Biological Forum – An International Journal 16(3): 175-180(2024)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Growth and Yield Enhancement of Carrot (*Daucus carota* L.) through Treated Ganga Sludge-based Organic Fertilizers

Acharya Balkrishna[1, 2, 3], Ajay Kumar Gautam[1, 3], Nidhi Sharma[1], Vedpriya Arya[1, 2] and Vikram Khelwade[1]*
[1]*Patanjali Herbal Research Department, Patanjali Research Institute, Haridwar (Uttarakhand), India.*
[2]*Department of Allied Sciences, University of Patanjali, Haridwar (Uttarakhand), India.*
[3]*Patanjali Organic Research Institute (PORI), Padartha, Laksar Road Haridwar (Uttarakhand), India.*

(Corresponding author: Ajay Kumar Gautam)*
(Received: 15 January 2024; Revised: 30 January 2024; Accepted: 22 February 2024; Published: 15 March 2024)
(Published by Research Trend)

ABSTRACT: During the present study, the effects of different Ganga sludge based organic fertilizers were investigated on the growth and yield attributes of carrot (*Daucus carota*). Six fertilizers Jaivik Prom, Pori Potash, Dharti ka Chaukidar, Jaivik Poshak, Jaivik Khad prepared from treated Ganga sludge were analyzed during the present study using a randomized complete block design (RCBD). A total of six fertilizer treatments and one control in three replications were used to study the effects of fertilizer application on length, Shoot and root biomass, area & number of leaves and root biomass & root diameter. All organic fertilizers showed positive impacts on the growth and yield of carrot crop, the superior performance was observed in the combination of potassium fertilizer and Javik Khad (T6) in various growth parameters. Similarly, T5 (Jaivik Khad) performed well in improving leaf area, fruit weight and total yield per plot. In addition, other treatments also exhibited a notable effect on different plant parameters. These results justified the potential of organic fertilizers in improving the growth and yields of crops in a safer and environmentally friendly way. Moreover, the production of organic fertilizers not only provide safer and environmentally friendly way of Ganga sludge management but providing a best alternative to chemical fertilizers. More research should be carried out on sludge-based organic fertilizers like processing, production and field application at laboratory level and on multiple field crops.

Keywords: Agriculture, carrot, sludge management, growth parameters, organic fertilizers, yield.

INTRODUCTION

The production of sewage sludge is now considered as one of the biggest challenges that poses environmental and health challenges. The contamination of water with sludge presents a big problem to deal with, and the numerous health impacts among users and consumers also pose a great concern to be considered (Bozkurt and Yarilgac 2003). There are several methods including incineration, sanitary burial and composting which are currently used to treat sludge, but their management is still a big deal both in economic and environment-friendly ways (Smith, 2009; Tchounwou *et al.*, 2012). Many incidences have been reported where farmers are using sewage sludge directly in their agriculture farms (Muter *et al.*, 2022). However, the presence of toxic heavy metals (Pb, Cd, Ni, Cr, Hg) along with pathogenic coliform has bacteria raised a serious concern over their direct use in field crops. Hence, it is necessary to process the sludge well to reduce all harmful components to atleast their safer limit before using them (Przewrocki *et al.*, 2004). As sewage waste encompasses a repertoire of essential plant nutrients, harnessing it for agricultural purposes, however, holds a promising solution. The sewage sludge also serves as a reservoir of organic matter that can not only foster soil fertility but also augment soil properties through the integration of organic components (Elmi and AlOlayan 2020). Therefore, the management of sewage sludge by its use in agriculture sector has become one of the key areas due to the presence of high organic carbon (OC), nitrogen (N) and phosphorous (P) content (Camargo *et al.*, 2016; Velasco *et al.*, 2021; Ali *et al.,* 2021). Utilizing them as organic fertilizer is a preferable substitute for synthetic fertilizers and an environmentally responsible method of management.

The use of organic fertilizers has now become a major part of the agriculture system. Because of the potential to alleviate the overall growth and production of crops, their positive effects may be variable as per the type, quality and quantity of their raw materials (Cen *et al.,* 2020; Riadi *et al.*, 2022). The presence of a sufficient amount of organic material, the wastes from agriculture and food industries, as well as the wastes generated as city compost, are now being utilized in the production of organic fertilizers (Velasco-Munoz *et al.,* 2021). The positive effects of various organic fertilizers on the growth and yield of several crops have already been studied. The improved soil properties as well as the growth and development of crops like red lettuce (Masarirambi *et al.,* 2010); mungbean (Abbas *et al.,* 2011); potatoes and peas (Wazir *et al.,* 2018) and many more have justified the beneficial effects of organic fertilizers.

Carrot is one of the major vegetable crops grown throughout the world (Cho *et al.*, 2021) and considered to be an important economical vegetable as it has a large yield per unit area (Sikora *et al.*, 2020). Besides, vitamin A and fiber, carrot is also enriched with carbohydrates, protein, minerals, fibers, iron and so on (Khomich *et al.*, 2020). From therapeutic point of view, carrot is more useful in curing human diseases, especially eyesight (Nagraj *et al.*, 2020). This root vegetable is used for different purposes in daily human diet and its roots are eaten uncooked in steamed or boiled vegetable salad and can also be used in soup and other foodstuff (Rahman *et al.*, 2020). Taking into consideration the beneficial aspect of integrated fertilizers, an experiment was conducted to study the effects of organic fertilizers based on treated sewage sludge of Ganga on the growth and yield of this useful crop carrot (*Daucus carota* L.).

MATERIALS AND METHODS

Experimental Site. This study was carried out at experimental farms of Patanjali Research Institute (PRI), Haridwar, India. The experimental area is located at 29° 54′ 49″ N and 77°59′ 51″ E and 314 m (1,030 ft) above sea level between September to December 2022 to May 2023. This area received total precipitation of 16.5mm with 27°C maximum and 7°C minimum temperature during the study. Soil samples were collected (0 – 20 cm depth) before the implementation of the field trial to determine the properties of soil likeavailable nitrogen, EC, organic carbon, pH, phosphorus and potassium as per the standard procedures (Jackson, 1973).

Processing of Ganga Sludge Samples. The Ganga sludge samples collected from the Sludge Treatment Plant (STP) located at the Jagjeetpur area of district Haridwar, Uttarakhand, India were processed at Patanjali Organic Research Institute (PORI) into five different organic fertilizer products based on the patented technology of Patanjali (Patent application number: 202211069280). Five major organic fertilizer products namely, Jaivik Prom, Pori Potash, Dharti ka Chaukidar, Jaivik Poshak and Jaivik Khad were prepared after a series of operations. The final products were evaluated on carrot crop for their effects on the growth and yield parameters.

Experimental Design and Treatment. The experimental design was framed with six fertilizer treatments replicated three times in a Randomized Block Design (RBD). The seed varieties namely, Namdhari were used for the field experiments. Five different organic fertilizer levels evaluated in this experiment under eight treatment combinations were as T0 (Control), T1 (Jaivik Prom @ 100 kg/ac), T2 (Pori Potash @100kg/ac), T3 (Dharti ka Chaukidar @10kg/ac), T4 (Jaivik Poshak @7 kg/ac), T5 (Jaivik Khad @80kg/ac), T6 (Jaivik Prom+ Jaivik Khad @50+ 40kg/ac), T7 (Pori Potash + Jaivik Poshak @50+ 3.5kg/ac). Treatment of carrot seeds with bio-pesticide (*Trichoderma* and *Pseudomonas* @ 5ml/liter each) was carried out by dipping their roots for about 20-25 minutes to avoid the attack of any soil-borne pathogen. The test fertilizer treatments were used at each 30-day interval after sowing. The sowing of carrot seeds was carried out in field trials with the dimensions as plot size (2 × 4m) 8m^2 with three biological replicates (R-R 50cm and S-S 5cm). The seed variety namely, Lalbadshah was used for the field experiments. Light irrigation of the crop was carried out immediately after sowing and later when required. Similarly, the weeding of the undesired weeds was carried out about three times. Sprays of neem oil were used only if required to eradicate the attack of many insects and pests.

Measurement of plant parameters. For analysis, nine plants were randomly selected from each treatment and their replicates. Plant length (cm), Shoot and root biomass (g), area (cm^2) and number of leaves, root biomass (g) and root diameter (mm) were measured at 55-60 days after sowing.

Statistical Analysis. The obtained experimental data for growth and yield parameters is presented as mean ± standard deviation (SD). Analysis of results with ANOVA (one-way) and Dunnett's multiple comparisons test was performed using GraphPad Prism version 8.02 for Windows.

RESULTS AND DISCUSSION

Positive effects of sludge-based organic fertilizers on the growth and yield of field trial crops were observed during the present study. A considerable alteration in soil chemical properties to increase in available nitrogen (AN), available phosphorus (AP) and available potassium (AK) was observed. The enhanced concentrations of total and available nutrients (NPK) in all treatments over control reflected the effect of organic fertilizers on chemical properties of the soil. The effects of alteration in soil chemical properties were also reflected in the growth and yield of carrots.

The experiment assessed the impacts of various treatments (T1-T7) on the growth parameters of carrot plants. Among these treatments, the combination of potassium fertilizer and Javik Khad (T6) consistently demonstrated superior results, exhibiting the highest shoot biomass, root biomass, shoot length, root length, leaf area, and root diameter compared to other treatments. Notably, the treatment (T5) involving Javik Khad with organic NPK also displayed significant improvements, particularly in root-related parameters. Conversely, the organic fertilizer mixed with neem oil and neem cake (T3) yielded mixed results, with notable effectiveness in shoot biomass and root diameter but varying performance in other parameters. These findings suggest that the combined application of potassium fertilizer and Javik Khad is particularly conducive to enhancing overall growth and development in carrot plants, underscoring the importance of nutrient synergy in optimizing plant outcomes (Table 1 and Fig. 1). Utilization of agriculture and food industries and city compost to make organic fertilizers is a growing trend and is regarded as an environmentally responsible way to handle these wastes. When the use of organic fertilizers has now proved to have a significant impact on yield and other attributes of crops, the suggestion to produce organic fertilizers with the use of sludge also fostered this research. Using a technique developed by BARC, microorganisms in the dried and treated sewage can be killed and the sludge is rendered safer for use by crushing the material and subjecting it to a dose of 10 kGy radiation. This material was transformed into a helpful bio-fertilizer by the inclusion of BIO-NPK bacteria (Krishijagran, 2019). Because of its high organic matter concentration, 40% of sewage sludge is employed as an organic soil amendment in the Mediterranean region (Milieu Ltd., 2010). A thorough analysis of the possible application of sewage sludge as fertilizer has been conducted by Lamastra *et al.* (2018). Sugurbekova *et al.* (2023) promoted the management and application of sewage sludge as a sustainable fertilizer. The parameter-wise results of the growth and yield of carrot crops are given below:

Plant Length. The plant height in the present study was measured and expressed as shoot and root length. Results on plant length (height) obtained during the present study showed a great improvement in the length of shoot and root for all treatments. The shorter plant length in control in comparison to treatment revealed their positive effects on plant growth and development. The greatest increase in shoot length over time was observed in treatment T2 (Pori Potash) with an increase of approximately 51.000± 6.658 cm shoot length at harvesting time. It was followed by T4 (45.000± 3.528), T1, T6, T3, T7 and T5 (40.889 ± 9.335 & 40.556± 10.543, 38.667 ± 7.506, 36.200 ± 7.083 and 33.111± 9.436 cm, respectively). Similarly, the highest root length (24.222 ± 1.575 cm) was observed in plants treated with Dharti ka Chaukidar (T3). The root length was observed approximately of equal length in treatments T1, T5 & T6 (23.667± 2.646, 23.444 ± 1.895 and 23.444± 1.171 cm, respectively) and in T7, T6 and T4 (21.611± 2.927, 21.444± 2.795 and 21.222 ± 1.388 cm, respectively) (Table 1 and Fig. 1). The effects of organic fertilizers even at the stage of later stages of the crop justified the fact that these fertilizers can ensure nutrient availability up to the maximum duration of the crop (Diacono and Montemurro 2010; Jannoura *et al.*, 2013; Lin *et al.*, 2023). There have been reports that organic fertilizers have significant positive long-term effects on many crops. Predicated on this supposition, the fundamental makeup of organic products employed in this investigation was formulated to furnish crops with a comprehensive nutritional equilibrium of nitrogen (N), phosphorous (P), and potassium (K) via mycorrhiza or organic materials (Balkrishna *et al.,* 2023; Balkrishna *et al.,* 2024). The presence of balanced nutrition enables the plants to regulate the opening and closing of the stomata, the exchange of water vapor, oxygen and carbon dioxide and overall growth and yield (Amanullah *et al.*, 2016; Xu *et al.*, 2020; Lin *et al.*, 2023), which established the suitability of Ganga sludge for production of organic fertilizers.

Shoot Biomass. All organic fertilizers used in the present study exhibited considerable effects on the shoot biomass of carrot plants. The highest weight of shoot biomass was observed in treatment Jaivik Prom+ Jaivik Khad (T6) (10.846± 1.697), which was followed by treatment (T7) (10.663± 1.647 g), T3 (10.038± 1.319 g), T 2 (9.360± 1.867 g), T 4 (9.232± 1.464 g), t % 9.187± 2.342 g) and T 1 (9.041± 1.800 g). In comparison to control, the treatments T3, T4, T6 and T7 showed significant effects of treatments on the shoot biomass of carrot crop. Like in roots, the shoot biomass of carrot plants grown in different treatments was also found greater than control plants. The slow release of organic fertilizers provides balanced doses of NPK and other essential nutrients and shows significant positive long-term effects (Diacono and Montemurro 2010). These observations also support the efficacy of organic fertilizers used in the present study on the growth and yield of different crops (Jannoura *et al.*, 2013). Because of the basic composition to ensure an ample supply of N, P and K, the use of organic fertilizers is now proving fruitful in agriculture and other plantation systems (Sardans and Peñuelas 2021). Besides these nutrients, mycorrhiza-based fertilizers also performed well in the present study. The ability of mycorrhizal fungi to absorb micronutrients for the plants even when they are available in trace amounts might be one of the possible reasons (Sharma and Agarawal, 2009; Aishwarya *et al.*, 2022) (Table 1 and Fig. 1).

Leaf Area and Number. The total leaf area was observed highest in the case of treatment T1 (6.000± 0.882cm^2) which was followed by T4 (5.889± 0.839 cm^2), T2 (5.889± 0.694 cm^2), T7 (5.778 ± 0.770 cm^2), T3 (5.556± 0.694 cm^2), T6 (5.444 ± 0.770 cm^2) and T5 (4.967±0.872 cm^2). The leaf area was found significantly high in all treatments (except T5) as compared to the control. This effect of organic fertilizers was found significant in all treatments, but it was found highly significantly high in treatments T4 & T2. However, no significant variation in of number of leaves was observed in any treatment. Here, the average number of leaves was observed between 4.778± 1.072 to 6.000 ± 0.882 (Table 1 and Fig. 1). Several previous studies have already demonstrated the influence of organic fertilizers on leaf area index as the result of improved chlorophyll content and influence on the growth of different crops which also support our present findings (Cen *et al.*, 2020; Kominko *et al.*, 2022). The higher leaf area obtained in the case of treatments in comparison to control during the present study is perhaps associated with improved photosynthetic efficiency (Hamblin *et al.*, 2014; Nagaraj *et al.*, 2019; Manjula *et al.*, 2022; Ye *et al.*, 2022). The effects of organic fertilizers on the final yield of crops like wheat (Koutroubas *et al.*, 2014; Balkrishna *et al.*, 2024), Spinach (Parwada *et al.*, 2020), Raspberry (Angin *et al.*, 2017) and Cowpea (Patil *et al.*, 2022) were observed in terms of growth and yield that highlighted the importance of useful products prepared form Ganga sludge and this eco-friendly way of sludge management.

Root Diameter and Biomass. The application of organic fertilizers displayed a prospective impact on the diameter of roots and their biomass. A variable increase in both the diameter and biomass of roots was observed in all treatments in comparison to the control. Here the application of organic fertilizers in combination showed the highest root diameter (29.256 ± 0.587 mm) observed in plants grown in treatment T7 followed by T1 (28.754 ± 1.852 mm), T2 (27.334 ± 1.774 mm), T6 (27.253 ± 2.023 mm), T5 (26.469± 1.628 mm), and T3 (25.318 ± 1.423 mm). Similarly, the highest root biomass was also observed in carrot plants grown in treatment T6 (Jaivik Prom + Jaivik Khad) with an average weight of 3.611 ± 0.795 g, which was followed by T5 (3.414 ± 1.049 g), T7 (3.082 ± 0.229 g), T4 (3.062 ± 0.996 g), T2 (3.057 ± 0.519 g), T3 (2.847 ± 0.829 g) and T1 (2.399 ± 0.406 g). In summary, the results underscore the importance of specific treatments used in combination to enhance the growth and development of this crop (Table 1 and Fig. 1). While the fertilizers combination like Jaivik Prom + Jaivik Khad and Pori Potash + Jaivik Poshak foster consistently the diameter and biomass of roots in carrot plants, the ample supply of basic nutrients N, P and K by organic fertilizers which can enhance nutrient uptake, including phosphorus, which is crucial for chlorophyll synthesis (Sharma and Agarawal 2009; Sardans and Peñuelas 2021; Bishnoi *et al.,* 2021; Surya *et al*., 2022). Moreover, the mycorrhiza-based fertilizers in combination or alone performed well due to the ability of their associated fungi that absorb micronutrients for the plants when they are available even in trace amounts (Aishwarya *et al*., 2022).

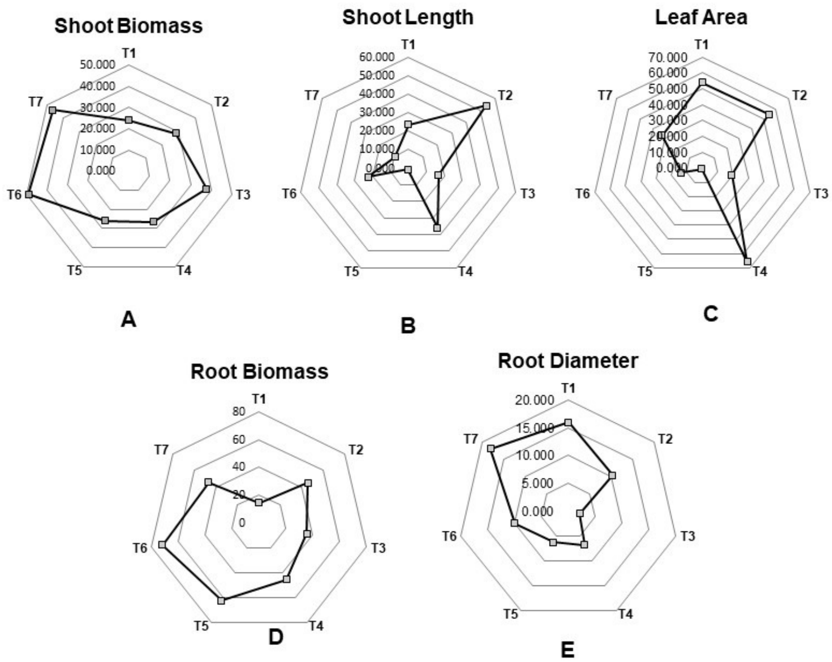

Fig. 1. Percentage increase in biomass (shoot & root), shoot length, leaf area and root diameter in treatments over control.

Table 1: Effect of Ganga sludge based organic fertilizers on plant characteristics of Carrot.

Treatment	Biomass (gm)		Plant Length (cm)		No. of Leaves	Leaf Area (cm^2)	Root Diameter (cm)
	Shoot	Root	Shoot	Root			
T0	7.286± 1.523	2.099± 0.683	33.111± 9.436	19.889± 4.221	4.556± 0.385	375.111± 118.121	24.787± 3.448
T1	9.041± 1.800*	2.399± 0.406*	40.889± 9.335*	23.667± 2.646*	6.000± 0.882**	578.222± 342.003*	28.754± 1.852**
T2	9.360± 1.867*	3.057± 0.519**	51.000± 6.658**	23.444± 1.171*	5.889± 0.694**	578.889± 139.989**	27.334± 1.774*
T3	10.038± 1.319**	2.847± 0.829*	38.667± 7.506*	24.222± 1.575**	5.556± 0.694**	447.333± 89.540*	25.318± 1.423
T4	9.232± 1.464**	3.062± 0.996*	45.000± 3.528**	21.222± 1.388*	5.889± 0.839**	622.371± 55.995**	26.469± 1.628*
T5	9.187± 2.342*	3.414± 1.049**	33.444± 10.839	23.444± 1.895*	4.778± 1.072*	378.222± 133.695	26.352± 1.193*
T6	10.846± 1.697**	3.611± 0.795**	40.556± 10.543*	21.444± 2.795*	5.444± 0.770**	426.222± 182.801*	27.253± 2.023*
T7	10.663± 1.647**	3.082± 0.229**	36.200± 7.083*	21.611± 2.927*	5.778± 0.770**	498.333± 174.188*	29.256± 0.587**

CONCLUSIONS

The superior performance of the combination of potassium fertilizer and Javik Khad (T6) in various growth parameters of carrot plants can be attributed to the synergistic effects of these two components. Potassium is known to play a crucial role in promoting overall plant growth, improving nutrient uptake, and enhancing stress tolerance. Javik Khad, being an organic NPK source, likely provides a well-balanced blend of essential nutrients, including nitrogen, phosphorus, and potassium, which are vital for plant development. The collaborative action of these nutrients in T6 appears to have positively influenced shoot and root biomass, shoot and root length, leaf area, and root diameter. Additionally, the organic nature of Javik Khad may contribute to improved soil structure and microbial activity, further supporting plant growth. Conversely, treatments with less comprehensive nutrient profiles or those lacking a balanced combination of essential elements may result in suboptimal outcomes for specific parameters. The effectiveness of T5 (Javik Khad with organic NPK) in root-related parameters underscores the importance of organic nutrient sources in promoting robust root development.

In contrast, the mixed results observed in T3 (organic fertilizer with neem oil and neem cake) may be attributed to the variable impacts of neem components, with potentially positive effects on shoot biomass and root diameter but less consistent benefits across other parameters.

FUTURE SCOPE

Overall, the success or failure of treatment for a particular parameter can be linked to the specific nutrient composition and interactions within each treatment, highlighting the significance of a well-balanced and synergistic nutrient approach in optimizing plant growth. The production of organic fertilizers offers the greatest substitute for chemical fertilizers and environmentally friendly method of managing Ganga sludge. Further studies on the manufacture, processing, and field application of sludge-based organic fertilizers, at laboratory level and on multiple field crops are needed.

Acknowledgements. The authors would like to express their gratitude to the revered Swami Ramdev for his inspiration. All organizations are gratefully acknowledged for providing all necessary facilities and every possible support throughout the study.

REFERENCES

Abbas, G., Abbas, Z., Aslam, M., Malik, A. U., Hussain, F. and Ishaque, M. (2011). Effects of organic and inorganic fertilizers on mungbean (*Vigna radiata* L.) yield under arid climate. *International Research Journal of Plant Science, 2*(4), 094-098.

Aishwarya, Manjula, Payal, Kaundal, S., Kumar, R., Singh, R., Avasthi, S. and Gautam, A. K. (2022). Arbuscular mycorrhizal fungal diversity and root colonization in *Pisum sativum*. *Biological Forum – An International Journal, 14*(1), 1626-1632.

Ali, U., Jatoi, G. H., Khuhro, S. A., Shar, T., Ahmad, R. and Khatoon, M. (2021). Potassium Management for the Improvement of Growth and Yield of Grass Pea (*Lathyrus sativus* L.). *International Journal on Emerging Technologies, 12*(1), 181–187.

Amanullah, Iqbal, A., Irfanullah and Hidayat, Z. (2016). Potassium management for improving growth and grain yield of maize (*zea mays* L.) under moisture stress condition. *Scientific Reports, 6*, 34627.

Angin, I., Aslantas, R., Gunes, A., Kose, M. and Ozkan, G. (2017). Effects of sewage sludge amendment on some soil properties, growth, yield and nutrient content of Raspberry (*Rubus idaeus* L.). *Erwerbs-Obstbau, 59* (2), 93–99.

Balkrishna, A., Arya, V., Bhat, R., Chaudhary, P., Mishra, S., Kumar, A., Sharma, V., Sharma, V., Sharma, N. and Gautam, A. K. (2023). Organic farming for sustainable agriculture and public health: Patanjali's perspective. *Vegetos*.

Balkrishna, A., Sharma, N., Gautam, A., Arya, V. and Khelwade, V. (2024). Enhancement of wheat (*Triticum aestivum* L.) growth and yield attributes in a subtropical humid climate through treated ganga sludge-based organic fertilizers. *Recent Advances in Food, Nutrition & Agriculture, (in press).*

Bishnoi, D., Umesha, C. and Sharma, C. S. (2021). Impact of Row Spacing on Growth and Yield of Cluster bean (*Cyamopsis tetragonoloba* L.) varieties. *Biological Forum – An International Journal*, *13*(3), 144-148.

Bozkurt, M. A. and Yarılgaç, T. (2003). The effects of sewage sludge applications on the yield, growth, nutrition and heavy metal accumulation in apple trees growing in dry conditions. *Turkish Journal of Agriculture and Forestry, 27*, 285-292.

Camargo, F. P., Sérgio Tonello, P., dos Santos, A. C. A. and Cristina, I. C. S. (2016). Duarte removal of toxic metals from sewage sludge through chemical, physical, and biological treatments-a review. *Water, Air, & Soil Pollution, 227* (12), 433.

Cen, Y., Guo, L., Liu, M., Gu, X., Li, C. and Jiang, G. (2020). Using organic fertilizers to increase crop yield, economic growth, and soil quality in a temperate farmland. *Peer J, 8,* e9668.

Cho, Y., Kim, B., Lee, J. and Kim, S. (2021). Construction of a high-resolution linkage map and chromosomal localization of the loci determining major qualitative traits in onion (*Allium cepa* L.). *Euphytica, 217*(1), 1-12.

Diacono, M. and Montemurro, F. (2010). Long-term effects of organic amendments on soil fertility. A review. *Agronomy for* Sustainable *Development 30* (2), 401–422.

Elmi, A., and AlOlayan, M. (2020). Sewage sludge land application: balancing act between agronomic benefits and environmental concerns. *Journal of Cleaner Production*, *250*, 119512.

Hamblin, J., Stefanova, K. and Angessa, T. T. (2014). Variation in chlorophyll content per unit leaf area in spring wheat and implications for selection in segregating material. *PLoS One, 9*(3), e92529.

Jackson, M. L. (1973). Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi, pp 498.

Jannoura, R., Brun, C. and Joergensen, R. G. (2013). Organic fertilizer effects on pea yield, nutrient uptake, microbial root colonization and soil microbial biomass indices in organic farming systems. *European Journal of Agronomy, 49,* 32-41.

Khomich, L., Perova, I. and Eller, K. 2020. Carrot juice nutritional profile. *Voprosypitaniia*, *89*(1), 86-95.

Kominko, H., Gorazda, K. and Wzorek, Z. (2022). Effect of sewage sludge-based fertilizers on biomass growth and heavy metal accumulation in plants. *Journal of Environmental Management, 305*, 114417.

Koutroubas, S.D., Antoniadis, V., Fotiadis, S. and Damalas, C.C. (2014). Growth, grain yield and nitrogen use efficiency of Mediterranean wheat in soils amended with municipal sewage sludge. *Nutrient Cycling in Agroecosystems, 100*(2), 227–243.

Krishijagran (2019). Retrieved from https://krishijagran.com/news/converting-municipal-sewage-waste-into-bio-fertilizer/

Lamastra, L., Suciu, N. A. and Trevisan, M. (2018). Sewage sludge for sustainable agriculture: contaminants' contents and potential use as fertilizer. Chemical *and Biological Technologies in Agriculture, 5*, 10.

Lin, S., Wang, C., Lei, Q., Wei, K., Wang, Q., Deng, M., Su, L., Liu, S. and Duan, X. (2023). Effects of Combined Application of Organic Fertilizer on the Growth and Yield of Pakchoi under Different Irrigation Water Types. *Agronomy, 13*, 2468.

Manjula, Aishwarya, Payal, Avasthi, S., Verma, R. K. and Gautam, A. K. (2022). Effects of arbuscular mycorrhizal fungi on growth parameters of *Pisum sativum*. *Asian Journal of Mycology 5*(2), 1–10.

Masarirambi, M. T., Mduduzi, M. H., Olusegun, T. O. and Thokozile, E. S. (2010). Effects of organic fertilizers on growth, yield, quality and sensory evaluation of red lettuce (*Lactuca sativa* L.) "Veneza Roxa". *Agriculture and Biology Journal of North America, 1*, 1319-1324.

Milieu, Ltd., WRc, Risk and Policy Analysts Ltd. (RPA) (2010). Environmental, economic and social impacts of the use of sewage sludge on land. Final Report, Part III: Project Interim Reports; 2010. DG ENV.G.4. / ETU/2008/0076r. http://ec.europa.eu/environment/archives/waste/ sludge/pdf/part_iii_report.pdf. Accessed 2 May 2018

Muter, O., Dubova, L., Kassien, O., Cakane, J., and Alsina, I. (2022). Application of the sewage sludge in agriculture: soil fertility, technoeconomic, and life-cycle assessment. Intech Open.

Nagaraj, D. M., Maheshwara Babu, B., Polisgowdar, B. S., Ayyanagowdar, M. S., Krishnamurthy, D., Kandpaland, K. and Ramesh, G. (2019). Influence of chlorophyll content and leaf area index on growth of pigeonpea. *International Journal of Current Microbiology and Applied Sciences, Special Issue, 9*, 43-51.

Nagraj, G. S., Jaiswal, S., Harper, N. and Jaiswa, A. K. (2020). Carrot, In: nutritional composition and antioxidant properties of fruits and vegetables. p. 323-337.

Parwada, C., Chigiya, V., Ngezimana, W. and Chipomho, J. (2020). Growth and performance of baby spinach (*Spinacia oleracea* L.) grown under different organic fertilizers. *International Journal of Agronomy*.

Patil, S., Toprope, V. N., Gaiwal, K. (2022). Correlation analysis for yield and yield contributing characters in F2 and backcross generations of Cowpea (*Vigna unguiculata* L.). *International Journal of Theoretical & Applied Sciences, 14*(2), 43-46.

Przewrocki, P., Kulczycka, J., Wzorek, Z., Kowalski, Z., Gorazda, K. and Jodko, M. (2004). Risk analysis of sewage sludge – Poland and EU comparative approach. *Polish Journal of Environmental Studies, 13*, 237–244.

Rahman, N., Uddin, M. B., Quader, M. F. B and Bakar, M. A. (2020). Optimization of mixed peels from banana, carrot and apple to develop high fiber biscuit. *International Journal of Natural and Social Sciences, 7*(1), 21-25.

Riadi, S., Susanti, H. and Purnomo, J. (2022). Effects of types and compositions of organic fertilizers in nursery growing media on the growth of vanilla seedlings. *IOSR Journal of Agriculture and Veterinary Science, 15* (6), 38-45.

Sardans, J. and Peñuelas, J. (2021). Potassium control of plant functions: ecological and agricultural implications. *Plants (Basel), 10*(2), 419.

Sharma, R. and Agarawal, A. (2009). Influence of organic fertilizers on total chlorophyll content and yield of wheat (*Triticum aestivum*). *Ecol Environm Conserv, 15*(3), 539-541.

Sikora, J., Niemiec, M., Tabak, M., GródekSzostak, Z., Szeląg-Sikora, Kuboń, A., M and Komorowska, M. (2020). Assessment of the efficiency of nitrogen slow-release fertilizers in integrated production of carrot depending on fertilization strategy. *Sustainability, 12*(5), 1982.

Smith, S. R. (2009). Organic contaminants in sewage sludge (Biosolids) and their significance for agricultural recycling. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 367*(1904), 4005-4041.

Surya, K., Sanbagavalli, S., Somasundaram, E., Renukadevi, A. and Panneerselvam, S. (2022). Effect of Potassium and Foliar Nutrition on Yield and Economics of Kodo Millet under Irrigated Condition. *Biological Forum – An International Journal, 14*(3), 42-46.

Sugurbekova, G., Nagyzbekkyzy, E., Sarsenova, A., Danlybayeva, G., Anuarbekova, S., Kudaibergenova, R., Frochot, C., Acherar, S., Zhatkanbayev, Y. and Moldagulova, N. (2023). Sewage sludge management and application in the form of sustainable fertilizer. *Sustainability, 15* (7), 6112.

Tchounwou, P. B., Yedjou, C. G., Patlolla, A. K. and Sutton, D. J. (2012). Heavy metal toxicity and the environment. *Experientia supplementum, 101*, 133-164.

Velasco-Munoz, J. F., Mendoza, J. M. F., Aznar-Sanchez, J. A. and Gallego-Schmid, A. (2021). Circular economy implementation in the agricultural sector: definition, strategies and indicators. *Resources, Conservation & Recycling, 170* (105618), 1-15.

Wazir, A., Gul, Z. and Hussain, M. (2018). Comparative study of various organic fertilizers effect on growth and yield of two economically important crops, potato and pea. *Agricultural Sciences*, *9*, 703-717.

Xu, X., Du, X., Wang, F., Sha, J., Chen, Q., Tian, G., Zhu, Z., Ge, S. and Jiang, Y. (2020). Effects of potassium levels on plant growth, accumulation and distribution of carbon, and nitrate metabolism in apple dwarf rootstock seedlings. *Frontiers in Plant Sciences, 11*, 904.

Ye, S., Peng, B. and Liu, T. (2022). Effects of organic fertilizers on growth characteristics and fruit quality in Pear-jujube in the Loess Plateau. *Scientific Reports, 12*, 13372.

How to cite this article: Acharya Balkrishna, Ajay Kumar Gautam, Nidhi Sharma, Vedpriya Arya and Vikram Khelwade (2024). Growth and Yield Enhancement of Carrot (*Daucus carota* L.) through Treated Ganga Sludge-based Organic Fertilizers. *Biological Forum – An International Journal, 16*(3): 175-180.