Effect of Different quantities of Magnesium Oxide Nanoparticles on the Growth of Black Gram V*igna mungo*

Muthuswami Ruby Rajan[1], Chinnaponnusamy Kalimuthu[2]

[1, 2]Department of Biology, The Gandhigram Rural Institute- Deemed to be University, Gandhigram -624 302, Tamil Nadu, India

*****Corresponding Author: Muthuswami Ruby Rajan
E. mail: *mrrrajanbio[at]gmail.com*
Orchid ID:0000-0003-1297-1245

Abstract: ***The present study aimed at the effect of different quantities of magnesium oxide nanoparticles on the growth of Black gram Vigna mungo. MgO nanoparticles were synthesized and characterized using UV-VIS,SEM, EDAX, XRD, and FTIR.Pot culture studies on different quantities of magnesium nanoparticles such as 100, 200, 300, 400 and 500mg for treatments T0 (control) T1, T2, T3, T4, and T5 respectively on the growth of black gram Vigna mungo were carried out.Growth characteristics such as seed germination efficiency, shoot length, root length, total fresh weight, total dry weight, leaf area index and vigour index (%) were measured for 30 days. The UV-Visible absorption spectra finding demonstrates that magnesium oxide nanoparticles were measured in wavelength within the range 300 to 600 and exhibits a strong absorption band at 550nm.SEM image of magnesium oxide nanoparticles was observed as clumped in shape. EDAX spectrum recorded on the magnesium oxide nanoparticles is shown as the peaks were located on the spectrum at 1.2 KeV. The FTIR spectrum of magnesium oxide nanoparticles were analyzed in the range of 400-4000cm^{-1} and spectral bands and functional groups are alcohol, alkane, carbon-di-oxide, anhydride, and sulfonate. The chemical composition of magnesium oxide nanoparticles was analyzed by XRD and the diffraction peaks are indexed as 9.4˚(110), 36.82˚(351), 42.81˚(123), 62.14˚(233),74.52˚(214),78.42˚(352.Germination efficiency of the black gram Vigna mungo was higher in T2(200mg) and lower in T1(100mg). Shoot and root length, fresh weight and dry weight, leaf area and vigour index of black gram were higher in T4.***

Keywords: Different, MgO, Nanoparticles, Growth, Black gram

1. Introduction

In an agricultural production system, the availability of magnesium to crops depends on soil texture and cation exchangeable capacity [1], site-specific climatic and anthropogenic factors, agronomic management practices, as well as crop species itself. Crops absorb magnesium from the soil mainly through their roots. Adequate soil magnesium is key to ensuring robust crop growth and production. Absolute magnesium deficiency in the soil dramatically reduces magnesium absorption by crop roots. Magnesium losses by mobilization and leaching in the soil.In good soil, magnesium condition is the prerequisite to ensuring magnesium uptake by crop roots and enhancing Magnesium utilization efficiency. Use of nanoparticles in crop sciences is consistently increasing. Several advantageous effects of nanoparticles have been observed on crop plants [2]. The work related to the effect of different quantities of magnesium nanoparticles on the growth of black gram *Vigna mungo* is wanting. Hence the present study was carried out.

2. Materials and Methods

Synthesis of magnesium oxide nanoparticles:
The synthesis of magnesium oxide nanoparticles is divided into various steps, such as mixing, stirring, filtering, drying, and calcinating the powder at 400^{0}C for 3h, the magnesium oxide is obtained in the form of nanoparticles. Initially, 5.21g (0.2M) magnesium nitrate hexahydrate was dissolved in 200 ml of distilled water. 0.8g (0.2M) of NaOH was dissolved in 200 ml of distilled water. Then 200 ml NaOH solution is added to a solution of $MgNO_2H_2O_6$ dropwise by using a pipette. After that, the solution was kept under magnetic stirring for 2h after stirring on the table at rest for 2h so that, the precipitation is formed at the bottom of the beaker. This precipitate was filtered and washed several times by using distilled and ethanol to get the final product. The final product is kept at room temperature for drying. This dried powder is then crushed and made into very fine powder by using a mortar and pestle. Finally, a fine powder of magnesium oxide is calcinated at 400^{0}C for 3h for the removal of impurities present in the powder.

Characterization of magnesium oxide nanoparticles:
The synthesized magnesium oxide nanoparticles were characterized using the following techniques.

UV-Visible Spectrophotometer
UV-Visible spectroscopy measures the extinction (scatter + absorption) of light passing through a sample. Nanoparticles have unique optical properties that are sensitive to the size, shape, concentration, agglomeration state and refractive index near the nanoparticle surface, which makes UV-Vis a valuable tool for identifying, characterizing, and studying nanomaterials. The most important factor of the technique is to give information about the material when light falls on it.

Scanning Electron Microscopy (SEM)
SEM analysis is a powerful investigative tool which uses a focused beam of electrons to produce complex, high-magnification images of a sample's surface topography. The

morphology of the magnesium was investigated using a scanning electron microscope (SEM) (LEO 1455 VP).

EDAX

A minute drop of nanoparticles solution was cast on aluminium foil and subsequently dried in the air before transferring to the microscope. An energy-dispersive X-ray detection instrument (EDAX) (HORIBA 8121-H) was used to examine the elemental composition of the MgO2 NPs.

X-Ray Diffraction (XRD)

The structure and crystalline size of MgO nanoparticles were determined by XRD using an X-ray diffractometer with nickel-filter CuKα radiations in the 20 range (λ=1.5418Å) from an X- ray tube run at 40k V and 30mg.

λ= 2d sinϴ

d= interplane spacing, λ= wavelength of x-ray.

Fourier Transform InfraredSpectroscopy (FTIR)

FTIR is a very versatile tool for the surface characterization of nanoparticles and provides a specific setup attached to the spectrometer. Under specific conditions, the chemical composition of the nanoparticles' surface is determined and the surface reactive sites responsible for the surface reactivity can be identified. In addition, the chemical reactions taking place at the surface of the nanoparticles can be monitored in situ as a function of various parameters, such as temperature and gaseous environment.

Source of material used in pot culture (seeds and cow dung):

The viable seedswere purchased from Velauthampalayam, Vadamadurai, Dindigul, Tamil Nadu, India. Cow dung was collected from the Dairy Unit of the School of Agriculture and Animal Sciences, The Gandhigram Rural Institute-Deemed to be University, Gandhigram, Tamil Nadu, India.

Physico- Chemical characteristics:

Physico-chemical characteristics such as pH, electrical conductivity, nitrogen, organic carbon, potassium, sodium, calcium and phosphorus were estimated in red soil and cow dung. (Table 1)[3].

Table 1: Analyticaltechniques used in red soil and cow dung:

S.No	Parameter	Analytic method	Reference
1	pH	pH Meter	APHA,2012[3]
2	Electrical conductivity	Conductivity Bridge	,,
3	Potassium	Flame Photometer	,,
4	Sodium	Flame Photometer	,,
5	calcium	Flame Photometer	,,
6	Nitrogen	Micro-kjeldhal method	,,
7	Phosphorous	Olsen's method	,,
	Carbon	Walky and Blacky method	,,

Pot culture studies:

For pot culture studies 18 plastic pots (25 cm diameter, 25 cm height) were filled with a mixture of red soil, and cow dung in a ratio of 1:1. The experimental soil was mixed with different quantities of magnesium oxide nanoparticles such as 0, 100, 200, 300, 400, 500 for To (control) T1,T2,T3,T4,and T5 respectively (Table 2). Triplicates were maintained and grown in a greenhouse for 45 days. Tap water is used as an irrigant and the procedure followed for growth characteristics is presented in Table 3.

Table 2: Pot culture studies

Treatment	Red soil (Kg)	Cow dung manure (Kg)	Magnesium oxide nanoparticles(mg)
T0	1	1	-
T1	1	1	100
T2	1	1	200
T3	1	1	300
T4	1	1	400
T5	1	1	500

Table 3: Procedure followed for growth characteristics of a Black gram (*Vigna mungo*)

S. No	Parameters	Reference
1	Germination, %	Carly and Watson,(1968)[4]
2	Shoot length, cm	Arts and Marks,(1971)[5]
3	Root length,	Burris et al.,(1969)[6]
4	Total fresh weight, g	Burris et al.,(1969)[6]
5	Total dry weight,	Burris et al.,(1969)[6]
6	Leaf area, cm^2	Ford Denison and Raymond Russotti(1997)[7]
7	Vigour index, %	Abdul Baki and Anderson,(1973)[8]

Growth characteristics:

10 seeds were sown in each pot for six treatments in three replicates.

3. Results and Discussion

Characterization of Magnesium oxide (MgO)

UV-Visible absorption spectroscopy is a widely used technique to examine the optical properties of the nanosized particle. The absorbance spectra of magnesium oxide nanoparticles were measured in wavelength within the range of 300 to 600.It exhibits a strong absorption band at 550nmas shown in Figure 1.UV-Vis spectrum is the most basic and important technique for identifying and characterizing nanoparticles [9]. The absorbance spectra of magnesium oxide nanoparticles were measured in wavelength within the range of 300 to 600. It exhibits a strong absorption band at 550nm.

The morphology of the material was studied through scanning electron microscopy. Scanning Electron Microscopy indicates that magnesium nanoparticles are clumped structures (Fig 2).SEM results reveal that the magnesium oxide nanoparticles are clumped in shape. Celin Hemalatha and Clement Lourduraj (2017)[10] reported that the SEM morphology of MnO_2nano crystalline particles was found to have an irregular spherical shape.

The elemental composition of the synthesized nanoparticles was identified by an energy-dispersive X-ray spectroscopy system (EDAX) (Fig 3).Magnesium content is higher than oxygen. The presence of oxygen (O), and magnesium (Mg) were revealed in synthesized nanoparticles by EDAX spectral analysis. EDAX result revealed that magnesium oxide nanoparticles and the peaks are located between 0.40 KeV and 2.0 KeV. Thirunavukkarasu Somanathan *et al.*, (2016) [11] reported that a couple of intense peaks correspond to the composition of Mg and O and the rest of the peaks arisefrom carbon tape. Finally, it was concluded that the synthesized MgO NPs are highly pure.

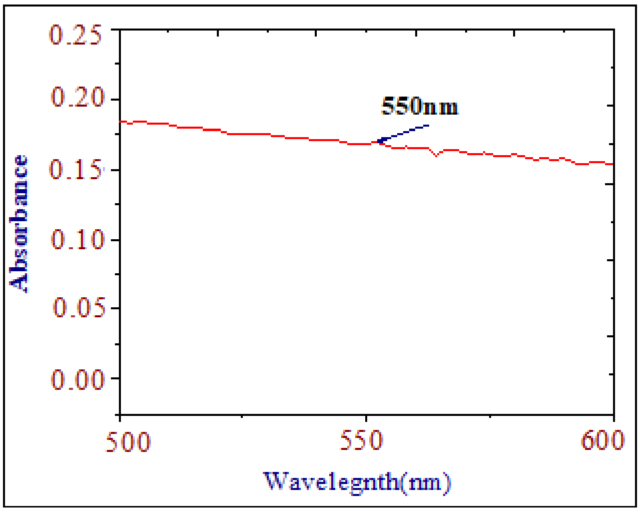

Figure 1: UV-Visible Spectroscopy Analysis of Magnesium Oxide Nanoparticles

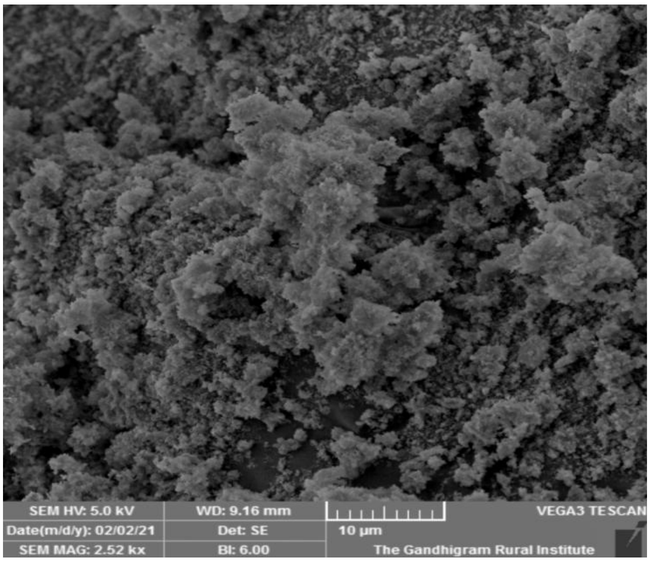

Figure 2: SEM Images of Magnesium Oxide Nanoparticles

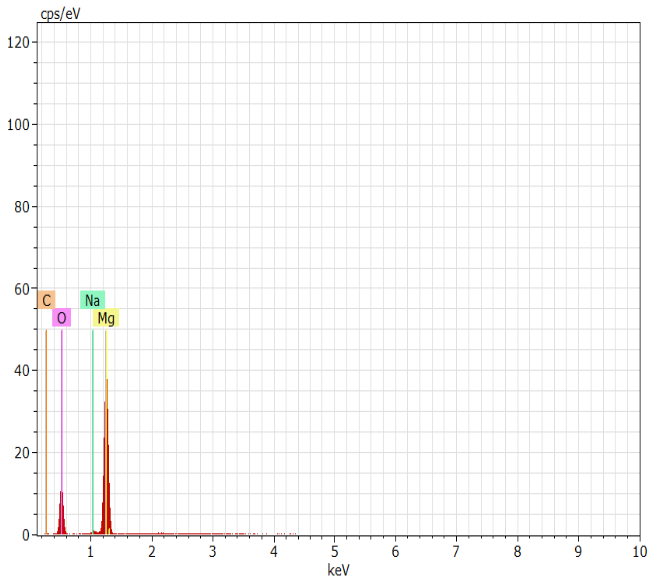

Figure 3: EDAX Images of Magnesium Oxide Nanoparticles

The phase structure of biosynthesized magnesium oxide nanoparticles is shown in Figure 4. In magnesium nanoparticle {2ϴ = 9.4˚(110), 36.82˚(351), 42.81˚(123), 62.14˚(233),74.52˚(214),78.42˚(352)}.The XRD spectra suggest that the range become increased the crystalline size of magnesium oxide nanoparticles. The crystal sizes were calculated using Scherrer's formula and were about 20-50nm.The XRD results revealed the high crystalline nature of magnesium oxide nanoparticles. Mihyun Park and Jung Ho Yo(2012)[12] reported that the tetrahedral MnO nanocrystals possess a cubic rock-salt crystal structure. In order to evaluate and identify the reaction product, XRD was used for the crystal size analysis and XRD diffraction peaks are indexed as to (110), (351), (123), (233), (214), (352).

The FT-IR spectrum of magnesium oxide nanoparticles was analyzed at the wave number range of 400-4000cm^{-1}. The FT-IR measurement was carried out to identify the functional groups of bioactive components based on the peak value in the infrared radiation region. The spectra show bands at 3421.12, 2918.73, 2303.55, 1628.59 and 1371.14 cm^{-1} are the bands have alcohol, alkane, carbon-di-oxide, anhydride and sulfonate(Fig.5).FT-IR spectrum of magnesium oxide nanoparticles was analyzed at the wave number range of 400-4000cm^{-}1. Synthesized magnesium oxide nanoparticles have a functional group such as alcohol, alkane, carbon-di-oxide, anhydride, and sulfonate. The peaks observed at 866.39cm^{-1} indicate the presence of magnesium. (Mohammad Imani and Moslem, 2019)[13] reported that the peaks observed below 800cm^{-1} confirmed the magnesium oxide.

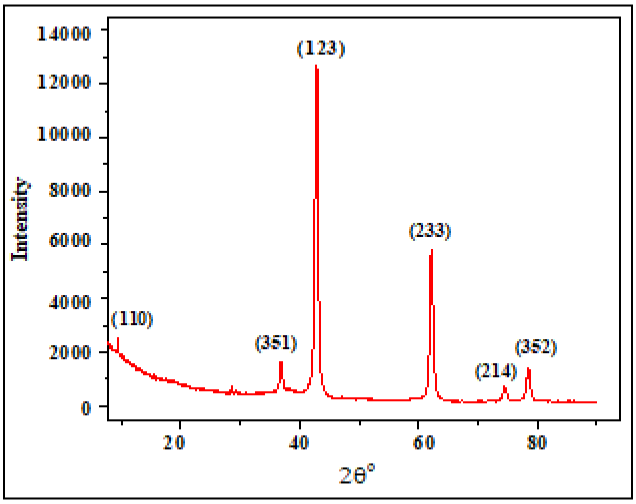

Figure 4: XRD images of Magnesium oxide nanoparticles

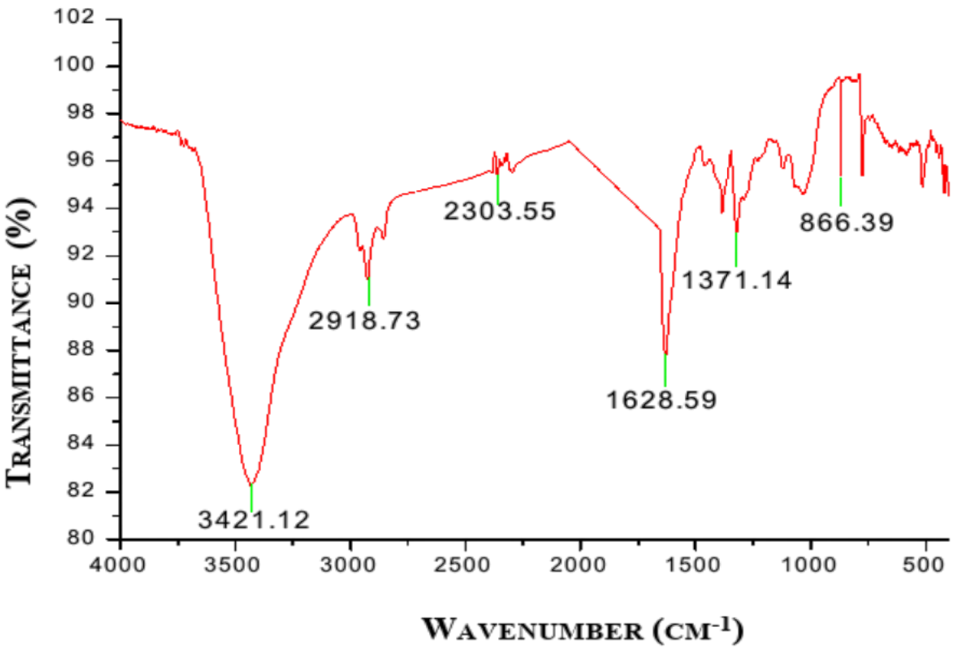

Figure 5: FTIR Images of Magnesium oxide Nanoparticles

Physico-chemical Parameters of Red Soil and Cowdung

The Physico-chemical parameter of red soil and cow dung used in pot culture studies are presented in Table 5. The pH of cow dung and red soil are 6.5 and 7. The Electrical conductivity is almost the same in red soil and cow dung is 1.37 and 1.36. The organic carbon is higher in red soil (0.61) and lowers in cow dung (0.42). The total nitrogen of red soil and cow dung is 0.056 and 0.084. The potassium is higher in cow dung (613.08) and lowers in red soil (247.65).The calcium is higher in cow dung (5) and lowers in red soil (2).The sodium is higher in cow dung (369.61) and lowers in red soil (178.94). The phosphorus content of red soil is 1.367 and cow dung is 0.598.

Table 5: Physico-chemical parameters of Red soil and Cow dung

S. No	Parameter	Red Soil	Cow dung
1.	pH	7	6.5
2.	Electrical conductivity (ms/cm)	1.37	1.36
3.	Organic carbon (%)	0.61	0.42
4.	Total Nitrogen (%)	0.056	0.084
5.	Potassium (ppm / l)	247.65	613.8
6.	Calcium (ppm / l)	2	5
7.	Sodium (ppm / l)	178.94	369.61
8.	Phosphorous (%)	1.367	0.598

Growth Parameters:

The effect of different quantities of magnesium oxide nanoparticles on the growth parameters of black gram *Vigna mungo*is presented in table 6.The germination efficiency of the black gramis presented in table 7.Prasad et al (2012) [14] reported 100% germination of pea nuts treated with zinc oxide nanoparticles. The shoot length of the black gram in the control is 23.5cm. Among the treatment, the shoot length is higher in T4 containing 400 mg of magnesium oxide nanoparticles and lower in T1 containing 100 mg of nanoparticles. Mahajan (2011) [15] reported that the shoot length of Mung and Gram increased in lower concentrations of nano ZnO nanoparticles decreasing the shoot length. Prasad et al., 2012) [14] also reported that the shoot length of peanuts is higher in 100mg of ZnO nanoparticles. The root length of the black gram in the control is 12.8. Among the treatment, the root length is higher in T4 and lower in T2. The fresh weight of the black gram in control is 18g. The dry weight of the black gram is higher in T4 and lower in T2. Sri Sindhura et al., (2013) [16] reported that the fresh weight of peanuts is higher in lower concentrations of ZnO nanoparticles. The leaf area is higher in T4. The leaf area of Ladies finger is higher in T3 containing 200 mg of MgO nanoparticles (17).The vigour index of black gram in control is 708.66. Among the treatment vigour index is higher in T4 and lower in T1.Prasadet al., (2012) [14] reported a Vigour index of 1701.3 in peanuts treated with ZnO nanoparticles. But low (176) vigour index was reported in cluster beans treated with selenium nanoparticles [18].

Table 6: Effect of various quantities of magnesium oxide nanoparticles on growth parameters of black gram (*Vigna mungo*) grown for a period of 30 days. each value is the average of 10 individual observations (average ± SD)

Parameters	Days	Treatment					
		T_0	T_1	T_2	T_3	T_4	T_5
Germination(%)	30	90	83	97	93	93	90
Shoot Length(cm)	30	23.5 ±8.55	19.8 ±7.40	21 ± 9.75	24.2 ±7.35	25 ±6.80	20.3 ±8.40
Root length(cm)	30	12.8±4.14	13.4 ±3.80	12.1±4.77	15 ±2.76	16 ± 5.67	12.3 ± 5
Fresh weight(g)	30	18 ± 6	17 ±5.87	19.5 ± 5.43	21.3 ± 4.89	25 ± 4.78	19.6 ± 5.50
Dry weight(g)	30	2.5 ± 1	2.3 ± 0.98	1.9 ± 0.79	2 ± 0.80	3 ± 1.40	2.2 ± 0.95

Leaf area	30	16 ± 4.12	21 ± 1.88	18 ± 3	21 ± 4.33	22 ± 1.11	19 ± 2.89
Vigor index	30	708.66	552.26	683.17	755.2	779.1	614.33

4. Conclusion

The present study concluded that treatment 4 containing 400mg of Magnesium oxide nanoparticles enhanced the growth of black gram.

Acknowledgement

The authors thank the Department of Biology, The Gandhigram Rural Institute- Deemed to be University, Gandhigram, Tamil Nadu, India for offering facilities to carry out this research work.

Disclosure of conflict of interest:

The authors declare no conflict of interest

References

[1] Hariadi Y, Shabala S. Screening broad beans (*Viciafaba*) for magnesium deficiency. I. Growth characteristics, visual deficiency symptoms and plant nutritional status. Functional Plant Biology.2004; 31: 529–537.

[2] Abdul Haffeez, Abdul Razzaq, Tariq Mahmood, Hafiz Muhammad Jhanzab.Potential of Nanoparticles to Increase Growth and Yield of Wheat. Journal of Nanoscience with Advanced Technology.2015;1(1): 6-11.

[3] APHA., AWWA and WEF. Standard Methods for the Examination of Water and Wastewater, 22nd Ed. E.W. Rice, R.B. Baird, A.D. Eaton, and L.S. Clesceri (eds). Washington, D.C. American Public Health Association.2012;

[4] Carley HE, Watson RD. Effect of various aqueous plant extracts upon seed germination. Bot gazette. 1968; 129 (1):57–62.

[5] Art HW, Marks PL. summary table of biomass and net annual primary production in forest ecosystems of the world. Maine Agr Exp Sta Misc Rep. 1971.

[6] Burris JS, Edje OT, Wahab AH. Evaluation of various indices of seed and seedlingigor in soybeans [Glycine max (L.) Merr.]. In Proceedings of the Association of Official Seed Analysts. 1969: 73–81.

[7] Ford Denison R, Raymond Roussotti. Field estimates of green leaf area index using laser-induced chlorophyll fluorescence. Field Crops Research, 1997; 52 (1–2): 143- 149.

[8] Abdul-Baki AA, Anderson JD. Vigour determination in soybean seed by multiple criteria Crop Science. 1973;13(6):630–3.

[9] Khurana JM, Vij K. Nickel nanoparticles as semi-heterogeneous catalyst for one-pot, three-component synthesis of 2-amino-4 H-pyrans and pyran annulated heterocyclic moieties. Synthetic Communications. 2013;43(17):2294-304.

[10] Cellin Hemalatha F, Clement Lourduraj A J.Synthesis and characterization of MnO_2 .Nanoparticles using co-precipitation Technique. International Journal Scientific Research in Science and Technology.2017; 2 (11): 125-128.

[11] Thirunavukkarasu Somanathan., Vemula Mohana Krishna.,VelauthamSaravanan.,Raju Kumar and RandhirKumar. MgO Nanoparticles for Effective Uptake and Release of Doxorubicin Drug: pH-Sensitive Controlled Drug Release. Journal of Nanoscience and Nanotechnology,2016;15: 1–11.

[12] Mihyun Park, Jung Ho Yu, Hyon Bin Na, Nohyun Lee, Jongnam Park, Seung Hong Choi, Chan Song, Woo Kyung Moon, TaeghwanHyeon.Synthesis of Uniformly sized manganese oxide nanocrystals with various sizes and shapes and characterization of their T1 magnetic Resonance Relativity. European Journal of Inorganic Chemistry.2012; 12 : 2148-2155.

[13] Mohammad Moslem Imani, Mohsen Safaei.Optimized synthesis of magnesium oxide nanoparticles as bacterial agents. Journal of Nanotechnology. 2019; 3: 1 - 6.

[14] Prasad TN, Sudhakar P, Sreenivasulu Y, Latha P, Munaswamy V, Reddy KR, Sreeprasad TS, Sajanlal PR, Pradeep T. Effect of nanoscale zinc oxide particles on the germination, growth and yield of peanut. Journal of plant nutrition. 2012; 35(6):905-27.

[15] Mahajan P,Dhoke S K, Khanna A S. Effect on Nano-ZnO Particle Suspension on Growth of Mung (*Vigna radiate*) and Gram (*Cicer arietinum*) Seedling Using Plant Agar Method, Journal of Nanotechnology. 2011; 696535:7.

[16] Sri Sindhura K, Panneer Selvam P, PrasadTNVKV, Hussain OM. Green Synthesisof Zinc Nanoparticles from *Senna auriculata* and Influence on Peanut Pot-Culture. International Journal of Research in Agricultural Sciences. 2013; 2(2): 2348-3997.

[17] RajanMR, Suriyakala C.(2022) Effect of different quantities of MnO Nanoparticles on Growth of Ladies Finger Abelmoschus esculentus Research & Reviews: A Journal of Toxicology. 2022;12(2): 8–15.

[18] Rajan MR, Hajira Parveen M. Impact of Selenium Nanoparticles on Growth, Biochemical Characteristics and Yield of Black gram *Vigna mungo*. International Journal of Innovation Science and Research Review, 2021;3(6): 1420–1425.