The Future of Horticulture

Article

Effect of Vermicompost and Foliar Spray with Potassium Nitrate on Vegetative Growth Characteristics and Yield of Lettuce Plants (*Lactuca sativa* L.) Var. Nader

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https://doi.org/10.37229/fsa.fjh.2026.08.10

Future Science Association

Available online free at www.futurejournals.org

Print ISSN: 2692-5826

Online ISSN: 2692-5834

Received: 20 May 2026
Accepted: 20 July 2026
Published: 10 August 2026

Publisher's Note: FA stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Abstract: During the 2024/2025 agricultural season, the Vegetable Research Station of the Department of Horticulture and Landscape Engineering / College of Agriculture and Forestry - University of Mosul, Mosul City Center conducted the research. The hybrid lettuce variety (Nader F1) was used, and the experiment was carried out using three levels of vermicompost (0, 50, 100 tons ha^{-1}) and foliar spraying of potassium nitrate at four concentrations (0, 1000, 2000, 3000 mg L^{-1} KNO3) at three times, starting after the formation of 3-4 true leaves, and the rest of the sprays with a time interval of 15 days between sprays. The research used a factorial experiment methodology and a three-replication Randomised Complete Block Design (RCBD). All attributes increased significantly with vermicompost soil treatment at both levels, with a slight difference between the two levels. The (50 t ha^{-1}) level had a noticeable influence on all traits. Foliar spraying with potassium nitrate resulted in substantial increases in most features, particularly at 3000 mg L^{-1} concentration. However, only total chlorophyll content and plant dry weight did not achieve significance. The treatment of applying (50 t ha^{-1}) of vermicompost and spraying (3000 mg L^{-1}) of potassium nitrate is regarded the most effective for most features tested.

Key words: Lettuce, vermicompost, potassium nitrate, vegetative growth, yield.

1. Introduction

Lettuce (*Lactuca sativa* L.) is one of the most essential culinary plants and a major component of salads. It is also one of the most popular leafy vegetables in the Asteraceae family. It is one of the most essential vegetables in winter, which is grown abundantly in Iraq as well as in other parts of the world owing to its high nutritional content and the amounts consumed in the world. It is native to the Mediterranean area and Europe **(Hassan, 2003 and Baslam, 2013)**. Lettuce contains many nutrients, particularly vitamins, proteins, fats, fiber, and minerals, providing a relatively high amount of calories for the human body **(Van Duyn and Pivonka, 2000)**. Lettuce is 94 to 95 percent water and minimal in calories. Besides the high level of vitamin C, it is also a rich source of vitamins, minerals and bioactive substances like as polyphenols, carotenoids and chlorophyll and their related health benefits **(Medina-Lozano *et al.*, 2021 and Yang *et al.*, 2022)**. For 2023, the Central Statistical Organization for Agricultural Statistics reported 10,882 dunams of lettuce cultivation in Iraq, yielding 1,987.6 kg/dunam and 21,629 tonnes **(Central Statistical Organization and Information Technology, 2023)**.

The use of organic and biological fertilisers in agriculture has increased in recent years, among them vermicompost that is a natural organic fertiliser resulting from the various biological activities of earthworms. It is rich in humus, macro and micronutrients and beneficial soil microbes such as nitrogen fixing bacteria and phosphate solubilising bacteri **(Tran *et al*., 2024)**. The term Vermicompost is a Latin word composed of two parts: Vermi, meaning worm, and Compost, meaning fertilizer. Thus, the term means "worm fertilizer," which is produced when earthworms consume organic waste such as plant and crop residues, animal and household waste. They then secrete some enzymes into their digestive system, decompose it, and excrete it as a fast-decomposing fertilizer rich in nutrients that plants need to grow. The proportions of organic compounds in worm fertilizer vary depending on the type of organic waste that the worms feed on. The Earthworm produces Vermicast, a rich organic fertiliser containing humic substances and major and minor nutrients necessary for the vital processes of plants. It also contains beneficial micro-organisms like bacteria that fix nitrogen and solubilise phosphorus and vitamins, growth hormones and some enzymes like protease, peroxidase and amylase **(Mizuta *et al*., 2004 and Azizi Yeganeh *et al*., 2024)**. The decrease in productivity is due to the factors that cause a decline in soil fertility. The most important among these factors is the continuous use of chemical fertilisers, which cause many health risks. Therefore, the focus has recently been largely on organic production, and vermicompost is one of the important organic fertilizers that has become a goal for sustainable production in modern agriculture **(Frasetya *et al*., 2019; Al-Dabbagh *et al*., 2020 and Aied *et al*., 2025)**.

Potassium plays an important role in many vital and physiological processes within the plant, especially when sprayed as a foliar spray, as it accelerates its absorption through the stomata and epidermis, leading to a direct physiological response that is then reflected in increased vegetative growth. It causes an increase in cell turgor pressure, resulting in cell elongation, expansion, and division, and thus causes an increase in plant length, leaf area, and number of leaves. It also stimulates the activity of endogenous growth hormones like as auxins and cytokines; this speeds up the rate of cell division in the developing tips **(Marschner, 2012)**. Potassium also plays a major role in many vital and physiological processes of the plant. Among these activities is the stimulation of many of the enzymes involved for growth and protein synthesis, and its function in raising the rate of photosynthesis and the transfer of carbohydrates and sugars generated in the leaves to other regions of the plant. It increases leaf chlorophyll and dry matter, which increases leaf size and head length and diameter. Thus, plant yield and overall yield per unit area rise **(Sinha and Khare, 2018 and Pandey and Mahiwal, 2020)**.

The study examines the effects of mixing soil with organic and bio-fertilizer vermicompost at various levels and foliar spraying with various potassium nitrate fertiliser concentrations on lettuce plants to eliminate the use of chemical fertilisers and reduce their impact on consumers, soil, and the environment, as well as improve soil properties.

2. Materials and Methods

The research was done in the 2024/2025 growing season in the Department of Horticulture and Landscape Engineering, College of Agriculture and Forestry, University of Mosul, Iraq, vegetable field. The land was prepared by plowing it twice perpendicularly with a disc harrow to level and prepare it. Then, a furrow was used to create the planting furrows. Each furrow was 80 cm wide and 210 cm long for each experimental unit. The spacing between plants was 35 cm, with a 50 cm gap between each experimental unit. Planting took place on both sides of the furrow, resulting in 12 experimental units per replicate. The study included two factors: first, the application of vermicompost at three levels (0, 50, and 100 tons per hectare). This worm compost was mixed into the soil before transplanting the seedlings to the field. Second, the foliage was sprayed with potassium nitrate (46% K2O) at four concentrations. (0, 1000, 2000, 3000 mg L^{-1} KNO_3) in three stages, the first after the formation of 7-8 true leaves, with a 15-day interval between each spray, calculated from the date of the first spray for subsequent applications. The study was conducted using a factorial experiment with a Randomized Complete Block Design (RCBD) and three replicates. Analysis of some physical and chemical properties of the field soil was performed by taking four random samples at a depth of (0-30 cm) from several different locations in the field, mixing them together, and analyzing them in the general laboratory of the Faculty of Agriculture and Forestry. The physical and chemical properties mentioned in Table (1) were estimated according to the methods described by **Black (1965) and Page *et al*. (1982)**. Lettuce seeds of the variety (Nader F1) were sown in germination trays on October 25, 2024, and placed under a wooden shade until the seedlings reached the stage of forming 3-4 true leaves. They were then transferred to the open field after 35 days. All agricultural operations were carried out, including irrigation, patching, thinning, and disease and insect control. As for fertilization, only half the recommended amount of nitrogen fertilizer **(Matloub *et al*., 1989)** was added, which is (200 kg ha^{-1}). No other type of chemical fertilizer was added, with the aim of achieving the study's objective of reducing reliance on chemical fertilizers. After that, the experimental units were harvested after the plants reached a suitable size for marketing, and data were collected for the following traits: head length, head diameter, number of leaves per plant, leaf chlorophyll content, average head weight, total yield per hectare, and plant dry weight (g). The results were statistically analyzed according to the design used, using the **SAS software. (2000),** and the means were compared using Duncan’s multiple range test at a probability level of 5% **(Al-Rawi and Khalaf Allah, 2000)**.

Table (1). Some physical and chemical properties of field soil

<table>
<tr><th colspan="2">Measurement</th><th colspan="2">Result</th></tr>
<tr><td colspan="2">N %</td><td colspan="2">0.0029</td></tr>
<tr><td colspan="2">P ppm</td><td colspan="2">9.48</td></tr>
<tr><td colspan="2">K ppm</td><td colspan="2">316</td></tr>
<tr><td colspan="2">pH</td><td colspan="2">8.1</td></tr>
<tr><td colspan="2">mS/cm Ec</td><td colspan="2">0.90</td></tr>
<tr><td colspan="2">CaCO3%</td><td colspan="2">27.5</td></tr>
<tr><td colspan="2">Organic Matter %</td><td colspan="2">2.38</td></tr>
<tr><td colspan="4">% for soil separators</td></tr>
<tr><td rowspan="3">Soil model</td><td>Sand</td><td>67.05</td><td rowspan="3">Sandy loam</td></tr>
<tr><td>Clay</td><td>18.95</td></tr>
<tr><td>Silt</td><td>14</td></tr>
</table>

The soil was analyzed at the Central Laboratory/College of Agriculture and Forestry – University of Mosul.

3. Results and Discussion

The results in Table (2) indicate significant differences when vermicompost is added to the soil at both levels, affecting head length, diameter, number of leaves, and total leaf chlorophyll content compared to the control treatment. This may be attributed to the fact that vermicompost often improves soil properties by retaining moisture and providing rich organic matter essential for vegetative growth, which is reflected in these characteristics **(Abdel-Razzak *et al*., 2019)**. Foliar spraying with potassium nitrate at the three concentrations also had the same significant effect on head length and diameter compared to the control treatment. Furthermore, the high potassium concentration (3000 mg L^{-1}) had a clear and significant effect on the number of leaves, which differed from the other treatments. The lowest dose (2000 mg L^{-1}) significantly impacted this feature compared to the control treatment. Foliar spraying with potassium nitrate increases its concentration in the leaves, which increases photosynthesis and transports carbohydrates and sugars from the leaves to other regions of the plant, where they have an effect. Regarding the chlorophyll content of the leaves, the number of leaves, and the length and diameter of the head **(Hong *et al*., 2022)**. From the interaction of vermicompost levels and foliar spraying with potassium on the head length trait, it was observed that the best treatment was at the level of (50 kg ha^{-1}) with spraying at a concentration of (1000 mg L^{-1}), which differed significantly with some treatments and did not differ with the other treatments. The best treatment for head diameter was adding (100 kg ha^{-1}) and spraying at (1000 mg L^{-1}), however it was only substantially better than the control and other treatments. Figure No. (1) shows that adding 50 kg ha^{-1} of vermicompost and spraying at 3000 mg litre^{-1} of potassium resulted in the highest number of leaves (72.3), outperforming the control treatment and other treatments, making it an important trait for lettuce crops. Total chlorophyll content in leaves did not vary significantly when vermicompost was added to the ground and potassium nitrate was sprayed on the foliar surface.

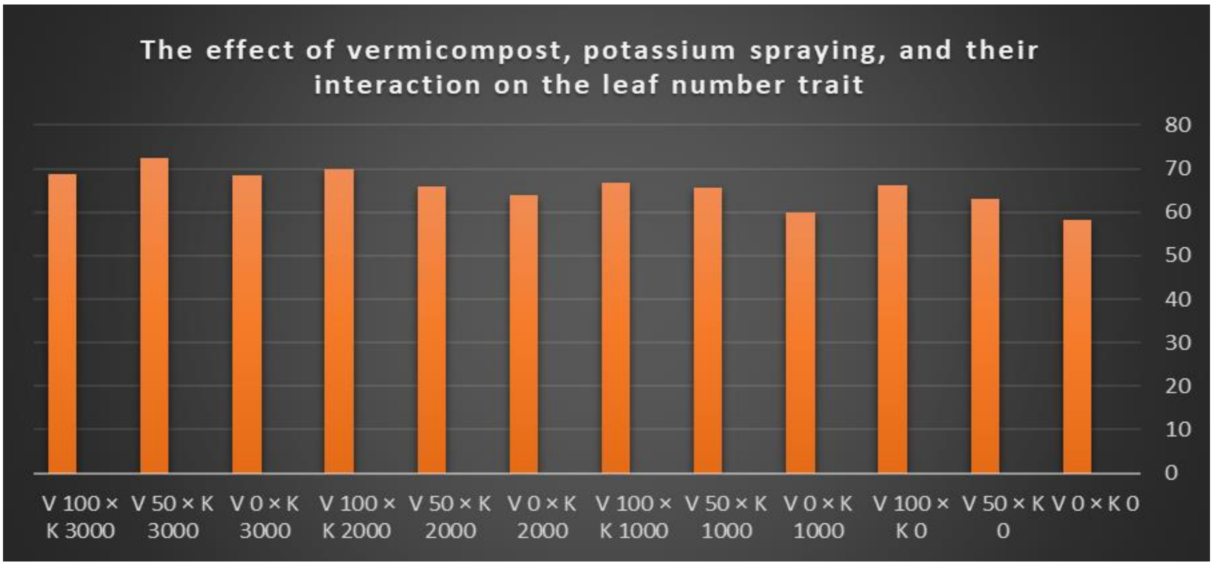

Figure No. (1)

Table (2). Effect of soil application of vermicompost, foliar spraying of potassium, and their interaction on head length, head diameter, number of leaves, and total leaf chlorophyll content

Potassium KNO_3 (ml L^{-1})	Vermi compost (ton hectar^{-1})	Length of Head (cm)	Head width (mm)	No. of Leaves	Chlorophyl (SPAD)
0	**0**	31.00 cd	44.33 c	58.3 f	19.33 a
	50	32.00 bcd	45.67 c	63.0 de	20.00 a
	100	30.33 d	45.33 c	66.3 bcd	20.67 a
1000	**0**	32.67 a-d	45.33 c	60.0 ef	18.67 a
	50	35.00 a	50.33 ab	65.7 bcd	21.00 a
	100	33.33 abc	52.67 a	66.7 bcd	19.67 a
2000	**0**	31.67 bcd	47.00 bc	64.0 cde	18.67 a
	50	33.33 abc	49.33 ab	66.0 bcd	21.33 a
	100	34.00 ab	51.33 a	70.0 ab	21.00 a
3000	**0**	31.67 bcd	49.67 ab	68.3 abc	19.33 a
	50	33.33 abc	49.33 ab	72.3 a	19.67 a
	100	34.33 ab	50.00 ab	68.7 abc	21.33 a
Mean of Vermi compost	**0**	31.75 b	46.58 b	62.7 b	19.00 b
	50	33.42 a	48.67 a	66.8 a	20.50 a
	100	33.00 a	49.83 a	67.9 a	20.67 a
Mean of Potassium	**0**	31.11 b	45.11 b	62.5 c	20.00 a
	1000	33.67 a	49.44 a	64.1 c	19.78 a
	2000	33.00 a	49.22 a	66.7 b	20.33 a
	3000	33.11 a	49.67 a	69.8 a	20.11 a

*The values of the letter-similar means for each factor or the two-factor overlap do not differ significantly from each other according to Duncan's multiple coefficient test under a probability level of 5%.

Table (3) shows substantial differences in average head weight, total yield per unit area, and dry weight per 100 g of wet weight between vermicompost treatments at both levels and the control treatment. These traits were similar at both levels. The potassium spraying effect was that foliar spraying at (3000 mg L^{-1}) significantly outperformed the control treatment and (1000 mg L^{-1}) only, but did not differ in average head weight or total yield per unit area. Nevertheless, we see that the dry weight characteristic does not significantly change across the potassium spraying treatments. The best treatment was adding the level (100 t ha^{-1}) of vermicompost with a high concentration of potassium nitrate (3000 mg L^{-1}), which reached (1038.3 g, 61.078 t ha^{-1}) respectively, and it significantly outperformed the control treatment, which recorded (784.33 g, 46.137 t ha^{-1}), according to the interaction between the levels of vermicompost and foliar spraying with potassium in terms of average head weight and total yield per unit area. It also differed significantly with some treatments and did not differ with most other treatments in both traits. As for the dry weight trait, the treatment of adding vermicompost at the level (50 t ha^{-1}) with spraying with a high concentration of potassium nitrate (3000 mg L^{-1}) recorded the highest value for dry weight and was significantly superior to the control treatment as well as to the treatment of not adding vermicompost and spraying with a concentration of (1000, 3000 mg L^{-1} of potassium, and it also differed significantly with some treatments and did not differ with most other treatments for this trait. In Table 3, the better treatment (100 kg ha^{-1}) of vermicompost with a high potassium nitrate content (3000 mg L^{-1}) yielded 32.38% more than the control treatment. This is a good percentage and a result with a high return through the use of cheap and readily available biological materials and fertilizers, which is considered a field for sustainable agriculture and reducing dependence on chemical fertilizers. The greater role of foliar spraying with potassium nitrate was greater than the role of vermicompost.

Table (3). Effect of soil application of vermicompost, foliar spraying of potassium, and their interaction on head weight, total yield, and dry weight

Potassium KNO_3 (ml L^{-1})	Vermi compost (ton $hect^{-1}$)	Head Weight (g)	Total Yield (ton hec^{-1})	Dry Weight (g)
0	0	784.33 d	46.137 d	2.167 b
	50	805.00 d	47.368 d	2.277 a
	100	825.00 cd	48.529 cd	2.227 ab
1000	0	907.67 bc	53.392 bc	2.167 b
	50	1015.7 a	59.745 ab	2.300 a
	100	943.30 ab	55.490 ab	2.253 a
2000	0	957.00 ab	56.293 ab	2.230 ab
	50	960.00 ab	56.470 ab	2.213 ab
	100	1013.3 ab	59.607 ab	2.233 ab
3000	0	1018.3 a	59.901 a	2.190 b
	50	1030.0 a	60.588 a	2.367 a
	100	1038.3 a	61.078 a	2.330 a
Mean of Vermi compost	0	916.83 b	53.931 b	2.188 b
	50	952.67 a	56.043 a	2.289 a
	100	955.00 a	56.176 a	2.261 ab
Mean of Potassium	0	804.78 c	47.345 c	2.223 a
	1000	955.56 b	56.209 b	2.240 a
	2000	976.78 ab	57.457 ab	2.226 a
	3000	1028.9 a	60.522 a	2.296 a

*The values of the letter-similar means for each factor or the two-factor overlap do not differ significantly from each other according to Duncan's multiple coefficient test under a probability level of 5%.

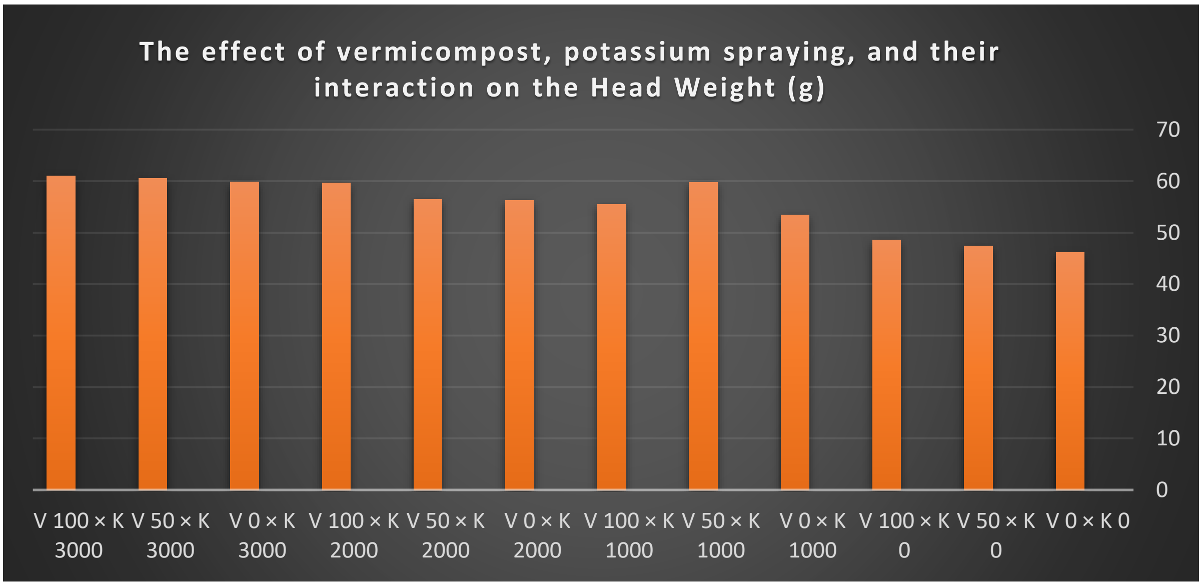

Figure No. (2)

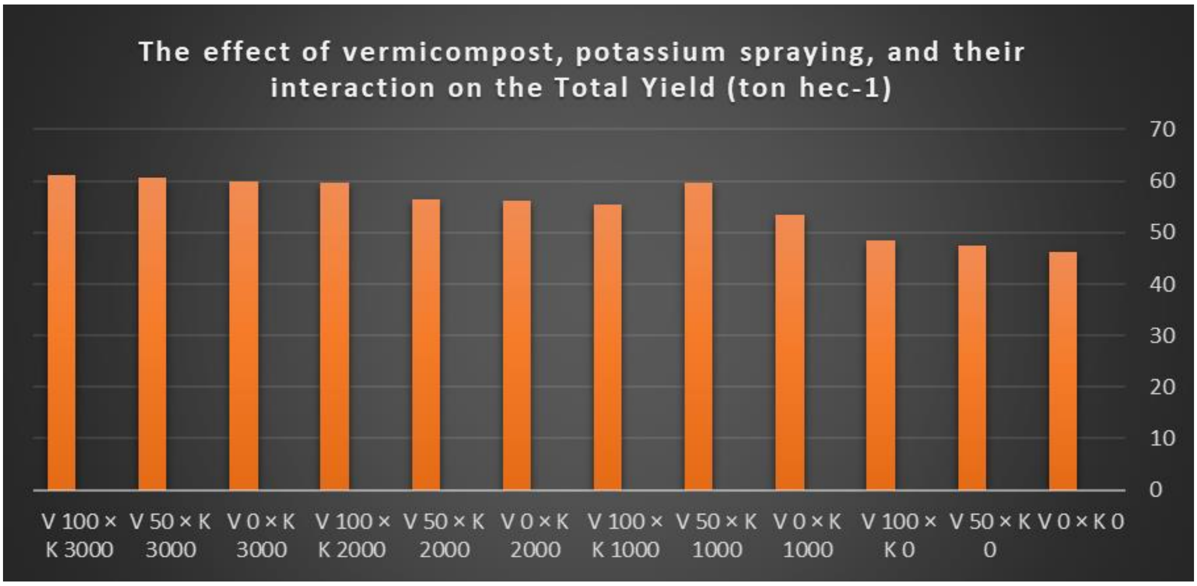

Figure No. (3)

4. Conclusions

From the results of the study, it is clear that the level of 50 tons per hectare of vermicompost with foliar spraying with a concentration of 3000 mg L-1 of potassium nitrate can be considered the best and most suitable treatment for producing the highest yield of lettuce and can be recommended and relied upon.

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تأثير الفيرميكمبوست والرش الورقي بنترات البوتاسيوم في صفات النمو الخضري والحاصل لنباتات الخس (*Lactuca sativa* L.) صنف نادر

عبدالله محمد سالم الدباغ - صفوان محمد حاجم الخشاب

قسم البستنة وهندسة الحدائق - كلية الزراعة والغابات - جامعة الموصل - العراق

الخلاصة

نفذ البحث في محطة أبحاث الخضروات التابع لقسم البستنة وهندسة الحدائق / كلية الزراعة والغابات – جامعة الموصل، مركز مدينة الموصل خلال الموسم الزراعي 2025/2024 ، أستخدم صنف الخس الهجين (Nader F1) ونفذت التجربة بأستخدام ثلاث مستويات من الفيرمي كمبوست وهي (صفر، 50، 100 طن هكتار$^{-1}$) والرش الورقي بنترات البوتاسيوم بأربعة تراكيز وهي (صفر، 1000، 2000، 3000 ملغم لتر$^{-1}$ KNO_3) وبثلاث أوقات البداية بعد تكوين 3-4 أوراق حقيقية وباقي الرشات بفاصل زمني 15 يوم بين رشة وأخرى، ونفذ البحث بتطبيق نظام التجارب العاملية وبتصميم القطاعات العشوائية الكاملة Factorial Experiment in a Randomized Complete Block (R.C.B.D.) Design وبثلاث مكررات. بينت النتائج أن الإضافة الأرضية للفيرمي كمبوست بكلا المستويين سبب زيادة معنوية في جميع الصفات المدروسة والفرق قليل جداً بين تأثير المستويين مما يعني أن المستوى (50 طن هكتار$^{-1}$) كان له تأثيراً واضحاً في جميع الصفات، وسبب الرش الورقي بنترات البوتاسيوم زيادة معنوية في معظم الصفات المدروسة وخصوصاً عند التركيز (3000 ملغم لتر$^{-1}$) ولم تصل الزيادة الى حد المعنوية فقط في صفة المحتوى الكلي للكلوروفيل والوزن الجاف للنبات، وتعتبر معاملة الإضافة بالمستوى (50 طن هكتار$^{-1}$) من الفيرمي كمبوست مع الرش بالتركيز (3000 ملغم لتر$^{-1}$) من نترات البوتاسيوم على العموم من أفضل المعاملات تأثيراً في أغلب الصفات المدروسة.

الكلمات المفتاحية: الخس، الفيرمي كمبوست، نترات البوتاسيوم، النمو الخضري، الحاصل