EFFECT OF VERMICOMPOST EXTRACT AND MINERAL FERTILIZER ON GROWTH, YIELD OF BARLEY AND SOME NUTRIENTS AVAILABILITY IN THE SOIL

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ABSTRACT

An experiment was conducted to study the effect of vermicompost extract and mineral fertilizer on growth, grain yield of barley and nutrients availability during the season 2021-2022, in clay loam soil using Randomized Complete Block design (RCBD). Vermicompost extract was added at three levels: without addition (VE_0), injected into the soil (VE_1) and applied as a foliar application (VE_2). Mineral fertilizer was added at (0, 50 and 100%) from the recommended level Symbolized (C_0, C_1 and C_2) sequentially. Results showed a significant effect of adding mineral fertilizer at 100% from the recommended level in available nitrogen and phosphorus in the soil achieved 32.06 mg N kg^{-1} and 21.55 mg P kg^{-1} respectively, and also excelled in plant height, leaf area, stalks number, 1000 grains weight, grain yield and biological yield) which achieved 66.36 cm and 18.45 cm^2, 7.91 stalks $plant^{-1}$, 41.78 g, 4.05 and 10.93 Mg ha^{-1} respectively. Vermicompost extract gave a significant effect as a spray on the plants compared to the injected into the soil in available nitrogen, phosphorus in the soil, stalks number, 1000 seeds weight, grain yield and biological yield which achieved 31.48 mg N kg^{-1}, 19.72 mg P kg^{-1}, 7.58 stalks $plant^{-1}$, 39.43 g, 4.02 and 10.34 Mg ha^{-1} respectively.

Keywords: leaf area; biological yield; barley.

تأثير اضافة مستخلص السماد الدودي والسماد المعدني في نمو وحاصل الشعير و جاهزية بعض المغذيات في التربة

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المستخلص

إجريت التجربة في احدى المحطات البحثية التابعة الى دائرة البحوث الزراعية/ وزارة الزراعة العراقية– واسط لدراسة تأثير مستخلص السماد الدودي مع مستويات من السماد الكيميائي الموصى به من قبل وزارة الزراعة العراقية وتقييم دور هذين السمادين في التربة ونمو وانتاجية نبات الشعير, إجريت التجربة بتصميم القطاعات التامة التعشية (RCBD). تم إضافة مستخلص السماد الدودي على ثلاث مستويات: بدون إضافة (VE_0) وحقنه في التربة (VE_1) ورشه على النباتات (VE_2)، وتم إضافة السماد المعدني بمستوى (0، 50 و100%) من التوصية السمادية ورمز لها (C_0، C_1 وC_2) بالتتابع. أظهرت النتائج تفوق التوصية السمادية 100% في النتروجين والفسفور الجاهز في التربة إذ أعطت 32.06 ملغم كغم $^{-1}$ و 21.55 ملغم كغم $^{-1}$ على التتابع كما تفوقت في صفات (أرتفاع النبات والمساحة الورقية وعدد الاشطاء ووزن 1000 حبة وحاصل الحبوب والحاصل البايولوجي) والتي اعطت (66.36سم و 18.45 سم^2 نبات$^{-1}$ و 7.91 فرع نبات$^{-1}$ و 41.78 غم و4.05 و 10.93 ميكاغرام هـ$^{-1}$ على التتابع) واعطت النباتات المعاملة بمستخلص الفيرمكمبوست تفوق معنوي عند اضافة السماد الدودي رشا على الجزء الخضري بالمقارنة مع الاضافة الارضية اذ بلغت قيم (النتروجين والفسفور الجاهز في التربة وأرتفاع النبات و المساحة الورقية وعدد التفرعات و وزن 1000 حبة وحاصل الحبوب والحاصل البايولوجي) (31.48 ملغم N كغم$^{-1}$ و 19.72 ملغم P كغم$^{-1}$ و 64.71 سم و 16.47 سم^2 نبات$^{-1}$ و 7.58 فرع نبات$^{-1}$و 39.43 غم و 4.02 و 10.34 ميكاغرام هـ$^{-1}$ على التتابع).

الكلمات المفتاحية: المساحة الورقية، الحاصل البايولوجي، شعير.

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INTRODUCTION

People face great challenges in providing food, especially with expectations the world population is expected to reach 9 billion in 2050 (27). The issue of nutrient availability in the soil is one of the fundamental and persistent challenges in arid and semi-arid regions. To address this problem, some countries such as Iraq have relied on using large amounts of chemical fertilizers to boost agricultural production and secure food supplies. However, the use of fertilizers leads to significant economic costs, environmental pollution. Statistics show that approximately 805 million people suffer from daily hunger (47). Most of the soils in arid and semi-arid regions are primarily calcareous soils with a high degree of interaction with a low content of organic matter, as well as a lack of availability of macro- and micro-nutrients for plants. Integrated Nutrient Management is one of the agricultural practices that aim to use the harmonious properties of fertilizer types, whether mineral, organic or soil amendments by creating a mixture that minimizes the excessive use of mineral fertilizers and achieve a balances fertilizer inputs with crop nutrients needs. These options can help maintain soil fertility, restore soil health and continuously supply plants with the necessary nutrients to achieve yield levels (3, 19, 39). The world has turned to using organic fertilization, as a complement to mineral fertilization. Consequently, the production and use of vermicompost produced from earthworms and vermicompost tea, have gained prominence due to their positive effects on both plants and improvement of soil properties (chemical, fertility, biological and physical (8, 10, 52). Vermicompost extract is produced by fermenting solid organic fertilizer from earthworms in water, transforming it into a nutrient liquid containing macro and micronutrients, organic acids and plant growth bacteria promoting (17, 24, 51). When applied as a foliar application, it enhances plant physiological properties, promoting growth and production (6, 49). Vermicompost extract is rich in enzymes and substances capable of protecting plants from pests and diseases (12, 20, 29). It plays a crucial role in improving soil biological properties by encouraging the growth and reproduction of essential bacteria and fungi, and it has a role in improving soil aeration by participating in soil structure building, increasing aggregates stability, reducing soil bulk density and enhancing water retention capacity and increasing organic matter and carbon content, and enhancing cation exchange capacity (21, 38, 50). Vermicompost extract plays a crucial role in enhancing seed germination and seedling vigor, it carries nutrients and water to seeds, stimulating germination and increasing the efficiency of various enzymes, particularly those responsible for oxidation and reduction reactions within the plant, thus positively influences the photosynthesis process, promoting cell growth and elongation which is reflected in an increase in the root system and increased nutrient uptake, Additionally, it contains hormones such as auxins, abscisic acid, and gibberellin (13, 16). Oyege and Balaji (41) obtained that vermicompost extract works to improve soil properties, increase nutrient availability, enhance crop productivity and enhance the plant’s ability to withstand pests and diseases. It works as an organic fertilizer, as it enriches the soil with essential nutrients, humic acids, growth-regulating hormones, and enzymes, and improves plant nutrition, photosynthesis, and crop quality in general. The study showed an increase in plant growth properties compared to not adding vermicompost extract. This study aimed to investigate the effect of vermicompost extract and chemical fertilizer on growth, yield of barley and nutrients availability in the soil.

MATERIALS AND METHODS

Several open boxes made of plastic were prepared with perforations at the bottom for the purpose of leaking excess water from the farmstead’s need, and to enhance air circulation. The area of the box was 0.2 m^2 and the depth was 0.35 m. The container was filled with an amount of fine sawdust and soil at a height of 7 cm. Worms were uniformly distributed, after which an amount of soil to a depth 4 cm. Nutrient materials were provided to the worms for three days at the beginning of preparation and after a period of 18 days, the addition was made on a daily basis due to the earthworms’ adaptation to their surrounding environment. Water was added for the purpose of providing appropriate humidity. The process continued for 130 days, adding water from time to time, and collecting the excess liquid extracted from the boxes during this period. Following the completion of the experiment, vermicompost was collected and the earthworms were removed and the liquid extracted from the farm was used in the field (7). The experiment was carried out at the Agricultural Research Department/ Ministry of Agriculture/ Iraq/ Higher grade seed multiplication program for barley. The land was plowed perpendicularly to its original orientation, followed by leveling and smoothing. The area was then segmented into experimental units, each measuring was 9 m^2. Soil samples was collected for chemical and physical analysis as stated in (15) as in Table (1). The treatments were assigned randomly according to a randomized complete block design. Barley seeds (Ibaa 99) were planted in lines with a spacing of 25 cm between each row. After harvesting the barley, soil and plant samples were randomly collected from each experimental unit, these samples were used to measure growth parameters, yield and determination of the available nitrogen and phosphorus in the experimental soil.

Leaf Area = Leaf Length × Leaf Width × 0.75

Table 1. Some chemical, physical and fertility properties of the Soil before planting

Soil Properties	Value	Unit
$EC_{1:1}$	3.61	$dS\ m^{-1}$
$pH_{1:1}$	7.23	-
Carbonate minerals	287.02	$g\ kg^{-1}$ soil
O. M	12.5	$g\ kg^{-1}$ soil
CEC	20.15	$Cmol.\ kg^{-1}$ soil
Available N	22.65	$mg\ kg^{-1}$ soil
Available P	14.82	$mg\ kg^{-1}$ soil
Available K	187.63	$mg\ kg^{-1}$ soil
Clay	341	
Sand	208	$g\ kg^{-1}$ soil
Silt	451	
Texture	Clay loam	

Vermicompost extract was added at three levels: without addition, injected into the soil and foliar application on the plants symbolized as (VE_0, VE_1, VE_2). Mineral fertilizer was added at (0, 50 and 100%) from the recommended level symbolized as (C_0, C_1, C_2). Nitrogen was applied as urea (46% N) at 80 kg N ha^{-1}. Phosphorus was added as DAP (21% P) at 40 kg P ha^{-1} and potassium was applied as potassium sulfate (42% K) at 80 kg K ha^{-1}. Vermicompost extract was foliar application on the barley plant using a 20 liter sprayer and drops of a spreader material were added with the fertilizer in order to decrease the water's surface tension to increase the efficiency of the foliar application process. The second was injection into the soil in the area of root spread using a 50 ml injector. The process of adding the vermicompost extract was done in two stages (after 20 days of germination and after 40 days when the spikes are sprouted).

RESULTS AND DISCUSSION

Available Nitrogen : The results of Tables (2) show a significant effect of treatment (C_2) on available nitrogen which achieved 32.06 mg N kg^{-1} soil compared to C_0 which achieved 20.95 mg N kg^{-1} soil. The addition of vermicompost extract had a significant effect on available nitrogen as VE_2 treatment achieve 31.48 mg N kg^{-1} soil superior to VE_1 and VE_0 treatments. VE_1 treatment achieved 26.69 mg N kg^{-1} soil was also superior to VE_0 which achieve 21.28 mg N kg^{-1} soil. There was a significant effect between the binary interaction treatments, as VE_2C_2 treatment achieved available nitrogen 38.45 mg N kg^{-1} soil which differed significantly from VE_1C_2 treatment, which gave available nitrogen 31.74 mg N kg^{-1} soil relative to VE_0C_0 which gave available nitrogen 17.54 mg N kg^{-1} soil.

Table 2. Effect of vermicompost extract and mineral fertilizer on available nitrogen in the soil after harvest (mg N kg^{-1} soil)

Mineral fertilizer (C)	Vermicompost extract (VE)			Mean (C)
	VE_0	VE_1	VE_2	
C_0	17.54	21.20	24.11	20.95
C_1	20.30	27.13	31.89	26.44
C_2	26.00	31.74	38.45	32.06
$L.S.D_{0.05}$ VE x C		0.85		$L.S.D_C$=0.44
Mean VE	21.28	26.69	31.48	$L.S.D_{VE}$=0.44

Available phosphorus

The results of Table (3) show a significant effect of treatment (C_2) on available phosphorus which reached 21.55 mg kg^{-1} soil compared to C_0 which reached 12.96 mg kg^{-1} soil. The addition of vermicompost extract had a significant effect on available phosphorus as VE_2 reached 19.72 mg kg^{-1} soil compared to VE_0 which gave 13.37 mg kg^{-1} soil. The results also showed a significant effect between the binary interaction treatments, as VE_2C_2 reached 23.87 mg kg^{-1} soil compared to VE_0C_0 which reached 9.72 mg kg^{-1} soil. The enhancing in the availability of nitrogen and phosphorus nutrients when adding full fertilizer recommendation is due to the availability of nitrogen and phosphorus in urea and DAP fertilizers.

Table 3. Effect of vermicompost extract and mineral fertilizer on available phosphorus in the soil after harvest (mg P kg^{-1} soil)

Mineral fertilizer (C)	Vermicompost extract (VE)			Mean (C)
	VE_0	VE_1	VE_2	
C_0	9.72	13.45	15.72	12.96
C_1	11.85	17.62	19.57	16.34
C_2	18.56	22.22	23.87	21.55
$L.S.D_{0.05}$ VE x C		0.70		$L.S.D_C$=0.41
Mean VE	13.37	17.76	19.72	$L.S.D_{VE}$=0.41

This results reveal that the effective and important role of adding mineral fertilizer in enhancing available nitrogen and phosphorus in the soil. They are among the nutrients whose quantity and availability increase with the increase in the amount of fertilizer sources (37). Also, the increase in the concentration of available phosphorus in it is due to the release of phosphorus from the added fertilizer, P availability decreases with time, and this is consistent with what was mentioned (42). The addition of vermicompost extract significantly influenced the nutrients in the soil, Vermicompost is rich in organic material that decomposes rapidly, releasing nitrogen in plant-available forms such as nitrate (NO_3^-) and ammonium (NH_4^+) and It stimulates beneficial soil microorganisms, including nitrogen-fixing bacteria, which convert atmospheric nitrogen into a usable form for plants. Additionally, Organic acids in vermicompost help dissolve phosphorus that is otherwise bound to soil particles, making it accessible to plants and vermicompost promotes the activity of soil microorganisms that release phosphatase enzymes, which mobilize phosphorus from organic and inorganic sources. Additionally, the presence of mineral fertilizer in the soil, which was unaffected, by the foliar spraying of vermicompost and the important nutrients it contains, helped increase the concentration of nutrients within the soil (18, 33). The addition of vermicompost extract had a significant effect on enhancing availability of nitrogen and phosphorus after planting, adding the vermicompost extract to the soil led to an increase in the availability of nitrogen in the soil, this may be due to that vermicompost includes nutritious mineral elements such as nitrogen and nitrogen-fixing bacteria in the vermicompost extract, this contributed to the elevated concentration of available nitrogen in the soil (1, 31, 32, 35). The foliar application of vermicompost extract promoted significant root development, including an increase lateral branches. This expansion of the root system enhanced root respiration, resulting in higher carbon dioxide (CO_2) emissions. The emitted CO_2 reacted with water in the soil, forming carbonic acid, which facilitated nutrient solubilization. Additionally, the secretion of organic acids by the roots contributed to lowering the soil's pH, improving phosphorus availability and promoting better nutrient absorption post-planting. (11).

Plant height : The results in Table (4) show a significant effect of the height of barley plants when adding treatment (C_2), which gave 66.36 cm, compared to the C_0, which achieved 61.10 cm. The foliar application treatment with vermicompost extract also excelled in influencing the mean plant height, as VE_2 achieved 64.71 cm compared to the VE_0, which achieved 61.33 cm. In addition, there was a significant effect between the binary interaction, VE_2C_2, which amounted to 68.14 cm, excelled compared to VE_0C_0, which gave less mean plant height was 59.93 cm.

Table 4. Effect of vermicompost extract and mineral fertilizer on plant height after harvest (cm)

Mineral fertilizer (C)	Vermicompost extract (VE) VE_0	VE_1	VE_2	Mean (C)
C_0	59.93	61.16	62.21	61.10
C_1	59.53	64.43	63.80	62.58
C_2	64.53	66.43	68.14	66.36
$L.S.D_{0.05}$ VE x C		4.01		$L.S.D_C$=3.34
Mean VE	61.33	64.00	64.71	$L.S.D_{VE}$=3.34

Leaf area : The results in Table (5) reveal a significant effect of leaf area when adding C_2, which achieve 18.45 cm^2 $plant^{-1}$, compared to C_0, which achieved 11.82 cm^2 $plant^{-1}$. The foliar application treatment with vermicompost extract also excelled, as VE_2 treatment, which achieved 16.47 cm^2 $plant^{-1}$ compared to the VE_0, which achieved 12.10 cm^2 $plant^{-1}$.

Table 5. Effect of vermicompost extract and mineral fertilizer on leaf area after harvest (cm^2 $plant^{-1}$)

Mineral fertilizer (C)	Vermicompost extract (VE) VE_0	VE_1	VE_2	Mean (C)
C_0	10.55	11.70	13.21	11.82
C_1	11.05	14.25	15.50	13.60
C_2	14.70	19.97	20.70	18.45
$L.S.D_{0.05}$ VE x C		N.S*		$L.S.D_C$=0.28
Mean VE	12.10	15.30	16.47	$L.S.D_{VE}$=0.28

***N.S: Non Significant**

Number of stalks: The results of Table (6) shows a significant effect on the number of stalks when adding C_2 which achieved 7.91 stalk $plant^{-1}$ compared to the C_0 treatment, which achieved 6.20 stalk $plant^{-1}$. The foliar application treatment with vermicompost extract also had a significant effect on the number of stalks, as it achieves 7.58 stalk $plant^{-1}$ in the VE_2, compared to the VE_0, which achieved 6.50 stalk $plant^{-1}$. The results showed that there was significant effect between the binary interaction, as the VE_2C_2 and achieved 8.43 stalk $plant^{-1}$ relative to VE_0C_0, which achieved lowest average number of stalks of 5.73 stalk $plant^{-1}$.

Table 6. Effect of vermicompost extract and mineral fertilizer on number of stalks after harvest

Mineral fertilizer (C)	Vermicompost extract (VE) VE_0	VE_1	VE_2	Mean (C)
C_0	5.73	6.40	6.49	6.20
C_1	6.64	7.95	7.84	7.47
C_2	7.15	8.15	8.43	7.91
$L.S.D_{0.05}$ VE x C		0.19		$L.S.D_C$=0.13
Mean VE	6.50	7.50	7.58	$L.S.D_{VE}$=0.13

Weight of 1000 grain : The results of Table (7) indicate a significant increase in the weight of 1000 grains when adding C_2, which amounted to 41.78 g compared to C_0, which achieved the lowest weight, amounted to 32.30 g. The spraying treatment with vermicompost extract VE_2 also affected and achieves a weight of 39.43 g, compared to VE_0, which achieve a weight 32.74 g. There was a significant effect between the binary interaction treatments, as the VE_2C_2 treatment achieves the highest weight, reaching 44.41 g, which was significantly superior to the VE_0C_0, which achieved a weight 29.57 g.

Table 7. Effect of vermicompost extract and mineral fertilizer on 1000 grains weight after harvest (g)

Mineral fertilizer (C)	Vermicompost extract (VE) VE_0	VE_1	VE_2	Mean (C)
C_0	29.57	32.30	35.05	32.30
C_1	30.85	37.25	38.85	35.65
C_2	37.80	43.13	44.41	41.78
$L.S.D_{0.05}$ VE x C		0.46		$L.S.D_C$=0.27
Mean VE	32.74	37.56	39.43	$L.S.D_{VE}$=0.27

Grains yield (Mg ha^{-1})

The results in Table (8) show a significant effect in grains yield when adding C_2, which achieved 4.05 Mg ha^{-1}, relative to C_0, which achieved 3.77 Mg ha^{-1}. It also affected the foliar application treatment with vermicompost VE_2, which achieved a grains yield 4.02. Mg ha^{-1} compared to VE_0, which achieved 3.78 Mg ha^{-1}. There was significant effect between the binary interaction, as VE_2C_2 achieved grains yield 4.21 Mg ha^{-1}, which differed significantly from VE_0C_0, which achieved 3.55 Mg ha^{-1}.

Table 8. Effect of vermicompost extract and mineral fertilizer on grains yield after harvest (Mg ha^{-1})

Mineral fertilizer (C)	Vermicompost extract (VE) VE_0	VE_1	VE_2	Mean (C)
C_0	3.55	3.87	3.89	3.77
C_1	3.84	3.96	3.96	3.92
C_2	3.95	4.01	4.21	4.05
$L.S.D_{0.05}$ VE x C		0.05		$L.S.D_C$=0.03
Mean VE	3.78	3.94	4.02	$L.S.D_{VE}$=0.03

Biological yield (Mg ha^{-1})

The results of Table (9) show a significant effect on the biological yield in C_2 treatment, which achieved 10.93 Mg ha^{-1} compared to C_0, which achieved a biological yield 8.63 Mg ha^{1}. The foliar application treatment with vermicompost extract VE_2 also had a significant effect, as it achieved 10.34 Mg ha^{-1} compared to VE_0, which achieved 8.78 Mg ha^{-1}. The results showed that there was significant effect between the binary interaction, as VE_2C_2 achieved 11.32 Mg ha^{-1}, followed by the VE_1C_2 11.16 Mg ha^{-1}, and the lowest value was in the VE_0C_0 treatment, which achieved 7.88 Mg ha^{-1}.

Table 9. Effect of vermicompost extract and mineral fertilizer on biological yield after harvest (Mg ha^{-1})

Mineral fertilizer (C)	Vermicompost extract (VE) VE_0	VE_1	VE_2	Mean (C)
C_0	7.88	8.98	9.05	8.63
C_1	8.14	10.36	10.65	9.71
C_2	10.32	11.16	11.32	10.93
$L.S.D_{0.05}$ VE x C		0.16		$L.S.D_C$=0.09
Mean VE	8.78	10.16	10.34	$L.S.D_{VE}$=0.09

The increase in plant growth indicators is attributed to the presence of appropriate and sufficient levels of mineral fertilizer leading to increasing its absorption by the plant. Additionally, nitrogen also contributes to enhance growth and development of root system, thus enhance nitrogen concentration , the process of photosynthesis and the synthesis of energy molecules, in addition to the role of phosphorus in increasing the efficiency of photosynthesis in the formation and transport of carbohydrates to absorption sites in the roots, which is a major source of biological absorption energy (14, 27, 44, 48). Foliar application with vermicompost extract, which is rich in nutrients, plays an essential role in plant growth and development. This explains the increase in plant height, grains yield, and biological yield as a result of the direct absorption by the plant of the vermicompost extract when it is sprayed on the plant, in addition to its containment of macro and micro-nutrients, as well as the role of Cytokinins, gibberellin and indole acetic acid contained in vermicompost extract, which led to increase the efficiency of the growth of the shoot and the branching of the roots and their depth in the soil, which results in an increased secretion of organic acids that enhance phosphorus availability in the soil, thereby enabling the plant to absorb nutrients and maintain a nutritional balance. The plant thus increases the concentrations of nutrients (32, 34, 36, 40), and this may be due to the role of vermicompost extract in increasing the effectiveness of vital processes such as respiration, increasing the permeability of cellular membranes and photosynthesis leads to increased vegetative growth and nutrients uptake from the soil (9, 11). Also, the addition of vermicompost extract releases phosphorus from its compounds as a result of it containing organic acids that lead to chelate Ca^{2+}, encapsulate phosphorus and prevent it from adsorption and precipitation, which is involved in the synthesis of enzymes and has a direct role in generating energy for the plant (2, 26, 45). Adding vermicompost extract contains organic and inorganic acids that act as mediators in the respiration process, which reflects positively on the activity of enzymes and hormones that cause an increase in the products of photosynthesis, which led to an increase in the activity of the cell division process and an increase in their size, which causes the formation of new parts, which leads to an increases the height and leaf area of plants, in addition to its containment of amino acids that contribute to the formation of the chlorophyll molecule in the leaves, as well as its role in increasing antioxidants, which maintains the chlorophyll content of the leaves from the process (5, 25, 28, 43). The increase in grain yield is attributed to the effect of vermicompost extract, which helped improve the vegetative growth characteristics of the plants. This improvement led to an increase in the production of materials that support vegetative activity. As a result, photosynthesis efficiency, carbohydrate formation, and the accumulation of metabolic substances in the leaves, which are transferred to the fruits, were all enhanced, contributing to a higher overall yield. Additionally, the extract boosts levels of plant hormones such as auxins, cytokinins, and gibberellins, which are essential for activating vital processes within the plant. These hormones also increase the rate of cell division in meristematic tissues, accelerating branch development and improving overall plant growth indicators (4, 10). The observed increase in plant growth can be explained by the application of vermicompost extract, both through soil injection and foliar spraying. This treatment supplied the plants with crucial nutrients involved in key processes such as photosynthesis, protoplasmic construction, respiration, and the production of plant hormones. This resulted in a marked improvement in the plant's physiological condition, which in turn had a positive effect on grain yield indicators. The extract also played a role in enhancing root system function, leading to better regulation of water balance and nutrient availability, thereby promoting improved yield growth. Direct application of the vermicompost extract to the soil also enhanced its physical properties, fertility, and overall vitality, further contributing to the growth of both the root and vegetative systems, and consequently, the yield (22, 23, 30, 46). Adding vermicompost extract causes an increase in the availability of nutrients in the soil. Foliar application the plant with vermicompost extract stimulates the growth of the vegetative system and increases the plant's growth and yield. Using 100% of the fertilizer recommendation with the presence of vermicompost extract achieves results close to adding 100% of the fertilizer recommendation and thus reduces the costs of mineral fertilizer and reduces environmental pollution. The use of organic fertilizers is complementary to mineral fertilizers and is healthier and safer for the environment.

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