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Effects of Calcium Nitrate Levels and Soaking Durations on Cocopeat Nutrient Content

Sheku N. Gbollie*, Samuel M. Mwonga, Anthony M. Kibe

Department of Crops, Horticulture and Soils, Faculty of Agriculture, Egerton University, Njoro, Kenya
Email: *shekunyumahgbollie@gmail.com

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Abstract

Cocopeat, a by-product of the coconut (*Cocos nucifera* L.), is an important soilless media that contains high potassium (K), sodium (Na), and electrical conductivity (EC) depending on its source. Methods for extracting these elements and thus lowering EC are yet to be standardized. This study was therefore carried out to investigate two extraction methods of these elements in cocopeat. A greenhouse pot experiment was carried out at the Climate and Water Smart Agriculture Centre of Egerton University, Kenya. It was laid out in a 5 × 4 factorial completely randomized design. Five soaking durations (12, 24, 36, 48, and 72 hours) and four calcium nitrate ($Ca(NO_3)_2$) levels (0, 60, 100, and 150 g) were used. The experiment was done in two folds: the leachate and treated cocopeat examination for their chemical properties. The General Linear Model procedures were used for Analysis of Variance at ($P \leq 0.05$). The results showed that the addition of $Ca(NO_3)_2$ 100 g extracted significantly more K and Na in the leachate than $Ca(NO_3)_2$ 0.0 g and 60 g. The EC levels in the leachate increased with the application levels of $Ca(NO_3)_2$ while the pH levels were reducing. In the treated cocopeat, $Ca(NO_3)_2$ 100 g and soaking duration 36 hours significantly reduced K and Na and sufficiently supplemented Ca and N. Irrespective of $Ca(NO_3)_2$ and soaking durations, after the cocopeat is washed, the EC and pH values fall within their suitable ranges. There was a strong negative correlation between Ca and Na, Ca and K, and between Na and EC. Also, strong positive correlation between Ca and N and Ca and EC. Effective supplementation of Ca and N, and optimal reduction of K and Na by 78.44% and 92%, respectively can be achieved with 100 g of $Ca(NO_3)_2$ 1.5 kg^{-1} of cocopeat in 15 liters of water with a soaking duration of 36 hours.

Keywords

Calcium Nitrate, Cocopeat, Leachate, Potassium, Soaking

1. Introduction

Cocopeat, also known as coconut (*Cocos nucifera* L.) fiber, coir, coir pith or coir dust, it is an organic planting media made from coconut husk that surrounds the shell of the coconut [1] [2]. Generally, cocopeat contains high K, Na, and EC but the concentrations vary with sources [3]. The husks are used to produce various types of growing substrates, including cocopeat, chips, and chunks [4]. Out of the total annual global production of coconut 62.8 million tonnes, only 10% of the coconut husks are being used for cocopeat extraction amounting to an estimate of 1.5 million metric tonnes [5] [6]. The importance of cocopeat cannot be overemphasized; it has an ideal pH, holds more than 22% air, and has excellent drainage properties. Its anti-fungicidal properties help plants to get rid of soil-borne diseases, and it is 100% renewable, easy to hydrate, has little or no weed, and is environmentally friendly [7] [8]. In Kenya, the total area covered by coconut was estimated at 82,921 and 84,824 hectares in 2018 and 2019, respectively and this was mainly in the coastal regions [5] [6].

Soilless culture has become one of the prominent means to achieve higher productivity around the globe. Regardless of cocopeat's importance, its use faces some challenges related to its chemical composition. The cation exchange capacity (CEC) of cocopeat is between 40 - 100 $cmol \cdot kg^{-1}$ [8]. This means that cocopeat can hold onto nutrients, but it can also lock certain nutrients out, leading to deficiencies in the plants. Cocopeat's initial cation exchange sites are naturally saturated with K and Na with little or no calcium (Ca) [9] [10] [11] [12]. Potassium which is the dominant element in cocopeat can be attached up to between 38.5 - 40 $cmol \cdot kg^{-1}$ of the total sites and Na at 13.04 - 15 $cmol \cdot kg^{-1}$ of the total sites [11]. Through cation exchange, in the presence of Ca, the sites will release their Na and K cations and lock onto Ca. Coconut trees have a naturally high tolerance for sodium chloride [8]. Most coconuts are produced along the coast or on highly saline soils. The origin of cocopeat has an impact on its nutrient content as those produced away from the ocean may not accumulate as much Na and K compared to those grown along the coast [13]. The EC of an untreated cocopeat is usually > 1.0 milli siemens per centimeter ($mS \cdot cm^{-1}$). For hydroponics purposes, it is advisable to maintain EC < 1.0 $mS \cdot cm^{-1}$ [12]. For maximum utilization of cocopeat for crop production, efforts must be made to reduce the high level of K and Na in cocopeat. Reducing the high level of K in cocopeat reduces K toxicity, enhances Ca uptake by the plant, and stimulates crop root development leading to higher productivity of crops [14].

Several methods are used to treat cocopeat for K and Na optimization: water, with and without $Ca(NO_3)_2$, magnesium nitrate, and barium chloride [11] [13] [15]. Although water or $Ca(NO_3)_2$ alone cannot extract the naturally bonded K and Na, when used simultaneously, the effects are observed. Most local cocopeat producers are randomly treating cocopeat with water and some are adding $Ca(NO_3)_2$ at different levels to reduce K and Na. The use of $Ca(NO_3)_2$ reduces elements that are naturally bonded to the cation exchange complex of cocopeat [8] [11]. The main goal of treating cocopeat is to reduce the quantity of K and Na and supplement with Ca and N. Using untreated cocopeat to grow crops creates a very unsuitable growth medium for many horticultural plants. When the untreated cocopeat is used for crop production, K and Na develop a stronger attraction to the peat's complex causing nutrient lockout for other elements. This causes K and Na to be displaced into the solution and be taken up by the plants instead of Ca. The objective of this study was to determine the ratio of $Ca(NO_3)_2$ to cocopeat and soaking duration suitable for K, Na, and EC minimization while supplementing Ca and N in cocopeat.

2. Materials and Methods

2.1. Determination of Chemical Properties of Cocopeat and Water Used

Initially, the untreated cocopeat sourced from Cocoponics Africa Limited, and water that was used to soak the cocopeat were analyzed at the Kenya National Agricultural Research Laboratory (NARL)-Kabete for K, Na, Ca, N, EC, and pH. The quality of water was evaluated because it affects the exchange reactions of K, Na and Ca on the adsorption complex of cocopeat [15]. The pH and EC were determined using a 1:2.0 (w/v) ratio of media to water suspension using a pH meter and conductivity meter for EC [16]. Total N, Ca, Na and K were extracted using concentrated 96% sulfuric acid (H_2SO_4), salicylic acid ($C_7H_6O_3$), hydrogen peroxide 30%, and selenium powder. Using the Kjeldahl digestion method as in [17] for total N determination, samples of the substrates were dried in an oven at 70˚C and oxidized with hydrogen peroxide 30% at a relatively low temperature (100˚C). After decomposition of the excess H_2O_2 and evaporation of water, digestion was completed with a concentrated 96% sulphuric acid (H_2SO_4) at elevated temperature (330˚C) under the influence of selenium powder as the catalyst. After the digested samples were cooled overnight, the exchangeable Ca was determined using an Atomic Absorption Spectrophotometer (AAS) at a wavelength (λ) of 422.7 nm, while exchangeable K and Na were determined using a flame photometer at λ of 766 nm and 589 nm, respectively [18] (**Table 1**).

Table 1. Chemical properties of the untreated cocopeat and water used.

Properties	K	Na	Ca	Nitrogen ($g \cdot kg^{-1}$)	EC ($mS \cdot cm^{-1}$)	pH
	($cmol \cdot kg^{-1}$)					
Untreated cocopeat	33.33	13.90	3.51	5.30	1.55	5.83
Water	0.03	0.09	0.003	0.00	0.52	7.7

2.2. Experimental Procedure and Treatments

A greenhouse pot experiment, each of height 30 cm, base diameter 28 cm, and top diameter 28 cm was conducted at the Climate and Water Smart Agriculture Centre of Egerton University, Nakuru County, Kenya. The study site is situated at 0˚22'S, 35˚36'E at an altitude of 2267 meters above sea level. The experimental site is in agro-ecological zone III (medium potentials) with annual rainfall between 950 and 1500 mm [19]. At the experimental site, the average maximum and minimum ambient and greenhouse temperatures recorded were: 22.0˚C, 10.0˚C, and 30.0˚C, 15.1˚C, respectively. The experiment was laid in a 5 × 4 factorial completely randomized design with 20 treatments and three replicates. Each replicate had 40 soaking pots (two pots treatment^{-1}). The treatments were five soaking durations (12, 24, 36, 48, and 72 hours) and four levels of $Ca(NO_3)_2$ (0, 60, 100, and 150 g) mixed with 1.50 kg of cocopeat in 15.0 L of water (**Table 2**).

The mixtures were then soaked for their respective soaking durations. After every six hours, each treatment was mixed and the leachate was collected after the respective soaking durations. Cocopeat media was then well rinsed using hydrogen peroxide (H_2O_2) (0.5 mL into one litre of tap water) as means of eliminating any harmful pest [20]. Each treatment was rinsed using ten litres of the H_2O_2 solution. A second rinsing was done with five litres of tap water (without

Table 2. Treatments combination for the leachate and treated cocopeat experiment.

Treatments	Grams of $Ca(NO_3)_2$ pot^{-1}	Soaking durations (hours)
C0D1	0	12
C0D2	0	24
C0D3	0	36
C0D4	0	48
C0D5	0	72
C1D1	60	12
C1D2	60	24
C1D3	60	36
C1D4	60	48
C1D5	60	72
C2D1	100	12
C2D2	100	24
C2D3	100	36
C2D4	100	48
C2D5	100	72
C3D1	150	12
C3D2	150	24
C3D3	150	36
C3D4	150	48
C3D5	150	72

Note: C0, C1, C2, C3: calcium nitrate 0, 60, 100, and 150 g, respectively. D1, D2, D3, D4, and D5: soaking durations 12, 24, 36, 48 and 72 hours, respectively.

H_2O_2) for each treatment, and the media was left standing for 24 hours to drain the remaining water. Samples of the treated media in each treatment were taken for laboratory analyses.

2.3. Data Collection

After the respective soaking durations, the leachate for each treatment was collected and analysed for: K, Na, EC, and pH levels. To determine the nutrient content in the treated cocopeat, samples of the treated cocopeat were also collected from each treatment and analysed for K, Ca, Na, total N, EC, and pH levels (see Section 2.1).

2.4. Data Analysis

To meet the assumptions of Analysis of Variance (ANOVA), data were subjected to the normality test [21]. General Linear Model (GLM) procedures of the statistical analysis system (SAS), version 9.0 were used for ANOVA at ($P \leq 0.05$) [22]. Treatment means for the main effects of soaking duration and $Ca(NO_3)_2$ were separated using Tukey's Honestly Significant Difference (HSD) test at 0.05 level of significance. Pearson's Correlation test at $P \leq 0.05$ was also performed between treated cocopeat elements extracted by the main effects of soaking duration and $Ca(NO_3)_2$. Microsoft Excel, 2015 was also used to develop graphs.

3. Results

3.1. Initial Analyses for the Untreated Cocopeat and Water

The results showed that the untreated cocopeat had excessive concentrations of K (33.33 $cmol \cdot kg^{-1}$) and Na (13.90 $cmol \cdot kg^{-1}$). The concentrations of Ca and total N were low while the EC was above the threshold of 1 $mS \cdot cm^{-1}$, and the pH value was found to be in the suitable range of 5.5 - 6.5 (**Table 1**). In the water used, the pH was mildly alkaline, EC was <1 $mS \cdot cm^{-1}$. The critical nutrients in water were suitable to be used for the soaking of cocopeat as none was excessive.

3.2. Effects of Calcium Nitrate Levels and Soaking Durations on the Chemical Properties of Cocopeat Leachate

Other than Na, no significant ($P > 0.05$) interaction effect between $Ca(NO_3)_2$ and soaking duration was observed for K, EC, and pH in the cocopeat lactate. The results showed that $Ca(NO_3)_2$ 100 g significantly increased K in the leachate by 15.5%, compared to $Ca(NO_3)_2$ (0.0 g). Electrical conductivity levels increase with an increase in the application levels of the $Ca(NO_3)_2$. The highest rate of $Ca(NO_3)_2$ (150 g) increased the EC by 56.28% compared to the treatment with no $Ca(NO3)_2$ application. On the other hand, pH was inversely proportional to the concentrations of $Ca(NO_3)_2$ and EC in the leachate. As the $Ca(NO_3)_2$ concentration increased, the pH values became more acidic to pH 5.88 for the highest level of $Ca(NO_3)_2$ application (**Table 3**). Soaking duration did not significantly ($P > 0.05$) influence K, EC, and pH, but significant differences ($P < 0.05$) were observed for Na.

Table 3. Means separation for the main effects of soaking duration and calcium nitrate on K, EC, and pH in the leachate.

Soaking durations (hours)	K ($cmol\cdot kg^{1}$)	EC ($mS\cdot cm^{-1}$)	pH
12	10.64^{a}	7.76^{a}	6.13^{a}
24	11.18^{a}	7.87^{a}	6.06^{a}
36	12.00^{a}	7.93^{a}	6.05^{a}
48	10.66^{a}	8.01^{a}	6.09^{a}
72	10.86^{a}	8.10^{a}	6.06^{a}
MSD	2.78	0.63	0.13
Calcium nitrate (g)	**K ($cmol\cdot kg^{1}$)**	**EC ($mS\cdot cm^{-1}$)**	**pH**
0.0	9.21^{b}	3.39^{d}	6.36^{a}
60.0	11.04^{ab}	6.81^{c}	6.07^{b}
100.0	12.59^{a}	9.42^{b}	6.00^{b}
150.0	11.44^{ab}	12.12^{a}	5.88^{c}
MSD	2.09	0.53	0.11

The means followed by the same letters in the same column are not significantly different using Tukeys' HSD test at 5% level of significance. 0.0, 60.0, 100, and 150 gram of $Ca(NO_3)_2$ and 12, 24, 36, 48, and 72 soaking durations hours.

3.3. Effects of Soaking Durations and Calcium Nitrate Levels on the Rate of Change of K, Na, EC, and pH in the Leachate

This section describes the rate of change of the measured parameter (K, Na, EC and pH) with an increase in $Ca(NO_3)_2$ application-level at a given soaking duration, and the rate of change of the measured parameters with increasing soaking duration at a given $Ca(NO_3)_2$ level. The fastest decreasing rate of change (-0.0024 $cmol\cdot kg^{-1}$) for K was observed in $Ca(NO_3)_2$ 100 g and the slowest rate of change (-0.0006 $cmol\cdot kg^{-1}$) was in $Ca(NO_3)_2$ 0 g (**Table 4**) and (**Figure 1(a)**). In Na, only $Ca(NO_3)_2$ 100 g gave a decreasing rate of change (-0.0014 $cmol\cdot kg^{-1}$). The Na concentration in 0 g, 60 g, and 150 g $Ca(NO_3)_2$ were increasing as durations increased. The highest rate of change for Na was in 0 g and the least was in 60 g of $Ca(NO_3)_2$ (**Figure 1(b)**). Although, there was no significant rate of change in the pH and the EC with increase in the soaking duration, the rate of change for EC was high in 60 g and low in 100 g. On the other hand, the rate of change for pH in the leachate was high in 100 g (-0.002) and low in 150 g of $Ca(NO_3)_2$ (**Figure 1(c)** and **Figure 1(d)**).

3.4. Effects of Calcium Nitrate Levels and Soaking Durations on Chemical Properties of the Treated Cocopeat

Amongst the parameters examined, the interaction between $Ca(NO_3)_2 \times$ soaking duration was only observed for N. No interaction effect was observed for K, Na, Ca, EC, and pH in the treated cocopeat. The main effects for $Ca(NO_3)_2$ showed that there was a significant inverse relationship between $Ca(NO_3)_2$ levels

Table 4. Interaction effects of calcium nitrate × soaking duration on the rate of change of K, Na, EC, and pH in the lactate.

$Ca(NO_3)_2$ (g)	Element	Equation	R^2	Rate of change
150	K	$y = -0.0005x^2 + 0.0128x + 11.886$	0.5812	−0.0010
60		$y = -0.0008x^2 + 0.0675x + 9.9453$	0.5725	−0.0016
100		$y = -0.0012x^2 + 0.0874x + 11.432$	0.2200	−0.0024
0		$y = -0.0003x^2 + 0.0548x + 7.5946$	0.7001	−0.0006
150	Na	$y = 0.0009x^2 - 0.1224x + 9.8904$	0.8045	0.0018
100		$y = -0.0007x^2 + 0.0092x + 8.321$	0.6349	−0.0014
60		$y = 0.0006x^2 - 0.0421x + 6.3371$	0.3789	0.0012
0		$y = 0.0011x^2 - 0.048x + 3.2754$	0.9363	0.0022
150	EC	$y = -0.0036x + 12.257$	0.3778	−0.0036
100		$y = 0.0011x + 9.3748$	0.0105	0.0011
60		$y = 0.0155x + 6.2097$	0.444	0.0155
0		$y = 0.0052x + 3.191$	0.6531	0.0052
0	pH	$y = -0.0017x + 6.4223$	0.3701	−0.0017
60		$y = 0.0007x + 6.0432$	0.1205	0.00070
100		$y = -0.002x + 6.0741$	0.3917	−0.0020
150		$y = -8E-05x + 5.8804$	0.0057	−8E−050

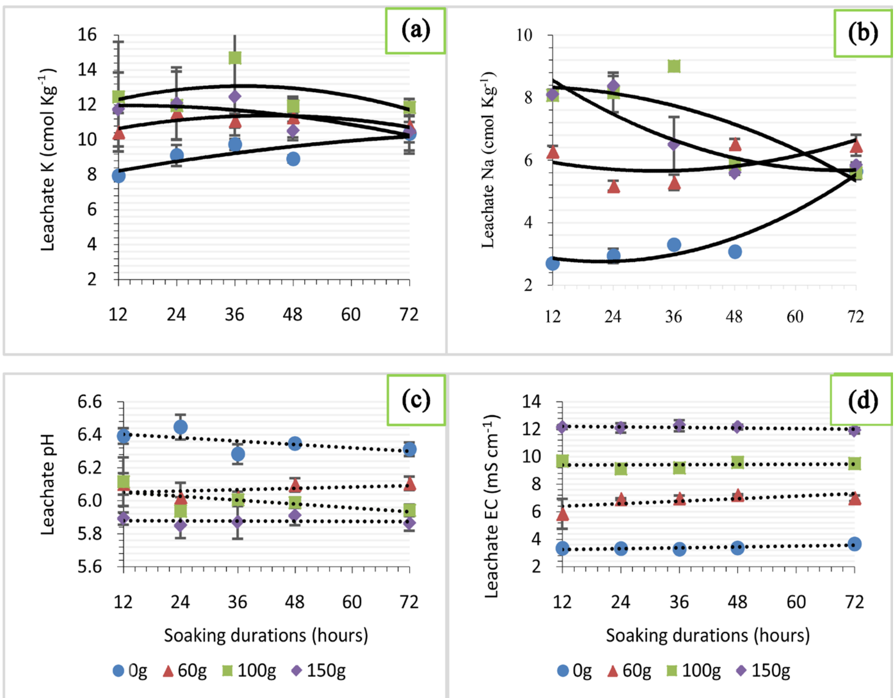

Figure 1. Effects of soaking durations and calcium nitrate levels on the rate of change of K, Na, pH and EC in cocopeat leachate.

versus K and Na while a direct relationship was observed between $Ca(NO_3)_2$ levels versus Ca and EC in the treated cocopeat (Table 5). Both $Ca(NO_3)_2$ levels and soaking durations did not significantly ($P > 0.05$) differ for pH in the treated cocopeat. The highest concentrations of K and Na were observed in $Ca(NO_3)_2$ (0.0 g) while the least concentrations of the two elements were found in the treatment receiving the highest level of $Ca(NO_3)_2$ (150 g) Similarly, the highest Ca (58.17 $cmol \cdot kg^{-1}$) and EC (0.98 $mS \cdot cm^{-1}$) were observed in the highest $Ca(NO_3)_2$ rate of 150 g, followed by 100 g, 60 g, and least from the treatments where $Ca(NO_3)_2$ was not applied. Soaking durations were also significantly ($P < 0.001$) different for K, Na, Ca, total N and EC. Soaking duration 12 hours had 9.8% and 10.9% more K than soaking durations 48 and 72 hours, respectively. Although durations 24, 36, 48, and 72 hours were not significantly different, a similar trend was observed for Na. The concentration of Ca was high in 72 and 48 hours (32.12 and 29.60 $cmol \cdot kg^{-1}$), respectively and low in 12 and 24 hours (22.63 and 24.25 $cmol \cdot kg^{-1}$), respectively. Electrical conductivity was below the threshold of 1 $mS \cdot cm^{-1}$ after the cocopeat was treated in both the main effects of $Ca(NO_3)_2$ levels and soaking durations.

3.5. Effect of Soaking Durations and Calcium Nitrate Levels on the Rate of Change of K, Ca, Na, Total N and EC in the Treated Cocopeat

The results showed that there was an increasing rate of change for Ca, N, and EC

Table 5. Means separation for the main effects of soaking duration and calcium nitrate on K, Ca, Na, EC, and pH in treated cocopeat.

Soaking durations (hours)	K	Ca	Na	EC ($mS \cdot cm^{-1}$)	pH
	($cmol \cdot kg^{-1}$)				
12	13.33^{a}	22.63^{b}	1.52^{a}	0.64^{c}	5.67^{a}
24	11.65^{ab}	24.25^{b}	1.39^{ab}	0.69^{bc}	5.71^{a}
36	11.37^{ab}	26.90^{ab}	1.29^{bc}	0.70^{b}	5.68^{a}
48	10.09^{b}	29.60^{a}	1.22^{c}	0.72^{ab}	5.68^{a}
72	9.72^{b}	32.12^{a}	1.16^{c}	0.78^{a}	5.67^{a}
MSD	1.98	5.30	0.15	0.06	0.16
Calcium nitrate (g)	**K**	**Ca**	**Na**	**EC ($mS \cdot cm^{-1}$)**	**pH**
	($cmol \cdot kg^{-1}$)				
0.0	19.59^{a}	3.60^{d}	1.97^{a}	0.48^{d}	5.68^{a}
60.0	11.28^{b}	15.03^{c}	1.57^{b}	0.63^{c}	5.70^{a}
100.0	7.09^{c}	31.60^{b}	1.07^{c}	0.73^{b}	5.68^{a}
150.0	6.96^{c}	58.17^{a}	0.67^{d}	0.98^{a}	5.66^{a}
MSD	1.66	4.45	0.13	0.05	0.14

The means followed by the same letters within the same column are not significantly different using Tukeys' honestly significant difference test at 5% level of significance. MSD: minimum significant difference.

Table 6. Interaction effects of calcium nitrate and soaking duration on the rate of change of Ca, K, Na, N, and EC in the treated cocopeat.

$Ca(NO_3)_2$ (g)	Element	Equation	R^2	Rate of change
150	Ca	y = 0.2609x + 48.149	0.8939	0.2609
100		y = 0.2697x + 21.243	0.9630	0.2697
60		y = 0.0843x + 11.797	0.8891	0.0843
0		y = 0.0466x + 1.8131	0.4801	0.0466
0	K	y = −0.0728x + 22.384	0.9520	−0.0728
60		y = −0.0915x + 14.796	0.9406	−0.0915
100		y = −0.0496x + 8.9990	0.9767	−0.0496
150		y = −0.018x + 7.64710	0.0921	−0.018
0	Na	y = −0.0066x + 2.2229	0.8654	−0.0066
60		y = −0.0082x + 1.8874	0.9888	−0.0052
100		y = −0.0052x + 1.2647	0.8426	−0.0052
150		y = −0.0035x + 0.8015	0.4956	−0.0035
150	N	y = 0.0533x + 10.245	0.8098	0.0533
100		y = 0.0307x + 7.309	0.9631	0.0307
60		y = 0.013x + 6.3027	0.8838	0.0130
0		y = 0.0045x + 4.9937	0.5560	0.0045
150	EC	y = 0.0031x + 0.8644	0.7032	0.0031
100		y = 0.0021x + 0.65	0.9725	0.0021
60		y = 0.0006x + 0.6045	0.9549	0.0006
0		y = 0.0032x + 0.356	0.9254	0.0032

while a decreasing rate of change was observed for K and Na due to the effects of $Ca(NO_3)_2$ and soaking durations (**Table 6**). In Ca, the highest rate of change (0.2697 $cmol \cdot kg^{-1}$) was observed in 100 g of $Ca(NO_3)_2$ followed by 150 g, 60 g, and 0.0 g giving the least rate of change (0.0466 $cmol \cdot kg^{-1}$) (**Figure 2(d)**).

The rate of change in the total N was directly proportional to the concentration of $Ca(NO_3)_2$ levels with 150 g giving the highest (0.0533 $g \cdot kg^{-1}$) although not significantly different from 100 g of $Ca(NO_3)_2$ while 0 g give the least positive rate of change (0.0045 $g \cdot kg^{-1}$) (**Figure 2(c)**). The EC rate of change was moderately high in 0.0 g and 150 g of $Ca(NO_3)_2$ (0.0032, 0.0031 $mS \cdot cm^{-1}$), respectively and low in 60 g (0.0006 $mS \cdot cm^{-1}$) (**Figure 2(e)**). For K, the highest decreasing rate of change was observed in 60 g (−0.0915 $cmol \cdot kg^{-1}$) and the least was observed in 150 g (−0.018 $cmol \cdot kg^{-1}$). As for Na, the highest decreasing rate of change was in 0 g (−0.0066 $cmol \cdot kg^{-1}$) while the least was in 150 g (−0.0035 $cmol \cdot kg^{-1}$).

3.6. Pearson Correlation for the Main Effects of Calcium Nitrate and Soaking Duration on the Nutrient Content in the Treated Cocopeat

The Pearson correlation test for the main effect of soaking duration revealed

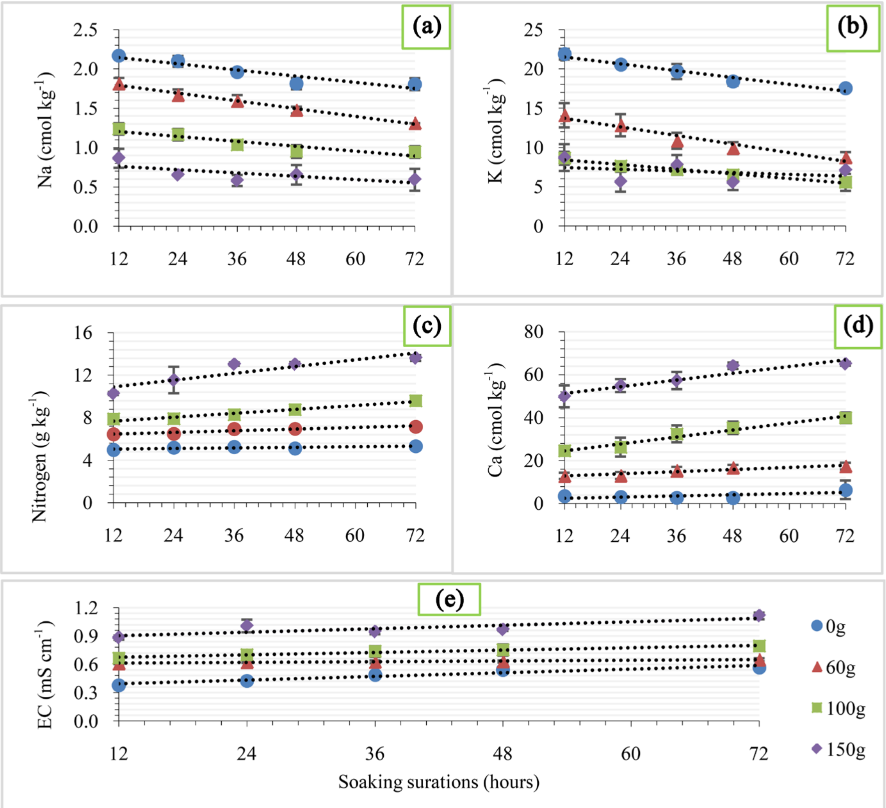

Figure 2. Effects of soaking durations and calcium nitrate levels on the rate of change of Na, K, N, Ca, and EC in the treated cocopeat.

Table 7. Pearson correlation coefficients of soaking durations between the treated cocopeat nutrients.

	N	K	Ca	Na	EC
K	-0.83^{ns}	–	–	–	–
Ca	0.87*	−0.95*	–	–	–
Na	−0.92*	0.98**	−0.97**	–	–
EC	0.84^{ns}	−0.94*	0.95*	−0.95*	–
pH	-0.28^{ns}	-0.07^{ns}	-0.36^{ns}	0.19^{ns}	-0.17^{ns}

strong negative correlations between Ca and K (r = −0.95*), Ca and Na (r = −0.97**), K and EC (r = −0.94*), Na and EC (r = −0.95*), and between total N and Na (r = −0.92*). On the other hand, strong positive significant correlations were also observed between N and Ca (r = 0.87*), K and Na (r = 0.98**), and between Ca and EC (r = 0.95*) (Table 7).

There was no strong significant ($P > 0.05$) correlation between pH and the rest of the elements/properties in both the soaking durations and $Ca(NO_3)_2$ levels. The correlation for the main effect of $Ca(NO_3)_2$ also showed that there were strong significant negative correlations between Ca and Na (r = −0.98*), EC and Na (r = −0.98), and between N and Na (r = −0.97*). Strong positive significant correlations were observed between N and Ca (r = 0.99*), N and EC (r = 0.99*),

Table 8. Pearson correlation coefficients of calcium nitrate levels between the treated cocopeat nutrients.

	N	K	Ca	Na	EC
K	-0.81^{ns}	–	–	–	–
Ca	0.99**	-0.83^{ns}	–	–	–
Na	−0.97*	0.92^{ns}	−0.98*	–	–
EC	0.99**	-0.85^{ns}	0.99**	−0.98*	–
pH	-0.73^{ns}	-0.30^{ns}	-0.74^{ns}	0.65^{ns}	-0.68^{ns}

and between Ca and EC (r = 0.99*) (**Table 8**).

4. Discussion

4.1. Chemical Properties of the Untreated Cocopeat and Water Used

The EC of the untreated cocopeat was above the threshold for hydroponics system production due to the high level of Na and K. The untreated cocopeat pH was in a suitable range for hydroponics crops (5.5 - 6.5) [7] [23]. Therefore, K, Na and EC were the major problems in the untreated cocopeat examined. Generally, the untreated cocopeat had high K and Na with low N and Ca as this has been reported by [10] [11] [12] [24]. The water used was suitable for treating cocopeat as it had low K, Na, and EC while the pH was basic.

4.2. Effects of Calcium Nitrate Levels and Soaking Durations on the Chemical Properties of Cocopeat Leachate

The leachate analysis was done to determine whether $Ca(NO_3)_2$ was capable of extracting excessive K and Na from cocopeat. The interaction effect of soaking duration × $Ca(NO_3)_2$ was not observed in the leachate for K, EC, and Ph because the buffering process was not completed as washing needed to be done for the full effect to be observed. After soaking, it is recommended to wash the cocopeat for complete K and Na extraction to be effective [8]. Cocopeat with $Ca(NO_3)_2$ 100 g significantly extracted K and Na by 7.63% and 16.08%, respectively more compared to the cocopeat without $Ca(NO_3)_2$ in the soaking solution. Lower extraction of Na was observed in $Ca(NO_3)_2$ 0.0 g, soaking durations 12, 24, 36, 48, and 72 hours probably due to the use of water (without $Ca(NO_3)_2$) in the mixture. Other researchers have similarly reported that the addition of $Ca(NO_3)_2$ to the cocopeat increases the extraction of K and Na [8] [25]. The interaction effects showed that for effective extraction of Na, both $Ca(NO_3)_2$ and soaking duration should be used simultaneously. Electrical conductivity is directly proportional to the concentration of dissolved ions in a sample [26]. Therefore, treatments with little and no $Ca(NO_3)_2$ had relatively low EC values. Neto and others [27] argued that when the concentration of $Ca(NO_3)_2$ increases, EC significantly increases in a solution. This occurs because the EC of a solution is influenced by the presence of either hydrogen or hydroxyl ions. The inverse relationship observed between $Ca(NO_3)_2$ and pH was due to the effect of ammonium present in the $Ca(NO_3)_2$. Excessive ammonium is known to acidify soils by decreasing the pH [28]. Even though there were significant differences between the levels of pH in the leachate, all the values were in the suitable pH range (5.5 - 6.5) [7] [23]. On the other hand, there was no significant difference amongst the soaking durations for K, EC, pH. The length of time taken for full reaction to occur between $Ca(NO_3)_2$ versus K, Na, EC, and pH may have occurred even earlier than 12 hours. A similar result was obtained by [29] who observed no significant ($P > 0.05$) effect of soaking durations for pH in cocopeat. It is evident that irrespective of soaking durations, the application of $Ca(NO_3)_2$ extracts K and Na while increasing the EC and reducing the pH in the leachate.

4.3. Effect of Soaking Durations and Calcium Nitrate Levels on the Rate of Change of K, Na, EC and pH in the Leachate

Though the K in the leachate was high in treatments with higher $Ca(NO_3)_2$ indicating higher K extraction, these concentrations tend to reduce over time. The decreasing rate of change observed in K at $Ca(NO_3)_2$ 0.0 g, 60 g, 100 g, and 150 g indicate that as soaking durations increase, the K present in the leachate tends to decrease. The rate of change in 100 g of $Ca(NO_3)_2$ was 32% faster than the rate of change in 0.0 g of $Ca(NO_3)_2$. The change in Na was decreasing with increasing with increase $Ca(NO_3)_2$ levels. There was no significant rate of change observed for EC and pH in the leachate. The changes in EC and pH do not require a long soaking duration.

4.4. Effects of Calcium Nitrate Levels and Soaking Durations on the Nutrient Content in the Treated Cocopeat

The inverse relationship between $Ca(NO_3)_2$ versus K and Na was due to their valences. As the concentration of Ca ions increases, the adsorption of K and Na decreases [15]. Ions adsorption on surfaces depends on several factors, such as the mineral surface structure, the valency, size and hydration of an ion. Divalent cations are expected to bind stronger to the negatively-charged surfaces than monovalent cations [30]. Hydrogen having the same valency as K and Na cannot replace them, as such, higher K was observed in treatments without $Ca(NO_3)_2$ as the buffering process was not effective. Less K was observed in treatments with $Ca(NO_3)_2$ after the leaching process, but the trend was inversely proportional to the concentration of $Ca(NO_3)_2$. Calcium nitrate levels 0.0 g and 60 g extracted less K compared to $Ca(NO_3)_2$ 100 g and 150 g. This means that $Ca(NO_3)_2$ 100 g is the equilibrium point for K extraction. A similar trend was observed in $Ca(NO_3)_2$ levels for Na. Calcium nitrate 0.0 g extracted less Na, thus the Na concentration in the treated cocopeat was relatively higher compared to the treatment with $Ca(NO_3)_2$ 150 g and 100 g. The hydration (soaking) effect which is one of the factors that affect K helps to detach K due to its low electrostatic force [31]. Potassium is subdued when competing with Ca (divalent cations) due to its monovalent ability. As observed in the leachate, K was extracted but was still attached in the cocopeat as such no significant difference was observed between the soaking durations treatments. Significant differences were observed only after the cocopeat was washed. For K extraction process to be fully completed, $Ca(NO_3)_2$ and water must be used, vigorous mixing and washing must be done after the soaking process. The movement of K in soils is largely by diffusion and this occurs more rapidly at adequate moisture levels. As observed by Afri-Sefa and others [32], moisture content greatly affects K availability since leaching is a source of K loss. The significant differences found in the $Ca(NO_3)_2$ levels for Ca and total N in the treated cocopeat occurred due to the application of $Ca(NO_3)_2$. The Ca in treatments with $Ca(NO_3)_2$ 150 g and 100 g was greater than $Ca(NO_3)_2$ 0.0 g. While total N in treatments with $Ca(NO_3)_2$ 150 g and 100 g was also greater than $Ca(NO_3)_2$ 0.0 g. Nitrogen was one of the main elements in the $Ca(NO_3)_2$ used for the extraction. Hence, its attraction was higher as the levels of $Ca(NO_3)_2$ increased. The higher exchange capacity of N and Ca was found with an increase in $Ca(NO_3)_2$ levels in the solution. Comparatively, higher EC (1.11 $mS \cdot cm^{-1}$) was observed in the interaction of $Ca(NO_3)_2$ 150 g × soaking duration 72 hours and $Ca(NO_3)_2$ 150 g × soaking duration 24 (1.01 $mS \cdot cm^{-1}$) due to the concentration of $Ca(NO_3)_2$. As observed in the leachate, the EC in these treatments were much higher compared to the other treatments. After the cocopeat was washed, the EC was significantly reduced. The levels of $Ca(NO_3)_2$ used gave significant differences on the amount of EC in the treated cocopeat. The concentration of EC was higher in 150, 100, 60, and 0 g of $Ca(NO_3)_2$, respectively. Although, all the EC values were <1.0 $mS \cdot cm^{-1}$ as observed [13], a similar trend was shown in the durations (longer durations had higher EC, but <1.0 $mS \cdot cm^{-1}$). Addition of $Ca(NO_3)_2$ above 100 g 1.5 kg^{-1} of cocopeat in 15 L of water during the soaking increases the EC above 1 $mS \cdot cm^{-1}$ in the treated cocopeat. After the cocopeat was washed, significant differences were observed among the durations for K, Ca, Na, and EC. To achieve EC below 1 $mS \cdot cm^{-1}$, cocopeat can be soaked without the addition of $Ca(NO_3)_2$ for economic reasons. The results obtained for EC and pH are in line with [33]. The extraction of K was lower in treatments with lower soaking durations. As the soaking durations increased, the extraction attained an equilibrium point. A similar trend was shown for Na. Soaking above 36 hours had no significant reduction of Na in cocopeat. In a nutshell, soaking durations did not reduce K and Na by a significant amount when soaked above 36 hours. Soaking duration 36 hours appears to be an equilibrium point for K, Ca, and Na. Soaking below this point extracts less K and Na, and soaking above will extract an insignificant amount to 36 hours. Also, Ca attraction attained its equilibrium at 36 hours as there was no significant difference above 36 hours.

4.5. Effects of Soaking Durations and Calcium Nitrate Levels on the Rate of Change of K, Ca, Na, Total N and EC in the Treated Cocopeat

The increasing rate of change for Ca, N, and EC was due to the effect of $Ca(NO_3)_2$. As the soaking durations were increasing with fixed $Ca(NO_3)_2$ levels, the dissolved $Ca(NO_3)_2$ ions in the solution tend to increase the rate of reaction thereby increasing the Ca, N, and EC concentrations on the surfaces. Calcium was 34%

faster in attraction in $Ca(NO_3)_2$ 100 g compared to 0.0 g of $Ca(NO_3)_2$. While total N attraction to the cocopeat was 49% and 26% faster in $Ca(NO_3)_2$ 150 g and 100 g, respectively compared to 0.0 g of $Ca(NO_3)_2$. From the initial analyses, it was observed that Ca and N were limited in the cocopeat. As such, the supplementation of these elements through soaking is as essential as the fertilization of soil. On the other hand, the decreasing rate of change observed in K and Na was also due to the effect of cation exchange through $Ca(NO_3)_2$. Potassium and Na are known to be monovalent cations. In the presence of divalent cations (Ca), the attraction of K and Na is expected to reduce while Ca increases [30]. Although the K extracted by 0.0 g and 60 g of $Ca(NO_3)_2$ was low, but the rate of reduction of K was much faster in treatments without low $Ca(NO_3)_2$ compared to treatment with 150 g of $Ca(NO_3)_2$. The rate of change was 31, 39, 21, and 8% in 0, 60, 100, and 150 g of $Ca(NO_3)_2$, respectively. A similar decreasing trend was observed for Na with 32, 25, 25, and 17% in 0, 60, 100, and 150 g of $Ca(NO_3)_2$, respectively. Though $Ca(NO_3)_2$ extracted more K and Na, but the rate of extraction is much slower with higher concentrations.

4.6. Pearson Correlation for the Main Effects of Calcium Nitrate Level and Soaking Duration on the Treated Cocopeat

Some of the elements obtained from the effects of $Ca(NO_3)_2$ and soaking durations showed significant correlations. In both $Ca(NO_3)_2$ and soaking durations, there were strong significant negative correlations between Ca and Na and between Na and N. These relationships showed as Ca and N increase, Na tend to reduce. In the soaking durations, there was also a strong significant ($P < 0.05$) negative correlation between Ca and K which showed significant reduction of K as Ca increases. On the other hand, there was a significant positive correlation between Ca versus N and between Ca versus EC in both $Ca(NO_3)_2$ and soaking durations. The use of $Ca(NO_3)_2$ may have contributed to these relationships. The $Ca(NO_3)_2$ used was reached in N and Ca, as such, as the concentration increases, Ca, N, and EC are expected to increase depicting a positive relationship. The salt content (EC) in a given sample is directly proportional to the concentration of dissolved ions [26]. Verhagen [15] found a significant positive correlation ($r = 0.53^{**}$) between K and Na in the leachate. Kumar and others [34] also found a weak negative correlation (-0.40^{ns}) between exchangeable K and pH in the soil.

5. Conclusion

The untreated cocopeat has high K, Na, and EC with limited Ca and N concentrations. Through the use of $Ca(NO_3)_2$, these excessive elements can be minimized while the limited elements are supplemented. In the leachate, $Ca(NO_3)_2$ is seen to have the ability for K and Na extraction while increasing the EC and reducing the pH. After the cocopeat is soaked and washed, the K, Na, Ca, N, EC, and pH are more responsive to the main effects of $Ca(NO_3)_2$ and soaking duration than the interaction effects of $Ca(NO_3)_2 \times$ soaking duration. Comparatively, the single effect of $Ca(NO_3)_2$ extracted more K and Na compared to the single effect of soaking duration. The use of 100 g $Ca(NO_3)_2$ significantly extracts K and Na in cocopeat. Although, 150 g of $Ca(NO_3)_2$ extract Na by 22.99% more than 100 g of $Ca(NO_3)_2$, the minimal ranges are significantly the same. Calcium and N significantly increase with an increase in $Ca(NO_3)_2$ up to 150 g. After the cocopeat is washed, the EC and pH reduce within their suitable ranges irrespective of $Ca(NO_3)_2$ levels or soaking durations. Soaking duration 36 hours is an equilibrium point for Ca and N supplementation, and for K and Na extraction. Higher Ca and N supplementation in cocopeat is observed when 100 g of $Ca(NO_3)_2$ is used. On the other hand, K and Na tend to decrease faster in 0 g and 60 g compared to 100 g and 150 g of $Ca(NO_3)_2$. There is a strong negative correlation between Ca versus Na, Ca versus K, Na versus N, and between Naversus EC. Also, there is a strong positive correlation between Ca versus N, Ca versus EC, and between N versus EC. For optimal reduction of K by 78.44% and for effective supplementation of Ca and N in cocopeat, 100 g of $Ca(NO_3)_2$ 1.5 kg^{-1} of cocopeat in 15 liters of water with a soaking duration of 36 hours is much effective. Sodium is also significantly reduced by 95.83% when 150 g is used and by 92.59% when 100 g of $Ca(NO_3)_2$ with a constant soaking duration of 36 hours. Information about the leachability of K and Na is important for the standardization of cocopeat for a variety of horticultural crops grown in a hydroponics system using cocopeat as a growing medium.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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