IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Impact Factor: 7.53

Volume 4, Issue 4, February 2024

An Overview of Rice Husk-Derived Nanosilica's Impact on Chili Plant Growth

Sachine Kushwaha[1] and Dr. Sudhir Singh[2]

Research Scholar, Department of Agriculture[1]

Research Guide, Department of Agriculture[2]

Sunrise University, Alwar, Rajasthan, India

Abstract: *Nanomaterials exhibit significant potential for the enhancement of plant growth, the controlled release of agro-chemicals, and the enhancement of plant disease resistance. In this investigation, the growth promotion of chile plants in greenhouses was investigated using nanosilica (10–30 nm) derived from rice husk. In a factorial design with three replications, the experiment of nanosilica treatment by foliar application was conducted at concentrations of 0, 40, 60, and 100 ppm. The chlorophyll content and plant growth characteristics were evaluated. The treatment with nanosilica resulted in an increase in the fresh weight, dried weight, and chlorophyll content. The concentration of nanosilica that was determined to be optimal was 60 ppm. Consequently, the chili plants' growth was improved by the treatment of nanosilica.*

Keywords: Nanoparticles, Plant growth, Development.

I. INTRODUCTION

Nanotechnology has a broad range of applications in a variety of disciplines, including medicine, pharmaceutics, electronics, and agriculture. Nanomaterials exhibit significant potential for the enhancement of plant growth, the controlled release of agro-chemicals, and the enhancement of plant disease resistance [1, 2]. Silica and nanosilica derived from rice husk have been utilized in a variety of applications, including adsorbents, carriers, additives, merging in Portland cement, zeolite production, and drug delivery systems [3 - 5]. In recent years, silica (SiO2) and nanosilica from rice husk (RH) have been utilized to produce porous ceramics for water remediation [6] and to stimulate plant growth and elicitation [2, 7, 8]. As an agro-waste product, approximately 600 million kilograms of RH are produced annually worldwide [9]. Rice productivity in Vietnam is estimated to be approximately 40 million kilograms per year. Consequently, an estimated 9.2 million tons of RH are produced annually. Based on a silica content of approximately 10% in RH [10], the silica quantity from the RH resource will be nearly 1 million tons per year. As a result, RH is a plentiful agro-waste resource that can be utilized to extract amorphous silica from RH ash (RHA) through combustion or burning techniques [3, 11-13] and nanosilica through incineration of acid-treated RH [4, 14, 15] or treatment of RHA using the sol-gel method [16, 17]. In order to mitigate the environmental concerns that are linked to the prevalent applications and disposal of RH [14].

Nanosilica was synthesized from RH in this study, and the impact of foliar applying nanosilica on the growth promotion of chile plants in a greenhouse was examined.

II. EXPERIMENTAL

Materials

Rice mills in the southern region of Vietnam supplied raw RH. Hydrochloric acid (HCl) of analytical reagent grade was acquired from Merck, Germany. Distilled water was employed in all investigations.

Preparation of nanosilica from rice husk

The method of nanosilica preparation was adapted from the one described by Athinarayanan et al. [4] and Wang et al. [14], with modifications. Initially, unprocessed RH was cleansed with water to eliminate soluble substances, particulates, and other contaminants. Subsequently, it was desiccated at 60°C in a forced air furnace supplied by Yamato (DNF 410, Japan). A magnetic stirrer was used to treat approximately 50 g of the desiccated RH with 500 ml of 1N HCl at ambient temperature for 2 hours. It was refrigerated and maintained its integrity overnight. Subsequently,

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 4, February 2024

it was decanted and thoroughly rinsed with distilled water until the rinse was acid-free. The treated RH was subsequently desiccated in a forced air oven until it reached the desired level of dryness. The resulting relative humidity was reduced to a fine powder. Nanosilica was produced by incinerating the RH powder at 700 oC for 2 hours in a programmable furnace (Nabertherm GmbH, Germany).

Characterization of nanosilica

The energy dispersive x-ray spectrometer (EDX) Horiba 7593-H was employed to estimate the silica content and the quantity of metallic impurities in the sample. Nanosilica's X-ray diffraction (XRD) pattern was captured using a D8 Advance A25 X-ray diffractometer from Brucker, Germany. Transmission electron microscopy (TEM) was employed to investigate the particle size of nanosilica, employing the JEM1010 model from JEOL, Japan.

Growth promotion of nanosilica for chili plant

The 60-day-old chili plants (Capsicum frutescens L.) were subjected to four treatments, each with three replications, of foliar spraying nanosilica. The treatments included a control (treated with water without nanosilica), 40, 60, and 100 ppm of nanosilica, all of which were administered in the green house of the Hi-Tech Agriculture Center in Cu Chi, Ho Chi Minh City, at a temperature of 30 ± 2 oC and a relative humidity of 60 ± 2%. The total number of chile plants utilized in the four regimens previously mentioned was 120, with 30 plants per treatment. The chili plants continued to thrive for an additional three weeks following two spraying sessions, which lasted for two weeks. Subsequently, the chlorophyll content, the desiccated weight, and the fresh weight were examined. The alcohol extraction method described by Dere et al. [18] was employed to spectrophotometrically determine the chlorophyll (a+b) content. The statistical analyses of the data were conducted in accordance with the field experiment method, using one-way ANOVA processing with a significance level of $P < 0.05$ [19].

III. RESULTS AND DISCUSSION

Nanosilica from rice husk

The nanosilica in Figure 1 was prepared from RH powder using acid treatment and subsequent incineration at 700 oC for 2 h in this investigation, with a yield of 10.21 ± 0.38 % [4, 14].

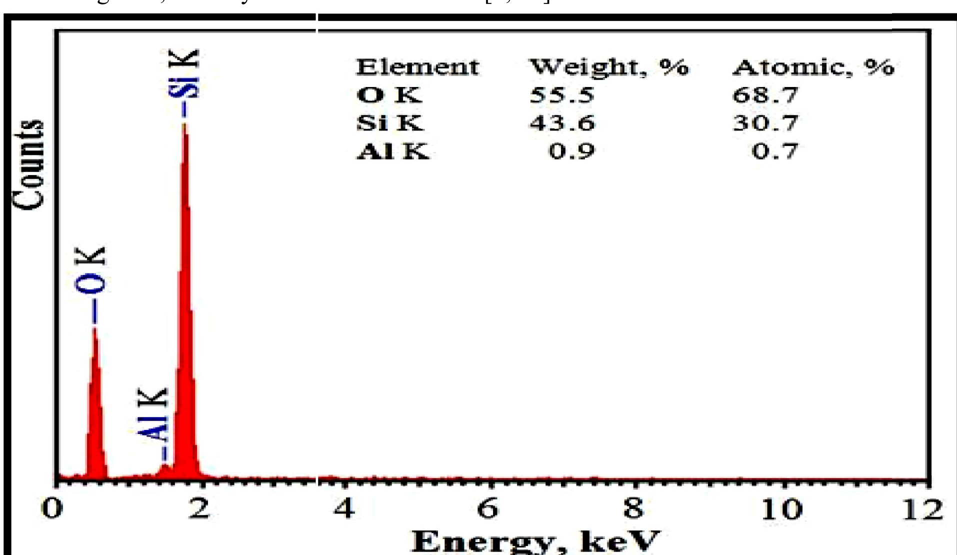

Figure 1. EDX spectrum of nanosilica from RH powder.

In the absence of acid treatment, Vietnamese RH ash comprises K_2O (0.39 %), Al_2O_3 (0.48 %), Fe_2O_3 (0.15 %), CaO (0.73 %), MgO (0.55 %), Na_2O (0.12 %), and SiO_2 (96.15 %), as per Le et al. [16]. The metallic impurities were effectively removed as a result of the treatment of RH (not RH ash) with 1N HCl prior to incineration in this study. Only Al_2O_3 at 1.486 keV retained a modest content of 0.7 % when calculated as atomic percentage (Figure 2). The k

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 4, February 2024

values of silicon (Si) and oxygen (O) in the EDX spectrum depicted in Figure 2 are 1.739 and 0.525 keV, respectively. Furthermore, Carmora et al. reported that organic acids, specifically citric and acetic acid, can be effectively employed to eliminate metallic impurities [15].

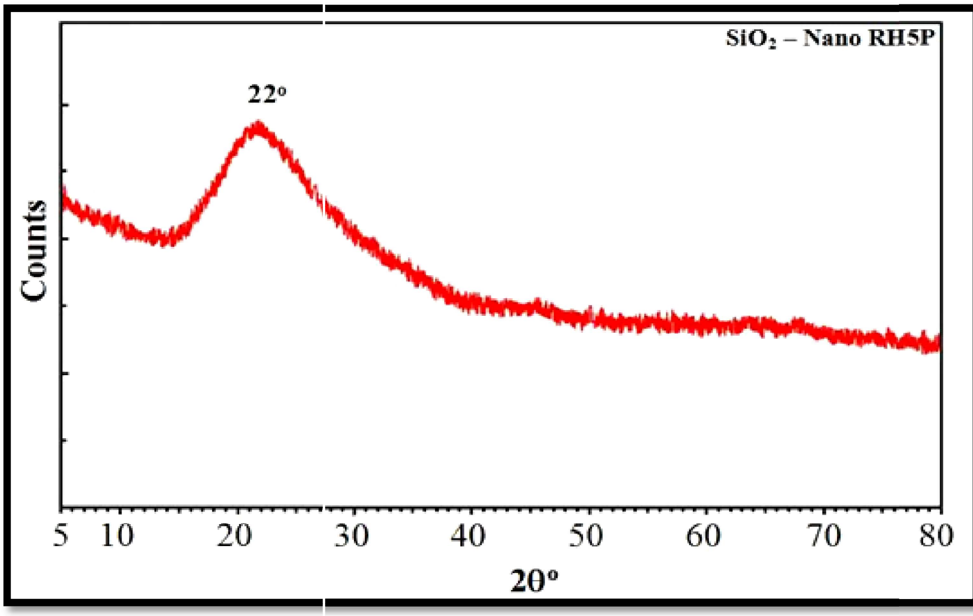

Figure 2. XRD pattern of nanosilica from RH powder.

Figure 3 illustrates the nanosilica's XRD pattern. The purity and amorphous structure of nanosilica generated from acid-treated RH powder were corroborated by the single peak at 2 22o in Figure 3 [4, 14, 16].

The TEM image in Figure 4 was used to estimate the size of the as-prepared nanosilica to be between 10 and 30 nm. Athinarayanan et al. also reported that the same size of nanosilica was extracted by incineration of RH powder at 700 oC for 2 h, while incineration at lesser temperatures, including 500 and 600 oC, produced nanosilica with a larger size [4].

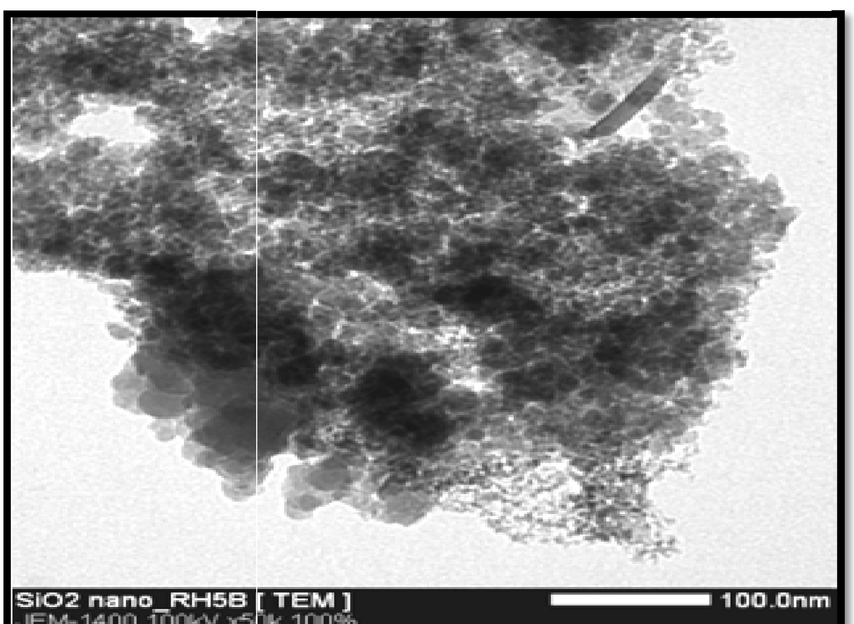

Figure 3. TEM image of nanosilica from RH powder.

IJARSCT ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 4, February 2024

Growth characteristics of chili plant treated with nanosilica

Table 1. Effect of nanosilica on growth parameters in chili plant after 35 days of growth.

Nanosilca Treatment	Shoot biomass, g/plant		Root biomass, g/plant		Chlorophyll (a+b), mg/g
	Fresh weight	Dry weight	Fresh weight	Dry weight	
Control	25.67d*	6.50d*	3.52b*	0.38c*	21.29d*
40 ppm	28.78b	7.51c	4.24a	0.47b	24.61c
60 ppm	30.17a	12.34a	4.59a	0.55a	36.67a
100 ppm	28.16c	11.51b	4.14a	0.45b	25.42b
**LSD0.05	0.13	0.53	0.61	0.03	0.55

*Different letters in the same column indicate significant differences at $P < 0.05$.

**Least significant difference (LSD) at $P < 0.05$.

The results in Table 1 clearly demonstrated that the treatment of 60 ppm of nanosilica was the most effective in enhancing the growth of the chili plant. Specifically, the fresh weight of the shoot and root increased by 17.5% and 30.4%, respectively, and the dry weight of the shoot and root increased by approximately 90% and 44.7%, respectively, in comparison to the control group (water spraying). Furthermore, the total chlorophyll (a+b) content increased significantly to 70.6 % (36.67 mg/g) in comparison to the control sample (21.29 mg/g). The results of the present study also indicated that the treatment of nanosilica on chili plants led to an increase in chlorophyll content, which in turn resulted in a higher photosynthetic rate [20]. Additionally, the results obtained indicated that the treatment of nanosilica had a beneficial impact on photosynthesis. In comparison to other treatments and the control group, Suriyaprabha et al. found that the application of 15 kg/ha nanosilica from RH in soil resulted in a more effective growth promotion of maize in terms of stem height and chlorophyll content [7]. They determined that the application of nanosilica fertilizers in soil was more effective than bulk silica and control for the purpose of enhancing maize growth. Siddiqui et al. also reported that the characteristics of seed germination, seedling fresh weight, and dried weight were considerably improved by the treatment of tomato seeds with nanosilica (8 g/L) [8]. The results of the present study, as well as those of Suriyaprabha et al. [7], Siddiqui et al. [8], and our own, indicate that nanosilica could be employed as a fertilizer through foliar sprinkling and/or soil modification to enhance crop yield. Furthermore, it is intriguing to observe that the plant can be safeguarded from pathogenic infection through the application of nanosilica treatment [2]. Additionally, Rodrigues et al. demonstrated that silica was instrumental in the resistance of rice to blast disease by stimulating the production of phytoalexins [21]. Kiirika et al. recently reported that the synergistic effect of silica and chitosan combined treatment against bacterial disease was observed in tomato plants [22]. Consequently, nanosilica is a promising candidate for use as a growth promoter and elicitor in plants.

IV. CONCLUSION

The production of nanosilica (10-30 nm) from RH was achieved through the incineration of acid-treated RH powder at 700 oC for 2 hours. The most effective growth enhancement of the chili plant was achieved through foliar application with nanosilica at a concentration of 60 ppm, as evidenced by the increase in fresh weight, dried weight, and chlorophyll content. Consequently, nanosilica from RH is a promising candidate for the application as an environmentally benign agro-chemical for the sustainable development of agriculture, as well as a growth promoter and elicitor for plants.

REFERENCES

[1]. Khot L.R. et al. - Applications of nanomaterials in agricultural production and crop protection: A review, Crop. Proct. 35 (2012) 64-70.

[2]. Huang S. et al. - Nanotechnology in agriculture, livestock, and aquaculture in China. A review, Agron. Sustain. Dev. (2014) DOI 10.1007/s13593-014-0274-x.

[3]. Chandrasekhar S. et al. - Processing, properties and application of reactive silica from rice husk-an overview, J. Mater. Sci. 38 (2003) 3159-3168.

[4]. Athinarayanan J. et al. - Synthesis of biogenic silica nanoparticles from rice husks for biomedical applications, Ceramics Inter. 41 (2015) 275-281.

[5]. Pode R. - Potential applications of rice husk ash waste from rice husk biomass power plant, Renew. Sust. Energ. Rev. 53 (2016) 1468-1485.

[6]. Nguyen T.A.T. et al. - Bactericidal activity and silver release of porous ceramic candle filter prepared by sintering silica with silver nanoparticles/zeolite for water disinfection, Adv. Nat. Sci.: Nanosci. Nanotechnol. 5 (2014) 035001.

[7]. Suriyaprabha R. et al. - Growth and physiological responses of maize (Zea mays L.) to porous silica nanoparticles in soil, J. Nanopart. Res. 14 (2012)1294.

[8]. Siddiqui M.H, Al-Whaibi M.H - Role of nano-SiO2 in germination of tomato (Lycopersicum esculentum seeds Mill.), Saudi J. Biol. Sci. 21 (2014) 13-17.

[9]. Feng Q. et al. - Adsorption of lead and mercury by rice husk ash, J. Colloid Interface Sci. 278 (2004) 1-8.

[10]. Liou T.H. - Preparation and characterization of nano-structured silica from rice husk, Mater. Sci. Eng. A 364 (2004) 313-323.

[11]. Habeeb G.A., Mahmud H.B. - Study on properties of rice husk ash and its use as cement replacement material, Mater. Res. 13 (2010) 185-190.

[12]. Della V.P., Kuhn I., Hotza D. - Rice husk ash as an alternative source for active silica production, Mater. Lett. 57 (2002) 818-821.

[13]. Fernandes I.J. et al. - Characterization of rice husk ash produced using different biomass combustion techniques for energy, Fuel 165 (2016) 351-359.

[14]. Wang W. et al. - Harvesting silica nanoparticle from rice husk, J. Nanopart. Res. 13 (2013) 6981-6990.

[15]. Carmona V.B. et al. - Nanosilica from rice husk: Extraction and characterization, Ind. Crops Prod. 43 (2013) 291-296.

[16]. Le V.H et al. - Synthesis of silica nanoparticles from Vietnamese rice husk by sol-gel method, Nanoscale Res. Lett. 8 (2013) 58.

[17]. Rafiee E. et al. - Optimization of synthesis and characterization of nanosilica produced from rice husk (a common waste material), Inter. Nano Lett. 2 (2012) 29.

[18]. Dere S. et al. - Spectrophotometric determination of chlorophyll-a,b and total carotenoid contents of some algae species using different solvents, Tr. J. Botany 22 (1998) 13-17, 1998.

[19]. Pham Chi Thanh - Method for field experiment, Agric. Publisher, Hanoi, 1976.

[20]. Ma L. et al. - Alleviation of exogenous oligochitosan on wheat seedlings growth under salt stress, Protoplasma (2011) DOI 10.1007/s00709-011-0290-5.

[21]. Rodrigues F.A. et al. - Silicon enhances the accumulation of diterpenoid phytoalexins in rice: a potential mechanism for blast resistance, Biochem. Cell Biol. 94 (2004) 177-183.

[22]. Kiirika L.M. et al. - Phenotypic and molecular characterization of resistance induction by single and combined application of chitosan and silicon in tomato against Ralstonia solanacearum, Physiol. Mol. Plant Pathol. 81 (2013) 1-12.