European Journal of Biological Sciences 15 (2): 28-32, 2023
ISSN 2079-2085

DOI: 10.5829/idosi.ejbs.2023.28.32

Effect of Potassium Fertilization Rates on Yield and Nutritional Status of Lettuce Plants under Different Levels of Vermicompost

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Abstract: Greenhouse experiments were carried out during the two successive season of 2021 and 2022 in the greenhouse of the National Research Centre, Dokki, Egypt, to study the effects of different levels of vermicompost (0.5, 1 and 2 ton fed^{-1}) combined with various rates of potassium fertilization (30, 50 and 70 kg fed^{-1}) on yield parameters and leaf nutritional content in lettuce (*Lactuca sativa* L. cv Batavia). The obtained results were an increase in the levels of vermicompost that was added to the sandy soil and this led to an improvement in the coordinates and quality of the lettuce yield, as well as the content of nutrients in the leaves, during the two successive growing seasons.While increasing the rate of potassium fertilization up to the second level was sufficient to obtain the best values for the crop coordinates, as there were no significant differences between the values obtained as a result of adding the second and third rates of potassium fertilization. The best experimental treatment through which it was possible to obtain the best values for the lettuce crop grown in sandy soil was 2 tons per feddan of vermicompost + 50 kg per feddan of potassium fertilizer. It can be said about the importance of using vermicompost as an organic fertilizer of high quality that gives great results in improving the growth and yield of lettuce plants grown in sandy soil, as well as determining the appropriate rate of potassium fertilizer for plants grown in sandy soil instead of using larger quantities that plants do not benefit from, which reduces the cost and increase profitability.

Key words: Lettuce · Yield · Nutritional status · Vermicompost · Potassium fertilization

INTRODUCTION

Lettuce (*Lactoca sativa*) is one of the most important vegetables in the leafy green group. It is used only as a fresh vegetable in salads and fast food. It is a very valuable vegetable that increases the income of high-yielding farmers. Lettuce contains many vitamins and minerals, such as K, P, Fe and Zn, which are important for human health, as well as biologically active compounds, that promote health [1].

Vermicompost is produced by biodegradation of organic waste by earthworms and some microorganisms. Vermicompost is highly moist due to the avalanche of waste produced by worms and microbes [2]. Vermicompost has greatly contributed to improving the productivity of various crops [3]. Increasing the rate of vermicomposting, which slowly releases nutrients from organic matter, increases the number of microorganisms and preserves the fertility of sandy soil compared to mineral fertilizers [4].

Potassium is a macronutrient required by plants for optimal growth and productivity. It's simple part of the physiological and biochemical processes in a plant [5, 6]. Potassium application to pea up to 100 kg K_2O per hectare had significant positive effects on vine length, number of pods/plant, pod length and green pod yield, beyond this dose further application of K_2O was ineffective [7].

The aim of the study was to find out the effect of adding vermicompost at different levels with different rates of potassium fertilization on the yield and nutritional status of lettuce plants, during two consecutive seasons.

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MATERIAL AND METHODS

Greenhouse experiments were carried out during the two successive season of 2021 and 2022 in the greenhouse of the National Research Centre, Dokki, Egypt, to study the effects of different levels of vermicompost (0.5, 1 and 2 ton fed^{-1}) combined with various rates of potassium fertilization (30, 50 and 70 kg fed^{-1}) on yield parameters and leaf nutritional content in lettuce (*Lactuca sativa* L. cv Batavia). The recommended fertilizer rates were added for each of nitrogen and phosphorus, where nitrogen fertilizer was added at a rate of 60 kg N per feddan in the form of ammonium nitrate and phosphate fertilizer was added at a rate of 15 kg P_2O_5 per feddan in the form of superphosphate.

Plastic pots (30 cm in diameter) were filled with 10 kg soil (sandy soil). Some chemical properties of the soil used in Table (1).

The vermicompost was produced in the Soil and Water Use Laboratory - National Research Centre- and using only different plant residues and using one species of earthworm (*Eisenia foetida*). Vermicompost analysis was determined in (Table, 2) using the standard procedures outlined by Cottenie [8]. As well as growth regulator analyses of vermicompost was determined (Table, 3) using the standard procedures outlined by [1].

The experiments were laid out in a randomized complete block design with five replications. The transplant was done when the seedlings were with four true leaves.

The lettuce plants samples were collected and the following measurements were recorded: fresh weight of leaves (g/plant), dry weight of leaves (g/plant), fresh weight of roots (g/plant), dry weight of roots(g/plant), leaf area (cm^2), leaves number plant^{-1}, root length (cm). Sample of leaves were oven dried at 70°C then fine grinded and wet digested N, P and K contents of leaves. Dry matter of each treatment was used for determination total carbohydrates% was determined colorimetrically using phenol-sulphoric acid reagent method as outlined by [10]. Vitamin C was estimated in lettuce leaves according to the method reported in [11].

All data obtained were subjected to analysis of variance according to [12]. The least significant differences (LSD) at P=0.05 level wasused to verify the difference between means of the treatments.

Table 1: Some chemical properties of soil used.

Soilproperty	Value
pH	7.50
EC (dS m^{-1})	1.20
Soluble ions (mmol L^{-1})	
Ca^{++}	5.73
Mg^{++}	4.21
Na^{+}	1.54
K^{+}	0.52
$CO3^{-}$	nd*
HCO_3^{-}	1.10
Cl^{-}	0.96
$SO4^{-}$	9.94

Table 2: Some chemical properties of vermicompost used

Analyses	Vermicompost
pH	6.50
EC (dSm^{-1})	2.60
Moisturecontent (%)	17.00
Organicmatter (%)	75.10
Organiccarbon (%)	43.60
Ash (%)	24.90
C/Nratio	1:18.20
N (%)	2.51
P (%)	0.59
K (%)	1.19

Table 3: Plant growth regulator analyses of vermicompost used.

Plant growth regulators (ppm)	Value
Indol Acetic Acid	51.22
Abscisic Acid	80.20
Cytokinin	41.69
Gibrilic Acid	77.10

RESULTS AND DISCUSSION

The results in Table (4) indicated that during the two consecutive growing seasons, increasing the level of vermicompost fertilization from 0.5 to 2 ton per feddan greatly helped to improve the growth and yield of lettuce grown in sandy soil. Increasing the rates of potassium fertilization from 30 to 70 kg K_2O fed^{-1} did not significantly improve the growth and yield of lettuce, especially the second and third rates, as the addition of the second rate (50 kg K_2O fed^{-1}) led to obtaining the highest yield values, as all yield parameters such as fresh weight of leaves and root, leaf area and number of leaves increased, which it indicate that fertilization at a rate of 50 kg K_2O fed^{-1}is sufficient to obtain the best yield parameters values. Thus, it can be said that with increasing the level of vermicompost, it led to an improvement in the coordinates of the lettuce yield, especially with the second rate of potassium fertilization.

Table 4: Effect of vermicompost levels and potassium fertilization rates on yield parameters of lettuce plants

Vermicompost levels ton fed^{-1}	K-fertilization rates Kg fed^{-1}	Fresh weight of leaves g	Dry weight of leaves g	No. of leaves	Leaf area cm^2	Root length cm	Fresh weight of root g	Dry weight of root g
				First season				
0.5	30	224.5	25.6	16.9	44.6	7.77	9.56	1.13
	50	233.6	28.6	22.8	59.3	11.2	12.6	1.54
	70	228.8	26.1	19.5	52.6	10.1	11.8	1.49
1	30	233.3	27.0	18.8	49.5	9.44	10.8	1.22
	50	250.2	31.6	23.1	77.2	12.2	13.6	1.54
	70	246.4	29.6	21.2	69.2	11.3	12.8	1.60
2	30	240.3	28.5	20.0	50.4	9.71	11.0	1.51
	50	266.4	35.8	27.1	84.1	13.5	14.2	1.64
	70	252.6	32.0	24.1	79.2	12.8	13.7	1.55
$LSD_{0.05}$		44.2	1.89	1.66	2.11	1.22	1.01	0.11
				Second season				
0.5	30	223.6	25.4	16.8	42.1	8.00	9.88	1.18
	50	234.2	28.4	22.7	58.3	11.4	12.5	1.52
	70	230.1	26.2	20.0	51.6	10.6	11.9	1.49
1	30	229.5	26.5	18.6	49.4	9.11	10.2	1.18
	50	249.2	30.5	22.9	76.1	12.5	13.2	1.51
	70	246.2	28.6	21.0	69.0	11.2	12.6	1.57
2	30	234.8	28.4	20.1	50.1	9.70	10.9	1.50
	50	264.1	34.6	26.8	83.1	13.3	14.0	1.61
	70	255.1	32.1	24.0	78.1	12.4	13.6	1.55
$LSD_{0.05}$		42.1	1.78	1.54	2.01	1.03	1.00	0.11

Table 5: Effect of vermicompost levels and potassium fertilization rates onyield quality of lettuce plants.

Vermicompost levels ton fed^{-1}	K-fertilization rates Kg fed^{-1}	Chlorophyll a (µg/g FW)	Chlorophyllb (µg/g FW)	Carotenoids (µg/g FW)	Vitamin C (mg/100gm FW)	Carbohydrates (%)
			First season			
0.5	30	19.2	8.78	4.11	3.51	20.1
	50	22.3	11.1	4.54	4.46	25.3
	70	23.4	12.0	4.90	4.44	25.6
1	30	20.4	10.5	3.77	3.72	21.2
	50	29.9	14.3	3.40	4.43	26.4
	70	30.1	15.5	3.00	4.38	26.5
2	30	24.2	11.8	3.11	4.11	21.8
	50	30.1	15.7	4.11	5.65	26.8
	70	31.1	15.6	4.12	5.61	26.9
$LSD_{0.05}$		0.95	0.11	0.02	0.33	1.11
			Second season			
0.5	30	19.1	8.77	4.10	3.52	19.1
	50	22.2	11.3	4.52	4.44	24.3
	70	23.4	11.6	4.88	4.45	24.5
1	30	20.3	10.6	3.76	3.70	21.0
	50	29.8	14.3	3.39	4.33	25.9
	70	30.0	15.3	3.01	4.32	25.8
2	30	24.2	11.7	3.13	4.12	21.4
	50	30.1	15.6	4.12	5.56	26.5
	70	31.0	15.5	4.12	5.59	26.5
$LSD_{0.05}$		0.96	0.12	0.02	0.40	1.01

Adding vermicompost to sandy soil leads to an increase in growth and yield time for all different crops and this is due to its containment ofnutrients [13]. Vermicompost has been found beneficial as a complete or partial replacement for mineral fertilizers in peat-based synthetic greenhouse media and as a soil fertilizer in field studies [14]. The values of lettuce yield parameters were high under the high rate of vermicompost (2 ton fed^{-1}), especially under second rate of potassium fertilization (140 kg fed^{-1}) [3].

The leaf content of chlorophyll (a & b) and carotenoids as well as vitamin C and carbohydrates were estimated as quality of the lettuce yield, as shown in (Table 5). It was proven through the results obtained that

Table 6: Effect of vermicompost levels and potassium fertilization rates onN, P and K content of lettuce plants

Vermicompost levels ton fed^{-1}	K-fertilization rates Kg fed^{-1}	N	P	K
		First season		
0.5	30	1.48	0.15	1.77
	50	1.73	0.16	1.81
	70	1.74	0.16	1.85
1	30	1.61	0.17	1.82
	50	1.96	0.22	1.92
	70	2.00	0.23	1.95
2	30	1.89	0.20	2.00
	50	2.35	0.28	2.35
	70	2.44	0.29	2.40
$LSD_{0.05}$		0.52	0.01	0.66
		Second season		
0.5	30	1.15	0.16	1.78
	50	1.71	0.18	1.82
	70	1.72	0.18	1.84
1	30	1.59	0.17	1.90
	50	1.95	0.24	1.94
	70	2.01	0.25	1.95
2	30	1.88	0.21	2.02
	50	2.34	0.27	2.33
	70	2.40	0.28	2.39
$LSD_{0.05}$		0.49	0.01	0.58

increasing the level of vermicompost from 0.5 to 2 ton per feddan helped greatly in increasing the content of leaves of chlorophyll and carotenoids, as well as their content of carbohydrates and vitamin C. Increasing the rate of potassium fertilization up to the second level was sufficient to obtain the best values for the quality of the lettuce yield, as there were no significant differences between the second and third levels of potassium fertilization, during the two successive growing seasons.. Potassium is an important nutrient for plant nutrition, affecting meristematic growth, water status, photosynthesis, long-distance transport of similar substances, enhancing the action of many enzymes and facilitating the transport of sugars and starches. It has the ability to promote, increase protein content and influence regulation [15]. Potassium plays a key role in many physiological and biochemical processes such as cell division and elongation, as well as carbohydrate and protein metabolism [6]. Anjaiah and Padmaja [16] who found that total carotenoids and totalsoluble solids increased with increasing levels of potassium fertilization. Manivannan *et al*., [17] showed that the treatment (50% vermicompost + 50% NPK) supplies higher macro and micronutrients to the soil and plants in the available from which results in better growth, yield and quality of beans.

The results in (Table 6) show the effect of increasing the levels of vermicompost fertilization with an increase in the rate of potassium fertilization on the nitrogen, phosphorus and potassium content of the leaves.Increasing the level of fertilization with vermicompost from 0.5 to 2 ton per feddan led to an increase in the leaf content of nitrogen, phosphorus and potassium, with an increase in the rate of potassium fertilization. It was possible to obtain the highest values of these elements when adding the third level of vermicompost with the second rate of potassium fertilization. The effect of increasing doses of vermicompost applications and found significant increase in the nutritional value [18]. Yassen *et al*., [4] reported that vermicompost at 4 ton fed^{-1} + vermiwash 150 ml/ L foliar application is important for inducing an increase in most leaf nutrient content in both leaves and head lettuce plants. Abd El-Rheem *et al*., [3] indicated that The highest values of N, P and K uptake was noticed with high rate of vermicompost (2 ton fed^{-1}) combined with second level of potassium fertilization (140 kg fed^{-1}) as compared with other treatments.

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