Response of caraway (*Carum carvi L.*) plants to organic manures in replacement of chemical fertilization

Almarie Ahmed A.[1]*, Al-Salmani Sinan A.A.[1] and Almohammedi Ali F.[2]
1. Field Crops Department, College of Agriculture, University of Anbar, Anbar, IRAQ
2. Center of Desert Studies, University of Anbar, Anbar, IRAQ
*ahmedalmaree@yahoo.com

Abstract
An experiment was conducted during the summer season of 2011 at the field of Research Institute, University of Anbar, Iraq in order to evaluate the response of caraway Carum carvi L. plants under two types of organic fertilization: Bat and ostrich manures used for various levels. The experiment was applied by a randomized complete block design (RCBD) arrangement with four replications. Results proved the superiority of organic manure via enhancing growth performance and yield components of caraway plants in comparing with no fertilizer. Bat manure showed the best results in most of the studied traits as compared with ostrich manure.

Furthermore, among all organic manure levels, bat manure at rate 135 kg ha^{-1} achieved the best results in most of the tested traits and the final seed yield was increased by 30.5% in this level as compared with no fertilizer. Accordingly, this study recommends the possibility of using organic manures as an attractive alternative to chemical fertilizers for improving growth performance and yield components in caraway plants. Using organic manure could help in decreasing soil contamination and synthetic residuals presented by chemical fertilizer.

Keywords: *Carum carvi* L., Medicinal plant, Organic manure.

Introduction

Utilization of the chemical fertilizer is a double-edged sword due to their effects on soil structure and increasing environmental pollution. Natural soil fertilization by organic manure can serve as a desirable alternative way to chemical fertilizers for improving soil structure and microbial biomass as eco - friendly natural soil feeding[17]. Chemical fertilizers application leads to loss of soil fertility due to imbalanced use of these fertilizers that have adversely impacted agricultural productivity and caused soil degradation.

Furthermore, the chemical fertilizer reduced the antioxidant levels in served plants in comparing with organic fertilizer which has been proven to enhance antioxidant content[11]. Conversely, using organic fertilizer improves the physical, chemical and biological conditions of the soil and ensures sustainable soil health[16]. Animal wastes are widely used as organic manure due to providing essential nutrients such as nitrogen, phosphorus, and potassium as ecofriendly fertilizers. Animal wastes can be used as organic manures such as Poultry, Mammals etc. Poultry residues are the most widespread bird's wastes used widely as organic manure. Other animal wastes definitely bat guano and ostrich residues also eligible to be used as organic manures.

There are many investigations indicating that bat guano application enhances plant growth of different plant species by exhibiting greater growth rates compared with chemical fertilizer treatments[18,19]. Bat guano also had achieved the desired results when used as natural fertilizer in medicinal plants. In this regard, Almohammedi et al[4] found that the application of bat guano at 175 kg ha^{-1} was superior in enhancing plant height, fruit branch per plant, dry weight, capsules per plant, seeds per capsule, 1000 seed weight and seed yield of Black Cumin (*Nigella sativa* L.).

Ostrich residues were also found to be used as organic manure with satisfactory results when used in different plant species[9]. Ostrich manure application showed a significant increase in plant height, branch number per plant, weight of dry stem and calyx yield of Roselle plant *Hibiscus sabdariffa* L. compared with other treatments of organic manures including hen manure[10].

On the other hand, organic manure is found to improve the productivity of the medicinal plants quantitatively and qualitatively in comparing with the chemical fertilizer. The utilization of organic manures and microbial symbiosis as natural nutrients helps to improve yield and quality traits of medicinal plants[6]. Organic fertilizer application enhanced the production of total phenolics, flavonoids, ascorbic acid, saponin and gluthathione content in *Labisia pumila* L. (traditional medicinal plant in Malaysia) as compared with the use of inorganic fertilizer[12]. In the same context, the study conducted by Priya et al[15] indicated that the application of a poultry manure as an organic fertilization recorded the maximum values of the growth of *Eclipta alba* L., Ethnomedicinal Herb Plant.

Caraway plant *Carum carvi* L. is an aromatic biennial plant belonging to the Apiaceae plant family. As any medicinal plant, caraway plant is used widely as a traditional medicine or in foods as a cooking spice[2].

The aroma in caraway seeds comes from essential oil which is about 3 to 7% of the seed weight. Carvone and limonene terpene compounds are the dominant compounds in caraway essential oil. Carvone composes about 50 to 85% and limonene abounds 20 to 30% from the caraway's essential oil

contents. As well as, caraway essential oil consists of other components in negligible amounts such as carveol, dihydro - carveol, α- pinene, β-pinene, sabinene and perillyl alcohol[1].

Material and Methods

The field experiment was conducted during the summer season 2011 using a local variety of caraway cultiverd commonly in north and west of Iraq.

The experiment was applied at the field of Research Institute which belonged to alternative site of University of Anbar at Abu Ghraib, Baghdad - Iraq, region: latitude 33°17′31″N; longitude 44°3′56″E to evaluate the growth performance and yield components of the caraway plants under animal residues as a natural feeding in replacement of chemical fertilizer by using two types of organic manure; bat guano with three levels 45, 90 and 135 kg ha^{-1} and ostrich residues with three levels 75, 150 and 225 kg ha^{-1}. Bat guano was collected from the fair building in college of agriculture – University of Baghdad, Iraq, while ostrich residues were collected from ostrich farm belonging to animal resources department at the same college.

The experiment field was plowed, settled and then divided into plots. Before adding organic manure, soil samples were taken from depth 0–30 cm and analyzed for its characteristics with the other two organic manures (Bat and ostrich) in Soil tested laboratory at the Soil and Water Resources Lab - College of Agriculture / University of Baghdad. The results of agrochemical analysis of soil are shown in table1 and the chemical contents of the two organic manures are shown in table 2.

Organic manure treatments were added and mixed well with the soil surface in each plot one week before planting. Then, caraway seeds were planted by rows in plots. An experimental plot size was 4 m^2 consisting of rows 2m long with 0.7m cm between rows and 0.25 m between holes. Three seeds were placed in each hole and thinned into one plant per hole 20 days after sowing.

Watering was applied according to the need of the plant and the soil condition. Weed plants were removed from plots by hand weeding continuously during the growing season. When caraway plants reach to maturity stage, the traits of plant height, number of branch per plant, umbel per plant, umbellate per umbel, number of seed per umbellate, seed per plant and weight of 1000 seed were measured by taking the mean of ten plants from each treatment. Total seed yield was determined based on harvest area 1m^2 from each plot and changed to ton ha^{-1}.

Data collected were subjected to one-way analyses of variance (ANOVA) using the SASS software system version[9]. The experiment was conducted in a randomized complete block design (RCBD) with four replications. The differences between mean values were determined using Duncan's multiple range tests ($P \leq 0.05$).

Table 1
Soil physical and chemical properties of the study field

Soil texture	Loam sandy
EC	0.9
Sand %	72.4
Silt %	12.8
Clay %	14.8
pH	7.8
N ppm	90
P ppm	50
K ppm	200
Mg mg/l	2.71
Na mg/l	3.4
So_4 mg/l	5.33
HCO_3 mg/l	1.9
O.M.%	0.7

Table 2
Characteristics of organic manure (bat and ostrich residues) used during the study

Organic manure	Bat	Ostrich
pH	7.12	8.45
N mg/g	10.3	10.6
P mg/g	5.7	3. 2
K mg/l	23.3	16.3
Mg mg/l	1.5	1.2
Fe mg/l	28.3	22.8
Zn mg/l	19.7	14.4

Results and Discussion

Data of growth performance and yield components affected by different levels of the two organic manures (Bat guano and ostrich residues) are presented in fig.1.

Plant height (cm) was increased significantly by using organic manures as shown in Fig.1a. All the tested levels of the two organic manure types showed the significant difference as compared with the control. The highest caraway plants were recorded in the treatment of 135 kg ha^{-1} of bat manure; 109.5cm which did not differ significantly with the treatment of 75 kg ha^{-1} ostrich and 90 kg ha^{-1} of bat manure which achieved 104 and 103.5 cm respectively. On the contrary, the lowest plant height was recorded in the control plants (no fertilizer) which was 75.6cm high. The results of the present study come in the lane with the study[20] which indicated that the organic manure has a pronounced effect on plant height of caraway plants. In the same context, plant high of Moldavian dragonhead (an aromatic medicinal plant) was also increased by using organic manure as a full replacement of chemical fertilizer[7].

A number of branches per plant were also affected by using organic manure as natural nutrients as presented in fig.1b. Caraway plants served by 135 kg ha^{-1} of bat manure had the highest number of branches which were 25 branches per plant and differed significantly with the other levels of organic manures of the two tested types as well as control. The other superior level of organic manure was observed in the rate of 90 kg ha^{-1} of bat manure; 18 branches per plant followed by a rate of 225kg ha^{-1} ostrich manure 13 branches per plant.

The other studied rates did not show any significant differences in comparing with the control which showed the lowest number in terms of branches per plant. These findings are in agreement with the results obtained from Malhotra[14] when the branches of caraway plants increased significantly as a response of serving by organic manure and the increase fluctuating depending on fertilizer levels.

Regarding the number of umbels in caraway plants, all the tested levels show a significant effect in terms of increasing plant umbels except the rate at 75 kg ha^{-1} of ostrich manure when the lowest number of umbels per plant was recorded in this rate which was 26.5 umbels (Fig.1c). The highest level of organic manure 225kg ha^{-1} ostrich and 90 kg ha^{-1} of the bat manure was the best treatment in terms of major umbels number recorded in comparing with other treatments tested. A number of umbels per plant were 44.3 and 43 in these treatments respectively. Improving umbels in apiales plant family (Caraway's family) by organic manures has also been reported earlier by studies[5].

The two types of organic manure with different levels affect positively in the number of Umbellet per umbel as shown in fig.1d. The number of umbellet per umbel was increased significantly in all studied treatments. However, there is no significant difference observed in the studied treatments from each other in terms of significantly except the trait of using 150kg ha^{-1} ostrich manure. The highest number of umbellet per umbel was recorded when caraway plants were served by 150kg ha^{-1} ostrich manure; 19.6 followed by bat manure treatments 135, 90 and 45 kg ha^{-1}, 19, 18.6 and 18 umbellets respectively.

Seed per umbellet has behaved differently from other treatments in terms of response to organic manure. Only the treatments of bat manure showed significant differences from the control Fig.1e while the ostrich manure treatments came in the same significant level with the control. The treatment of the bat manure at rate 90 kg ha^{-1} achieved the highest number of seed per umbellet which were 18 seeds followed by the treatment of bat manure at rate 135 kg ha^{-1} and 45 kg ha^{-1} when recorded 17 and 15.3 seed per umbellet respectively. However, although the treatments of ostrich manure did not show any significant difference in comparing to the control, ostrich manure at the rate 150 kg ha^{-1} recorded higher value in terms of seed per umbellet while another two treatments of ostrich manure recorded the same value observed in the control: 14 seed per umbellet.

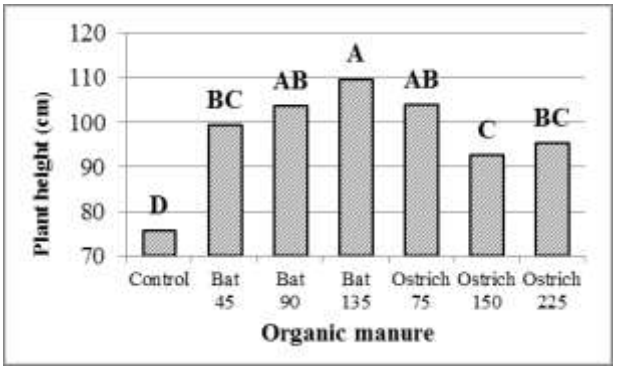
The increasing of seed per plant continued significantly by increasing levels of the two tested organic manures tested as illustrated from the data presented in fig.1f. The significant increase of seed per plant was observed clearly in all studied treatments as compared to the control except the treatment of using ostrich manure at the rate 75 kg ha^{-1} which also achieved the higher value than the number of seed per plant recorded in control. The highest number of caraway seed per plant was observed in the treatment of 135 kg ha^{-1} of bat manure when showed the superior significant to the other tested treatments when achieved seed per plant reach to 4944 seed followed by 90 kg ha^{-1} of bat manure which achieved 4553 seed. Regarding the ostrich manure, the rate 225 kg ha^{-1} of this manure was the most effective by increasing the number of seed per plant which were 4209 seed followed by 150 kg ha^{-1} of the same manure.

The significant supremacy of the two studied organic manures in all the tested levels in comparison to the control was done in the trait of the weight of 1000 seed as shown in fig.1g. Bat organic manure with the highest level, 135 kg ha^{-1} was the best among all treatments when the weight of 1000 seed was 5.7 g followed by 225 kg ha^{-1} of ostrich and 90 kg ha^{-1} of bat manure 5.4 and 5.36 respectively. These three treatments exceeded the limit of 5 gram. Although the other three treatments, 45 kg ha^{-1} of the bat and 150 and 75kg ha^{-1} of ostrich manure differed significantly in comparing to the control, it did not succeed to increase the weight of 1000 seed over 5g which were 4.9, 4.9 and 4.7g respectively.

Caraway plants planted in control recorded only 4.1g in terms of weight of 1000 seed.

Final seed yield of caraway plants was also affected by using organic manure as presented in fig.1h. It can be noticed that the bat manure was more effective than ostrich manure and showed the idol efficiency when the final yield increased by increasing the levels of this manure. As regards to ostrich manure, the increase of final seed yield was in fluctuate performance when the final seed in ostrich manure of 150 kg ha^{-1} recorded higher value than the final seed yield of caraway plants served by 225 kg ha^{-1}. However, the highest seed yield was observed when caraway plants were served with 135 kg ha^{-1} of bat manure; 1.05 ton ha^{-1} followed by 90 and 45 kg ha^{-1} of bat manure; 1.04 and 0.96 ton ha^{-1} respectively.

The ostrich manure behaves differently than the bat manure when the medium level,150 kg ha^{-1} achieved the best value of seed yield as compared with the other two levels; 225 and 75 kg ha^{-1}. Such results supported by many researchers found that the seed yield of caraway plants showed significant increases as a result of serving by organic manure[3,8,14].



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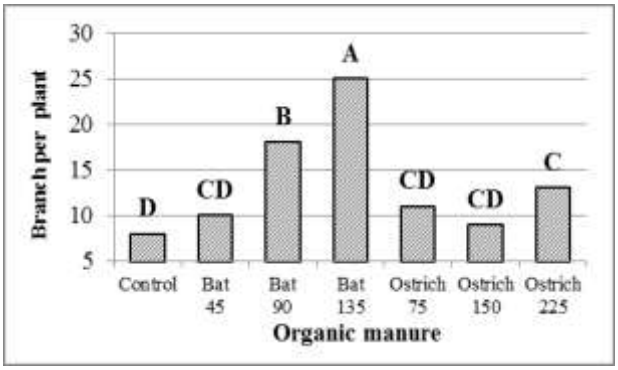

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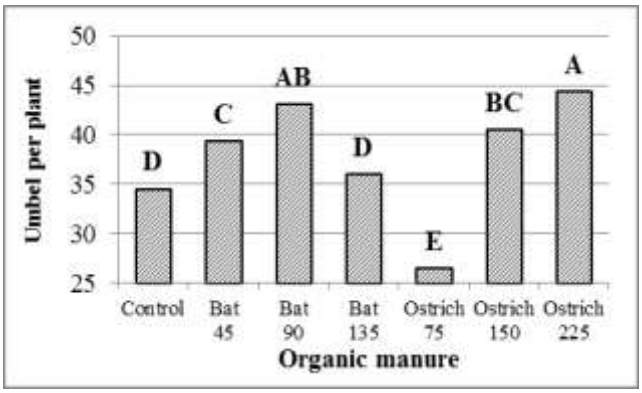

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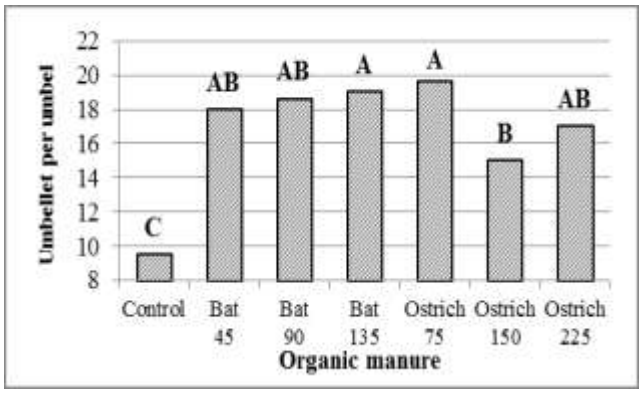

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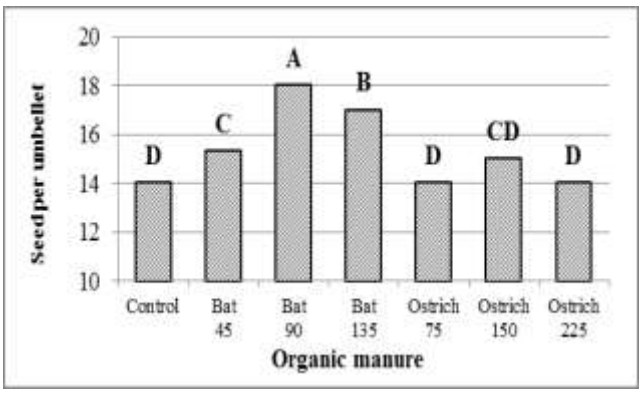

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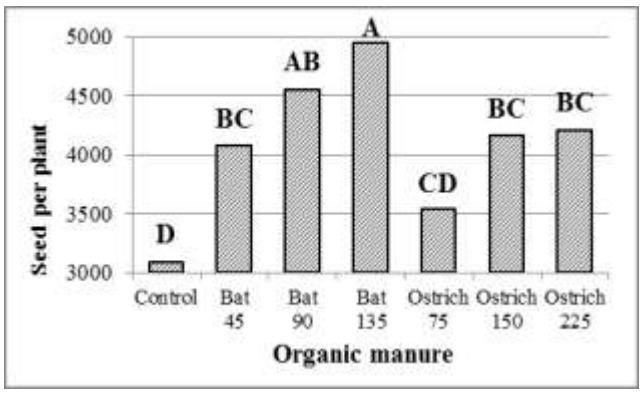

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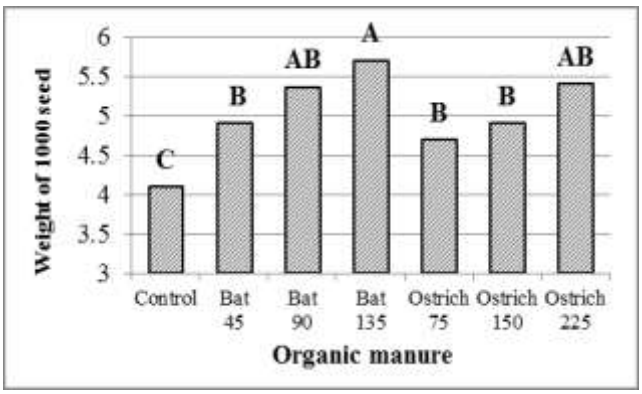

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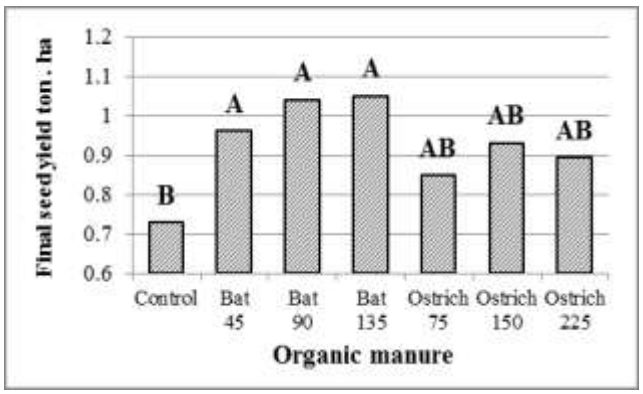

(H)

Fig. 1: Effect of various levels of organic manure (Bat and Ostrich residues) on growth performance and yield components in caraway plant *Carum carvi* L.

NOTE: (A) PLANT HEIGHT (CM), (B) BRANCH PER PLANT, (C) UMBEL PER PLANT (D) UMBELLET PER UMBEL (E) SEED PER UMBELLET (F) SEED PER PLANT (G) WEIGHT OF 1000 SEED AND (H) FINAL SEED YIELD TON HA^{-1}

The superiority of seed yield in caraway plants served by 135 kg $ha^{-1}$of bat manure is due to the superiority of this level in traits which most relevant to the final seed; seed per plant and weight of 1000 seed (Fig.1f and g). This result agreed with the result of Kilian et al[13] who indicated that these traits showed high relevant with the final seed yield in many umbel inflorescences plants such as caraway.

Increasing percent of the final seed yield depending on the final yield of controls is presented in fig. 2. The best increasing of the final yield was achieved when caraway plants were served by bat manure when all the three levels completed the highest seed yield and when the increase percent were 30.5, 29.8 and 24% by 45, 90 and 135 kg ha^{-1} of bat manure respectively according to the final seed yield in control. Although the ostrich manure caused satisfying results of increasing seed yield, the increasing achieved by ostrich manure did not reach to the results achieved by bat manure.

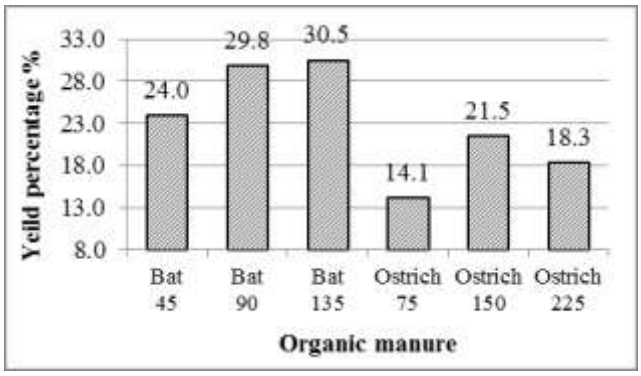

Fig. 2: Increasing percentage of the final seed yield of caraway *Carum carvi L.* plant effecting by different levels of the two studied organic manure as compared to the control

Conclusion

Organic manure enhanced the growth performance and seed yield components in caraway plants which encourage the possibility to produce medicinal plants under organic manures. Moreover, organic manure can also help to decline in bio-environmental sustainability due to the indiscriminative usage of chemical fertilizers in the conventional cropping system.

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