European Journal of Biological Sciences 14 (2): 86-92, 2022
ISSN 2079-2085

DOI: 10.5829/idosi.ejbs.2022.86.92

Effect of Potassium Fertilizer and Organic Amendment on Some Morphological and Nutritional Status of Lettuce Plants Grown in Sandy Soil

[1]Abd El-Rheem Kh. M., [2]A.A. Yassen, [1]Soad M. El-Ashry and [3]A.E. Hamza

[1]Soils and Water Use Department, National Research Centre, Dokki, Cairo, Egypt
[2]Plant Nutrition Department, National Research Centre, Dokki, Cairo, Egypt
[3]Vegetable Research Department, National Research Centre, Dokki, Cairo, Egypt

Abstract: A field experiment was conducted during two successive seasons at the Experimental Station of the National Research Center in Nubaria region, Egypt. To study the effect of potassium fertilizer rates (0, 50, 100 and 150 kg K_2O fed^{-1}) and three rates of organic amendment (1, 2 and 3 ton fed^{-1}) on growth, yield and nutritional status of lettuce plants (*Lactuca sativa* L.). The results showed that applying different at rates of compost alone or in combination with potassium sulphate can promote of most growth parameters (number of leaves/plants, leaf area, fresh weight of leaves and root, dry weight of leaves and root) and yield in both seasons when compared to the control treatment. Also, using organic amendment at a rate of 3 ton fed^{-1} with a high level of potassium fertilizer (100 Kg fed^{-1}) significantly improved growth characteristics growth parameters, yield and e nitrogen, phosphorous and potassium content of lettuce leaves when compared to other treatments of lettuce in both two seasons. The improvement of growth and yield specifications resulted in an improvement in lettuce yield quality by increasing the content of pigments, vitamin C and carbohydrates in its leaves.

Key words: Lettuce plants · Compost · Potassium fertilization · Growth · Yield · Nutrient's content

INTRODUCTION

Lettuce (*Lactuca sativa*) is considered as the most important vegetable in the group of leafy vegetables. It is almost exclusively used as a fresh vegetable in salads and fast food but some forms are also cooked [1] and [2]. It is a very important exotic vegetable that can increase the income of farmers of high yield. Lettuce contains several vitaminsæ dietary minerals significant for human health such as K, P, Fe and Zn and as well as it has contained other health-promoting bioactive compounds [3], [4] and [5].

Fertilizer is a major input in crop production. To reduce mineral fertilizers cost, environmental degradation and restore soil fertility, the use of organic amendment has a significant value. To fulfill agricultural sustainability, the use of organic amendment has achieved main significance in recent years, particularly under intensive cropping system in most countries in a world [6] and [7]. Sustainable agriculture requires use of organic fertilizers for steady nutrients supply and improving soil organic matter, soil physical and chemical properties and crop productivity [8], [9] and [10]. Compost is commonly used organic amendments in agriculture. Compost is an aerobically decomposed organic material derived from plants and/or animal residues by mesophilic and thermophilic microorganisms [11] and [12]. Compost application to agricultural lands has been recognized as a reliable way to improve the properties of most soils, especially soils with poor structure and low levels of organic matter [13].

Potassium is an essential nutrient for plant nutrition and its ability to influence meristem growth, water status, photosynthesis, long distance transport of assimilates, enhance many enzyme actions, helps translocate sugars and starches, increase protein content as well as control ionic balance [14] and [15]. Generally, plants require large quantities of K and hence, K is classified as a 'macro'-

Corrsponding Author: Abd El-Rheem Kh. M., Soils and Water Use Department, National Research Centre, Dokki, Cairo, Egypt

nutrient, plants with minor K deficiencies may suffer from reduced growth and productivity [16] and sustain balance between monovalent and divalent cations [17].

The aim of the paper was to study the effect of compost as an organic amendment to sandy soil with potassium fertilizer rates on growth, yield and nutritional status of lettuce plants grown in sandy soil conditions at two successive seasons.

MATERIALS AND METHODS

Two field experiments were carried out during the two successive seasons of 2019-2020 and 2020-2021 at the experimental station of the National Research Centre in Nubaria region, Egypt to study the effect different rates of potassium fertilization and organic amendment (compost) on growth, yield and nutritional state of lettuce plants (*Lactuca sativa* L.) Cv. Batavia green was grown in sandy soil and using a drip irrigation system. Some physical and chemical properties of the soil used in the experiments are shown in Table (1) using the standard procedures outlined by Cottenie *et al*. [18].

Seedlings were transplanted when two leaves were completely expanded 30days after sowing Seeds of lettuce (*Lactuca sativa* L.) cv. Batavia green. Seedlings were set up in the field on 20th of November and 15th of November in the first and second seasons, respectively. Seedlings were planted on one side of ridges 25cm apart, ridges were 80 cm in width and 4 m length. Each plot included 4 ridges and the plot area was about 12 m^2. The experimental design was a complete randomized block with five replications for each treatment. The recommended dose of NPK chemical fertilizers used in this experiment according to the Ministry of Agriculture, Egypt.

The treatments consisted of compost with different rates (1, 2 and 3 ton fed^{-1}) and incorporated in the top 15 cm layer of soil in the experimental beds before the plantation of lettuce seedlings, Compost was determined (Table 2) using the standard procedures outlined by Cottenie *et al.* [18].

Potassium fertilizer was applied as potassium sulphate (46% K_2O) at rates of (0, 50, 100 and 150 Kg K_2O fed^{-1}) were add to lettuce plant after 30 days from seedlings at two doses. All agricultural practices operation -other than experimental treatments- necessary for growth as cultivation, irrigation and pest control were followed whenever it was necessary and were done according to the recommendations of Ministry of Agriculture, Egypt.

Table 1: Some physical and chemical properties of the soil used

Soil property	Value	Soil property	Value
Particle size distribution %		pH	7.70
Sand	92.65	EC (dS m^{-1})	1.60
Silt	5.07		
Clay	2.28		
Texture	Sandy		
Soluble ions (mmol L^{-1})			
Ca^{++}		8.02	
Mg^{++}		3.23	
Na^{+}		3.92	
K^{+}		0.91	
CO_3^{--}		-	
HCO_3^{-}		2.20	
Cl^{-}		3.98	
SO_4^{--}		9.90	
$CaCO_3$ %		1.90	
Saturation percent %		22.5	
Organic matter %		0.15	
Available N (mg kg^{-1})		24.5	
Available P (mg kg^{-1})		2.90	
Available K (mg kg^{-1})		56.4	

Recorded Data: After 60 days from transplanting, the plants were harvested and total yield was recorded for each plot. Five plants were randomly chosen from each experimental plot to determine number of leaves/plants, leaf area, fresh weight of leaves and root, dry weight of leaves and root and total yield ton fed^{-1}.

Chemical Constituents: Prior to digestion the samples were re-dried in order to remove possible moisture gained before the analyses:

- The percentage of N, P and K in leaves were determined according to the methods in [18].
- Chlorophyll a, chlorophyll b and carotenoids content were estimated according to the method described by Moran [19].
- Total carbohydrate percentage in leaves (%): dry matter of each treatment was used for determination total carbohydrates% were colorimetrically determined using phenol-sulphoric acid reagent method as outlined by Dubois *et al*. [20].
- Vitamin C was estimated in lettuce leaves according to the method reported in A.O.A.C. [21].

Statistical Analysis: All data were subjected to statistical analysis using Mstatc software. The comparison among means of the different treatments was determined, as illustrated by Snedecor and Cochran [22]. Means of the treatments were compared by the Least Significant Differences Test at (0.05) level of significance.

Table 2: Some chemical properties of compost used

pH 1:2.5	EC (dS m^{-1})	Moisture content	Organic Matter	Organic Carbon	Ash content	N	P	K	C:N ratio
		(%)							
8.10	2.20	21	30.8	17.9	69.2	0.86	0.16	0.59	1:20.8

RESULTS AND DISCUSSION

The data in Table (3) showed that applying different at rates of compost (1.2and3 and ton fed^{-1}) alone or in combination with potassium sulphate rates (0, 50, 100 and 150 Kg K_2O fed^{-1}) can promote of most growth parameters (number of leaves/plants, leaf area, fresh weight of leaves and root, dry weight of leaves and root) and yield ton fed^{-1} in both seasons when compared to the control treatment. The results thus obtained compatible with Abd El-Fattah *et al.* [23]. [24] found that the application of compost had higher on width, leaf number per plant and plant fresh weight as well as chemical fertilizer. In comparison, between with different levels of compost (1, 2 and 3 ton fed $^{-1}$) data indicated that the higher level of compost (3 ton fed^{-1}) had significantly enhancing effects of growth parameters and yield in both two seasons of lettuce plant under study. The increasing of growth parameters and yield may be due to the complete decomposition of compost and release of nutrients in the available form. Moreover, organic amendment stimulates root development partially to large increases in soil microbial biomass and improves the activities of microorganisms, particularly those involved in mineralization after compost applications These findings confirm those obtained by [25] [26]. In addition, compost contributes to increasing soil aggregates in the sandy soil, thus improving the texture and porosity of the soil, which helps it hold erosion, thus creating an environment for the growth of roots in a better way [27]. Interestingly, the results inspection in Table (3) revealed that the addition of 100 K_2O fed^{-1} with compost at a rate of 3 ton fed^{-1} increased the highest values of most vegetative growth character measurements and yield as compared to application 150 K_2O fed^{-1} with 1 and 2 ton fed^{-1}. The maximum-recorded values were number of leaves $plant^{-1}$ (51.67), leaf area (355.7 mm^2), fresh matter of leaves (464.1g $plant^{-1}$), dry weight of leaves (51.46 g), fresh matter of root (47.48g) , dry weight of root (6.623g) and total yield (6.770 ton fed^{-1}) in the first season. Whereas the highest value was number of leaves $plant^{-1}$ (50.55), leaf area (349.6 mm^2), fresh matter of leaves (450.1g $plant^{-1}$), dry weight of leaves (49.87g), fresh matter of root (46.77g), dry weight of root (7.600 g) and total yield (7.102ton fed^{-1}) in the second season. The obtained results are in harmony with [28]. Also, [29] and [30] they found that increasing potassium fertilizer levels increased number of leaves / plant and shoot fresh weight and root fresh weight, root yield fresh weight / plant as compared to low potassium yield. Potassium is one of major elements for crop growth and yield development, although it is not an integral component of any cellular organelle or structural part of plant. It is the most abundant cation in plants and is associated or involved with many physiological princesses supporting plant growth and development.

Chemical Constituents: Nitrogen, phosphorus and potassium content of lettuce plants as affected by different rates of compost and potassium fertilizers are shown in Table (4). Results revealed that all treatments tended to increase N, P and K concentration and uptake in the first and second seasons in leaves of lettuce as compared with the control treatment. These results are in a good harmony with [31], [32] reported that the nitrogen, phosphorus, potassium contents in lettuce leaves increased with the application of organic compost reported that the nitrogen, phosphorus, potassium contents in lettuce leaves increased with the application of organic compost. Organic composts increase nutrients content in soil and their availability for plants [33].

The obtained results of both seasons in Table (4) clearly revealed that the maximum N and potassium content was observed when applying a organic amendment at rate of 3ton fed^{-1} with potassium sulphate at a rate of 100 Kg fed^{-1} (N = 2.69 % and 2.60 %) and (K= 2.44 % and 2. 46 %) of leaves in the first and second seasons, respectively. On the other hand, N, P and K concentration tend by increasing with using compost at rate of 2ton fed^{-1} and potassium sulfate at rate of 150 Kg fed^{-1}(N= 2.23% and 2.30%) and (P= 0.26%and 0.27%) and (K= 2.34%and 2. 30%) of leaves in the first and second seasons respectively. [34] found that potassium in organic fertilizers is already mineralized and its availability is similar to potassium derived from mineral fertilizers due to the rapid release of the potassium in organic fertilizers. Also, (35) reported that the highest potassium fertilization at a rate of 75 kg K_2O fed^{-1} gave the highest value of N, P and K content of carrot plants.

Table 3: Effect of different rates of compost and potassium fertilizer on growth and yield of lettuce plant in both seasons of study

Compost rates ton fed^{-1}	Potassium fertilizer K_2O fed^{-1}	Fresh matter of leaves	Dry matter of leaves	Fresh matter of roots	Dry matter of roots	No. of leaves	Leaf area mm^2	Yield ton fed^{-1}
		------------------------------- g			-----------------------------------			
				First season				
Control (RDF)		166.3	25.89	27.44	2.888	26.74	123.6	2.156
1	0	218.5	28.67	29.31	3.923	30.10	144.8	2.776
	50	296.7	32.99	32.78	4.660	33.33	167.3	3.371
	100	317.6	35.91	35.09	4.840	34.33	200.0	3.652
	150	328.8	37.14	36.15	5.613	37.00	203.7	4.181
2	0	256.0	35.88	34.31	4.000	36.44	176.6	3.879
	50	367.3	40.43	38.73	5.453	44.67	232.3	4.621
	100	394.0	42.69	41.23	6.127	41.33	244.3	4.820
	150	410.4	43.39	45.77	6.150	45.67	251.7	5.480
3	0	376.1	37.50	38.80	4.753	38.55	230.8	4.602
	50	424.4	43.57	40.56	5.533	42.00	337.7	5.900
	100	464.1	51.46	47.48	6.623	51.67	355.7	6.770
	150	441.4	47.60	45.80	6.473	46.67	347.3	6.050
LSD $_{0.05}$		19.1	2.37	2.53	0.25	3.10	4.53	0.69
				Second season				
		183.2	24.90	26.15	2.523	27.37	133.6	2.268
1	0	251.3	29.54	30.2	3.3.08	31.70	156.8	3.030
	50	300.1	31.80	31.68	3.870	33.31	172.3	3.370
	100	322.5	35.52	34.87	4.656	34.21	199.7	3.655
	150	333.2	36.94	36.11	5.600	36.88	202.4	4.017
2	0	286.9	37.61	35.11	4.156	37.80	200.6	4.008
	50	372.5	39.32	37.62	5.353	41.23	229.5	4.560
	100	395.8	41.28	40.00	6.022	44.68	238.8	4.782
	150	415.2	43.00	42.56	5.981	45.62	249.5	5.358
3	0	393.1	37.66	37.48	4.920	37.15	253.1	4.386
	50	422.3	43.60	40.01	5.522	42.20	328.9	5.881
	100	450.1	49.87	46.77	7.600	50.55	349.6	7.102
	150	439.5	46.56	44.58	6.756	46.76	340.2	6.000
LSD $_{0.05}$		19.3	2.33	2.51	0.26	3.11	4.55	0.69

It was evident from the obtained data in Table (5) the effect of potassium fertilizer treatments in the presence of organic soil conditioner on the yield quality of lettuce plants, by estimating the lettuce leaves' content of vitamin C and carbohydrates, as well as the plant pigments of chlorophyll A, B and carotenoids.

Increasing the rates of adding potassium fertilizer from 50 to 150 kg fed^{-1} significantly enhanced the content of lettuce leaves from plant pigments, vitamin C and carbohydrates, especially with the increase in the rate of adding organic soil conditioner from 1 to 3 ton per feddan, during the two growing seasons.

Olfati *et al*. [36] reported that increasing lettuce yield quality was dependent on increasing rate applying of compost from 0 to 100 Mg ha^{-1}. Compost is an efficient soil amendment rich in essential nutrients and beneficial elements. Thus improve the nutritional quality of the yield and vitamin C and carbohydrate content of plants [37]. The increase in vitamin C content of lettuce plants may be attributed to the role of potassium in photosynthesis is very important due to the activation of enzymes by K and its involvement in adenosine triphosphate (ATP) production is probably more important in regulating the rate of photosynthesis. As it is known that, ascorbic acid synthesized from sugars supplied through photosynthesis in plants [38]. Potassium played a major role in many physiological and biochemical processes such as cell division, elongation and metabolism of carbohydrates and protein compounds [30]. Anjaiah and Padmaja [39] who found that total carotenoids and total soluble solids increased with increasing levels of potassium fertilization.

Table 4: Effect of different rates of compost and potassium fertilization on N, P and K content of lettuce leaves in both seasons of study

		First season			Second season		
		N	P	K	N	P	K
Compost rates ton fed^{-1}	Potassium fertilization Kg fed^{-1}	%					
Control (RDF)		1.43	0.12	1.68	1.53	0.14	1.70
1	0	1.48	0.15	1.77	1.66	0.15	1.80
	50	1.73	0.16	1.81	1.82	0.17	1.80
	100	1.79	0.19	1.85	1.84	0.19	1.86
	150	1.88	0.22	1.89	1.92	0.21	1.90
2	0	1.61	0.17	1.82	1.66	0.16	1.84
	50	1.96	0.23	1.90	1.95	0.23	1.98
	100	2.09	0.25	1.95	2.11	0.26	2.11
	150	2.23	0.26	2.34	2.30	0.27	2.30
3	0	1.89	0.21	2.00	1.94	0.23	2.09
	50	2.35	0.28	2.35	2.39	0.28	2.35
	100	2.69	0.34	2.44	2.60	0.33	2.46
	150	2.41	0.30	2.40	2.44	0.29	2.42
LSD 0.05		0.51	0.01	0.69	0.53	0.01	0.68

Table 5: Effect of different rates of compost and potassium fertilization on yield quality of lettuce plant in both seasons of study

Compost rates ton fed^{-1}	Potassium fertilizer K_2O fed^{-1}	Carbohydrate %	Vitamin C mg/100gm	chlorophyll a	chlorophyll b	Carotenoids
				mg g^{-1}		
			First season			
Control (RDF)		0.71	2.8	5.44	1.33	1.24
1	0	0.79	3.6	6.30	1.79	1.50
	50	1.02	4.46	7.54	2.58	2.67
	100	1.11	4.40	8.60	2.96	2.94
	150	1.26	4.67	9.27	3.20	3.39
2	0	1.23	3.80	8.31	2.88	3.22
	50	1.50	4.04	9.90	3.43	3.53
	100	2.20	4.43	10.0	3.42	3.56
	150	2.55	4.20	10.6	3.60	3.73
	0	1.86	3.90	9.3	3.67	3.22
3	50	2.40	4.15	10.8	3.66	3.82
	100	2.80	5.70	11.1	3.76	3.95
	150	2.83	5.05	11.5	3.80	3.98
LSD 0.05		0.28	0.32	1.20	0.93	0.95
			Second season			
Control (RDF)		0.75	3.01	6.12	1.58	1.42
1	0	0.85	3.62	6.85	1.97	1.68
	50	1.11	4.26	7.44	2.46	2.45
	100	1.22	4.30	8.52	2.74	2.72
	150	1.30	4.4	9.17	3.10	3.17
2	0	1.37	4.00	8.90	3.00	3.25
	50	1.58	4.14	9.95	3.21	3.41
	100	2.18	4.33	10.0	3.18	3.50
	150	2.45	4..70	10.5	3.34	3.63
3	0	1.94	4.12	9.9	3.41	3.43
	50	2.50	4.45	10.7	3.45	3.72
	100	2.70	5.70	11.9	3.65	3.90
	150	2.70	5.10	11.2	3.46	3.83
LSD 0.05		0.29	0.33	1.26	0.92	0.95

CONCLUSION

The importance of compost is due as a good organic amendment suitable for sandy soil, which improves its natural and chemical properties as well as its fertility, which leads to improving the growth, yield and nutritional status of Batavia lettuce plants. This remarkable good on lettuce plants will only occur in the presence of potassium fertilization, which is added in the appropriate amount to achieve the highest growth, yield and good nutritional status of lettuce plants grown in sandy soil during the two successive growing seasons.

REFERENCES

1. Lebeda,. A., E.J. Ryder, R. Grube, I. DoleŽalovÁ and E. KŘÍstkovÁ, 2007. Lettuce (*Asteraceae*; Lactuca spp.). In: SINGH R.J. (ed.), Genetic Resources, Chromosome Engineering and Crop Improvement, Vol. 3, Vegetable Crops. Boca Raton, CRC Press, Tailor and Francis Group: 377-472.
2. Mota, W.F., R.D. Pereira, G.S. Santos and J.C.B. Vieira, 2012. Agronomic and economic viability of intercropping onion and lettuce. Hortic. Bras., 30: 349-35.
3. Christopoulou, M., S.R.C. Wo, A. Kozik, L.K. McHale, M.J. Truco, T. Wroblewski and R.W. Michelmore (2015). Genome-wide architecture of disease resistance genes in lettuce. G3 (Bethesda, MD), 5(12): 2655-69.
4. Kim, M.J., Y. Moon, J.C. Tou, B. Mou and N.L. Waterland, 2016. Nutritional value, bioactive compounds and health benefits of lettuce (*Lactuca sativa* L.). Journal of Food Composition and Analysis, 49: 19-34.
5. Amoozgar, A., A. Mohammad and M.R. Sabzalian, 2017. Impact of light-emitting diode irradiation on photosynthesis, phytochemical composition and mineral element content of lettuce cv. Photosynthetica, 55: 85-9.
6. Pradeepkumar, T., B.P. Bonny, R. Midhilaa, J. Johnc, M.R. Divya and C.V. Roch, 2017. Effect of organic and inorganic nutrient sources on the yield of selected tropical vegetables. Scientia Horticulturae, 224: 84-92.
7. Sultana, M., M. Jahiruddin, M. Rafiqul Islam, M. Mazibur Rahman and M.d. Anwarul Abedin, 2021. Effects of nutrient enriched municipal solid waste compost on soil fertility, crop yield and nutrient content in brinjal. Eurasian Journal of Soil Science, 10: 191-198.
8. Cunha, E.Q., L.F. Stone, E.P.B. Ferreira, A.D. Didonet and J.A.A. Moreira, 2012. Atributos físicos, químicos e biológicos de solo sob produção orgânica impactados por sistemas de cultivo. Rev. Bras. Eng. Agríc. Ambient., 16: 56-63.
9. Oliveira, L.B., A.M.A. Accioly, C.L.R. Santos, R.A. Flores and F.S. Barbosa, 2014. Características químicas do solo e produção de biomassa de alface adubada com compostos orgânicos. Rev. Bras. Eng. Agríc. Ambient., 18: 157-164.
10. Rekabya, S.A., Mahrous Y.M. Awada, Sabry A. Hegaba and Mamdouh A. Eissa, 2020. Effect of some organic amendments on barley plants under saline condition. Journal of Plant Nutrition, 43: 1840-1851.
11. Insam, H. and M. De Bertoldi, 2007. Microbiology of the composting process. In L.F. Diaz, M. de Bertoldi, W. Bidlingmaier and E. Stentiford (Ed.), Waste Management Series, Amsterdam, The Netherland, 8: 25-48.
12. Dimitri, C.L. Kemp, J. Sooby and E. Sullivan, 2012. Organic Farming for Health and Prosperity. Organic Farming Research Foundation. Washington, D.C. Ofrf.org., pp: 75.
13. Kranz, C.N., R.A. McLaughlin, A. Johnson, G. Miller and J.L. Heitman, 2020. The effects of compost incorporation on soil physical properties in urban soils - A concise review. Journal of Environmental Management, 261: 1-10.
14. Mengel, K. and E.A. Kirkby, 2001. Principles of Plant Nutrition. 5th Ed. London, Kluwer Academic Publishers.
15. Makus, D.J., 2010. Impact of Potassium Nutrition on Food Quality of Fruits and Vegetables: A Condensed and Concise Review of the Literature. Better Crops 94: 18-21.
16. Bernardes Cecílio Filho, Alexson Filgueiras Dutra and Gilson Silverio Da Silva, 2017. Phosphate and potassium fertilization for radish grown in a latosol with a high content of these nutrients. Revista Caatinga, 30(2).
17. Zahoor, R.H. Dong, M. Abid, W. Zhao, Y. Wang, Z. Zhou, 2017. Potassium fertilizer improves drought stress alleviation potential in cotton by enhancing photosynthesis and carbohydrate metabolism. Environmental and Experimental Botany, 137: 73-83.
18. Cottenie, A., M. Verloo, L. Kiekens, G. Velghe and R. Camerlynck, 1982. Chemical Analysis of Plant and Soil, pp: 100-129. Laboratory of Analytical and Agrochemistry, State Univ. Ghent. Belgium.

19. Moran, R., 1982. Formulae for determination of chlorophyllous pigments extracted with N, N-dimethylformamide. Plant Physiol., 69: 1376-1381.
20. Dubois, M., K.A. Gilles, J.K. Hamilton, P.A. Rebers and F. Smith, 1956. Colorimetric method for determination of sugars and related substances. Anal.Chem., 28: 350.
21. A.O.A.C., 1995. 'Official methods of Analysis'. Association of official analytical chemist. 16th edition, Washington DC.
22. Snedecor, G.W. and W.G. Cochran, 1980. Statistical Methods. 7th ed., Iowa State Univ. Press, Ames, Iowa, USA.
23. Abd El-Fattah A. Daila, F.A. Hashem and Abd-Elrahman H. Shaimaa, 2022. Impact of applying organic fertilizers on nutrient content of soil and lettuce plants, yield quality and benefit-cost ratio under water stress conditions. Asian J. Agric & Biol., (2).
24. Suwor, P., S. Jeakkhajorn and S. Kramchote, 2020. Effects of different compost manures application on growth of lettuces (*Lactuca sativa* L.). International Journal of Agricultural Technology, 16: 1257-1266.
25. Zheljazkov, V.D. and P.R. Warman, 2004. Source-Separated Municipal Solid Waste Compost Application to Swiss Chard and Basil. J. Environ. Qual., 33: 542-552.
26. Saison, C., V. Degrange, R. Oliver, P. Millard, C. Commeaux, D. Montange and X. Le Roux, 2006. Alteration and resilience of the soil microbial community following compost amendment: Effects of compost level and compost-borne microbial community. Environ. Microbiol., 8: 247-257.
27. Hepperly, P., D. Lotter, C.Z. Ulsh, R. Seidel and C. Reider, 2009. Compost, manure and synthetic fertilizer influences crop yields, soil properties, nitrate leaching and crop nutrient content. Compost Sci Util., 17: 117-126.
28. Hossain, M.B. and K.S. Ryu, 2017. Effects of organic and inorganic fertilizers on lettuce (*lactuca sativa* L.) and soil properties. AARC J. Agri., 15: 93-102.
29. Hossain, A.K.M.M., M.R. Islam, M.S. Bari, M.H.A. Amin and M.A. Kabir, 2009. Effects of mulching and levels of potassium on growth and yield of carrot. Bangladesh Research Publications Journal, 3: 963-970.
30. Saud, S., J. Chun, M. Razaq, M. Luqman, S. fahad, M. Abdullah and A. Sadiq, 2013. Effect of potash levels and row spacing on onion yield. Journal of Biology, Agriculture and Healthcare, 3: 118-127.
31. Vilas, B.R.L., J.C. Passos, D.M. Fernandes, L.T. Bull, V.R.S. Cezar and R. Goto, 2004. Efitos de doses de compostos organicos na producao de alface em dois solos sob ambiente protegido. Horticultura Brasileira, 22: 28-34.
32. Souza, P.A., M.Z. de Negreiros, J.B. de Menezes, F. Bezerra Neto, G.L. Souza, C.R. Carneiro and R.C. Queiroga, 2005. Chemical evaluations of lettuce leaves grown under the residual effect of soil fertilized with organic compost. Hortic. Bras., 23: 754-757.
33. Boldrin, A., J.K. Andersen, J. Moller, T.H. Christensen and E. Favoino, 2009. Composting and compost utilization: accounting of greenhouse gases and global warming contributions. Waste Manag. Res., 27: 800-812.
34. Ernani, P.R., J.A. Almeida, F. Santos and C. Potassium, 2007. In: Novais RF (Org). Fertilidade do Solo (Soil Fertility). Sociedade Brasileira de Ciência do Solo.
35. Abou El-Nasr, M.E. and E.A. Ibrahim, 2011. Effect of different potassium fertilizer rates and foliar application with some sources of potassium on growth, yield and quality of carrot plants (*Daucus carota* L.). Plant Production, Mansoura Univ., 2: 559-569.
36. Olfati, J.A., G. Peyvast, Z. Nosratie-Rad, F. Saliqedar and F. Rezaei, 2009. Application of municipal solid waste compost on lettuce yield. International Journal of Vegetable Science, 15: 168-72.
37. Seran, T.H., S. Srikrishnah and M.M.Z. Ahamed, 2010. Effect of different levels of inorganic fertilizers and compost as basal application on the growth and yield of onion (*Allium cepa* L.). The Journal of Agricultural Sciences, 5: 64-70.
38. Lee, S.K. and A.A. Kader, 2000. Preharvest and postharvest factors influencing vitamin C content of horticultural crops. Postharvest Biol. and Techn., 20: 207-220.
39. Anjaiah, T. and G. Padmaja, 2006. Effect of potassium and farm yard manure on yield and quality of carrot. Journal of Research ANGRAU., 34(2): 91-93.