e-ISSN 2581-0405

Asian Journal of Applied Research for Community Development and Empowerment

Journal home page: http://ajarcde-safe-network.org ISSN 2581-0405

The Efficacy of Nano Biochar Coated Urea in Enhancing Soybean Growth and Yield

Hariyono[*,1], *A.R Putra*[1], *Mulyono*[1], *B.H. Isnawan*[1]

[1] *Department of Agrotechnology, Faculty of Agriculture, Universitas Muhammadiyah Yogyakarta, Yogyakarta, Indonesia*

ARTICLE INFO

Article History:
Received: 12 April 2025
Final Revision: 29 May 2025
Accepted: 29 May 2025
Online Publication: 31 May 2025

KEYWORDS

Sandy land, nano-material, nitrogen efficiency, soybeans growth, soybeans yield

CORRESPONDING AUTHOR

*Email: hary@umy.ac.id

A B S T R A C T

One agricultural product with significant economic worth is soybeans. In Indonesia, soybean production is still low, while demand is high. Soybean productivity on coastal sandland can be increased by increasing the effectiveness of fertilizer with the use of nano biochar-coated urea fertilizer. This investigation seeks to evaluate the efficacy of nano-biochar coatings applied to various forms of urea as a nitrogen slow-release mechanism to enhance the growth and yield of soybean crops in coastal sandy terrain. This empirical research was executed within the Agricultural Experiment Greenhouse at Muhammadiyah University of Yogyakarta from March to June 2022. The methodology employed was experimental research utilizing a single-factor design organized according to a Completely Randomized Design (CRD) comprising six treatments. Each treatment included six plant samples with three replications, specifically: Urea Prill, Nano Biochar Coated Urea Prill, Urea Granules, Nano Biochar Coated Urea Granules, Urea Tablet, and Nano Biochar Coated Urea Tablet. The findings indicated that applying nano biochar derived from coconut shells to urea prill significantly promotes the growth and yield of soybeans within coastal sandy soil. In future agronomic applications, nano biochar-coated urea prill can enhance urea's efficacy and improve soybean yields.

Contribution to Sustainable Development Goals (SDGs):
SDG 2: Zero Hunger
SDG 6: Clean Water and Sanitation
SDG 13: Climate Action
SDG 15: Life on Land

1. INTRODUCTION

1.1. Research Background

Soybeans (Glycine max (L.) Merrill) represent a crucial food commodity, ranking third in significance following rice and maize. The need for soybeans continues to increase along with the increase in population. Soybean production in Indonesia is also still experiencing fluctuations from 2017 to 2021. In 2017, the production of soybeans attained a volume of 538,728 tons; in the subsequent year, 2018, this figure experienced an increase to 650,000 tons. However, in 2019, there was a significant decline in production, resulting in 424,190 tons. The downward trend continued in 2020, with production diminishing further to 290,784 tons, and this decline persisted into 2021 when the output was recorded at 212,863 tons. Efforts to meet the need for soybean consumption are increasing production and productivity. Increasing soybean productivity to meet soybean needs can be done by agricultural intensification and agricultural extensification. One of the agricultural intensification methods is fertilization and agricultural extensification by expanding marginal land. Marginal land is sub-optimal land with potential for agriculture, whether for gardens, forests, or food crops. However, the fertility level of this marginal land is relatively low.. One of the marginal lands is beach sand land.

Sandy soil has many macropores, few intermediate pores, and few micropores. The characteristics of this kind of soil make it less able to retain water, but has optimal air circulation and drainage. As the annual demand for soybeans continues to escalate, it is imperative to expand agricultural territories to bolster production capabilities. Nevertheless, agricultural land within Indonesia is progressively diminishing each year due to the conversion of such land into non-agricultural uses, including industrial zones, residential areas, and transportation infrastructures, consequently leading to a decline in the productivity of horticultural crops.

A predominance of sand particles, high porosity, and a lack of clay minerals and organic matter characterize coastal sandy soil. This composition results in sandy soil's inability to retain water and a low capacity for cation storage. The rapid water drainage through sandy soils adversely impacts the efficiency of nitrogen (N) nutrients. Urea, known for its hygroscopic and volatile nature, leads to a significant loss of N from the soil, consequently diminishing nitrogen uptake by plants. To address this issue, one viable solution is to coat urea, thereby enhancing plants' absorption of N fertilizer. Biochar-coated urea has been shown to improve nutrient absorption efficiency due to its slow-release properties while also helping to mitigate pesticide residues in both soil and water.

Charcoal made from rice husks, with a mesh size of 100 and subjected to a reflux time of 150 minutes, can decrease the ash content by 91.8% and facilitate the absorption of 331 mg/g of iodine through the application of potassium carbonate and hydrochloric acid washing. This advantage stems from the fact that the nanometer scale can enhance the resulting material's surface area, mechanical characteristics, and reactivity. This research aims to assess whether using different types of urea coated with nano-biochar can successfully reduce the nitrogen release rate, thus promoting the growth and yield of shallots in sandy coastal soil. The urea fertilizer coating underscores this study's originality and significance in facilitating a slow release, which minimizes leaching and increases its effectiveness in improving growth and yield in red soil.

1.2. Literature Review

Soybeans are an important source of vegetable protein and fat, so they are potential raw materials for processed products on a small scale and for food industry purposes [1]. Production, which tends to be low, can still not meet the consumption needs of 2.3 million tonnes per year [2]. Sand soil has a single-grain structure: a mixture of large primary grains without any aggregate binding material [3].

Conversely, numerous marginal lands remain suboptimally utilized for soybean cultivation [4]. One up-and-coming category of marginal land with significant development potential within Indonesia is coastal sandy terrain. As an archipelagic nation comprising thousands of islands, Indonesia features extensive beaches and boasts a coastline measuring 106,000 kilometers, alongside a potential land area of 1,060,000 hectares, constituting marginal land [5]. Using biochar or activated charcoal can reduce the contamination levels of organophosphate pesticides by over 50%. [6]

Biochar is derived from readily accessible agricultural byproducts, specifically sawdust and rice husks. The carbon in charcoal can absorb anions, cations, and molecules, whether organic or inorganic compounds, in the form of solutions or gases. [13] The yield of activated charcoal from teak sawdust varies between 10.0% and 35.7%; the moisture content is between 11.9% and 20.6%; the ash content fluctuates from 7.7% to 48.8%; the volatile substances range from 7.8% to 17.9%; the bonded carbon content is between 39.2% and 73.4%; the iodine absorption capacity is between 385.10 mg/g and 994.10 mg/g, while the benzene absorption capacity ranges from 15.1% to 40.7%. [8]

By adjusting the biochar material to dimensions between 1 and 100 nm, it becomes possible to alter it and create what is known as Nano Biochar [10]. The utilization of nanotechnology can aid in the creation of slow-release fertilizers that can significantly improve nutrient retention within the soil, as demonstrated by a ratio of 6:1 urea-hydroxyapatite nanohybrids [11], which suggests that materials or composites at the nanoscale possess unique chemical and physical properties that render them superior to their bulk counterparts.

1.3. Research Objective

This investigation seeks to evaluate the efficacy of nano-biochar coatings applied to various forms of urea as a nitrogen slow-release mechanism to enhance the growth and yield of soybean crops in coastal sandy terrain.

2. MATERIALS AND METHODS

2.1. Research design

This experimental research method applies an entirely randomized design (CRD) with a single-factor setup. Six treatments were offered. Each treatment consisted of 6 plant samples with three replications, namely Urea Prill (A), Nano Biochar Coated Urea Prill (B), Urea Granules (C), Nano Biochar Coated Urea Granules (D), Urea Tablet (E), Nano Biochar Coated Urea Tablet (F).

2.2. The procedure for the preparation of nano-biochar from coconut shells.

Coconut shells are burned anaerobically to produce coconut shell charcoal. Subsequently, the coconut shell charcoal pieces are blended into a powdered form. This coconut shell charcoal powder is then processed using a ball mill. The charcoal is placed in a bottle containing 100 g of coconut shell charcoal powder, 500 g of steel balls, and 60 ml of water, and milled for four hours. The steel balls facilitate milling, and the resulting suspension is filtered for separation. The remaining mixture is allowed to settle for two days. Afterward, the sediment is dissolved in water. The sediment is then sun-dried for two days. The sediment is separated from the water and dried in the sun for two more days.

Upon completion of the drying process, coconut shell biochar is obtained in nano size. Scanning electron microscopy was employed to analyze the particle size, while energy-dispersive X-ray spectroscopy was utilized to assess the particle distribution. The samples were positioned on a carbon tape sample stage designed for electric flow transmission. Images were captured at a magnification of 1500 x. X-ray data was collected for thirty seconds at an angle of 35.73o.

2.3. The utilization of nanobiochar obtained from coconut shells

Coating urea with coconut shell nano biochar involves blending the nano biochar with each variety of urea in a 1:6 ratio. After the coating is uniformly applied, the fertilizer is prepared for use. The urea nano biochar was employed thrice at 30, 20, and 10 days after planting.

2.4. Statistical analysis

Data analysis was performed utilizing Test F at a significance level of 5%. Following this, further tests were executed using the Duncan Multiple Range Test at a significance level of 5% to evaluate the different treatments.

3. RESULT AND DISCUSSION

3.1. The findings from the examination of coconut shell nano biochar

The analysis results regarding the dimensions of the coconut shell nano biochar are detailed in Table 1. According to the findings from the SEM test presented in Table 1, the average particle size of the coconut shell nano-biochar sample measures 53.307 nm. The calculation of the percentage of the coconut shell Nano-Biochar particle diameter is categorized into five distinct size groups. The predominant diameter of the coconut shell Nano Biochar particles ranges from 20 nm to 100 nm, accounting for 95% of the total. In contrast, the diameter of the sawdust Nano Biochar particles, which ranges from 100 nm to 2,500 nm, constitutes 5% of the total.

Table 1. Coconut Shell Nano Biochar Particle Dimensions

Particle diameter (nm)	Amount	Percentage (%)
1 – 10	0.00	0.00
10 -20	0.00	0.00
20 – 100	8,321.00	95.00
100 – 2,500	436.00	5.30
2,500 – 10,000	0.00	0.00

Mean =53.31

The properties of the coconut shell Nano Biochar were analyzed using SEM analysis to examine the microstructure, which facilitates the observation of the shape and size of the granules. During the milling process, a cavitation phenomenon occurs, leading to the breakdown of microparticles into nanoparticles due to friction and collisions among particles and agglomerates, intensified by increased water content.

The composition of Coconut shell Nano Biochar can be evaluated through an analysis employing the analytical method known as energy-dispersive X-ray Spectroscopy. This EDX analysis is performed to determine both the qualitative and quantitative composition of the components in coconut shell Nano Biochar, with an error margin of 10% [11]. The findings from the composition analysis of Nano Biochar in sawdust are presented in Table 2.

The results from the EDX analysis shown in Table 2 reveal the elemental compositions present in the sawdust Nano Biochar, namely Si, C, O, and, with corresponding percentages of 1.5%, 83.50%, and 14.80%.

Table 2. The results of the EDX Nano Biochar tests obtained from the coconut shell

Elements	Contents (%)
C	83.50
O	14.80
Si	1.50

Source: Outcome of the sample analysis conducted at the Central Laboratory of Life Sciences – Universitas Brawijaya (LSIH-UB).

3.2. Plant Growth of Soybeans

The growth of plants is a process that leads to alterations in their size and is a key factor in determining crop yields. Modifications in shape invariably accompany this growth process. The phrase "vegetative growth" describes the increase in volume, shape, quantity, and size of leaves, roots, and plant's stems from germination until the formation of the generative organs begins [9]. For successful plant growth, it is essential to have access to nutrients, water, and other elements that promote growth, along with suitable environmental conditions. Table 3 presents the average growth and development of soybean plants, detailing leaf count, leaf area, plant height, and chlorophyll content in the leaves.

According to the variance results with a 5% error rate, no significant difference was observed in plant height and leaf chlorophyll; however, notable differences were identified in leaf number and leaf area parameters. The coconut shell treatment led to a decrease in the number of leaves and a reduction in leaf area compared to the other treatments.

Plants absorb nutrients according to their needs, which depend on the amount of nutrients available in the growing medium. When not coated with nano biochar and applied to sandy soil, Prill urea demonstrates hygroscopic properties and is susceptible to leaching. A lack of nutrients in the planting medium during the plant's growth phase will impede its growth and development. The growth and increase in height of plants are significantly influenced by the effective absorption of nutrients that are directly utilized in photosynthesis.

 https://doi.org/10.29165/ajarcde.v9i2.673

Table 3. The Effect of Employing Coconut Shell Urea Nano Biochar Coating on Plant Height, Leaf Count, Leaf Area, and Chlorophyll Levels in Soybeans

Treatments	Plant Height (cm)	Leaves Number	Leaf Area (cm^2)	Leaf Chlorophyll (mg/l)
A	54.35 b	19.45 b	1,320.33 b	36.78 b
B	73.35 a	28.15 a	3,153.70 a	44.86 a
C	60.40 b	24.60 ab	2,335.10 ab	38.40 b
D	70.10 ab	25.30 ab	2,241.70 ab	42.66 a
E	59.10 b	24.16 ab	2,142.67 ab	37.74 b
F	55.37 b	18.30 b	1,218.70 b	37.64 b
CV.	6.02	6.08	11.60	6.68

Note: The DMRT test indicates that, at a 5% error level, values in each column followed by the same letter do not show significant differences.

Using a coating made from coconut shell Nano Biochar urea can reduce nitrogen leaching while improving the efficiency of nitrogen fertilizer use in the soil. Research conducted by Alfianto [7] suggests that micro-fertilizers can offer slow-release capabilities, as activated charcoal is an effective carrier for these fertilizers. Activated charcoal features highly effective pores that aid in storing and binding soil nutrients. These nutrients are then released gradually, in line with the consumption rate of plants. Additionally, activated charcoal is hygroscopic, preventing nutrient leaching from the soil.

Plants, particularly stems, branches, and leaves, necessitate nitrogen for growth enhancement. Nitrogen-rich fertilizers encourage leaf development, which indicates plant growth throughout photosynthesis. Higher plants possess two distinct forms of chlorophyll: the lighter green chlorophyll b and the darker green chlorophyll a. During the process of leaf development; there is a significant synthesis of chlorophyll a concerning chlorophyll b, which is subsequently followed by the maturation of the leaf.

The development of chlorophyll b occurred in tandem with the expansion of the leaves, marked by a shift in hue from light green to dark green. The level of chlorophyll in dark green leaves is 50% greater than that found in light green leaves. Chlorophyll a and b are the primary pigments within the thylakoid membrane. Both chlorophyll a and b are found in all green plants. Among the various types of chlorophyll, chlorophyll accounts for 75% [10]. The assimilation process is enhanced due to the leaves' ability to capture a uniform light distribution. As a result, a larger quantity of assimilation products is produced and used as energy for the plant's growth, aiding in the development of its vegetative structures, encompassing leaves and height [13].

Plants that successfully acquire and utilize nitrogen can undergo accelerated growth, increased protein production, and enhanced chlorophyll synthesis, resulting in greener leaves, a higher overall leaf count, and a better shoot-to-root ratio. This nitrogen is subsequently transported to the plant's vegetative parts to aid in forming new organs [12]. A lack of nitrogen nutrients can impede vegetative development, ultimately affecting the rate of photosynthesis per unit area. This reduced photosynthesis rate may lead to the development of narrower leaves. The ability of Nano Biochar to absorb nitrogen from urea can help reduce nitrogen loss due to its hygroscopic and volatile properties.

Plants, photosynthetic microorganisms, and algae display a green hue due to a pigment called chlorophyll. This pigment allows plants to perform photosynthesis by capturing light energy and transforming it into chemical energy within their leaves. During the process of photosynthesis, chlorophyll captures solar energy and begins the conversion of CO2 into carbohydrates. The degree of defoliation at 5 and 10 cm, along with nitrogen fertilization up to a maximum of 90 kg N/ha, did not affect leaf area, chlorophyll concentration, photosynthetic efficiency, or phosphorus uptake [10]. The carbohydrates produced through photosynthesis via anabolic pathways are converted into proteins, nucleic acids, fats, and other organic substances. Chlorophyll is insoluble in water but can dissolve in ethanol, methanol, and chloroform. Using spectrophotometric techniques, chlorophyll a, chlorophyll b, and other pigments such as carotene and xanthophyll were examined. The concentration of chlorophyll pigments in green leaves is highest in the first leaf, which is the oldest, and lowest in red leaves at the third leaf level, which is the youngest [17].

Water is available when the conditions are favorable, and the temperature is suitable. Sunlight is a limiting factor for growth due to the relationship between radiation and photosynthesis results. Nitrogen is crucial for forming chlorophyll, which gives plants their green hue. Dark green leaves indicate a high nitrogen level in the plant, while pale yellow leaves indicate a nitrogen deficiency [10].

One of the significant physical characteristics of chlorophyll is its ability to absorb and/or reflect light across different wavelengths. Chlorophyll mainly absorbs light in the 400–700 nm wavelength range, especially red and blue light. Higher plants have two distinct types of chlorophyll: dark-green chlorophyll a and light-green chlorophyll b [20]. Chlorophyll a and chlorophyll b show the least absorption of green light (500–600 nm), while they are most efficient at absorbing light in the red spectrum (600–700 nm). Table 4 demonstrates the effects of applying a coconut shell urea nano biochar coating on parameters such as fresh weight, dry weight, root fresh weight, and head dry weight.

The results concerning the variance at a 5% error rate demonstrated no notable difference among all varieties of urea treatment concerning the parameters of crown fresh weight, shoot dry weight, root fresh weight, and root dry weight. The noted increase in the crown's fresh weight was ascribed to the division and expansion of cells within the onion plant tissue. The amount of chlorophyll produced will lead to the generation of photosynthate products that can affect the division and expansion of cells in plants. Nitrogen is essential for plant growth, particularly in synthesizing lipids, enzymes, chlorophyll, and other compounds. The optimal formation of compounds and biomass in plants will enhance the fresh weight of the crown, thereby positively affecting soybean yields. The impact of applying coconut shell urea nano biochar coating on the fresh weight of the canopy, the dry weight of the canopy, and the fresh and dry weights of the roots are presented in Table 4.

Table 4. The Effect of Employing Coconut Shell Urea Nano Biochar Coating on the Fresh Weight of the Canopy, the Dry Weight of the Canopy, and the Fresh and Dry Weights of the Roots

Treatments	Fresh weight of canopy (g)	Dry weight of canopy (g)	Roots fresh weight (g)	Dry weight of roots (g)
A	32.58 b	8.54 b	8.50 a	1.16 a
B	95.67 a	20.27 a	10.26 a	1.97 a
C	68.16 ab	15.46 ab	9.40 a	1.46 a
D	70.36 ab	16.48 ab	9.45 a	1.47 a
E	65.58 ab	14.56 ab	9.20 a	1.21 a
F	30.40 c	7.50 b	8.63 a	1.18 a
CV	6.03	5.06	5.03	4.65

Note: The DMRT test indicates that, at a 5% error level, values in each column followed by the same letter do not exhibit significant differences.

Ammonia is generated through evaporation from urea located on the soil's surface. Various factors, including temperature, humidity, soil pH, and fertilizer application rate, all play a role in increasing the amount of nitrogen lost as ammonia [20]. Improving the soil's ability to retain nitrogen will enhance fertilizer use efficiency and reduce negative environmental impacts. Ref, [18] noted that using biochar can improve the soil's nitrogen storage capacity, boost its use efficiency, and decrease nitrogen loss. Despite having a small covalent radius of 71 pm [13], nanoscale biochar can absorb nitrogen.

An example of the biomass that plants absorb can be observed in the dry weight of the canopy. The efficiency with which solar energy is captured and utilized during the growing season is reflected in the dry weight. A greater dry weight of the canopy is associated with a higher rate of photosynthesis. Photosynthesis results significantly affect the fresh weight of the crown in the growth of stem cells, leaves, and roots. The dry weight of the canopy was determined after the plants were harvested and air-dried for three days until the crown was entirely dry, followed by drying in an oven at 60ºC and weighing with an analytical balance until a consistent weight was reached. The dry weight of the canopy exemplifies the quantity of biomass that plants take in. By assessing dry weight, it is possible to evaluate the efficiency of solar energy absorption and utilization throughout the growing season. An increase in nutrient uptake will enhance plant physiology. Plant biomass encompasses the byproducts of photosynthesis, including nutrition and water absorption. Since dry weight constitutes 90% of the outcomes of photosynthesis, it is a reliable indicator of plant production.

Roots function as absorbers of water and nutrients and serve as respiratory organs in the soil. The fresh weight of roots reflects the amount of root biomass produced by plants during their growth, allowing them to take in nutrients and water from coastal sandy soil before a decrease in water content occurs within the root tissue. A greater number of plant roots and their spread improve their capacity to obtain water and nutrients from the growing medium.

The supply of fertilizers or organic materials containing adequate nitrogen elements is crucial for ensuring optimal initial growth in plants, promoting the development of a robust root system. A plant's extensive root network plays a vital role in its overall growth, as it is responsible for storing water and nutrients from the soil, which are later utilized in the plant's metabolic processes. In essence, roots are one of the key organs of a plant that facilitate its growth [22]. When the roots are healthy, the growth of other parts of the plant will likely flourish since the roots can effectively absorb the necessary nutrients for the plant's development.

The dry weight of roots serves as an indicator of the volume of water that plant roots are capable of absorbing. The capacity of the roots to absorb water influences their efficiency in distributing it throughout the plant [23]. The biomass produced in the plant's roots was assessed by evaluating the root dry weight. To obtain the root dry weight, moisture content was eliminated from the root tissue by utilizing an oven set at 65º C, ensuring that the plant tissue remained undamaged by heat.

The low dry weight of roots may be attributed to inadequate water content and the nutrients that plant roots absorb. An increase in root weight improves the uptake of nutrients, particularly potassium, thus optimizing the photosynthesis process and resulting in a greater photosynthate yield at the dry weight of the roots. Potassium absorption is also affected by the nitrogen content in the soil. The nitrogen element is essential for the vegetative growth of plants. When plant growth is restricted, especially at the root level, the uptake of potassium from the soil is compromised. In addition to nitrogen's role in enhancing root

 https://doi.org/10.29165/ajarcde.v9i2.673

weight, phosphorus also catalyzes root development, which relies on the photosynthetic supply from the leaves. The byproducts of photosynthesis will support the growth of new roots, and phosphorus can aid in the formation of new cells within the roots, facilitating the expansion of the root zone and the development of new primary roots. A high root dry weight can be linked to the optimal ability of plant roots to absorb water and nutrient levels. A higher root weight value signifies that the absorption of nutrients, particularly nitrogen, is maximized, enabling the photosynthesis process to operate effectively and the resulting photosynthate to contribute to an increase in root dry weight. As the roots' dry weight rises, the photosynthesis process's efficiency is enhanced, leading to improved productivity and accelerated development of tissue cells, thereby fostering better plant growth. The nitrogen present in urea fertilizer, a vital protein component, plays a crucial role in promoting the division of meristem tissue and stimulating root growth and leaf development.

3.3. Soybeans Plant Yield

One can estimate the biomass generated within the roots of plants by assessing the roots. Shallots prepared for harvest display traits such as wilting, yellowing foliage, and softened leaf bases. Table 5 demonstrates the impact of utilizing coconut shell urea nano-biochar as a cover for soybeans on several metrics, including the number of pods, the fresh weight of the pods, the dry weight of the pods, the weight of 100 seeds, and the dry weight of the seeds.

Table 5. The Effect of Coconut Shell Urea Nano Biochar Coating on the Number of Pods, Fresh Weight of Pods, Dry Weight of Pods, Weight of 100 Seeds, and Dry Weight of Seeds

Treatment	Number of Pods	Pods Fresh Weight (g)	Pods Dry Weight (g)	Seeds 1.000 Weight (g)	Seed Dry Weight (g)
A	32.58 c	22.54 c	18.50 c	13.20 a	8,58 c
B	75.67 a	45.27 a	35.26 a	13.52 a	19,97 a
C	56.16 b	35.46 b	28.40 b	13.36 a	13,56 b
D	70.36 ab	41.48 ab	30.45 ab	13.48 a	16,47 ab
E	35.58 c	25.56 c	19.20 c	13.35 a	8,61 c
F	30.41 c	20.51 c	17.63 c	13.12 a	7,66 c
CV	6.05	5.07	5.05	6.07	6.15

Note: The DMRT test indicates that at a 5% error level, values in each column followed by the same letter do not exhibit significant differences.

According to the variance analysis conducted at an error rate of 5%, there are notable differences in the parameters concerning the number of pods, the fresh weight of pods, the dry weight of pods, and the dry weight of seeds in soybean plants. Nevertheless, no significant difference was observed in the weight parameter of 100 seeds. The use of urea granule fertilizer coated with nano biochar led to the highest counts of pods, fresh weight of pods, dry weight of pods, and dry weight of seeds; however, this was not significantly different from the results obtained with the application of urea granule fertilizer coated with nano biochar.

Urea nano-biochar obtained from coconut shells can supply nitrogen nutrients by absorbing and holding them for the benefit of plants. The production of tubers may rise depending on the nitrogen content available in the soil. The weight of fresh pods is a factor that is directly associated with the quantity of pods produced on the plant. The pod formation process results from photosynthesis carried out by the plant. Photosynthesis influences the process of pod formation in plants, and this is because plants experience the process of converting CO2 and H2O into carbohydrates, proteins, fats, and oxygen, where these complex compounds are stored in the stems, seeds, fruit, and pods of plants.. [25] also states that the process of forming pods and filling seeds in plants requires the availability of sufficient water so that the process of accumulating photosynthesis results in plants takes place optimally. The weight of the pods is influenced by the seeds in the pods and the number of seeds produced, where elements support the formation of the pods. Macro nutrients, especially N, are well absorbed by plants. If the N requirement is met, soybean plants can form pods well.

The dry weight of pods reflects the effectiveness of absorbing and utilizing the available energy from sunlight. A higher dry weight of the pod corresponds to an increased yield from photosynthesis. The results of photosynthesis greatly influence the dry weight of the pods. Pod weight not only depends on the availability of N elements, but is also influenced significantly by the availability of phosphorus (P) and potassium (K). K elements and good translocation during pod formation also influence soybean pod weight. Photosynthesis transitions from the vegetative phase to the generative phase, resulting in the storage of food reserves as carbohydrates in the form of seeds. Consequently, an increase in photosynthesis leads to a higher production of seeds [26].

Seed dry weight is one of the parameters that determine the success of soybean plants in producing seeds. The yield of high and low soybean seeds is affected by the plant's capacity to take in nutrients from the soil solution. The nitrogen content present in urea can fulfill the requirements of soybean plants.The availability of sufficient N during the photosynthesis process can help increase the weight of planted seeds. Generally, plants with good vegetative growth will also have good generative growth results. Sufficient supply of assimilate during seed filling is caused by increased transport of assimilate from the plant's source organs (leaves and stems) to the sink (pods) for the seed filling process. The element N found in fertilizers is a vital component of the nutritional ingredients present in seeds, including amino acids, proteins, coenzymes, chlorophyll, and various other substances. Consequently, applying fertilizers that contain N to plants will enhance the dry weight of the seeds. That high seed weight can be produced if the seeds as a sink can accommodate the assimilate results; conversely, if there are enough sinks but the assimilate results are low, resulting in empty seeds. [27]. Another study also stated that the translocation of seed dry matter was strongly influenced by Cl. the seed's ability as an organ to accommodate assimilate. The presence of adequate assimilation in plants will enhance seed weight. Nitrogen is categorized as one of the macro elements essential for plants, serving as a crucial component in protein synthesis and cellular division. It acts as a vital nutrient for plants, integral to amino acids, amides, and other necessary elements that facilitate cell division and the growth of entire plant cells, including tubers. Moreover, potassium, phosphorus, and nitrogen are significant contributors to tuber development. Phosphorus is the fundamental building block of nucleic acids, essential for cell division. In addition, potassium enhances plant growth by activating various other enzymes [28].

4. CONCLUSION

The findings indicated that the nano biochar derived from coconut shell-coated urea prill significantly enhances the growth and yield of soybeans cultivated in coastal sandy soil. In the future, the application of nano biochar-coated urea prill may be utilized to improve the effectiveness of urea and boost soybean yields.

ACKNOWLEDGMENT

The authors would like to thank Universitas Muhammadiyah Yogyakarta for the financial support during the research.

REFERENCE

[1] Lagiman, Suryawati, A., & Widayanto, B. 2022. Cultivation of Soybean Plants on Beach Sand Land. Yogyakarta: LPPM UPN Veteran Yogyakarta

[2] Ministry of Agriculture 2018 Food Consumption Statistics

[3] Wan H, Chen Y, Cui B, Liu X, Hou J, Wei Z, Liu J and Liu F 2023 J. Soil Sci. Plant Nutr. 23.1576–1588

[4] Birnadi, S. (2014). Effect of Soil Processing and Bokashi Organic Fertilizer on Growth and Yield of Soybean Plants (Glycine max L.) Tulisivar Wilis. ISTEK Journal, VIII(1), 29–46.

[5] Puspasari, R., Setyana, A. K., & Makmur, S. (2018). Pod Formation and Soybean Plant Yield (Glycine Max (L) Merrill) with Nitrogen Application in the Generative Phase. Journal of Crop Production, 6(6), 1096–1102

[6] Indradewa, D., Alam, T., Suryanto, P., Kurniasih, B., Sartohadi, J., Rogomulyo, R., … Taryono. (2021). Agronomic Technology Innovation in Coastal Sand Land (D. Indradewa, Ed.). Yogyakarta: Deepublish

[7] Luo K, Xie C, Yuan X, Liu S, Chen P, Du Q, Zheng B, Fu Z, Wang X, Yong T and Yang W2023 BMC Plant Biol. 23 1–10

[8] Allium S and Imbo S B 2021 Combined and Singular Effects of Ethanolic Extract of Persian

[9] Bahmani M, Shirzad H, Majlesi M, Shahinfard N and Rafieian-Kopaei M 2014 Asian Pac.J.Trop. Med. 7 43–53.

[10] Alfianto R, Sumawinata B and Darmawan 2011 Study of Activated Carbon Production fromRice Husks by Silica Dissolution Technique (Institut Pertanian Bogor)

[11] Komarayati S, Nurhayati T and Setiawan D 1997 Bul. Penelit. Has. Hutan 15 1–6

[12] Solihudin S, Noviyanti A R and Rukiah R 2015 Chim. Nat. Acta 3 1–6

[13] Santi and Goenadi D H 2010 Menara Perkeb. 78 52–60

[14] Setyanti Y H, Anwar S and Slamet W 2013 Anim. Agric. J. 2 86–96

[15] Handa yani A and Wuryanto 1996 Pros. Pertem. dan Present. Ilm. PPNY-BATAN, Yogyakarta23-25 April 1996 116–20

[16] Solihin 2013 Pertumbuhan Vegetatif Dan Generatif Stachytarpeta Jamaicensis(L.) Vahl. vol10

[17] Maulid R R and Laily A N 2015 Semin. Nas. Konserv. dan Pemanfaat. Sumber Daya Alam. Pros. KPSDA 1 225–230

[18] Engelstad O P 1997 Technology and Fertilizer Use

[19] Novizan 2007 Guidelines for Effective Fertilization

[20] Evila T and Amrullah S 2019 J. Pengendali. Pencemaran Lingkung. 1 28–33

[21] Wang J, Chen Z, Xiong Z, Chen C, Xu X, Zhou Q and Kuzyakov Y 2015 Soil Use Manag.31.375–383

[22] Wahyudin A and Irwan A W 2019 J Kultiv. 18 899–893

[23] Handoyo G C and Agusta H 2018 Makal. Semin. Dep. Agron. dan Hortik. 10 3

[24] Febriyono, R., Susilowati, Y. E., & Suprapto, A. 2017. Increasing Crop Yields Land Water Spinach (Ipmoea repants, L.) Through Planting Spacing and Number Treatment Plants Per Hole. Journal of Tropical and Subtropical Agricultural Sciences, 2(1), 22–27.

[25] Setubal, I. S., Andrade Júnior, A. S. d., Silva, S. P. d., Rodrigues, A. C., Bonifácio, A., Silva, E. H. F. M. d., Vieira, P. F. d. M. J., Miranda, R. d. S., Cafaro La Menza, N., & Souza, H. A. d. (2023). Macro and Micro-Nutrient Accumulation and Partitioning in Soybean Affected by Water and Nitrogen Supply. *Plants*, *12*(9), 1898. https://doi.org/10.3390/plants12091898

[26] Joshua L. Sloan ,†, Francis K. Salifu and Douglass F. Jacobs 1, 2021. Nitrogen Recovery from Enhanced Efficiency Fertilizers and Urea in Intensively Managed Black Walnut (Juglans nigra) Plantations' Forests | An Open Access Journal from MDPI

[27] Raniele Souza, Itamar Teixeira1, Elton Reis1, and Alessandro Silva. 2016. Soybean morphophysiology and yield response to seeding systems and plant populations. Chilean Journal Of Agricultural Research 76(1) .

[28] Ahmed Jaafar Zyarah Al-Shamary1 and Abdul-Mahdi Salih Al-Ansari. 2022. Response of Growth and Productivity of Wheat Cultivars (Triticum aestivum L.) to Nano -N and Urea Fertilizer.https: //iopscience.iop.org/article/10.1088/1755-15/1060/1/012040

 https://doi.org/10.29165/ajarcde.v9i2.673