Journal of Advanced Zoology
ISSN: 0253-7214
Volume 44 Issue 5 Year 2023 Page 1340-1345

Studies Of Composite Based NPK Fertilizer Its Application For Sustainable Agriculture

B.R.Saikishore Kumar[1], Jagadeesh Kumar Ega[2*], Suma Sanikommu[3]

[1]*Research Scholar, Chaitanya Deemed To Be University, Hanamkonda -506001, Telanagana, India, E-Mail:- kishorechemistry.87@gmail.com,*

[2*]*Prof Department Of Chemistry, Chaitanya Deemed To Be University, Hanamkonda - 506001, Telanagana, India, E-Mail:-jkjagadeeshkumare@gmail.com,*

[3]*Prof Department Of Biochemistry Chaitanya Deemed To Be University, Hanamkonda - 506001, Telanagana, India, E-Mail:- sumareddy197420@gmai.com*

***Corresponding Author:** - Jagadeesh Kumar Ega*
**Prof Department Of Chemistry, Chaitanya Deemed To Be University, Hanamkonda - 506001, Telanagana, India, E-Mail:- jkjagadeeshkumare@gmail.com.*

Abstract

The aim of this research is to study the effect of NPK fertilizer concentration on composite based Cellulose Gluconated NPK hydrogel characteristics. The raw material used in this study was corn cobs cellulose and Gluconic acid. The experiment was conducted in a completely randomized design with three replicates of different doses of fertilizer (0, 5, 10 and 15%). The parameters monitored were swelling rate, moisture content, nitrogen content, potassium content, phosphorus content, texture and surface morphology. Enriched Cellulose Gluconated NPK hydrogel were used as soil conditioners and fertilizers for agricultural crops. The results of analysis of variance (ANOVA) showed that different types of fertilizers dose had a significant effect ($P^H<0.05$) on their physicochemical properties. The higher the number of fertilizers, the less swelling will occur.

INTRODUCTION:

Chemical fertilizers have played an important role worldwide in maintaining adequate food supply and increasing crop production. Many researchers have been published based on the effects of chemical fertilizer use on agro ecosystems. Long-term use of chemical fertilizers for land use practices has led to environmental challenges due to the subsequent release of gases into surface or groundwater and atmosphere. Many problems associated with the use of chemical fertilizers have been reported, including eutrophication, loss of biodiversity, loss of soil fertility, soil acidification, atmospheric and groundwater pollution, and high energy consumption in the synthesis process. The synthesized fertilizer in application for agricultural field leads us for sustainable development. Therefore, huge efforts are being made during the last decade to replace chemical fertilizers with environmentally friendly nano composite fertilizers and bio fertilizers (1).Excessive use of fertilizers can cause heavy metals to enter the soil, plant systems and food chain, posing a major threat to life. The total worldwide nitrogen demand in 2019 is estimated at 115.5 million tones and about 65-80% of nitrogen is used in the fertilizer industry. Therefore, the extended presence of commercial fertilizers pollutes both groundwater and surface water leading to nitrate contamination and eutrophication. Toxic chemicals released from fertilizers with water flow eventually reach water bodies like oceans, rivers, lakes and cause great damage to ecosystems. The use of conventional fertilizers generates huge waste which directly or indirectly causes various health problems and has a negative impact on the economy.

Growing enough crops without depleting soil nutrients with this limited land is a major challenge for an overpopulated world. In the past decades, nanotechnology has led to an industrial revolution due to the unique properties of nanomaterials. Their superior properties are put to good use in the controlled delivery of pesticides, fertilizers, nutrients and genetic material. Furthermore, it was reported that nanomaterials are used to retain essential nutrients for plants for a long time. NPK are nano-sized fertilizers that contain nanoparticles and nutrients and can systemically release micro- and macronutrients to target specific sites in plants(2). Nanostructured components in NPK are often incorporated into carrier complexes by absorption or adsorption into the matrix. Chitosan, polyacrylic acid, clay and zeolite were previously reported as carriers for nano-fertilizers. Nano porous zeolite has attracted attention in agriculture to increase the fertilizer use efficiency of crops against adverse effects of chemical fertilizers on agro-ecosystems. Due to the high surface area, mesoporous structure and high nutrient loading capacity of nonporous zeolite, it was previously reported that the slow release of nanocarriers was used to enhance the nutrient retention capacity of soil(3).

Generally, macronutrients are used to increase soil fertility to promote plant growth. Macronutrients must be added to agricultural soils to compensate for mineral and nutrient deficiencies. Primary and secondary micronutrients like potassium, nitrogen, phosphorus is essential for plant gardening and cultivation. To improve nutrient use efficiency and prevent nutrient loss in the environment, NPK and nanocomposites have been widely used as slow- release fertilizers in agriculture. Incorporation of various macro and micro nutrients into zeolite effectively reduced soil nutrient deficiencies as reported by many researchers (4). Although most of the previous reports focused on NPK fertilizers incorporated with different nanoparticles, the effect of NPK hybrid fertilizer on slow-release has never been studied. This work presents the synthesis and characterization of cellulose Gluconated NPK hydrogel based fertilizer impregnated with macronutrients. Nutrient uptake capacity and slow-release studies of the proposed compound fertilizer were carried out (5). Furthermore, a comparative study of the effect of both formulated cellulose Gluconated NPK hydrogel and commercial fertilizers on the growth of lettuce cultivars was conducted.

MATERIAL AND METHOD:

1. Material:

Raw materials used are corn cobs, Gluconic acid, sodium hypochlorite (NaClO), sodium hydroxide (NaOH 9%), and chemicals used polyethylene glycol (PEG 5%). Equipment for Cellulose Gluconated NPK hydrogel prepared by using autoclave, magnetic stirrer, digital balance, hot plate, cold room freezer and oven. For hydrogel characterization, particle size analyzer (PSA), Malvern ultrafine grinder, atomic absorption spectrophotometer (AAS)(6) , texture analyzer Texture Pro CTV1.2 build10 and scanning electron microscopy (SEM) Zeiss EVO1 were used in this research.

2. Nano Cellulose Gluconated NPK hydrogel Preparation:

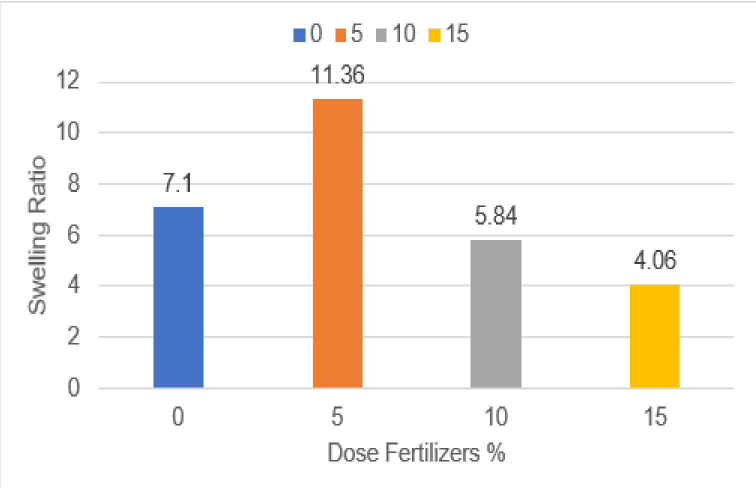
The first step of nano Cellulose Gluconated NPK hydrogel preparation is delignification process with NaOH and NaClO. The method of the delignification process was as follows: 225 g of corn cobs powder & 150 ml of Gluconic acid and 2.5 L of 1 M NaOH solution were placed in an autoclave and heated at 120 degrees Celsius for 45 minutes. After cooling, the suspension was filtered using filter paper and rinsed with excess water. Extraction with NaOH was repeated twice and extraction was continued twice for 1.5 hours at 80°C using 0.5% NaClO. Then, the suspension was washed with excess water until neutral. The Cellulose Gluconated gel was then stored in a refrigerator (7). Cellulose particle size reduction was performed on the Cellulose Gluconated suspension using an ultra-fine grinder with a ratio of cellulose: distilled water in 1:15. Incorporation of NPK fertilizer was done by soaking a known weight of hydrogel in NPK solution of three treated concentrations and reacted for 10 hours. The adsorbed Cellulose Gluconated NPK hydrogel was then dried using an oven at 100 degrees Celsius.

3. Analysis:
Cellulose Gluconated NPK hydrogel were analyzed for performance such as swelling ratio, moisture content, nitrogen content, phosphorus content, potassium content and surface morphology using scanning electron microscopy (SEM). Agronomic parameters such as plant height, root length, shoot length and numbers of leaves were measured. The experiment was set up in a completely randomized design, with different doses of fertilizers with three replicates(8). All data were subjected to analysis of variance (ANOVA). Differences between mean values were estimated using Duncan's multiple range tests at a confidence level of 96%. All experiments were performed in triplicate.

RESULT AND DISCUSSION:

1. Ratio for Swelling:
The main essential properties of Cellulose Gluconated NPK hydrogels for agricultural purposes are high swelling rates. The swelling ratio is the ratio between the weight of the Cellulose Gluconated NPK hydrogel and the dry weight. The swelling ratio has a linear relationship with the adsorption capacity, where a higher swelling ratio indicates a higher adsorption capacity. Addition of Cellulose Gluconated NPK hydrogel fertilizer at a dose of 8% showed the highest swelling rate compared to other treatments. The higher the dose of fertilizers, the lower the swelling ratio value. Statistical analysis showed that the dose of fertilizers the swelling ratio was significantly different(9). This happens because the compounds in the Cellulose Gluconated NPK hydrogel fertilizer can inhibit the process of water absorption in the nano Cellulose Gluconated NPK hydrogel. The type of hydrophilic monomers, hydrogel composition, particle size and surface area greatly influence the swelling kinetics results have been shown in the figure 1.1. This is mainly due to slow water permeation into the hydrogel through capillary and diffusion into the glass phase, and then swelling is high as the entrained water is absorbed by the hydrophilic groups and the swelling slows down until equilibrium.

Figure 1.1 Swelling ratio of nano Cellulose Gluconated NPK



1. Content of Moisture:
Moisture content affects shelf life and swelling ratio. High humidity is suitable for fungi and will affect the quality of the hydrogel. However, for agricultural applications, nano Cellulose Gluconated NPK hydrogels with high moisture content are preferable because they can act as water storage or soil conditioners, especially in dry conditions. Statistical analysis revealed that moisture content varied significantly among treatments (10). However, there were other factors affecting the moisture content of the hydrogel, such as the number of cross linked molecules in the hydrogel, not just the fertilizer dose.

2. Content of Nitrogen, Phosphorus and Potassium:

Nitrogen is an essential plant nutrient and an important contributor to agricultural productivity. This nutrient has the main function of synthesizing chlorophyll which is then used by plants in the process of photosynthesis. Each plant requires a different amount of nitrogen, but the critical nitrogen limit ranges from 1.7 to 4.5%. Based on the critical limit of nitrogen, it can be said that addition of 7% NPK 15:15:15 is the optimum treatment, which is 2.50%. Statistical analysis showed that these treatments differed significantly for nitrogen content (11).

The phosphorus component in these nano Cellulose Gluconated NPK hydrogels acts as a nutrient supplier for plant growth. In addition, phosphorus also has other functions for photosynthesis, respiration, energy transfer and storage, and other processes in plants. However, the critical limit adequacy of phosphorus must also be considered, where it ranges from 0.07 to 0.30%. Based on the extent of phosphorus adequacy, it can be said that addition of 7% NPK 15:15:15 fertilizer is the optimum treatment, containing 0.194% of the component. Statistical analysis showed that these treatments differed significantly for phosphorus content (12).

Potassium is one of the three essential macronutrients and an important factor controlling crop productivity. Potassium contributes to tolerance against salinity as the plant competes with sodium for binding and maintaining water status. Potassium concentrations in Cellulose Gluconated NPK hydrogels that are too high or too low to apply to plants can affect plant growth. Potassium nutrient adequacy in plants ranges from 1 to 4.50%. Addition of NPK 15:15:15 fertilizer at 7% is the optimum treatment which can produce 3.822% potassium nutrients. Statistical analysis showed that these treatments were significantly different for potassium content results discussed in the Table no 1.(13).

Figure 1.2 SEM Image of as-prepared NPK

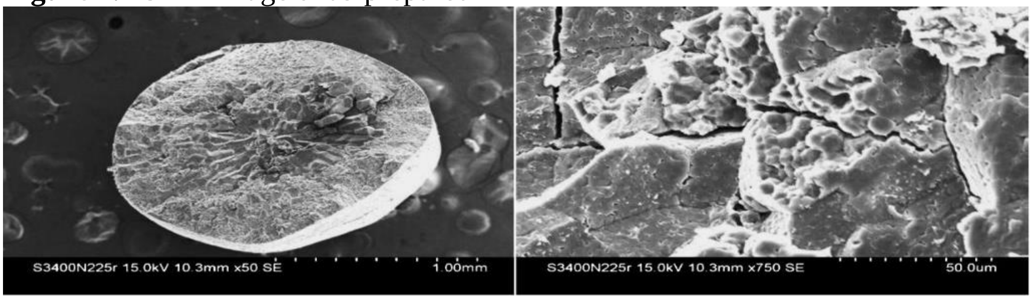


Table 1.1: Nitrogen, phosphorus, and potassium content of Cellulose Gluconated

Fertilizers Dose (%)	Nitrogen Content (%)	Phosphorus Content (%)	Potassium Content (%)
0	0.15±0.10	0.02±0.10	0.85±0.10
5	2.45±0.10	2.50±0.10	3.85±0.10
10	4.70±0.10	4.35±0.10	4.83±0.10
15	5.56±0.10	5.41±0.10	4.86±0.10

1. Texture:

Statistical analysis of data showed that almost all treatments were not significantly different for textures. However, there was a tendency that the hardness, consistency and springiness values decreased as the viscosity increased. The high swelling capacity leads to the presence of solutes during dissolution of the hydrogel which weakens some of the cross linking of the hydrogel (14). Addition of fertilizer can reduce stiffness and stickiness but increase springiness and cohesiveness.

Table 1.2: Texture of Cellulose Gluconated NPK hydrogels

Fertilizers Dose (%)	Hardness	Springiness	Adhesiveness	Cohesiveness
0	53.15±0.10	3.35±1.12	13.35±0.92	0.55±0.18
5	25.20±0.10	4.25±0.10	9.95±2.80	0.65±0.05
10	51.85±0.10	3.60±0.10	12.45±0.35	0.55±0.18
15	29.02±0.10	3.81±0.10	11.50±0.78	0.70±0.25

Cohesion between similar molecules is an attractive feature to explain how strong the cross linking of a hydrogel is. This means that the addition of fertilizer at different doses can weaken the cross linking of the Cellulose Gluconated NPK hydrogels. Springiness refers to the ability of a hydrogel to return to its original state after receiving pressure. Addition of fertilizer increases the rebound after stress. Viscosity is an attractive force between molecules that describes how weak the cross linking is. It shows the opposite characteristics for homogeneity (15). Statistical analysis showed that these treatments were not significantly different for textures.

APPLICATION OF CELLULOSE GLUCONATED NPK HYDROGELS

Treatment of cultivation media with added nano Cellulose Gluconated NPK hydrogels can increase the height of pepper plants compared to the control. However, maximum increase in plant height was observed in 3rd week of addition of 10% NPK fertilizer. This is according to the optimum requirements of nitrogen, phosphorus and potassium for treatment (16). This was also consistent with leaf number in agricultural plants, where 10% NPK fertilizer addition was better than other treatments 3rd week.

Table 1.3: The percentage of height increase in several treatments

Treatment	1st Week	2nd Week	3rd Week
Control	0.30±0.02	0.75±0.04	0.86±0.06
Dose 0%	3.75±0.90	5.85±1.10	6.20±2.68
Dose 5%	0.31±0.03	3.76±0.78	7.22±1.24
Dose 10%	0.46±0.07	4.75±0.87	16.52±1.75
Dose 15%	3.28±0.94	3.85±0.74	4.60±1.12

Table 1.4: The number of agricultural leaves in several treatments

Treatment	1st Week	2nd Week	3rd Week
Control	8.04±2.19	6.35±1.15	6.70±1.34
Dose 0%	7.02±1.40	5.69±0.98	5.70±1.22
Dose 5%	6.04±0.87	4.70±1.14	5.35±1.18
Dose 10%	7.35±1.08	7.35±1.38	9.04±1.12
Dose 15%	6.36±1.02	4.02±1.05	4.37±1.09

CONCLUSION:

Fertilizer addition with 10% dose produced the highest swelling ratio and improved the performance of agricultural plants. This product contains 15.90% moisture, 4.70% nitrogen, 4.83% potassium, 4.35% phosphorus and 25.19 mJ hardness. The studies show that the use of cellulose Gluconated NPK hydrogel fertilizers can increase in nutrient efficiency reduces soil toxicity, minimizes the frequency of application. The cellulose Gluconated NPK hydrogel NPK influence the positive effects on the entire period of experiment shows variations in the growth of root length and shoot length, water content and leaf area of various plants. As we found cellulose Gluconated NPK hydrogel NPK fertilizer possesses such unique physic chemical properties that they can fulfill all plant requirements more efficiently as compared to the conventional normal fertilizer.

REFERENCES:

1. Anon 2017 Komoditas jagung Indonesia siap swasembada di Tahun 2017 (in Bahasa) Newsletter Pusdatin 14 (151) 1-12
2. L.Bai C, Zhang S, Huang L, Wang H, Wang W and Qingfu Y 2015 Starch-based hydrogel loading with carbendazim for controlled-release and water absorption Carbohydrate Poly. 125 376–383.
3. Bashir, I.; Lone, F.A.; Bhat, R.A.; Mir, S.A.; Dar, Z.A.; Dar, S.A. Concerns and threats of contamination n aquatic ecosystems. In: Bioremediation and Biotechnology, Sustainable Approaches to Pollution Degradation. Berlin, Germany: Springer. 2020, pp. 1–26; https://doi.org/10.1007/978-3-030-35691-0_1.
4. Bortolin A, F A. Aouada, M R. de Moura, C Ribeiro, E Longo and L H C Mattoso 2011 Application of

polysaccharide hydrogels in adsorption and controlled-extended release of fertilizers processes Journal of Applied Polymer Science.

5. Carmo J B, Piccolo M C, Cristiano A A, Cerri C E P, Feigl J B, Neto F S and Cerri C C 2007 Short-term changes in nitrogen availability, gas fluxes (CO2, NO, N2O) and microbial biomassa fertilize during pasturere-establishment in Rondônia, Brazil, SoilTill. Res. 71 250–259.
6. Chaudhary, S.; Dheri, G.S.; Brar, B.S. Long-term effects of NPK fertilizers and organic manures on carbon stabilization and management index under rice-wheat cropping system. Soil and Tillage Research 2017, 166, 59-66, https://doi.org/10.1016/j.still.2016.10.005.
7. Khan M.Z.H, Islam M.R., Nahar N., Al-Mamun M.R., Khan M.A.S., and Matin M.A. 2021, Synthesis and characterization of nanozeolite based composite fertilizer for sustainable release and use efficiency of nutrients, Cell Press Heliyon, - 7, 2021.pp. 1-6.
8. Soniya Goyal, Raman Kumar and Vikas Beniwal 2022, Biogenic Synthesis of Nanoparticles for Sustainable Crop Production: A Review, Nanobioletters, Vol-12, Issue-1, pp. 1-18.
9. Winarti C, Sasmitaloka K.S. and Arif A.B. 2021, Effect of NPK fertilizer incorporation on the characteristics of Nanocellulose-based hydrogel, 1st International Conference on Sustainable Tropical Land Management, IOP Conf. Series: Earth and Environmental Science 648 (2021) 012180, doi:10.1088/1755-1315/648/1/012180.
10. A.K. Bansiwal, S.S. Rayalu, N.K. Labhasetwar, A.A. Juwarkar, S. Devotta, Surfactant- modified zeolite as a slow-release fertilizer for phosphorus, J. Agric. Food Chem. 54 (2006) 4773–4779.
11. N. Kottegoda, C. Sandaruwan, G. Priyadarshana, A. Siriwardhana, U.A. Rathnayake, D.M. Berugoda Arachchige, A.R. Kumarasinghe, D. Dahanayake, V. Karunaratne, G.A.J. Amaratunga, Urea-Hydroxyapatite nanohybrids for slow release of nitrogen, ACS Nano 11 (2017) 1214–1221.
12. A. Lateef, R. Nazir, N. Jamil, S. Alam, R. Shah, M.N. Khan, M. Saleem, Synthesis and characterization of zeolite-based nano-composite: an environment friendly slow-release fertilizer, Microporous Mesoporous Mater. 232 (2016) 174–183.
13. Schneider Teixeira A, Deladino L and Zaritzky N 2016 Yerba mate (Ilex paraguariensis) waste and alginate as a matrix for the encapsulation of N fertilizer ACS Sustain. Chem. Eng. 4 2449–2458.
14. Yusnaidar, Wirjosentono B, Thamrin and Eddiyanto 2017 Synthesized superabsorbent based on cellulose from rice straw for controlled-release of urea, Orient J. Chem. 33 (4)1905–1913.
15. Kono H and Fujita S 2012 Biodegradable super absorbent hydrogels derived from cellulose by esterification cross linking with 1, 2, 3, 4-butane tetra carboxylic di anhydride Carbohydr. Polym. 87 (4) 2582–2588 doi:http://dx.doi.org/10.1016/j.carbpol.2011.11.045
16. Yang Y C, Tong Z H, Geng Y Q, Li Y C and Zhang M 2013 Bio based polymer composites derived from corn Stover and feather meals as double-coating materials for controlled release and water-retention urea fertilizers Journal of Agricultural and Food Chem. 61 (34) 8166–8174.