reported that the strawberry fruit solution's total soluble solids were affected by compost consumption and increased. Llaven et al. (2008) in pepper and Patidar et al. (2017) in garlic also stated that vermicompost use incremented the solids contents of the fruit compared to the control.

### Ascorbic acid contents

Levels of cow vermicompost application significantly affected the ascorbic acid contents (vitamin C) of hot pepper fruits in both years. The maximum vitamin C was detected in the 5 t ha$^{-1}$ level of cow vermicompost treatment with 190.00 and 159.01 mg 100 g$^{-1}$. However, the minimum content was presented at control with 125.00 and 132.00 mg 100 g$^{-1}$ in the first and second years, respectively. While the differences between the 5 and 10 t ha$^{-1}$ levels of cow vermicompost treatments were not significant in 2018 (Table 7).

An increment in ascorbic acid contents in the fruit using vermicompost was found by the findings of Densilin et al. (2011) and Chauhan (2015), who stated high ascorbic acid contents in the fruit of chili were provided with organic manures. Also, higher ascorbic acid contents were reported in tomatoes using vermicompost (Meena et al. 2014). Besides, Zaller (2007) results in the tomato plant and Singh et al. (2010) in the strawberry plant demonstrated that the application of vermicompost and its various levels increased the contents of vitamin C in the fruit.

**Table 7** The effect of cow vermicompost on the qualitative traits in hot pepper (Red Chili cultivar) in 2017-2018

| Year | Treatments | pH | Titratable acidity (g L$^{-1}$) | Total soluble solids (°Brix) | Vitamin C (mg 100 g$^{-1}$) |
|---|---|---|---|---|---|
| 2017 | VC 0 (Control) | 4.83$^{a}$ | 33.66$^{a}$ | 9.16$^{c}$ | 125.00$^{b}$ |
| | VC 1 (5 t ha$^{-1}$) | 5.08$^{a}$ | 31.40$^{ab}$ | 10.06$^{bc}$ | 190.00$^{a}$ |
| | VC 2 (10 t ha$^{-1}$) | 5.44$^{a}$ | 27.86$^{b}$ | 11.76$^{a}$ | 162.00$^{ab}$ |
| | VC 3 (15 t ha$^{-1}$) | 5.19$^{a}$ | 25.90$^{b}$ | 11.33$^{ab}$ | 147.50$^{b}$ |
| 2018 | VC 0 (Control) | 4.77$^{a}$ | 31.85$^{a}$ | 9.50$^{b}$ | 132.00$^{b}$ |
| | VC 1 (5 t ha$^{-1}$) | 4.83$^{a}$ | 30.80$^{a}$ | 9.93$^{b}$ | 159.01$^{a}$ |
| | VC 2 (10 t ha$^{-1}$) | 4.95$^{a}$ | 30.10$^{ab}$ | 10.80$^{a}$ | 158.40$^{a}$ |
| | VC 3 (15 t ha$^{-1}$) | 4.87$^{a}$ | 28.7$^{b}$ | 10.45$^{a}$ | 145.20$^{ab}$ |

Different letters within columns in each year indicate significant differences among treatments ($P \leq 0.05$).

## Conclusion

This study shows that cow vermicompost is an acceptable alternative for organic hot pepper growth. The current research provides the best description of hot pepper with various growth, yield, and quality parameters. Treatment with cow vermicompost especially, at 10 and 15 t ha$^{-1}$ showed the general best fruit yield, growth, and quality in hot pepper. It is essential to develop organic food studies that could be utilized as a source of nutrients for organic agriculture, combined or individually.

## Compliance with ethical standards

**Conflict of interest** The authors declare that there are no conflicts of interest associated with this study.



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