EUROPEAN JOURNAL OF BIOMEDICAL AND PHARMACEUTICAL SCIENCES
http://www.ejbps.com

ISSN 2349-8870
Volume: 6
Issue: 4
189-194
Year: 2019

METHODS INVOLVED IN THE SYNTHESIS OF SELENIUM NANOPARTICLES AND THEIR DIFFERENT APPLICATIONS- A REVIEW

Gayathri Murugesan, Karuppusamy Nagaraj, D. Sunmathi and Karthik Subramani*

PG and Research Department of Biotechnology, Dr. N.G.P. Arts and Science College, Coimbatore, Tamilnadu, India.

***Corresponding Author: Karthik Subramani**
PG and Research Department of Biotechnology, Dr. N.G.P. Arts and Science College, Coimbatore, Tamilnadu, India.

Article Received on 29/01/2019 **Article Revised on 19/02/2019** **Article Accepted on 12/03/2019**

ABSTRACT
Selenium, an essential trace microelement, is necessary for the growth and development of living organisms. There are different methods involved in the synthesis of selenium nanoparticles such as physical, chemical and biological methods. Among all the available methods, the green synthesis or biological methods are mostly preferred due to less toxicity. Different types of selenium - based products are commercially available as selenium supplement tablets and fertilizers. They are also used in drug delivery, waste water treatment and photocatalytic activity. This review paper highlighted the methods for the synthesis of Selenium nanoparticles and its applications.

KEYWORDS: Nanoparticles, Selenium, chemical synthesis, green synthesis, plants, microbes.

INTRODUCTION
Nano, the word which means tiny matter. The particles which are in nano form are called as nanoparticles. [1] The technology used for the production of nanomaterials known as nanotechnology. Many nano based things are commercially available in the market. [1] Nanotechnology plays a vital role in many fields such as transportation, automobiles, food, cosmetic and biosensors. The nanotechnology includes the synthesis of nanomaterials. The nanomaterials which includes nanoparticles or nanospheres. These nanoparticles are in one or more dimensions which include size range from 1-100nm. The physical, chemical and biological properties of the nanoparticles are depending on the size, shape, surface area/volume of ratio. The first synthesis of metallic gold nanoparticles most probably dates back to the 5th or 4th century BC where gold specimens were reported in China and Egypt. The nanoparticles include metals such as Silver, Gold, Zinc, Copper, Titanium, Platinum, Selenium, Silicon and Carbon.[2]

There are different methods involved in the production of the nanoparticles. They are physical, chemical and biological / green synthesis. [1] Initially, the physical and chemical methods are followed. But commercial production is not successful so far. Because, metals are high toxic to the human which are used in medical fields such as drug delivery and targeting. To decrease the toxicity of those metals, new way of approaches such as biological and green synthesis has been developed.

Physical method includes the evaporation, condensation and laser absorption. The chemical method includes sol-gel process, chemical precipitation, reverse micelle method, hydrothermal method, microwaves and chemical vapour deposition.[3]

The biosynthesis and green synthesis of nanoparticles are synthesized with the help of microbes and plants. The microbes such as *Bacillus*, *Pseudomonas* and *Staphylococcus* sp were used for the NPs synthesis. Medicinal plants were used for the synthesis of NPs because it contains phytochemicals. The plants contain phytochemicals such as flavonoids, phenols, alkaloids. Those secondary metabolites are involved in the reduction of precursor molecules to nanoparticles synthesis by reduction process. The metabolites act as a reducing agent in this reaction and also involved in the stability of the nanoparticles.[4]

Selenium
The word “selenium” originates from the Greek word “Selene,” which refers to the moon goddess. It was discovered by Jacob Berzelius in 1818. Selenium is a non- metallic element present in the 16th group of the periodic table between sulphur and tellurium. It is trace micronutrient element which play a vital role in the environment. Selenium plays a vital role in the metabolic process. Selenium is a trace and essential nutrient for humans and animals. It is essential for increasing the immune response, reproduction in animals and also for the proper growth of plants.

It is involved in the structural formation of many enzymes such as glutathione peroxidase (GPx), thioredoxin reductase (TRx) and deiodinases. These enzymes play a vital role in anti-oxidation, reproduction, muscle function and tumour prevention. It is also used in the electronic industries for manufacturing rectifiers, photoelectric cells. In glass and ceramic manufacturing industries it is used as a decolourizer. It is used as pigments in paints, lubricants in metallurgy and in various aerospace devices. In the agricultural area, sodium selenite in low dosage is used in fertilizer for plant breeding. Se is known for its adsorptive ability as it can interact with the proteins, hence, they can be used as carriers of redox enzymes, which may trigger the use of Se in the treatment of many autoimmune diseases.[5]

Se puzzles researchers, because it is known to be essential and yet toxic at high doses. Seat an optimum concentration is essential for human health. Scientists are still finding its mechanism of action aiming further to reduce its toxicity and improve its efficacy. The strategically promising solution towards improving Se's efficacy and reducing its toxicity seems to be fulfilled by nanotechnology.

Nano selenium

The application of selenium is increasing in day to day life. There is a huge demand for the large-scale production of selenium nanoparticles. Nano based technology is essential for the production of selenium in large scale production. Because chemical based large scale production is more toxic and not much effective. To overcome that problem, nano selenium production was introduced.

Synthesis of SeNPs

Basically, there are three methods involved in the synthesis of NPs such as physical, chemical and biological. The chemical salts or solutions are used as precursor molecule for synthesis of nanoparticles.

Chemical synthesis

In this method different types of chemicals were used. Selenious acid(H_2SeO_3) or sodium selenite (Na_2SeO_3) or thiosulfuric acid (H_2SeO_3) is taken as precursor molecule for selenium NPs synthesis. Along with these precursor molecules ascorbic acid and also some polysaccharides are added to the solution as a reducing and capping agent respectively. When using sodium selenite as a precursor, the catalyst was not recommended. By maintaining temperature, pH, the red colour precipitate was obtained. The solution was centrifuged at 10,000rpm for 30 mins, the pellet was obtained. Then pellet was then air dried, lyophilized to obtain powder form for future uses.

Biological synthesis

The biological synthesis of selenium nanoparticles was obtained with the help of secondary metabolites which were synthesized by the plants and microbes. It is also called as phytochemicals or phytocols. Metabolites contain phenols, alkaloids which help in the reduction and stability role in the NPs synthesis. The toxicity level of the nanoparticles may be decreased.

Synthesis from microbes

The microbes such as bacteria, fungi, protozoa are involved in the synthesis of NPs. It may be an intracellular or extracellular production. It helps in the large-scale production of nanoparticles. Some of the microbes involved in the synthesis of selenium nanoparticles are probiotic lactic acid producing bacteria, *Agrobacterium* sp., Actinomycetes *Streptomyces griseoruber*, *Azoarcus* sp., *Bacillus licheniformis*, *Aspergillus terreus*, *Klebsiella pneumoniae*, *Pleurotus ostreatus*, *Lentinus edodes*, *Grifola frondosa* and *Ganoderma lucidum* of Basidiomycetes sp (Table 1). The microbes which naturally have selenium for their metabolic process such as *Veillonella atypica*, *Bacillus selenitireduces* and *Geobacter sulfurreducens.* Apart from these microbes, some microbes which doesn't have selenium also used for synthesis of selenium nanoparticles.

Table 1: shows the different microbial species used for biosynthesis of selenium nanoparticle at different methods.

Microbial species	Methods involved in synthesis of NPs	Reference
Agrobacterium	Sodium selenite taken as precursor, culture centrifuged supernatant is taken as reducing and stabilizing agent which contain secondary metabolites	[6]
Duganella sp.and Agrobacterium	Culture supernatant was mixed with Sodium selenite	[7]
Probiotic Lactic Acid bacteria	Selenium was introduced in culture media and recovery from the culture product	[8]
Streptomyces griseoruber (Actinomycetes)	Culture supernatant was mixed with Sodium selenite	[9]
Azoarcus sp.	Intracellular and extracellular isolation of Selenium by introducing selenite in media	[10]
Bacillus licheniformis	Intracellular synthesis (Bacterial culture was allowed to grow in selenite containing medium and nanoparticles were collected through centrifugation)	[11]
Aspergillus terreus (fungus)	Culture supernatant was collected and mixed with Se^{4+} ions solution	[12]

Synthesis from plant extract

In green synthesis of nanoparticles, the plants play a major role in it. The metabolites produced from the plants helps in the reduction of precursor molecule. It also acts as catalyst and also stabilizer for synthesis of nanoparticles. Initially, selenium contains plants are

mainly involved in the synthesis of SeNPs. Plant uptake selenium from the soil which was released from the sedimented rocks (Figure1).[13] Plants containing Se may be grouped into two broad categories:

- Those that accumulate Se in direct proportion to the amount of Se available from the soil (e.g. wheat)
- Those that actively accumulate Se in orders of magnitude greater than the Se concentrations in the soil (e.g. *Astragalus* sp.).

Different plant species often contain different chemical forms of Se, and the chemical form of Se often determines its bioactivity. Forms of Se can be safely stored in membrane-bound structures within the plant. A key enzyme necessary for synthesis of many of these methylated compounds is selenocysteine-specific methyltransferase.

Plants belong to other species which do not utilize selenium are also involved in the production of selenium nanoparticles (Table 2). Examples are *Aloe vera*, *Withiania somnifera*, *Diospyros Montana* and *Trigonella foenum-graecum.*

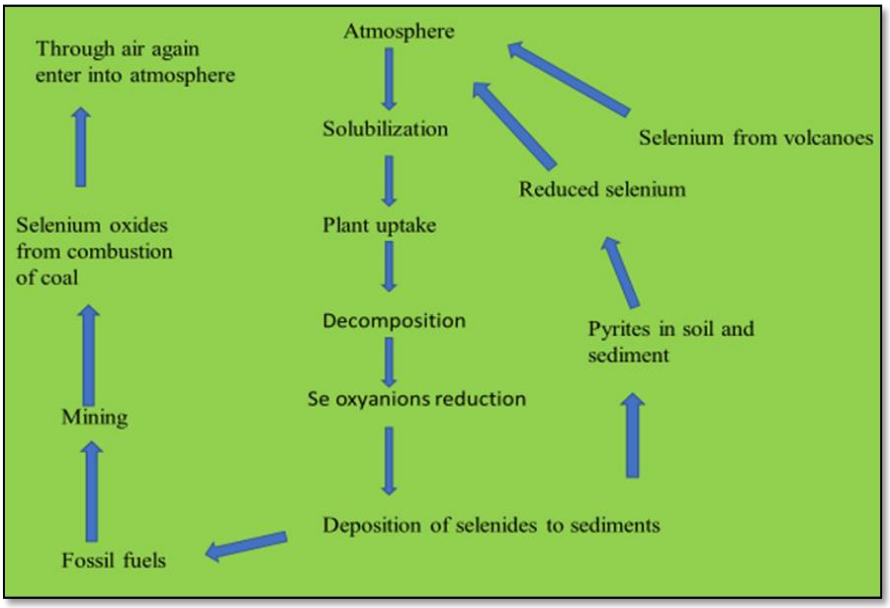

Figure 1: Global selenium cycle in nature.

Table 2: Different plant species used for selenium nanoparticles synthesis at different methods.

Plants	Methods used for SeNPs synthesis	Reference
Withiania somnifera	Plant extract mixed with 50mM Selenious acid	[14]
Diospyros montana	300mM Selenious acid was treated with plant extract	[15]
Trigonella foenum-graecum	Plant extract was mixed with 30mM selenious acid along with 40mMascorbic acid as initiator of reduction reaction	[16]
Aloe vera	5mMSodium selenite solution was treated with plant extract	[17]
Broccoli	Thiosulfuric acid taken as precursor along with plant extract	[18]
Allium sativum	Garlic extract was treated with 20mM Sodium selenite solution	[19]
Vitis vinifera	Extract was treated with Selenious acid	[20]
Petroselenium crispum	Plant leaf extract was treated with Selenious acid	[21]
Leucas lavandulifolia	Plant extract with 50mM Selenious acid along with 40mM ascorbic acid (act as initiator of reduction reaction)	[22]
Citrus reticulata	Orange peel extract were mixed with sodium selenite solution at different pH and temperature	[12]
Orthosiphon stamineus	Plant extract with 30mM selenious acid along with 40mM ascorbic acid as reaction initiator	[23]

Applications of the Selenium nanoparticles

The selenium nanoparticles play a vital role in different fields such as drug, medicine, cosmetics, fertilizer, electronics and glass productions. Apart from the above-mentioned application it plays a vital role in the diet. Selenium is essential for humans to regulate their metabolic activities and its deficiency need supplementation. The supplementation such as Se salts, amino acids, Selenium-enriched Yeast supplement and next generation selenium supplement are emerging nowadays. Likewise, different applications are emerging nowadays. Some of them are listed below. Figure 2 shows the multiple applications of Selenium nanoparticles.

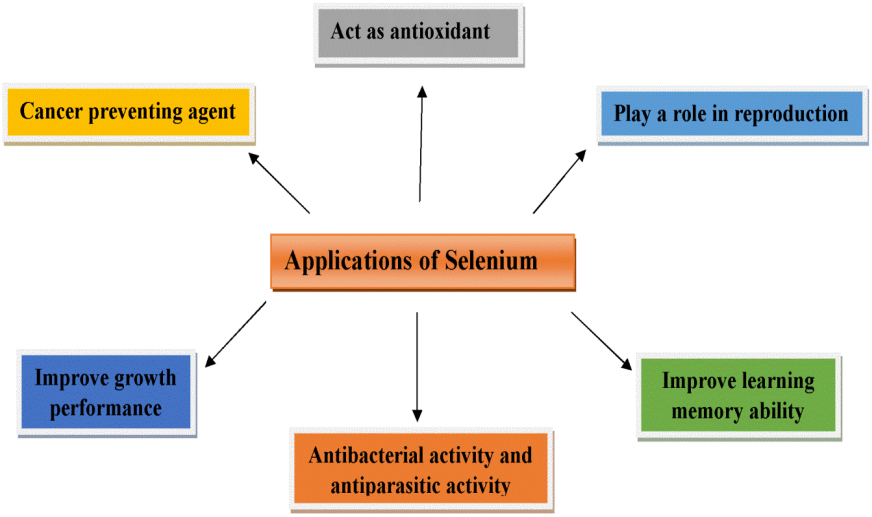

Figure 2: Applications of Selenium nanoparticles.

Anticancer property

Se NPs-functionalized folic acid (FA) isused in the treatment of cancer which can induce the apoptosis in cancer cell lines (breast cancer cell line (MCF-7).[24] The apoptosis process was carried by producing reactive oxygen species and cause mitochondria damage results in the cell death. Some researchers also found that the selenium nanoparticle cause cell shrinking and cause damage to the prostate cancer cell lines during culture by causing cytotoxic activity. For cancer study purpose, the selenium synthesized with the help of plant or microbes source is mostly used. The SeNPs also shows effective result in killing the cancer cells by apoptosis process.

Antioxidant property

The oxidation process occurs in every cell in our body due to single electrons present in the outermost layer. To compensate that the atom obtain electron from the protein molecule or DNA molecule which will result in damaging of cell by cleaving double strand of DNA molecule into single strand. The outermost electron is also called as free radicals. The free radicals scavenging property is called as antioxidant. Different assays have been performed to confirm the antioxidant property of SeNps. The SeNPs prepared from the different plant extract can be analysed with this property such as Se obtained from *Withania somnifera*, [14] *Diospyros montana*[25]performed antioxidant assay on rats to determine the property of selenium nanoparticle but it also showed some side effect in liver due to higher concentration. The dosage level determination of nanoparticle usage in drug delivery must be analysed by the researchers.

Antibacterial property

In this environment, more than thousand species of microbes are naturally present. They all have both beneficial and non-beneficial properties. In hospitals mostly, urinary tract infection and hospital acquired infection is common nowadays. Because they form bio film in the surgical instruments, catheters such as urinary catheter, intravenous catheter, stent. [26]Those microbes are high resistance to antibiotics and also for some drugs which are chemically synthesized. Instead of using antibiotics and drugs, the nanoparticles are suggested by the researches.[27] Initially Silver NPs was involved in the antibacterial activity. After that number of metal and metal oxides are involved in this are silver, copper, zinc, selenium which was chemically or biologically synthesized. The microbial species which are involved in NPs synthesis such as *Bacillus* sp., *Streptomyces* sp and *Pseudomonas* sp. The antibacterial studies showed effective result in killing those microbes.[28]

Selenium as Nano fertilizer

The number of nano based pesticides and herbicides productions are increased nowadays. Because the plant disease is not controlled by the chemical fertilizer and also usage of chemicals fertilizers cause pollution to the environment.[29] The nanofertilizers are synthesized with the help of metal ions such as silicon, selenium so far.[30] The bean plant is used for the analysis of the soil fertility which increases the growth of the plant. The chlorophyll and protein content of the plant were estimated and analysed. In high concentration of SeNPs, plants showed effective growth. So,the selenium can be used as fertilizer.[31]

CONCLUSION

The application of nanoparticles is increasing nowadays due to their effectiveness in all fields of science. The nanoparticles which are commonly synthesized for solving different kinds of problems in medicine, drug delivery vehicle and agriculture. There are some drawbacks in the using of metal oxides because of their higher toxicity when it is used in higher concentration. The appropriate dosage of nanoparticles for the drug or medicine for different diseases could be undergone by researchers. In future the metal oxide nanoparticles play a vital role in drug delivery for many diseases.

REFERENCES

1. Shubhangi Shirsata, Ambadas Kadam, Mu. Naushad and Rajaram Manec, Selenium Nanostructures: Microbial Synthesis and Applications, Royal Society of Advance Journal, 2015; 1-13.
2. Ayesha Arshad, Bacterial Synthesis and Applications of Nanoparticles, Nano Science and Nanotechnology: An Indian Journal, 2017; 11(2): 1-30.
3. Laura Castro, Ma Luisa Blazquez, Jesus Angel Munoz, Felisa Gonzalez Gonzalez, and Antonio Ballester, Mechanism and Applications of Metal Nanoparticles Prepared by Bio-mediated process, Rev. Adv. Sci. Eng, 2014; 3(3): 1-18.
4. Haleemkhan AA, Naseem, Vidya Vardhini B, Synthesis of Nanoparticles from Plant Extracts, International Journal of Modern Chemistry and Applied Science, 2015; 2(3): 195-203.
5. Diana Constantinescu-Aruxandei, Rodica Mihaela Frîncu, Luiza Capra and Florin Oancea, Selenium Analysis and Speciation in Dietary Supplements Based on Next-Generation Selenium Ingredients, Nutrients, 2018; 10: 1-33.
6. Ali E N, Sonbaty S M and Salem F M,Evolution of Selenium nanoparticle a potential chemopreventive agent against lung carcinoma, International Journal of Pharmaceutical Biological and Chemical Sciences, 2014; 2(4): 38-46.
7. Santanu Sasidharan, Sowmiya R, Balakrishnaraja R, Biosynthesis of Selenium Nanoparticle using Orange peel extract, World Journal of Pharmaceutical Research, 2014; 4(1): 1322-1330
8. PeterEszenyi, Attila Sztrik, Beata Babka and JozsefProkisch, Elemental, Nano-Sized (100-500 nm) Selenium Production by Probiotic Lactic Acid Bacteria, International Journal of Bioscience, Biochemistry and Bioinformatics, 2011; 1(2): 148-152.
9. Atul, Green synthesis of Selenium nanoparticle under ambient condition, 2010: 7: 485–489.
10. Parisa Jafari Fesharaki,Pardis Nazari,MojtabaShakibaie, Sassan Rezaie, Maryam Banoee, Mohammad Abdollahi, Ahmad Reza Shahverdi,Biosynthesis of Selenium nanoparticles using Klebsiella pneumoniae and their recovery by a simple sterilization process, Brazilian Journal of Microbiology, 2010; 41: 461-466.
11. Sweety a Wadhwani, Mahadeo gorain, Pinaki Banerjee, Utkarsha U shedbalkar, Richa singh, gopal c Kundu, Balu a chopade, Green synthesis of selenium nanoparticles using Acinetobacter sp. sW30: optimization, characterization and its anticancer activity in breast cancer cells, International Journal of Nanomedicine, 2017; 12: 6841-6855.
12. Chitra Sivakumar, Karthikeyan Jeganathan, In-vitro cytotoxicity of java tea mediated selenium nanoballs against L6 cell lines, Journal of Drug Delivery & Therapeutics, 2018; 8(6): 195-200.
13. Biplabsakar, Surajit Bhattacharjee, Akshay Daware, Prosun Tirbedi, Krishnani K Kand Minhas P K, Selenium nanoparticle for stress- resilient fish and livestock, Nanoscale Research Letters, 2015; 10(371): 1-14.
14. Nancharaiah Y V, Lens P N L, Ecology and Biotechnology of Selenium-Respiring Bacteria, journal of microbiology and molecular biology review, 2015; 79(1): 61-80.
15. Venkatesan Alagesan, Sujatha Venugopal, Green Synthesis of Selenium Nanoparticle Using Leaves Extract of *Withania somnifera* and Its Biological Applications and Photocatalytic Activities, Bio Nano Science, 2018, http://doi.org/10.1007/s12668-018-0556-8.
16. Karuppannan Kokila,Nagaraj Elavarasan and Venugopal Sujatha, Diospyros montana Leaf Extract-Mediated Synthesis of Selenium nanoparticles and its Biological applications, New J. Chem., 2017, DOI: 10.1039/C7NJ01124E:1-27.
17. Ramamurthy CH, Sampath KS, Arunkumar P, Suresh Kumar M, Sujatha V, Premkumar K, ThirunavukkarasuC, Green synthesis and characterization of selenium nanoparticles and its augmented cytotoxicity with doxorubicin on cancer cells, Bioprocess Biosyst Eng., 2013; 36: 1131–1139.
18. Jay Vyay, Shafkat Rana, Antioxidant activity and green synthesis of selenium nanoparticle using*Allium sativum* extract, International Journal of Phytomedicine, 2017; 9(4): 634-641.
19. ManaviKapur, Kriti Soni and Kanchan Kohli,Green Synthesis of Selenium Nanoparticles from Broccoli, Characterization, Application and Toxicity, Adv Tech Biol Med., 2017; 5(1): 1-7.
20. Jay Vyas and Shafkat Rana, Biosynthesis of Selenium Nanoparticle using Aleovera extract, International Journal of Phytomedicine, 2017; 9(4): 634-641.
21. Garimasharma, Ashish Ranjan Sharma, Riju Bhavesh, Jongbong Park, BilguunGanbold, Ju-Suk Nam and Sang-Soo Lee, Biomolecule-Mediated Synthesis of Selenium Nanoparticles using Dried *Vitis vinifera* (Raisin) Extract, Molecules, 2014; 19: 2761-2770.
22. LuminitaFritea, VasileLaslo, Simona Cavalu, TraianCostea and Simona IoanaVicas, Green biosynthesis of Selenium nanoparticle using Parsely (*Petroselinum crispum*) leaves extract, 2017; 27(3): 203-208.
23. Kirupagaran R, Saritha A and BhuvaneswariS, Green Synthesis of Selenium Nanoparticles from Leaf and Stem Extract of Leucas lavandulifolia Sm. and Their Application, Journal of Nanoscience and Technology, 2015; 2(5): 224–226.
24. Ali E N, Sonbaty S M and Salem F M, Evolution of Selenium nanoparticle a potential chemopreventive agent against lung carcinoma, International Journal of Pharmaceutical Biological and Chemical Sciences, 2014; 2(4): 38-46.

25. Lenka Urbankova, et.al., Antioxidant status of rats' blood and liver affected by sodium selenite and selenium nanoparticles, 2018, PeerJ, DOI 10.7717/peerj.4862, 1-11.
26. Steven L. Percival, Healthcare-associated infections, medical devices and biofilms: risk, tolerance and control, Journal of Medical Microbiology, 2015; 64: 323–334.
27. Elena Piacenza, Alessandro Presentato, Emanuele Zonaro, Joseph A. Lemire, Marc Demeter, Giovanni Vallini, Raymond J. Turner and Silvia Lampis, Antimicrobial activity of biogenically produced spherical Se-nanomaterials embedded in organic material against Pseudomonas aeruginosa and Staphylococcus aureus strains on hydroxyapatite-coated surfaces, Microbial Biotechnology, 2017; 10(4): 804–818.
28. Rajalakshmi Ramachandran and D Sangeetha, Antibiofilm efficacy of silver nanoparticles against biofilm forming multidrug resistant clinical isolates, The Pharma Innovation Journal, 2017; 6(11): 36-43.
29. Mujeebar Rahman khan and Tanveer Fatima Rizvi, Nanotechnology: scope and application in plant disease, plant pathology journal, 2014; 13(3): 214-231.
30. Ajey Singh, Singh NB, ImtiyazHussaina, Himani Singha and Singh SC, Plant-nanoparticle interaction: An approach to improve agricultural practices and plant productivity, International Journal of Pharmaceutical Science Invention, 2015; 4(8): 25-40.
31. Ragavan, Ananth, Rajan, Impact of Selenium Nanoparticles on Growth, Biochemical Characteristics and Yield of Cluster Bean *Cyamopsistetragonoloba*, International Journal of Environment, Agriculture and Biotechnology, 2017; 2(6): 2917-2926.