Use of foliar fertilizers, poultry manure and plant compost for better cabbage growth and yield

Mohammed Sahib Hadi Al-Kemawee and Zainab Hassan Thajeel

Department of Horticulture and Landscape, Faculty of Agriculture, University of Kufa, Najaf-54001, Iraq

*E-mail: msahb4380@gmail.com

Coauthor E-mail: zainab.alkhuzaie@uokufa.edu.iq

Abstract

The study was conducted to evaluate efficacy of complete and rational poultry manure to palm fronds compost and foliar fertilization on growth and yield of cabbage. The experiment was RCBD factorial with three replication (4 x 3) of two factors: the first is organic fertilizer at 4 levels: control, chicken manure CM 100g/plant, palm frond compost PFC 100g/plant, or PFC:CM 50:50 g/plant, while the second factor was foliar organo-fertilizer at 0-, 2- and 4 ml. L-1. The results showed that using CM 100g. plant-1 improved plant height and yield indicators, head diameter and head height. While fertilization with 100g. plant-1 PFC led to a significant increase in number and dry weight of outer leaves compared to the control. The treatment 50:50g PFC/CM showed a significant increase in the number of inner leaves and leaf area, yield of fresh weight of head and total yield compared to the control. The foliar fertilizer at 4 ml. L-1 increased significantly ($P \leq 0.05$) all the growth and yield studied indicators. The interaction of 100g. plant-1 CKM and spraying with 4 ml. L-1 foliar fertilizer resulted in much higher ($P \leq 0.05$) increase in plant height, head diameter, and head height. While, the dry weight of outer leaves was at highest in the interaction of PFC 100g. plant-1 and foliar fertilizer 4 ml. L-1. However, the 2 ml. L-1 water foliar fertilizer and 100 g. plant-1 PFC recorded the highest significant ($P \leq 0.05$) increase in the number of outer leaves. The soil balanced fertilization PFC/CKM 50:50 in the presence of foliar spray 4 ml. L-1 recorded the highest value in the number of inner leaves, leaf area, head fresh weight, and total yield.

Keywords: Cruciferae, ground application, organic agriculture, sustainable Agronomy

Introduction

The Cruciferae plant family has important leafy crops especially the winter leafy Cabbage Brassica oleracea var. capitata L., which is widely cultivated in Iraq (21). This plant family includes 300 genera and 3000 species of plants that are distributed all over the world. They are biennial plants, but grown annually for their heads. Their species differ in color, leaf nature, shape, and head size (24). Cabbage annual global production was estimated to 71,707,238.96 tons cultivated on 2,450,601 hectares, with an approximately 29,261 tons. h-1. Iraq cultivates about 1,100 hectares, with a total production of 11,687 tons, with an average productivity of 10,622 tons. h-1 (7). Added fertilizers, especially chemical fertilizers, play a significant role in increasing productivity, despite the associated harm to human health through increased nitrates and oxalates, which result in toxic effects in the edible portion of the crop. Excessive chemical fertilizer application is usually expensive and often followed by a deterioration of the physical and chemical properties of the soil. Therefore, there has been a shift toward using organic fertilizers in various forms, such as farm waste, poultry

ISSN 2072-3857

manure, or palm frond waste, which have demonstrated clear positive effects on the physical and biological properties of various crops. Organic fertilizers are a sustainable source of nutrients for plants, are environmentally safe, improve soil quality, increase its water-holding capacity, and enhance its high cation exchange capacity, they also promote the growth of a variety of beneficial microorganisms in the soil (12). It has been observed that the nutritional value of organic fertilizers is high, the quality of head preservation is enhanced by the application of organic fertilizer, which indirectly enhances root growth and improves leaf area growth, thus nutrient availability, crop yield, and quality (22). Foliar fertilization is an effective means of supplying plants with nutrients, these nutrients are absorbed through the leaf surfaces, either through the stomata or through the microscopic cracks that occur in the waxy layer covering the leaf surfaces, or through both routes (9). Foliarly applied nutrients is used to enhance the growth and productivity of leafy green plants in particular, by applying nutrient solutions directly to the leaves (17). It is an effective, rapid, and complementary method of supplying nutrients to plants, especially in difficult environmental conditions such as environmental stress or salinity soil, thus improving growth and productivity by increasing leaf size in leafy crops (19). Therefore, this study aimed to evaluate the effect of complete and rational of poultry manure and palm fronds compost and foliar fertilization on growth and yield indicators of cabbage crop.

Materials and Methods

The experiment was conducted at the Research Station, College of Agriculture, University of Kufa, in the field during the growing season of 2024. The factorial experiment (4 x 3) was implemented to determine the response of cabbage plant to fertilization with organic fertilizer (chicken manure with or without palm frond compost) and fertilization with liquid organic foliar fertilizer in terms of vegetative growth and yield. The experiment was three replication RCBD factorial (4 x 3) with two factors: the first is four levels of organic fertilizer as soil amendment: control, chicken manure CKM 100g plant-1, palm frond compost PFC 100g plant-1, or PFC:CM 50:50 g plant-1, while the second factor was three concentrations of organic foliar fertilizer (0, 2, 4) ml. L-1

Cabbage seeds (Club Star F1 variety produced by Alsa Holland) were sown on 15/8/2024 in cork trays (11 x 18) filled with peat moss with one plant per hole. After 45 days, when 4-5 true leaves appeared and the plant was approximately 10-15 cm tall, the plants were transferred to the field on 29/9/2024 in holes on terraces in two rows, the experimental unit was 3 m long and 1 m wide, the distance between each plant is 50 cm, and the distance between terraces is 1 m. The experimental unit area is 3 m2, 12 plants/experimental unit. All services, irrigation, weeding and pest control were carried out according to the plant's needs. Liquid organic foliar fertilizer was sprayed on 10/20/2024, the second spray was 28 days after the first spray and the third spray was 28 days after the second spray. The adhesive spreader (Mogent Lineco, Spanish made) was added at a rate of 1 ml/L of water to the spray solution to increase the absorption efficiency through the leaf surface and improve the fertilization efficiency (8). Barriers were placed between treatments during the spraying, which was carried out in the early morning using a 15-liter backpack sprayer.

Statistical analysis

At the end of the experiment, data were collected and statistically analyzed using the computing software statistical program GenStat 12th edition (23), where the averages were compared among treatments for significant differences according to Duncan's multiple range tests ($P \leq 0.05$.(

ISSN 2072-3857

Table 1. Content analysis of the organic fertilizers: poultry manure and palm frond compost, used in the study

Property/content	Poultry manure	Palm frond compost
pH	7.72	7.51
)cm/(ms EC	50.3	41.1
N(%)	1.06	2.1
P(%)	1.037	0.36
K(%)	0.818	0.6
C	16.74	36.62

Table 2. Constituents of the foliar organic liquid fertilizer used in the study

Constituents	Value w/v
Organic Extract	11.25
Phosphorus (P2O5)	1.33
Potassium (K2O)	2.65
Zinc	1.33
Iron	1.27
Manganese	1.33

Studied Indicators

Data were collected for six plants from each experimental unit, including: vegetative growth indicators: plant height (cm), and number of outer and inner leaves (leaf. plant-1). Leaf area (cm2 leaf-1) was calculated for three leaves of different sizes from three plants using a scanner and Image-J software (18). The dry weight of outer leaves (g. plant-1) was estimated. Yield indicators also included head diameter (cm) between the two farthest points, head height (cm), fresh head weight (g. plant-1) after removing unfit leaves, and total yield (tons. ha-1.(

Results and Discussion

Vegetative Growth Indicators

The results of Table (3) showed that the use of organic poultry manure fertilizer at a level of 100 g plant-1 significantly increased plant height 19- 26 cm compared to the control of 17-20 cm. Similarly, palm frond compost at a level of 100 g. plant-1 increased number of leaves to 18.3 leaves plant-1 and outer leaf dry weight 80.8 g compared to the control of 13.4 leaves plant-1 and 58.9 g respectively. Liquid organic foliar fertilizer (4 ml. L-1 water) also had a significant effect on plant height, outer leaf dry weight, inner leaf number, and leaf area. Foliar spray at 2 ml. L-1 had a greater effect on the number of outer leaves than other levels. The use of poultry manure and decomposed palm fronds at an equal ratio of 50:50 had in the presence of foliar fertilizer greater increase in most of the vegetative growth indicators under study. The interaction of poultry manure 100 g. plant-1 and foliar fertilizer 4 ml. L-1 recorded the highest increase in plant height of 26.13 cm compared to the control treatment of 17.10 cm. While the interaction of palm frond compost 100 g. plant-1 and foliar fertilizer 2 ml. L-1 water gave the highest increase in the number of outer leaves of 18.324 leaves plant-1 compared to the control treatment of 13.297

ISSN 2072-3857

leaves plant-1. The interaction of palm frond compost (100 g. plant-1) and foliar fertilizer (4 ml. L-1) achieved the highest significant increase in the dry weight of outer leaves of 80.841 g compared to the control treatment of 58.021 g. The interaction using 50:50 poultry waste, palm frond compost and foliar fertilizer 4 ml. L-1 water achieved a significant increase in the number of inner leaves, leaf area (with the highest increase reaching (48.55 leaves, 172.44 cm2) respectively compared to the control treatment which recorded (27.00 leaves, 154.02 cm2) respectively.

Table3. effect soil amendment with poultry manure and/ or plant compost in the presence of foliar fertilization on Cabbage growth parameters

Organic solid fertilizer g. plant^{-1}	Foliar liquid fertilizer FLF ml L^{-1}	Plant Height	No. of outer leaf (Leaf. Plant^{-1})	Outer leaf (Dry weight)	No. of inner leaf (Leaf. Plant^{-1})	leaf area cm^2
Control	**0**	17.1	13.297	58.021	27	154.02
	2	20.17	13.227	57.874	32.76	156.79
	4	18.88	13.487	58.904	37.05	158.85
CKM 100	**0**	19.12	14.169	62.743	35.7	163.92
	2	18.5	14.385	64.056	43.11	158.97
	4	26.13	14.674	70.087	38.12	161.57
PFC 100	**0**	18.18	15.443	68.627	35.64	152.78
	2	18.42	18.324	71.082	43.38	167.91
	4	18	17.245	80.841	43.08	159.67
CKM: PFC 50: 50	**0**	20	14.976	66.74	42.46	160.19
	2	19.27	17.109	78.191	46.87	167.43
	4	19.63	17.078	75.028	48.55	172.44
L.S.D. ($P\leq0.05$)	**CKM**	1.824	0.3526	0.3351	0.903	0.712
	PFC	0.912	0.3054	0.2902	0.782	0.617
	Interaction	1.053	0.6107	0.5804	1.563	1.233

*Values are means of 3 replications, treatments are: foliar commercial fertilizer FLF (ml. L-1), chicken manure CKM and palm frond compost PFC at 50 or 100g. plant-1

The results indicated improved vegetative growth characteristics of lettuce plants grown in soil treated with chicken manure fertilization, as poultry manure was found to improve the physical condition of the soil and increase the activity of beneficial soil microorganisms. Moreover, poultry manure contains all essential macro- and micronutrients. This in turn, encourages the plant to produce auxins and synthesize amino acids and proteins, which are important for chlorophyll synthesis, increased availability of amino acids and nitrogen enhances chlorophyll synthesis, leading to increased chlorophyll levels within plant cells. This increase in chlorophyll reflects higher efficiency of photosynthesis and carbohydrates metabolism in plant growth indicated by cell division, elongation, and volume increase, thus leading to increased plant vegetative growth indicators (1, 2.(

In the same context, palm frond compost continuously adds nutrients to the soil, which may restore its nutrient balance (11). Compost helps improve soil porosity and its ability to hold and regulate water and air movement, making the soil loose and allowing plant roots

ISSN 2072-3857

to penetrate and spread. This increases root activity in absorbing water and nutrients, i.e., increasing root growth and, consequently, increasing plant growth (4, 6.(

The clear improvement in vegetative growth in foliar fertilizer treatments is generally due to the nutrients present in the compost, the fertilizer combination, especially phosphorus, potassium, and trace elements, contributes to stimulating cell division and elongation, leading to increased vegetative growth by increasing leaf number and leaf area. Foliar nutrients also increase the leaf's ability to photosynthesize, thereby increasing substances level produced by the leaves, thus increasing yields in both quantity and quality and improving plant characteristics (16). Several studies have shown that foliar spraying with elements such as phosphorus and potassium, in addition to micronutrients such as iron and zinc, leads to a significant increase in plant height, due to their role in stimulating cell division and expansion in growing tissues. These elements also contribute to enhancing leaf formation and improving their physiological efficiency, which is reflected in increased leaf dry weight, as an indicator of dry matter accumulation and improved photosynthesis (9). The number of cabbage leaves, a key indicator in assessing head quality and size, has been observed to significantly increase with foliar fertilization, which is mostly due to improved balanced plant growth and the encouragement of the formation of overlapping leaves that form the head. Furthermore, the total leaf area increases, which It improves the plant's ability to absorb light and carry out vital processes more efficiently, which ultimately leads to increased overall yield and quality (19 .(

Yield parameters

Regarding the effect of treatments on yield indicators, it was noted (Table 4) that the use of poultry manure fertilization at (100 g. plant-1) significantly increased head diameter and head height, while the use of a balanced fertilizer (50:50 CKM: PFC) had greater effect on fresh head weight and total yield (Table 4 and Figure1). An increase in head diameter, head height, fresh head weight, and total yield was also observed using foliar fertilization, especially at 4 ml/L, compared to spraying at 2 ml. L-1 or the control. Similarly, it was observed that the highest yield values were in the interaction treatment of 100 g. plant-1 poultry manure (CKM) or palm frond compost (PFC) in the presence of foliar fertilizer at 4 ml. L-1 with foliar fertilizer recording significant increase in cabbage head diameter and cabbage head height with values of 17.216 cm and 17.90 cm compared to 13.066 cm and 12.42 cm in the control, respectively. While, the interaction treatment of balanced fertilizer 50:50 CKM: PFC and foliar fertilizer at 4 ml L-1 achieved the highest significant head fresh weight 1356.4 g, and total yield 54.61 tons.h-1 compared to the control, where the total yield was increased by 110% over the control (Figure1.(

The humic acids in these fertilizers enhance the activity of soil microorganisms, accelerating the process of phosphorus mineralization and making it more available to plants. Additionally, these organic materials contribute to the transport of nutrients from the leaves to the heads, leading to increased cell volume and overall improved crop quality. Poultry manure contains most of the essential plant nutrients, such as nitrogen, potassium, and phosphorus, in addition to other elements important for plant growth and fruiting (5, 10). Organic fertilizers are characterized by their content of humic and fulvic acids that increase the cation exchange capacity (CEC) in the soil, enhancing its ability to retain nutrients (26). These acids contribute to the formation of natural chelating compounds that play an important role in fixing nutrients, especially microelements in the soil (13 (

ISSN 2072-3857

Table4. effect soil amendment with poultry manure and/ or plant compost in the presence of foliar fertilization on Cabbage yield components

Organic fertilizer solid	Foliar fertilizer liquid	Head diameter	Head height	Head FW	total yield
OSF	FLF				
g. plant^{-1}	ml L^{-1}				
	0	13.066	12.42	648.2	25.92
Control	**2**	13.343	13.04	707.8	28.31
	4	13.27	12.33	770.4	30.82
	0	14.62	14.23	817.9	32.72
CKM	**2**	15.703	12.38	847.8	33.91
100	**4**	17.216	17.9	887.6	35.50
	0	13.734	11.21	905.2	36.21
PFC	**2**	13.94	12.33	942.9	37.72
100	**4**	14.602	12.08	1113.1	44.52
	0	14.044	15.08	1175.2	47.01
CKM: PFC	**2**	15.686	12.79	1275.1	51.00
50: 50	**4**	15.046	14.3	1356.4	54.61
L.S.D. ($P \leq 0.05$)	**OSF**	0.1489	0.828	26.88	**2.044**
	FLF	0.129	0.717	23.28	**1.926**
	Interaction	0.2579	1.434	46.56	**3.677**

*Values are means of 3 replications, treatments are: foliar commercial fertilizer FLF (ml. L-1), chicken manure CKM and palm frond compost PFC at 50 or 100g. plant-1

ISSN 2072-3857

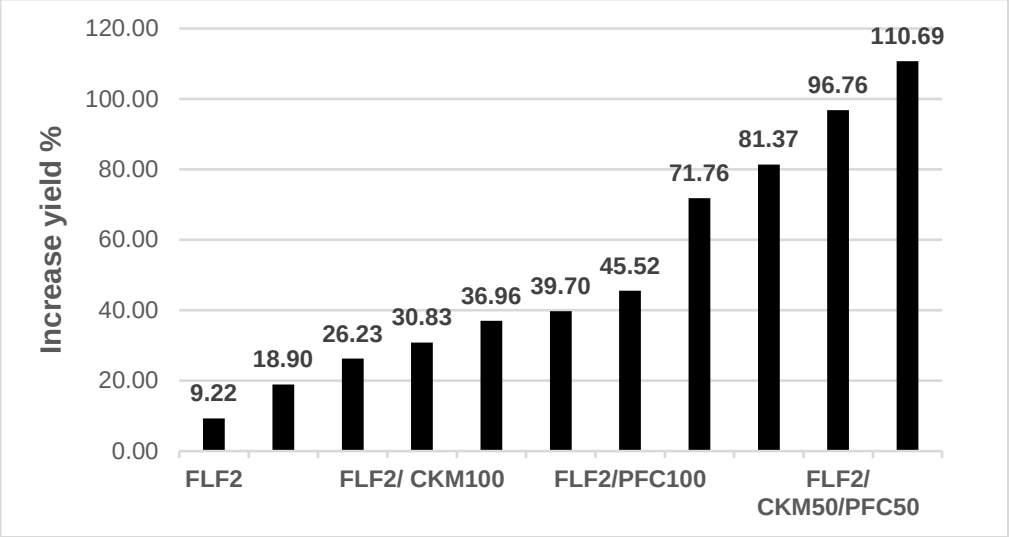

Figure1. Percent increase over the control of cabbage yield as affected by different fertilization types and levels. Where the treatments are: foliar commercial fertilizer FLF (ml. L-1), chicken manure CKM and palm frond compost PFC at 50 or 100g. plant-1

Generally, compost of palm frond waste often releases nitrogen and potassium, which are important in photosynthesis processes, potassium plays a vital role in activating the carbon synthesis process and transporting the materials manufactured in the leaves to be stored in the heads. Potassium is necessary for transport processes across cell membranes, which is reflected in increasing the plant shoot weight and the yield. The role of potassium in the crop is also attributed to its accumulation in cells, cell expansion and increase in size, and the presence of potassium in cells works to stabilize the acidity of the cytoplasm (pH) as well as regulate the osmotic pressure of the cells, which contributes to increasing the size of the cells (14, 15.(

It is no doubt that organic acids, when sprayed on the vegetative parts of plants, can enhance the permeability of cell membranes, facilitating the movement of nutrients within the plant, the availability and increase of added elements increase the plant's ability to absorb nutrients and thus increases the permeability of these materials through the stomata, which leads to enhancing the plant's absorption in general (16). They also contribute to increasing the total amount of nutrients absorbed by the roots by contributing to the development of a healthy root system (3, 25). The increase in vegetative growth due to organic foliar fertilizer increased the number of leaves and leaf area, thus increasing dry matter weight and total yield, this is coupled with the foliar fertilizer's content of macronutrients, phosphorus and potassium, and micronutrients, iron, zinc, copper, and manganese. Phosphorus is one of the essential elements for plant nutrition, it plays a major role in photosynthesis, protoplasm, and respiration, it is also involved in the formation of energy compounds (ADP) and (ATP) (15). Potassium is important in increasing energy and has a positive impact on increasing the utilization of nitrogen and phosphorus and controlling the vital activities associated with plant growth and enzyme activation, most of which are involving in the transfer of sugars from the leaves to other parts of the plant and increasing the concentration of carbohydrates (20.(

ISSN 2072-3857

Conclusion

The results of the study demonstrated the possibility of increasing the growth and yield of cabbage using foliar fertilizer, especially those containing nutrients in balanced proportions suitable for vegetative fertilization. Spraying with organic nutrient concentrations indicated that most of the characteristics showed a gradual increase with increasing concentrations used within the limits of this study, especially using the concentration of 4 ml. L-1. Although chicken manure or palm frond compost at 100 g. plant-1 showed a clear improvement in plant growth and yield, the best results were achieved using a equivalent combination of the two fertilizers (CKM/PFC 50:50 g. plant-1). It was also found that the latter was the best when combined with foliar spraying with commercial organic fertilizer at 4 ml. L-1 in achieving the highest growth and yield indicators.

References

.1 Abdel-Mouty, M., Mahmoud, A. R., El-Desuki, M., & Rizk, F. A. (2011). Yield and fruit quality of eggplant as affected by organic and mineral fertilizers application. Res. J. Agric. Biol. Sci, 7(2), 196-202.

.2 Al-Dulaimy, Q. Z. A. (2022). Effects of planting date and spraying with organic fertilizers on vegetative growth indices of dill plant (Anethum graveolens L.). Tikrit Journal for Agricultural Sciences, 22(2), 45–56.

.3 Barış, S., Gülser, F., & Candemir, F. (2013). The effects of humic acid applications on nutrient uptake of pepper plants. Journal of Agricultural Faculty of Gaziosmanpasa University, 30(1), 15–22.

.4 Barsyme, A. N., Ahmed, S. M.,&Salman, A. A. (2010). Effect of organic fertilizers on growth and productivity of some vegetable crops. Egyptian Journal of Agricultural Research, 88(3), 521–535.

.5 Bot, A., and Benites J. 2005. The importance of soil organic matter, FAO Soils Bulletin.

.6 Dinel, H., Schnitzer, M., & Paré, T. (1991). Chemistry and biology of humic substances in soil. In Soil Biochemistry (Vol. 6, pp. 139–168.(

.7 FAO. 2020. The State of World Fisheries and Aquaculture 2020. Sustainability in action. Rome.

.8 Fernández, V., Eichert, T. (2009). Uptake of hydrophilic solutes through plant leaves: current state of knowledge and perspectives of foliar fertilization. Critical Reviews in Plant Sciences, 28(1-2), 36–68. https://doi.org/10.1080/07352680902743069

.9 Fernández, V., Gil-Pelegrín, E., Eichert, T. (2021). Foliar Water and Solute Absorption: An Update. Plant J. 2021, 105, 870- 883. [CrossRef] [PubMed[

.10 Hamidu, J.A., Osie-Adjei, A., & Oduro-Owusu, A.D. 2024. Poultry waste management – manure. In Encyclopedia of Meat Science. https://doi.org/10.1016/b978-0-323-85125-1.00136-8

.11 Hao, X. H., S. L. Liu, J. S. Wu, R. G. Hu, C. L. Tong and Su, Y. Y. (2008). Effect of long–term application of inorganic fertilizer and organic amendments on soil organic matter and microbial biomass in three subtropical paddy soils. Nutr.Cycling in Agroeco

.12 Islam, M., Ferdous, G., Akter, A., & Hossain, M. (2017). Efect of organic fertilizers and plant spacing on the growth and yield of cabbage . Agriculture , 7(4) ,Article 31 . cross Ref

.13 Mabagala, F. S. (2022). On the tropical soils; The influence of organic matter (OM) on phosphate bioavailability. Saudi Journal of Biological Sciences, 29(5), 3635-3641.

.14 Marschner, P. (2012). Marschner's mineral nutrition of higher plants (3rd ed.). Academic Press.

.15 Mengel, K., & Kirkby, E. A. (2012). Principles of plant nutrition. Springer Science&Business Media.

.16 Naseem, M.J., Hussain, M.A.A. and Mohammed Ali, W.H. (2019) Basics of Plant Nutrition. Alexandria University-Faculty of Agriculture, Saba Pasha, Egypt

.17 Niu, J., Liu, C., Huang, M., Liu, K., & Yan, D. (2021). Effects of foliar fertilization: a review of current status and future perspectives. Journal of Soil Science and Plant Nutrition, 21(1), 104-118.

.18 Sadik, K.s., N.S. Al-Taweel, D. hyeab and Khalaf M.Z. (2011). New computer program for estimating leave area of several vegetable crops. American. Eurasian Journal of Sustainable Agriculture, 5(2): 304-309.

.19 Scientia Horticulturae. (2023). Foliar application of nutrients improves growth and productivity of leafy vegetables under abiotic stress conditions. Scientia Horticulturae, 316, 112065. https://doi.org/10.1016/j.scienta.2023.112065

.20 Shabala, S., Wu, H.,&Bose, J. (2022). Potassium in plant physiology: Roles in growth, signaling, and stress tolerance. Plant Physiology, 188(2), 531–547. https://doi.org/10.1093/plphys/kiac016

.21 Tawfiq, G. K.,&Al-Sahaf, F. H. (2017). Role of different manure source and level on quantitative and qualitative characteristics of cabbage and spinach yield. Kufa Journal For Agricultural Sciences, 9(1), 267-239.

.22 Timsina ,J.(2018) .Can organic sources of nutrients increase crop yields to meet global food demand ?Agronomy,8(10),1020.cross Ref.

.23 VSN International (2009) GenStat for Windows 12th Edition. VSN International, Hemel Hempstead, UK.

.24 Welbaum, G. E. (2015). Vegetable production and practices. CABI.

.25 Yadav, A., Kerketta, A., & Topno, S. E. (2022). Effect of Organic Fertilizers on Growth, Yield and Quality of Cauliflower (Brassica oleracea var. Botrytis.). International Journal of Environment and Climate Change, 12(11), 1079-1085.

.26 Yang, X., Kong, Y., Guo, E., Chen, X., & Li, L. (2022). Organic acid regulation of inorganic phosphorus release from Mollisols with different organic matter contents. Soil Use and Management, 38(1), 576-583.

ISSN 2072-3857