BIOSCIENCES BIOTECHNOLOGY RESEARCH ASIA, June 2024. Vol. **21**(2), p. 645-654

Composting as a Sustainable Option for Converting Undesirable Weeds like *Parthenium hysteropherous*, *Solanum nigrum*, *Calotropis procera* and *Trianthema portulacastrum* into Organic Manure

Tanvi Taneja[1], Indu Sharma[2], Bikram Jit Singh[3], Amarjeet Singh[4], Mukesh Kumar[1] and Raj Singh[1]*

[1]Department of Bio-Sciences and Technology, Maharishi Markandeshwar (Deemed to Be University), Mullana, Ambala, Haryana, India.
[2]Department of Biotechnology, NIMS Institute of Allied Medical Science and Technology, NIMS University Rajasthan, Jaipur, Rajasthan, India.
[3]Department of Mechanical Engineering, Maharishi Markandeshwar (Deemed to be University), Mullana-Ambala (Haryana), India.
[4]Department of Agriculture Engineering, SCRIET, CCS University, Meerut, India.

http://dx.doi.org/10.13005/bbra/3253

(Received: 14 February 2024; accepted: 30 May 2024)

Composting is the natural process of transforming organic wastes, such as leaves and food scraps, into fertile manure that can enrich the soil with humus, helpful bacteria, and critical plant nutrients, thus enhancing soil fertility and structure. India's soil today is low in organic matter and nutrients, particularly micronutrients. Compost includes 2% nitrogen, 0.5–1.0% phosphorus, around 2% potassium, and trace amounts of all critical micronutrients. Biodegradable weeds, including Parthenium hysterophorus, Solanum nigrum, Calotropis procera, and Trianthema portulacastrum, were degraded using the Bangalore pit compost method. The fresh vegetation of Parthenium, Solanum, Calotropis and Trianthema for making compost were collected from nearby localities of Mullana village from November, 2022 to April 2023. As a result, applying compost to soil increases organic matter and enhances soil fertility, restoring minerals and organic matter lost during harvesting. It also enhances the chemical, physical, and biological qualities of the soil, increasing crop output. Compost increases the soil's water holding capacity, which reduces crop water requirements and irrigation frequency. The nitrogen, phosphorus, potassium, and carbon-to-nitrogen ratios of the compost were measured every 20 days for up to 100 days. The results demonstrate that compost has a high calcium, nitrogen, phosphorus and potassium content but a lower carbon and nitrogen ratio.

Keywords: Biodegradable Weeds; Compost; Humus; Micronutrient; NPK,pit.

Weeds are an unwanted plant that grow in, garden, crop fields, lawns, or landscape area and prevent growth of the desirable plants. Weed management is an increasingly significant feature in such situations, particularly in tropical countries. Weeds can be available in every landscape area, industries, parks, highways and railways or urban areas[1]. The uncontrolled growth of weeds

*Corresponding author E-mail: dr.rajsingh09@gmail.com

globally reduces the yield of major crops around 34% [2]. However, by this process, too much weed-species are removed from the farmed landscape, as a result, the wild species of plants decline[3]. Todays' agricultural system is currently dominated by a paradigm of intense mechanized farming of a few key crops supported by mineral fertilizers and crop protection chemicals[2]. These techniques rely on the heavy, long-term use of pesticides and/or tillage to manage weeds, which can have a severe impact on agricultural productivity and the environment pollution due to the over and injudicious use of herbicides causes loss of natural vegetation, damage to the non-target crop plants and soil biodiversity and shows the negative impact on health of the farmworkers and the society[4,5]. Weed control is critical in agriculture for ensuring excellent crop yields. The various motivations for weed control become more complex as technology advances. Some of the common weeds that disturb the environment are congress grass (*Parthenium hystrerophorus*), blackberry nightshade (*Solanum nigrum*), *Aak* (*Calotropis procera*) and giant pigweed (*Trianthema portulacastrum*) as reported by Rai and Suthar[6].

Parthenium hysterophorus is a deadly herbaceous weed that originated on the American continent and has since spread to more than 45 tropical countries throughout the world. Some adaptive processes, such as the lack of natural enemies, extensive adaptive success, drought tolerance, photo-insensitivity, rapid seed production rate, simple seed dispersals, and allelopathic qualities[7,8]. *Parthenium* contains several allelochemicals, including sesquiterpene lactones and phenolic acid (gallic acid, chlorogenic acid, ferulic acid, etc.), which can be toxic to grazing animals and have a negative impact on crop production, plant diversity, and the distribution of native flora and fauna[6].

A dicot weed in the Solanaceae family is *Solanum nigrum* Linn., more often known as black nightshade. It is an African pediatric plant, which is used to treat a variety of conditions, including feverish convulsions, which are linked to a high newborn death rate. The annual plant *Solanum nigrum* has oval or lance-shaped, juicy, dull dark green leaves that are toothless to moderately serrated on the margins. It can grow up to a height of 90 cm with numerous lateral branches. With a short pedicellate and five widely spaced petals, the flowers are tiny and white[9]. When ripe, its fruits are tiny and black. *Solanum nigrum* is mostly found near waste land, abandoned fields, ditches and roadside fence rows, as well as the boundaries of wooded areas and cultivated land. It is a typical plant that may be found over most of Europe and the continent of Africa. The fact is that Solanine, a glycoalkaloid found in most of the plant parts, has the highest quantity in the unripened berries[10,11]. Although it is regarded as a rich source of one of the most well-known plant poisons but it has been shown to be a reservoir of phytochemicals with potential for use in pharmaceuticals.

The genus *Calotropis* is found in tropical and subtropical parts of Asia and Africa. *Calotropis procera*, a member of the apocynaceae family, is an erect soft-wooded evergreen perennial shrub. Akra and milk weed are popular names for the plant *Calotropis procera*. This plant is well known as it yields lot of latex. All components of this plant, including root, stem, leaf and flowers, are frequently used in traditional medicine12. *Calotropis* is a plant genus that produces milky sap and is therefore, frequently referred to as milkweed. *Calotropis procera* latex is supposed to have mercury-like effects on the human body, is frequently referred to as vegetable mercury, and is used in place of mercury in aphrodisiacs. This plant has numerous applications, but the leaves are occasionally cooked in oil for therapeutic purposes13. Cattle avoid *Calotropis procera* and *Calotropis gigantea* plants because of their disagreeable taste and the presence of cardiac glycosides in their sap. *Calotropis procera* root bark has a digitalis-like action on the heart; however, it was formerly utilized as an alternative to ipecacuanha14. Calotropin, a toxic chemical discovered.

Trianthema portulacastrum (horse purslane) an Aizoaceae family member, is a common weed that affects a variety of crops in India, Pakistan, and Sri Lanka, including direct-seeded rice, cotton, sugarcane, pearl millet, sorghum, maize, summer rainy season pulses, oilseed crops, fodder crops, vegetables, and horticultural crops[15]. *Trianthema portulacastrum* is a dangerous weed in Australia, Ghana, India, the Philippines, and Thailand, and a big weed in Cambodia, Guyana, and Nicaragua. When left untreated, horse purslane, a potent competitor, reduces the production of mung beans by 50 to 60%[15]. This weed is also responsible for significant yield loss in maize, soybean and peanut[14]. Horse purslane extracts have been shown to have adverse allelopathic effects on germination of soybean seed, seedling vigor and its productivity. A few available strategies to control this weed include physical or mechanical harvesting, eradication, prevention quarantining of agricultural items and biological control[16,8]. However, no effective technique for controlling this weed has yet been identified. Several studies have been conducted to investigate the possible use of weed biomass as a resource for the production of various industrial products, including anaerobic digestion, ethanol-fermented compost, and vermicompost[17-20] Composting has been suggested as a useful approach for reducing weed biomass while also maintaining soil fertility using organic additions[16]. Composting is an environmentally benign method that turns organic material into a product, which is high in humic acid and plant-available nutrients with very low population of pathogenic bacteria. According to a few earlier research, composting and vermicomposting may be a sustainable method for recovering nutrients and other components from weed biomass[21-23] This study was planned to prepare compost from *Parthenium hysterophorus*, *Solanum nigrum*, *Calotropis procera* and *Trianthema portulacastrum*the. It offers weed management, improve material recycling, soil structure, nutrients contents and to develop inexpensive technology.

MATERIAL AND METHODS

This experiment was done at the Department of Agriculture's Research Farm in Maharishi Markandeshwar. Deemed to be University, Mullana, district of Ambala, Haryana, India. The fresh vegetation of *Parthenium*, *Solanum*, *Calotropis* and *Trianthema* for making compost were collected from nearby localities of Mullana village from November, 2022 to April 2023 and chopped in the pit (30.2753°N, 77.04760 E). The raw material of these plants was converted into compost was using pit method. The process of composting was followed as described by Vyankatrao[24]. After six months, depending on various factors, the compost matured into a dark, crumbly substance with an earthy aroma, ready to be used as a nutrient-rich soil amendment. The uniformly mixed samples (100 g) from each treatment were collected, oven-dried every 20 days for up to 100 days, and used for nutrient analysis.

Chemical analysis

The samples were collected separately from the decomposing *Parthenium*, *Solanum*, *Calotropis* and *Trianthema* and chemically analyzed at every 20 days up to 100 days. The chemical analysis of compost provides valuable insights into its nutrient content and overall quality as a soil amendment. Calcium, Nitrogen, Potassium and Phosphorus test using by soil test kit.

Calcium test

The calcium content of the sample was determined by titrating the acid-soluble ash solution with a 0.01N $KMnO_4$ solution and using methyl red as an indicator.

Nitrogen test

The nitrogen concentration of the sample was determined using the micro-kjeldahl method after it had been digested with concentrated sulphuric acid.

Potassium test

A flame photometer was used to evaluate potassium concentration, as recommended by Jackson[25].

Phosphorus test

The available phosphorus in soil was determined by the Olsen's method.

The carbon to nitrogen ratio was also calculated by walkley and black's rapid titration method. Figure 1 shows weed compost created by using the pit method.

$$OC\% = O.5\ (B\text{-}S) \times 0.003 \times \frac{100}{weight\ of\ sample}$$

OC = Organic carbon, B = Blank reading and S= sample

RESULTS

The nutritional value of weed compost samples obtained by using pit method is shown in table 1.

Further Figure 2 depicts the changes in nitrogen percentage of all manure types from 20 to 100 days. In the end of composting after 100 days, the maximum percentage of calcium was reported in the compost followed by nitrogen, phosphorus and potassium with lowering carbon and nitrogen ratio. High nitrogen levels are most likely caused by ammonia excretion and organic waste conversion to nitrogen during the composting process.

According to the graph in Figure 2, 3, 4, 5 and 6, the changes occurred in content of phosphorus, potassium and calcium including the carbon to nitrogen ratio. Increased nutritional content was evident from the data in Table 1. The current experiment's results confirm the findings[26], who also reported the mobilization and mineralization of phosphorus caused by bacterial and fecal phosphatase activity during the composting process, which caused the overall rise in phosphate level from starting to end of the experiment. According to Jaikumar[27], the prepared manure had the second-highest potassium content but released potassium into the soil very slowly, preventing wastage from washing it away.

The Fig. 2 representing the carbon to nitrogen ratio changes from 20 to 100 days of composting. Similarly Ansari and Rajpersaud[28] demonstrated a decrease in the carbon to nitrogen ratio as the litter broke down and decomposed. The microorganisms consume the carbon for respiration while the nitrogen is mineralized and converted to nucleic acids, ammonia, urea and nitrates[29]. Overall, the carbon to nitrogen ratio decreased as a result of degradation process. The content of nitrogen, phosphorus, potassium and calcium was found maximum in the weed-compost prepared by using pit method at the end of 100 days. Earlier investigations with weed-composting also revealed high content of nitrogen, phosphorus and potassium[24]. The nutritional levels in compost prepared from weeds were observed consistent from 20 to 100 days[30]. All forms and types of compost manure exhibited an increase in the content of nitrogen, phosphorus, potassium and calcium and a decrease in carbon to nitrogen ratio. Microorganisms were observed more active at breathing with the advancement of decomposition process.

Figure 2 showed that main effect of nitrogen according to days, pH, EC and MC.

Fig. 1. Compost preparation: (1) Fresh weeds dumped in pit and (2) Compost prepared after decomposition of weeds

Table 1. Percentage of nutritional contents in per gram compost

Duration (days)	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Calcium (%)	C:N (%)
20	0.45	0.06	0.06	1.98	35.67
40	0.50	0.08	0.08	2.11	34.55
60	0.57	0.09	0.10	2.28	28.66
80	0.70	0.10	0.13	2.41	27.57
100	0.79	0.18	0.16	2.47	26.45

The relationship between N and days is statically significant ($p<0.05$). The 97.43% regression model may explain a significant portion of the variation in N (Refer Annexure A for details). Positive correlation (r=0.99) indicates that when days increases N also tends to increases. The relationship between N and pH is statistically significant ($p<0.005$) and 99.81% the regression

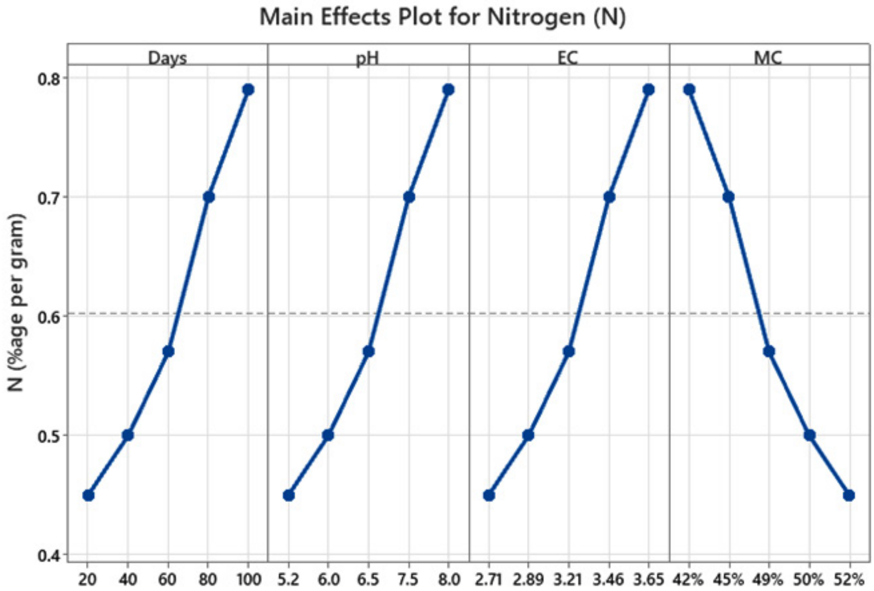

Fig. 2. Main Effects Plot for N Changes in nitrogen ratio of weed manure prepared by pit methods from 20 to 100 days

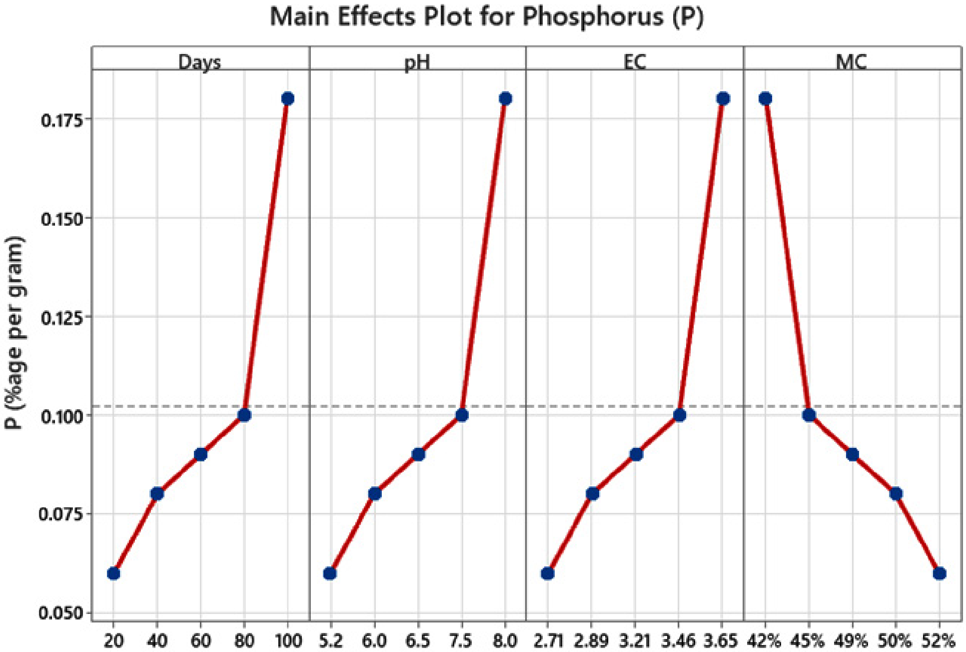

Fig. 3. Main Effects Plot for P ratio of weed manure prepared by pit methods from 20 to 100 days

model can explain the majority of the variation in N. The relationship between N and EC is statically significant ($p<0.05$) and 96.88% of the variation in N be explained in graph. The positive correlation (r=0.98) indicates that when EC increases then N also tends to increase. The relationship between N and MC is statically significant ($p<0.05$) and 99.09% of the variation explained by model.

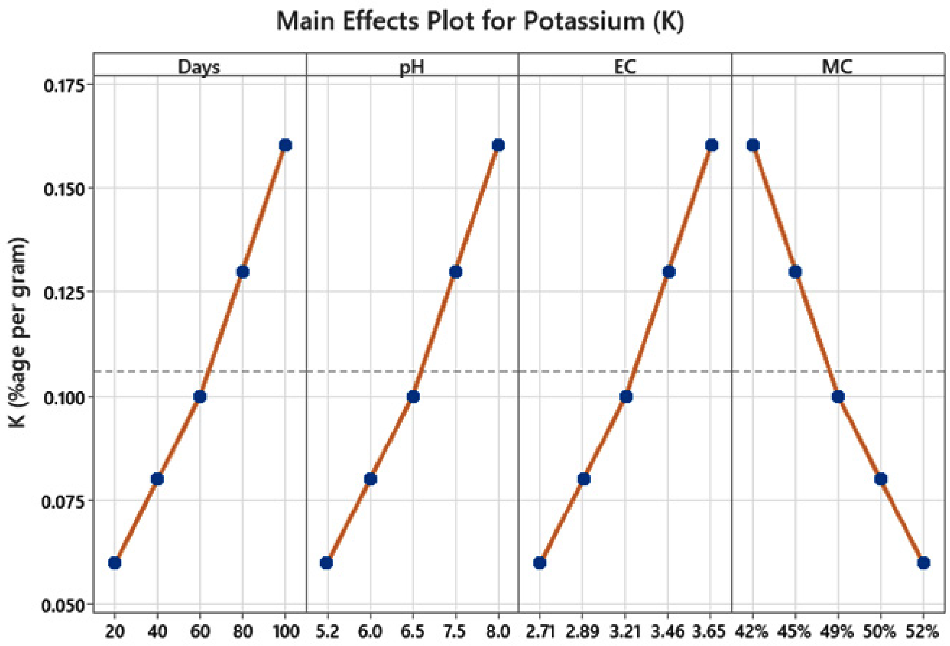

Fig. 4. Main effect of Potassium content of weed manure prepared by pit methods from 20 to 100 days

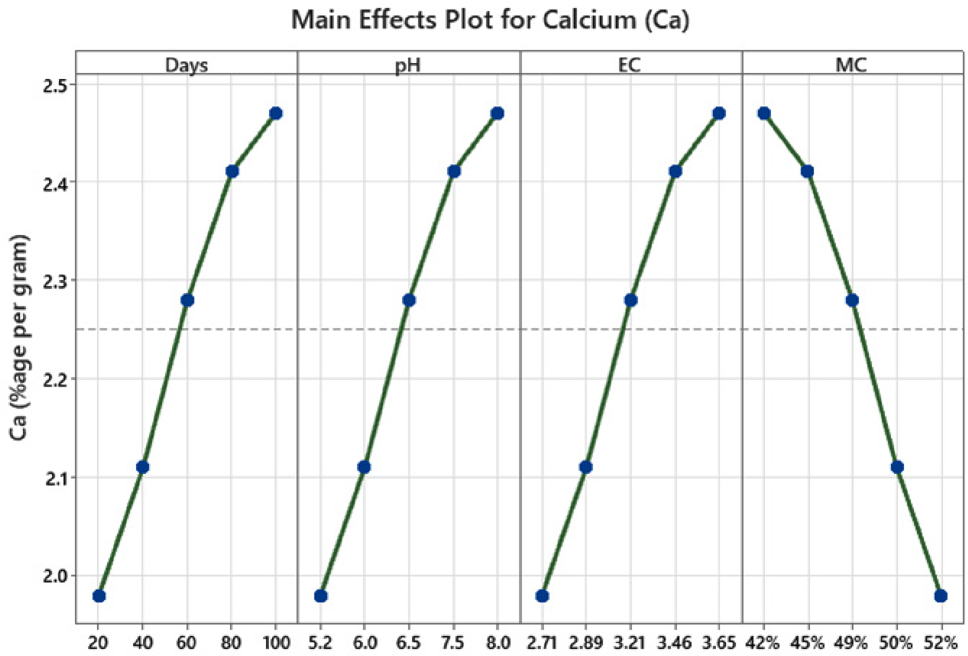

Fig. 5. Main Effects Plot for Ca content of weed manure prepared by pit methods from 20 to 100 days

Negative correlation (r= -1.00) indicates that MC increases tend N decreases.

Figure 3 represents that main effect of posphorus according to days, pH, EC and MC. The relationship between P and days is statically significant (*p*<0.05). The 79.72% regression model may explain a significant portion of the variation in P (Refer Annexure B for details). Positive correlation (r=0.89) indicates that when days increases, P also tends to increase The relationship between P and pH is not statistically significant (*p*>0.05) and 75.54% the regression model can explain the majority of the variation in P. The correlation between P and pH is not significant (p>0.05). The relationship between P and EC is not statically significant (p>0.05) and 74.57% variation can be explained by regression model. The correlation between P and EC is not significant (*p*>0.05). The relationship between P and MC is statically significant (*p*<0.05). The 85.11% of the variation in P explained by model and negative correlation indicate (r= -0.02) that MC increases and P decreases.

Figure 4 represents that main effect of potassium according to days, pH, EC and MC. The relationship between K and days is statically significant (*p*<0.05). The 99.91% regression model may explain a significant portion of the variation in K (Refer Annexure C for details). The relationship between K and pH is not statistically significant (*p*<0.05) and 98.23% the regression model can explain the majority of the variation in K. The positive correlation found between K and pH is significant (r= 0.99) an increase in pH tends to increase the K also. The relationship between K and EC. The 97.55% of variation K explained by model is statically significant (*p*<0.05). Positive correlation (r= 0.99) indicate that EC increases then K also increases. The relationship between K and MC is statically significant (*p*<0.05) and 98.78% K variation can be explained by regression model. The negative correlation indicates (r= -0.99) that, K content decreases when MC is increase.

Figure 5 Represents that main effect of calcium according to days, pH, EC and MC The relationship between Ca and days is statically significant (*p*<0.05). The 97.87% regression model may explain a significant portion of the variation in Ca. The positive correlation (r=0.99) indicate that days increases and Ca also increases. The relationship between Ca and pH is statistically significant (*p*<0.05) and 97.36% % the regression model can explain the majority of the variation in Ca (Refer Annexure D for details).. The positive correlation (r= 0.99) pH increases tend to increase the Ca content. The relationship between Ca and

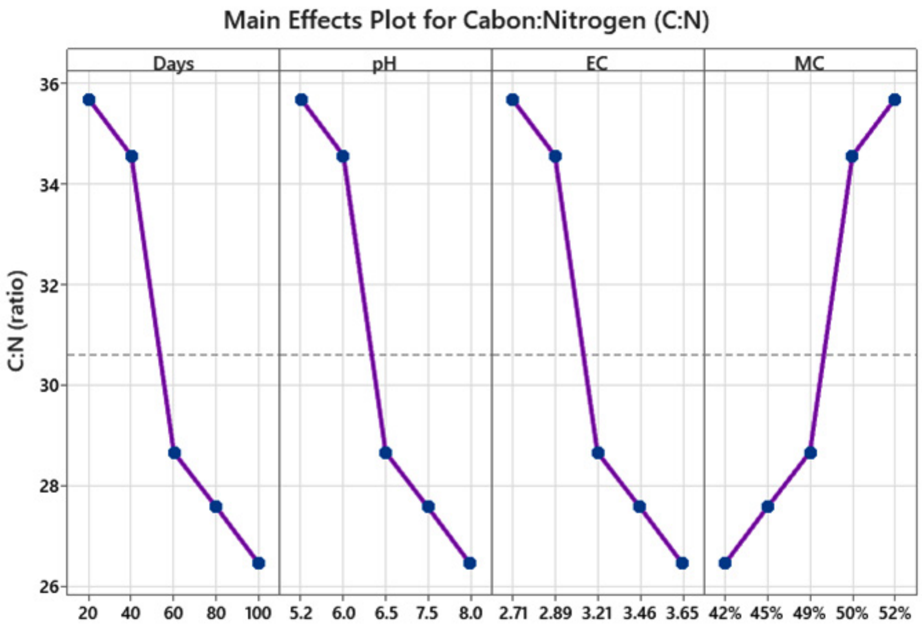

Fig. 6. Main Effects Plot for C:N content of weed manure prepared by pit methods from 20 to 100 days

EC is statically significant. The 99.90% of variation Ca explained by model. The relation Ca and MC is statically significant (p<0.05). The 89.76% variation of Ca explained by regression model. Negative correlation indicates (r= -0.95) that, MC is increases as Ca decreases.

Figure 6 Represents that main effect of calcium and nitrogen according to days, pH, EC and MC. The relationship between C: N and days is statically significant (p<0.05).The 90.41% regression model may explain a significant portion of the variation in C: N. The negative correlation (r=-0.95) indicate that days increases and CN also decreases. The relationship between CN and pH is statistically significant (p<0.05) and 87.13% the regression model can explain the majority of the variation in C: N (Refer Annexure E for details). The negative correlation (r= 0.93) of pH increases tend to decrease C: N ratio. The relationship between CN and EC is statically significant (p<0.05). The 94.27% of variation C: N explained by model. The negative correlation (r= -0.97) indicates EC increases and CN decreases. The relation CN and MC is statically significant at (p<0.05). The 77.74% variation of CN explained by regression model. The positive correlation indicates (r= 0.88) that MC is increases and CN increases.

DISCUSSION

The best method for managing weeds is composting, which also improves the quality of the final product[18,19] Through this method, weed biomass may be safely disposed of and converted into extremely rich manure, which advances sustainable development[31]. According to the findings of Sivakumar[32], the compost prepared from *Parthenium*, *Solanum*, *Calotropis* and *Trianthema* when used sparingly with cow or goat manure aids in the eradication and better usage of these plants. Composting helps in controlling weeds while feeding the intended crops with nutrients[33,34]. Sustainable farmers grow food crops without harming the environment by employing farming methods like composting. Sustainable farms genuinely improve and protect the land, so that future generations can continue to use it for food production. Employing troublesome weeds to prepare compost, the environmental risks caused using chemical herbicides and fertilizers can be avoided. This strategy of increasing soil productivity is environmentally benign and promotes sustainable agriculture. By turning toxic weeds including *Parthenium solanum*, *Calotropis* and *Trianthema* into compost can be a source of nutrients for the agricultural crops. Composting in a pit, which is the most effective approach, increased the content of nitrogen, phosphorus, potassium and calcium but decreased the carbon to nitrogen ratio from 20 to 100 days. Nutrient-rich compost can be prepared from weeds. Composting technology is simple to use, safe for the environment and profitable. Utilizing weeds to prepare compost will open up new possibilities for managing weeds and soil nutrients.

CONCLUSION

Composting is the best method of recycling organic waste, enabling the production of useful ingredients *viz*. humus contents and minerals from organic waste. The plants can safely be used to prepare the useful and nutrients rich compost. It also offers adaptable total waste management, improve material recycling and is relatively inexpensive to implement. The utilization of composting presents a compelling and sustainable solution for managing unwanted weeds like *Parthenium hysterophorus, Solanum nigrum, Calotropis procera* and *Trianthema portulacastrum,* effectively converting them into valuable organic manure. Overall, the integration of composting as a waste management strategy not only mitigates environmental challenges posed by weed proliferation but also contributes to the creation of a circular economy where waste is transformed into a valuable resource. As we strive for more sustainable agricultural practices, composting stands out as a practical and environmentally friendly solution that holds promise for addressing both waste management and soil fertility concerns in the long term.

Conflict of Interest

Authors have no conflict of interest.

Funding Sources

There was no source of funding.

Ethical Approval

There are no ethical issues in this manuscript.

Availability of data and materials

Data as well as material available and will provide on request.

REFERENCES

1. Martins D, Martin CC, Silva JR. Weed management and Herbicide selectivity in Ornamental plants. *Plantas Daninha*. 2019; 37: 37-46.
2. MacLaren C, Storkey J, Menegat A, Metcalfe H, Dehnen-Schmutz K. An ecological future for weed science to sustain crop production and the environment. A review. *Agron. Sustain. Dev*. 2020; 40: 1-29.
3. Bretagnolle V, Gaba S. Weeds for bees? A review. *Agron. Sustain. Dev*. 2015; 35: 891-909.
4. Myers JP, Antoniou MN, Blumberg B, Carroll L, Colborn T, Everett LG, Benbrook CM. Concerns over use of glyphosate-based herbicides and risks associated with exposures: a consensus statement. *Environ. Health*. 2016; 15(1): 1-13.
5. Almberg KS, Turyk ME, Jones RM, Rankin K, Freels S, Stayner LT. Atrazine contamination of drinking water and adverse birth outcomes in community water systems with elevated atrazine in Ohio, 2006–2008. *Int. J. Environ. Res. Public Health.* 2018; 15(9): 1889-1903.
6. Rai R, Suthar S. Composting of toxic weed *Parthenium hysterophorus*: Nutrient changes, the fate of faecal coliforms, and biopesticide property assessment. *Bioresour. Technol*. 2020; 311:123523-123534.
7. Yadav A, Garg VK. Vermicomposting–An effective tool for the management of invasive weed *Parthenium hysterophorus*. *Bioresour. Technol*. 2011;102(10): 5891-5895.
8. Kaur M, Aggarwal NK, Kumar V, Dhiman R. Effects and management of *Parthenium hysterophorus*: A weed of global significance. *Int. Sch. Res. notices*. 2014. http://dx.doi.org/10.1155/2014/368647
9. Cooper MR, Johnson AW. Poisonous plants in Britain and their effects on animals and man. HM Stationery Office. *Fisheries Food*. 1984;161:219-220.
10. Smith SW, Giesbrecht E, Thompson M, Nelson LS, Hoffman RS. Solanaceous steroidal glycoalkaloids and poisoning by *Solanum torvum*, the normally edible *susumber* berry. *Toxicon*. 2008; 52(6): 667-676.
11. Ostreikova TO, Kalinkina OV, Bogomolov NG, Chernykh IV. Glycoalkaloids of plants in the family Solanaceae (nightshade) as potential drugs. *Pharm. Chem. J*.2022; *56*(7): 948-957.
12. Kaur A, Batish DR, Kaur S, Chauhan BS. An overview of the characteristics and potential of *Calotropis procera* from botanical, ecological, and economic perspectives. *Front. Plant Sci*. 2021;12: 690806.
13. Singh R, Upadhyay SK, Rani A, Kumar P, Sharma P, Sharma I, Singh C, Chauhan N, Kumar M. (2020) Ethnobotanical Study of Weed Flora at District Ambala, Haryana, India: Comprehensive Medicinal and Pharmacological Aspects of Plant Resources . *International Journal of Pharmaceutical Research. 2020;* Jan.-June 12(Spl.)1:1941-1956.
14. Ferdosi MF, Khan IH, Javaid A, Nadeem M, Munir A. Biochemical profile of *Calotropis procera* flowers. *Pak. J. Weed Sci. Res*. 2022;27(3): 341.
15. Sukalingam K, Ganesan K, Xu B. *Trianthema portulacastrum* L. (giant pigweed): Phytochemistry and pharmacological properties. *Phytochem. Rev.* 2017; 16: 461-478.
16. Evans HC. *Parthenium hysterophorus*. a review of its weed status and the possibilities for biological control. *Biocontrol News and Information*. 1997;18: 89-98.
17. Gusain R, Pandey B, Suthar S. Composting as a sustainable option for managing biomass of aquatic weed Pistia: A biological hazard to aquatic system. *J. Clean. Prod.*2018; 177: 803-812.
18. Kumar M, Singh BJ, Sharma P, Mukherjee TK, Singh R. Evaluation of *Boerhavia diffusa* and *Echhornia crassipes* plant extracts as potential antifungal agents against human pathogenic fungi: A comparative study *Journal of Applied and Natural Science*. 2023;15(4), 1636 - 1645. https://doi.org/10.31018/jans.v15i4.5010
19. Taneja T, Sharma I, Kumar M, Rana MK, Singh R. Compost Preparation from Different Organic Wastes: Their Biochemical Analysis and Effect on Growth of Bottle Gourd**.** *Asian Journal of Biological & Life Sciences.*2023; 12(3): 1-7.
20. Taneja T, Kumar M, Sharma I, Kumar R, Sharma A, Singh R. Composting of Agro-Phyto wastes: An Overview on Process, factors and Applications for Sustainability of Environment and Agriculture. *Current World Environment*, 2024;19(1): 1-10.
21. Himanshi, Kumar M. Singh R. (2023). An *in-vitro* Evaluation of Antifungal Potential of *Withania somnifera* and *Ageratum conyzoides* weed plants against *Alteneria solani***.** *Bio-Science Research Bulletin*. 2023; 39(2), 69-74.
22. Meng L, Li W, Zhang S, Wu C, Lv L. Feasibility of co-composting of sewage sludge, spent mushroom substrate and wheat straw. *Bioresour.*

Technol. 2017; 226: 39-45.

23. Soobhany N. Preliminary evaluation of pathogenic bacteria loading on organic municipal solid waste compost and vermicompost. *J. Environ. Manag*. 2018; 206: 763-767.
24. Dissanayaka DMNS, Udumann SS, Dissanayake DKRPL, Nuwarapaksha TD, Atapattu AJ. Review on aquatic weeds as potential source for compost production to meet sustainable plant nutrient management needs. *In Waste*. 2023; 1(1): 264-280.
25. Vyankatrao NP. Conversion of *Parthenium hysterophorus* L. Weed to compost and vermicompost. *Bioscience Discovery*. 2017;8(3): 619-627.
26. Jackson ML. Soil Chemical Analysis, Prentice Hall of India. Private Limited, New Delhi 1973.
27. Ansari AA, Rajpersaud J. Physicochemical changes during vermicomposting of water hyacinth (*Eichhornia crassipes*) and grass clippings. *International Scholarly Research Notices*. 2012;1-7.
28. Jayakumar M, Sivakami T, Ambika D, Karmegam N. Effect of turkey litter (*Meleagris gallopavo* L.) vermicompost on growth and yield characteristics of paddy, *Oryza sativa* (ADT-37). *Afr. J. Biotechnol*. 2011;10(68):15295-15304.
29. Ansari A A, Rajpersaud J. Physicochemical changes during vermicomposting of water hyacinth (*Eichhornia crassipes*) and grass clippings. *Int. Sch. Res. notices*. 2012.
30. Ismail SA. *The Earthworm Book*. 2005 Other India Press, Mapusa, Goa 101
31. Yadav RH. Assessment of different organic supplements for degradation of *Parthenium hysterophorus* by vermitechnology. *J. Environ. Health Sci. Eng*. 2015;13:44.
32. Sharma R, Dwivedi H S , Dwivedi P. Utilization of three obnoxious weeds (*Parthenium hysterophorus*, *Lantana camara* and *Eichhornia crassipes*) through vermicomposting and their response on vegetative growth of soybean crop. *IJARBS*. 2016;3(9):13-20.
33. Sivakumar S, Kasthuri H, Senthilkumar P, Subbhuraam CV, Song YC. Efficiency of composting *Parthenium* plant and neem leaves in the presence and absence of an oligochaete, *Eisenia fetida*. *IJEHSE*. 2009;6:201-208.
34. Ameta SK, Ameta R, Soni D, Ameta SC. Vermicomposting of Parthenium hysterophorus with different organic wastes and activators. *Academ Arena*. 2016;8(4):34-38.