JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Gamma Radiation Effect on Sewage Sludge as a Fertilizer on Sacha Inchi Plant in Agriculture

[1]KHIN MYO SETT, [2]MOE MIN HTWE

[1]Deputy Director, [2]Deputy Director
[1]Department of Atomic Energy,
[1]Ministry of Science and Technology, Nay Pyi Taw,Myanmar

Abstract: The present study was carried out to determine the effects of Gamma radiation on sewage sludge and without sludge on the plant growth and fruits of Sacha Inchi as a test plant have been studied in field test. Sewage sludge was irradiated with 6 and 25 kGy radiation dose. There was no significant effect of irradiated sludge on plant heights compared with non-irradiated sludge and without sludge. However, significant increase in fruits production in the present of irradiated sludge growing after one year. In addition, mineral compositions in sacha inchi seeds also increased by using irradiated sewage sludge. The results found that copper, zinc, iron, nickel, lead, arsenic and cadmium concentrations in sewage sludge were below the recommended levels for United States of Environmental Protection Agency (USEPA, 40CFR 503). Sewage-sludge application is provided the benefits of major nutrients increased. It was found that Gamma Irradiated sewage sludge indicates a beneficial effect for agricultural applications.

IndexTerms - Sacha Inchi, Gamma Irradiated Sewage Sludge, Non-irradiated, Mineral Composition, Major Nutrients.

I. INTRODUCTION

Sacha inchi (Plukenetia volubilis L.) of the family Euphorbiaceae is also known as sacha peanut, mountain peanut, Inca nut or Inca peanut. It is native to the tropical rain forest of the Amazon region of South America that includes parts of Peru and northwestern Brazil. Sacha inchi is being developed as an economic crop. Sacha inchi has a star- shaped fruit capsule (3–5 cm). As the fruit matures, the color turns from green to blackish brown. The seeds contain lipids (35–60%) (Including ω-3, 6, and 9 fatty acids), proteins (25–30%) (Including essential amino acids such as cysteine, tyrosine, threonine, and tryptophan), vitamin E, polyphenols, minerals, and others [1].

Sewage sludge (SS) is a secondary product of wastewater treatment process. It will be explored for potential replacement or supplement to mineral fertilizers in crop production because it contains available amount of nutrients (nitrogen, phosphorus, and potassium) which are essential elements for the growth of plants. In this regard, the suitability of sewage sludge as a fertilizer and its effect on plant growth and crop yields, e.g., cotton, bread wheat, barley, and maize have been investigated. Sludge contains heavy microbiological load, toxic heavy metals and organic pollutants like pesticides, polyaromatic hydrocarbons, drugs and other persistent pollutants which may hazard on soil quantity as a fertilizer [2].

Gamma radiation was found to be an effective tool for hygienisation of municipal sewage sludge. The following factors were found Gamma radiation effect on sewage sludge: (i) inactivation of microorganisms; (ii) oxidation of organic compounds; (iii) degradation of the sewage sludge structure, including degradation of soluble organic compounds of heavy metals and promoting micronutrients [3]. The main objective of the current research work is to study the effects of Gamma irradiated sewage sludge on the plant growth parameters of sacha inchi (plant height, number of fruits) and chemical composition for Sacha inchi seeds.

II. RESEARCH METHODOLOGY

2.1 Sewage Sludge Description and Samples Preparation

Sewage sludge was collected from Sewage Treatment Plant in Botataung Township, Yangon, Myanmar. It was operated in January 2005 where domestic waste is treated by activated sludge process with the aid of surface aerators. The sacha inchi was selected for the study because it is as a sustainable economic plant for human nutrition, synthesis of nanoparticles, health and cosmetic use. Sacha inchi seeds were purchased from the local market.

2.2 Irradiation

Gamma irradiation was performed by research scale Gamma Chamber (12000Ci, 5000A) with the dose rate of (1.56 kGy/hr) at Department of Atomic Energy in Hmawbi. Samples were irradiated in the cylindrical irradiation chamber (diameter- 17.2 cm and height- 20.5 cm). Sewage sludge samples were prepared in plastic bags and treated at radiation doses 6 and 25kGy.

2.3 Analytical Measurements

Heavy metals and major nutrients concentrations in sewage sludge were determined according to Arthur I Vogel, F.A.A.S, Indian Standard, Nitrogen Analyzer method at Department of Research and Innovation (DRI). Nutrient agar plate count by Serial Dilution Method was used microbial concentration in sewage sludge samples at Biotechnological Research Division. In addition, mineral elements compositions in sacha inchi seeds were determined by Inductively Coupled Plasma-optical Emission Spectrometry (ICP-OES; Shimadzu ICPE-9820).

2.4 Statistical Analysis

In our research studied, statistical analysis was carried by one way ANOVA test.

III. RESULTS AND DISCUSSION

3.1 Heavy Metals Analysis of Sewage Sludge

The usage of sewage sludge for Agriculture application should not exceed the specified limits for the presence of pollutants (Arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc) to avoid the potential damage for the environment and for human health [4]. Table 3.1 showed that concentration levels of the heavy metals in non-irradiated sewage sludge and Gamma irradiated sewage sludge for this research work. This study found that heavy metal contents were much lower than the maximum permissible limits confirmed by agricultural practices of United States of Environmental Protection Agency (USEPA, 40CFR 503) [5].

Table 3.1: Gamma Radiation Effect on Heavy Metal Concentration in Sewage Sludge

Elements	Non-Irradiated sewage sludge (mg/kg)	6kGy (Irradiated sewage sludge) (mg/kg)	25kGy (Irradiated sewage sludge) (mg/kg)	Permissible limits* (mg/kg)
Arsenic	0.083	0.082	0.033	75
Nickel	93.39	102.03	92.05	420
Cadmium	5.38	5.13	4.94	85
Chromium	197.17	161.24	166.77	3000
Lead	159.13	150.00	131.70	840
Zinc	0.15	0.19	0.15	7500
Copper	273.45	287.94	240.49	4300

*Agricultural practices of USEPA, 40CFR 503

3.2 Effects of Gamma Radiation on Major Nutrients in Sewage Sludge

Municipal sewage sludge contains an important quantity of plant nutrients such as nitrogen, phosphorus and potassium, which can be used fertilizing source in irrigation. As indicated in Table 3.2, major nutrients concentrations such as phosphorus, nitrogen and potassium (N, P, and K) in sewage sludge were measured. The results showed that there were slightly changes N, P_2O_5 and K_2O in the irradiated sewage sludge compared with non-irradiated sludge. These amounts sufficiently provided to plant growth requirements.

Table 3.2: Gamma Radiation Effect on Major Nutrients in Sewage Sludge

Radiation Dose (kGy)	Nitrogen (N)	Potassium (K_2O)	Phosphorus (P_2O_5)
0	0.63	1.30	N.D
6	0.91	1.45	0.76
25	0.86	1.48	0.99

N.D= Non Detection

3.3 Microbiological Analysis of Sewage Sludge Samples

In this research study, Plate count methods were enumerated the microbial count (CFU/ml). Nutrient agar plate was used for total bacterial count, 3MTM Petrifilm plate agar for coliforms and Erosin Methylene Blue (EMB) agar medium for Ecoli was used. The sewage sludge samples were treated at radiation doses 6 and 25kGy. Total bacterial count and total coliforms count in the sewage sludge samples were as shown in Table 3.3. Our study on irradiated sewage sludge sample showed that both total bacterial and coliforms were reduced to below detection level. The total bacterial count reduced from 2.8×10^3 to below detectable level at 6kGy, whereas this dose was sufficient to reduce total coliforms count. The initial count for the sludge (10^7 CFU/L) was completely eliminated at 25 kGy. The quantitatively total bacterial counts showed significantly reductions via the radiation dose increased. Escherichia coli (E. coli) were not detected in non-irradiated and irradiated sewage sludge samples. Acceptable level of Total coliforms count is less than 1000 CFU/ml at the time of disposal which is based on USEPA recommendation [6].

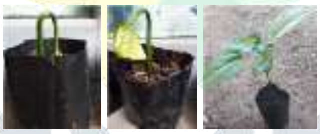
Table 3.3: Gamma Radiation Effect on Microbial Parameters in sewage sludge

Radiation Dose (kGy)	Total Bacterial Count (CFU/ml)	Coliform Count (CFU/ml)	Ecoli Count (CFU/ml)
0	4.0×10^7	12	-
6	2.0×10^3	-	-
25	-	-	-

3.4 Effects of Irradiated Sewage Sludge on Plant Growth

In this research work, fields test were conducted on an alluvial soil (pH- 6.0 to 8.0) at the Materials Science Research Division in Kyaukse, Mandalay region. Irradiated and non-irradiated sewage sludge was mixed with soil to a depth of 45cm. Treatments were arranged in a block design with 2m separating with the three replicate blocks. Sacha inchi seedlings were transplanted with row spacing of 3m and 3m between plants. Each treatment contained six sacha inchi plants. Plants were irrigated using a Furrow Irrigation system.

The research work consisted of four treatments which were soil without sewage sludge and non-irradiated sewage sludge used as a control, irradiated with 6 kGy, and 25 kGy respectively. No significant effect on plant height was observed in plants grown in soil containing either the non-irradiated or irradiated sludge, compared to those grown in soil alone (without sludge) ($p > 0.05$). However, the application of irradiated sewage sludge significantly enhanced fruits production at 6kGy radiation dose as shown in Figure 2. Regarding the effects of irradiated sewage sludge, our results showed that fruit production was increased. It was found that Gamma radiation effect on oxidation and degradation of organic matter in sewage sludge. This effect could increase nutrient values which is essential for plant growth.



(a)

(b)

Figure 1 (a) Seedling stages of Sacha inchi (b) Sacha inchi plant in Field test

(a) (b) (c) (d)

Figure 2 Sacha inchi seeds (a) without sludge (b) non-irradiated sewage sludge (c) irradiated-6kGy (d) irradiated-25kGy

3.5 Minerals Composition of Sacha Inchi Seed

The mineral composition of sacha inchi seed analyzed by ICP-OES was shown in Table 3.5. In this research study showed that significant increased amounts of essential minerals, such as magnesium, calcium, potassium and zinc at irradiated sewage sludge were occurred. From this research study, not only Phosphorus was the most abundant mineral found in sacha inchi seed but also minor amounts of iron, sodium and copper were also presents. These minerals are essential for human health and diet.

Table 3.5: Composition of Mineral Elements in Sacha Inchi seed

Mineral Elements (mg/kg)	Sewage Sludge			
	Without sludge	**Control**	**6kGy**	**25kGy**
Potassium	840.70	985.71	789.69	736.36
Magnesium	2755.84	2740.26	3153.72	3129.87
Calcium	923.26	903.89	1197.39	946.75
Iron	86.05	29.87	68.07	43.51
Zinc	48.37	53.51	58.59	65.97
Sodium	35.46	36.62	43.46	37.53
Copper	14.88	24.55	27.05	25.45
Phosphorus	5546.56	6999.99	6320.26	6688.31

IV. CONCLUSION

In accordance with our research study that effect of Gamma radiation has benefits for sewage sludge on Agricultural application. The radiation doses were sufficient completely elimination of Total Bacterial count, Total Coliforms count at dose 25 kGy. Sewage-sludge application is provided benefits in terms of increased availability of major nutrients as well as mineral compositions in sacha inchi seeds. The results of this study also indicate that the level of heavy metals remains below the acceptable limit by USEPA after Gamma Irradiation. There was no significant difference effect of Gamma radiation in terms of increasing the plant heights among without sludge, non-irradiated sewage sludge and irradiated sewage sludge in this experiment. The effect of Gamma irradiated sewage sludge on the fruits production of sacha inchi plant at 25kGy found that significantly higher than without sludge. In further studies needed to optimize the irradiation process and the effects of sewage sludge on soil fertility and crop yields in order to provide municipal sewage sludge disposal and reduce chemical fertilizer usage in Agriculture.

V. ACKNOWLEDGMENT

The author would like to acknowledge Department of Research and Innovation (DRI) for doing analysis, support research fund and Department of Atomic Energy (DAE) for using Gamma Irradiator. We would also like to special thanks all team members of Irradiation Technology Research team for cooperation and successful implementation of this research work.

REFERENCES

[1] Sunan Wang, Fan Zhu, and Yukio Kakuda . 2018. Sacha inchi (Plukenetia volubilis L.): Nutritional composition, biological activity, and uses. Food Chemistry, 265: 316-326.

[2] Spyridon, D., Koutroubas, Vasileios, Antoniadis, Christos, A., Damalas and Sideris Fotiadis. 2020. Sewage Sludge Influences Nitrogen Uptake, Translocation, and Use Efficiency in Sunflower. Journal of Soil Science and Plant Nutrition.

[3] Behnam Asgari Lajayer, Nosratollah Najafi, Ebrahim Moghiseh, Mohammad Mosaferi, and Javad Hadian. 2019. Micronutrient and heavy metal concentrations in basil plant cultivated on irradiated and non-irradiated sewage sludge- treated soil and evaluation of human health risk. Regulatory Toxicology and Pharmacology, 104: 141-150.

[4] Khalid Usman, Sarfaraz Khan, Said Ghulam, Muhammad Umar Khan, Niamatullah Khan, Muhammad Anwar Khan, and Shad Khan Khalil. 2012. Sewage Sludge: An Important Biological Resource for Sustainable Agriculture and Its Environmental Implications", American Journal of Plant Sciences, 3: 1708-1721.

[5] [6] United States Environmental Protection Agency (USEPA) 503 standards for the use or disposal of sewage sludge, 58 FR 9387, 1993.