RESEARCH AND PRODUCE FERTILIZER FROM NPK FERTILIZER AND BIOCHAR FOR AGRICULTURAL PRODUCTION

X. A. Le[1], A. H. Pham[2], Q. V. Nguyen[2], T. H. Tran[3], T. T. T. Nguyen[1] and B. T. Nguyen[1]
[1]Division of Land Use, Soils and Fertilizers Research Institute (SFRI), Dong Ngac, Tu Liem, Hanoi, Vietnam
[2]Faculty of Environmental Sciences, VNU University of Science, Vietnam National University, Hanoi, Thanh Xuan District, Hanoi, Vietnam
[3]Research Centre for Environmental Monitoring and Modelling, VNU University of Science, Vietnam National University, Hanoi, Thanh Xuan District, Hanoi, Vietnam
E-Mail: hungphamanh@vnu.edu.vn

ABSTRACT

Biochar contains long-term and high carbon content when applied to the soil. When applying biochar to increase the ability to absorb and retain water, keep nutrition in the soil, improve the nutritional content available. Fertilizer is an important factor to increase crop productivity and soil fertility stability. However, to minimize the harm caused by excessive fertilizer use, and improve soil, this study uses NPK chemical fertilizers in combination with biochar to produce fertilizers for annual crops. The results of this study show that the production of NPK fertilizer combined with biochar will increase the price of fertilizer, whereas the increase in biochar content reduces the possibility of nitrogen loss during storage and when applied to soil. In the type of fertilizer added different biochar ratios, type NPK (5: 10: 3) added 20% biochar best suited for mass production.

Keywords: fertilizers, biochar, NPK, compost, soil nutrition, agriculture.

1. INTRODUCTION

Biochar contains high carbon content and long-term maintenance when applied to the soil. Applying biochar to the soil increases the ability to absorb and retain water in the soil and provide it back to the plant during the drought period [1]. The large surface area of Biochar is responsible for increasing water retention and increasing soil absorption capacity [2-4]. In soil, biochar interacts with a variety of minerals and organic compounds, thereby enhancing microbial activity and plant roots. Biochar in the soil increases microorganisms that are beneficial for nitrification and denitrification [5], soil microorganisms associated with biochar can increase the ability to resolve nutrients that have been fixed in the soil, making them retain in microbial biomass [2, 6, 7]. Applying biochar to soil increases the ability to absorb nutrients and limit leaching, making chemical fertilizers less likely to be lost due to water leaching, increasing growth and crop productivity [8, 9]. The results of the study by Bhupinder *et al*., 2010 showed that with the wetting-drying (W-D) cycles, biochar applied to the soil (Alfisol and Vertisol) reduced 54 - 93% of ammonium loss due to leaching. This study propose that the increased effectiveness of biochar in reducing N_2O emissions and ammonium leaching over time was due to increased sorption capacity of biochars through oxidative reactions on the biochar surfaces with ageing [10].

Biochar also reduces soil acidity due to exchanging alkaline ions of biochar into the soil solution, reducing the acidity of the soil. Experimental results of Kishimoto and Sugiura, 1985 showed that after 3 years of applying biochar, the soil pH reached 6.3 compared to before applying fertilizer was pH = 5.8 [11]. The study of Mbagwu and Piccolo, 1997 suggested that biochar fertilization reduces mobile aluminum in acidic soils in high tropical and intensive areas, the increase can be up to 1.2 units [12].

In addition to the above land reclamation characteristics, the studies also show that the use of biochar in combination with fertilizer will contribute to soil improvement, fertilizer efficiency and crop productivity. Research by Schmidt *et al.* [13] shows that biochar enriched with NPK when applied to the soil, the average yield is 20% ± 5.1% higher than only NPK fertilizer without biochar. Biochar enriched with cow urine mixed with compost results in higher average yield of 13 crop species than cow urine-blended compost and outcompeted NPK-enriched biochar at 123% ± 76.7% and 103% ± 12.4% respectively [13]. Other studies have also shown that biochar use in combination with NPK or with organic fertilizer increases maize yield [14-16], rice yield [17, 18], vegetable yield [18] and enhances yield and quality of tomato under reduced irrigation [19, 20].

In Vietnam, biochar has been used for years; farmers call it the cinder, using the method of burning smoldering straw and using water to quell the fire quickly to create it. Farmers using this coal combined with manure for composting. However, this method creates dust burning coal causes environmental pollution, increasing greenhouse gas emissions. In recent years, there has been much research on biochar and its application in agriculture. Nguyen C.V. *et al.* [18] studied the use of biochar in combination with NPK fertilizer, compost to apply for vegetables and rice in the northern mountainous region (Thai Nguyen and Thanh Hoa province), the results showed that compared with only NPK fertilizer, rice yields were increased by 5.9-22.3% in treatments with biochar and by 26.3- 34.2% in treatments of compost mixed with 5% biochar. Application of biochar for vegetables increased the yields by 4.7-25.5%, compared with farmer practices in both sites [18]. Using biochar in combination with compost to apply for leafy vegetables and rice in sandy soil in Central Vietnam (Ha Tinh, Quang Tri and Quang Nam Provinces) shows that, applying biochar at the rate of 2.5 - 5.0 ton/ha for leafy vegetables and rice can partially replace or completely replace manure for coastal sandy soil in study areas. Using 2.5 tons of TSH added 10 tons of compost for yield of green mustard increased from 54 - 65%, cabbage yield increased by 38.4% and rice yield increased from 15.4 to 27.9% compared with NPK fertilizer application [21]. Research results of Hoang T.L.T *et al.* [22] show that biochar substitutes for 20% of mineral fertilizer (NPK), maize still has good growth and development ability and yields 4.27 tons / ha equivalent to the control formula.

The evaluation results of Nguyen V.B. [23] show that, in Vietnam, fertilizers contribute more than 40% to crop productivity, the efficiency of fertilizer use is very low, on average, the recovery rate for applied N is only 40-45%; for P is about 25-30 % (including the residual effect) and for K it is 55- 60%. Inefficient fertilizer use and subsequent losses not only increase production costs, so reducing farmer incomes, but they also cause negative environmental impacts, such as eutrophication of ground and surface water, increased GHG emissions, etc.

In order to improve the efficiency of fertilizer use, while improving soil properties towards sustainable agricultural production, this study produced fertilizer using biochar enriched with NPK fertilizer, the criteria to evaluate fertilizer products are: (i) Cost of producing NPK-Biochar fertilizer; (ii) Chemical properties of fertilizer (iii) Nutrient retention of products during storage and (iv) when applied to soil.

2. MATERIALS AND METHODS

2.1 Materials

Biochar: Produced from rice husk and straw at the rate of 50:50 and burned under the condition of lack of oxygen in DK-TR3 furnace at a temperature of 600^0C. This furnace made of materials available in rural areas of Vietnam, the principle of coal production is to use heat to burn part of the material and use this heat to burn the remaining material to make biochar [21]. The characteristics of biochar after production are presented in Table-1.

Table-1. Characteristics of biochar.

Parameters	Units	Results
pH	-	9.07
OC	%	47.33
N	%	0.23
P_2O_5	%	0.21
K_2O	%	1.47
CaO	%	0.67
MgO	%	0.22
CEC	meq/100g	13.37
Cu	mg/kg	2.73
Cd	mg/kg	0.032
Pb	mg/kg	4.03
As	mg/kg	0.026

NPK: Use fertilizers include ammonium sulphate fertilizer (SA) with N ratio of 20%; Lam Thao phosphate (S.P) with P_2O_5 ratio of 16%; Potassium fertilizer (Kali) K_2O ratio is 60%; DAP (Diamonium phosphate) has a ratio of N and P_2O_5 of 18% and 46%, respectively. Also can use additional peat suitable for mixing ratio.

2.2 Methods

2.2.1 Fertilizer production

Using NPK support with N: P: K ratio of 5: 10: 3, mixed with biochar according to the following formula:
Formula 1 (F1): NPK (5:10:3) + 10% Biochar
Formula 2 (F2): NPK (5:10:3) + 15% Biochar
Formula 3 (F3): NPK (5:10:3) + 20% Biochar
Formula 4 (F4): NPK (5:10:3) + 25% Biochar
Formula 5 (F5): NPK (5:10:3) + 30% Biochar

According to the above formulas for the production of 10 kg of mixed Fertilizer by each formula, it is necessary to use the materials according to the weight, in units of kilogram calculated in Table-2.

Table-2. Raw materials for producing NPK-Biochar fertilizers.

Unit: kilogram

Formulas	$N:P_2O_5:K_2O$+Biochar	S.A	SP	Kali	DAP	Peat	Biochar
F1	5:10:3+10%	2,21	5,68	0,5	0,2	0,42	1,0
F2	5:10:3+15%	2,12	5,39	0,5	0,3	0,19	1,5
F3	5:10:3+20%	1,95	4,81	0,5	0,5	0,24	2,0
F4	5:10:3+25%	1,78	4,24	0,5	0,7	0,28	2,5
F5	5:10:3+30%	1,61	3,66	0,5	0,9	0,33	3,0

Biochar and peat are dried and finely ground. Weigh all kinds of NPK inorganic fertilizer into the mixer, after mixing well, it will support bio-coal and peat and continue to mix all materials. The materials after mixing with a weight of 10 kg for each experimental formula, will be incubated after 24 hours, then be created by a Pellet Machine at the Research Center for Fertilizers and Plant Nutrients - Viet Nam Soils and Fertilizers Research Institute (Figure-1).

Figure-1. Mixer Machine and Pellet Machine in NPK-Biochar fertilizer production.

2.2.2 Fertilizer samples analysis

Biochar and fertilizer products are analyzed parameters for evaluation with the detailed analysis method presented in Table-3.

Table-3. Parameters and methods for analyzing fertilizer samples.

Parameters	Units	Methods
pH	-	TCVN 5979 : 2007, Soil quality - Determination of pH [24]
OC	%	TCVN 8941:2011, Soil quality - Determination of total organic carbon - Walkley Black method [25]
N	%	TCVN 8557:2010, Fertilizers - Method for determination of total nitrogen [26]
P_2O_5	%	TCVN 8563:2010, Fertilizers – Method for determination of total phosphorus [27]
K_2O	%	TCVN 8562:2010, Fertilizers – Method for determination of total potassium [28]
CaO, MgO	%	TCVN 12598:2018, Fertilizers – Determination of total calcium, magnesium by volumetric method [29]
CEC	meq/100g	*TCVN 8568:2010, Soil quality– Method for determination of cation exchange* capacity (CEC) by ammonium acetate method [30]
Cu	mg/kg	TCVN 9286 : 2012, Fertilizers - Determination of total copper by flame atomic absorption spectrometry [31]
Cd	mg/kg	TCVN 9291:2012, Fertilizers - Determination of total cadmium by electrothermal atomic absorption spectrometry [32]
Pb	mg/kg	TCVN 9290:2012, Fertilizers - Determination of total lead by flame and electrothermal atomic absorption spectrometry [33]
As	mg/kg	TCVN 11403:2016, Fertilizers - Determination of arsenic content by atomic absorption spectrometry [34]

2.2.3 Statistic analysis

Data are stored, synthesized and graphed with Microsoft Excel software. Comparison of nutrient retention capacity of fertilizer formulas were evaluated by software IRRISTAT 5.0 and formula's means were compared by least significance difference (LSD) at the probability of 0.05% [35].

3. RESULTS AND DISCUSSIONS

3.1 Cost of NPK-Biochar fertilizer

The results of calculating the cost of products through the input materials prices are shown in Table-4. The results show that when increasing the biochar content, the product cost will increase because to maintain the NPK ratio, it is necessary to add DAP fertilizer with high pure content and high price (10,800 VND / kg).

Table-4. Cost of fertilizer formulas.

Unit: 1,000 VND (1 USD=23,500 VND)

Formulas	S.A	SP	Kali	DAP	Peat	Biochar	Total
F 1: 10% Biochar	6.52	19.9	3.5	2.16	0.84	3.0	35.90
F 2: 15% Biochar	6.25	18.9	3.5	3.24	0.38	4.5	36.74
F 3: 20% Biochar	5.75	16.8	3.5	5.40	0.48	6.0	37.97
F 4: 25% Biochar	5.25	14.8	3.5	7.56	0.56	7.5	39.21
F 5: 30% Biochar	4.75	12.8	3.5	9.72	0.66	9.0	40.44

Note: Fertilizer prices are as follows Sulphate fertilizer (S.A): 2,950 VND/kg; Lam Thao phosphate (S.P): 3,000 VND/kg; Potassium fertilizer (Kali): 7.000 đ/kg; DAP (Diamonium phosphate): 10,800 VND/kg; Peat: 2,000 VND/kg; Biochar: 3,000 VND/kg [36].

Table-4 shows that the cost of input materials for F1, F2, F3, F4, F5 fertilizer form is respectively 3,590 VND / kg; 3,674 VND / kg; 3,797 VND / kg; 3,797 VND/kg; 3,921 VND / kg and 4,044 VND / kg. With the highest cost of 4,044 VND / kg, farmers can accept this price when compared with fertilizer on the market. However, this price does not include other costs such as machinery, operation and labor. If these types of costs are included, the price will increase, resulting in farmers' acceptability will decrease. Therefore, in order for people to apply this fertilizer, technical assistance is required for farmers to make their own materials from their agricultural activities.

3.2 Characteristics of NPK-Biochar fertilizers

3.2.1 Chemical properties

Results of chemical properties analysis of fertilizer formulas and comparison with NPK mixture and biochar fertilizers are presented in Table-5. The results showed that biochar has alkaline pH; NPK mixture has slightly acidic pH. When mixing pH of fertilizer formulas from low acidity to near neutral, with this pH range, the fertilizer formulas are suitable for fertilizer for plants. The CEC value of biochar is medium, the NPK mixture fertilizer is low, the fertilizer formulas are low and higher than the NPK mixture fertilizer.

Organic carbon in the formula F3, F4, F5 achieve required levels of organic carbon in organic mineral fertilizer (OC $\geqslant$ 5%) [37]. Nutrient content (N, P, K) in 4 formulas (F1, F2, F3, F4) satisfactory organic mineral fertilizer is individual concentrations of N, P_2O_5, K_2O less than 3.0% and total three elements $\geqslant$ 18% [37].

CaO content in 05 formulas is higher than in the NPK mixture, this is due to the addition of high CaO content in biochar. The content of MgO in formula F1, F2 and F3 is higher than the original NPK mixture, while the F4 and F5 formulas are lower because the MgO content in biochar is lower than in the NPK mixture, the increase in content biochar leads to a reduction in MgO of fertilizer formulas.

The content of heavy metals Cu, Cd, Pb, As are very low, the content of these metals in 5 formulas are lower than those of NPK mixture and Biochar.

In general formulas F3 and F4 with biochar additional amount of 20% and 25% have achieved the nutrient content requirements for Organic mineral fertilizer production.

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Table-5. Chemical properties of fertilizer.

Parameters	Unit	F 1	F 2	F 3	F 4	F 5	NPK (5:10:3)	Biochar
pH	-	6.21	6.47	6.81	6.86	6.97	5.61	9.07
CEC	meq/100g	8.05	8.84	8.75	9.13	9.18	6.73	13.37
OC	%	3.74	4.53	5.72	6.49	7.72	1.46	47.33
N	%	5.15	5.09	5.06	5.03	3.33	4.72	0.23
P_2O_5	%	10.45	10.27	10.41	10.22	10.31	10.05	0.21
K_2O	%	3.25	3.32	3.35	3.45	3.49	2.94	1.47
CaO	%	0.42	0.49	0.47	0.53	0.56	0.35	0.67
MgO	%	0.29	0.22	0.31	0.17	0.20	0.27	0.22
Cu	mg/kg	1.05	1.33	1.00	0.84	0.81	1.56	2.73
Cd	mg/kg	0.026	0.017	0.021	0.025	0.019	0.042	0.032
Pb	mg/kg	4.17	3.95	4.52	4.35	3.94	4.53	4.03
As	mg/kg	0.036	0.031	0.037	0.032	0.038	0.039	0.026

3.2.2 Nitrogen loss during storage

Fertilizer products after production are kept in plastic bags with a weight of 2kg / bag at room temperature, initial sampling (0 weeks), after 1, 2, 4, 6 and 8 weeks for nitrogen content analysis total in fertilizer.

Analysis results show that, for the mixture of NPK (5: 10: 3) before testing (0 weeks), the total N content is 4.72%, after 8 weeks the content of total N decreases to 3.92% (Table 6). For the mixing formulas, before testing (0 week), the total N content in 5 formulas F1, F2, F3, F4 and F5 are 5.15%, 5.09%, 5.06%, 5.03% and 3.33% respectively. After 8 weeks, the total N content remained at 3.92%, 4.80%, 4.75%, 4.74% and 3.11% respectively (Table-6).

The concentration of N in the fertilizers lost the fastest in the first 1-2 weeks and then decreased. In which, the NPK mixture lost N faster than the formula mixed with biochar for the entire period of 1-8 weeks (Figure-2). The reason is that the nitrogen content used for mixing is sulfate (chemical formula is $(NH_4)_2SO_4$), so biochar has NH_4^+ adsorption capacity and reduces N loss of fertilizer, this is suitable with other authors [10, 38] suggest that biochar increases NH_4^+ soil adsorption capacity.

Table-6. The content of total N remaining of the formulas after the experiment time.

Unit: %

Formulas	Time					
	0 week	1 week	2 weeks	4 weeks	6 weeks	8 weeks
NPK (5:10:3)	4.72	4.18	4.03	3.98	3.91	3.92
F 1	5.15	4.86	4.85	4.82	4.81	4.80
F 2	5.09	4.82	4.80	4.81	4.80	4.75
F 3	5.06	4.83	4.79	4.76	4.75	4.74
F 4	5.03	4.80	4.80	4.77	4.76	4.70
F 5	3.33	3.18	3.16	3.13	3.12	3.11
CV (%)	5.41	5.16	5.72	6.03	5.38	5.05
LSD (5%)	0.856	0.672	0.722	0.942	0.623	0.603

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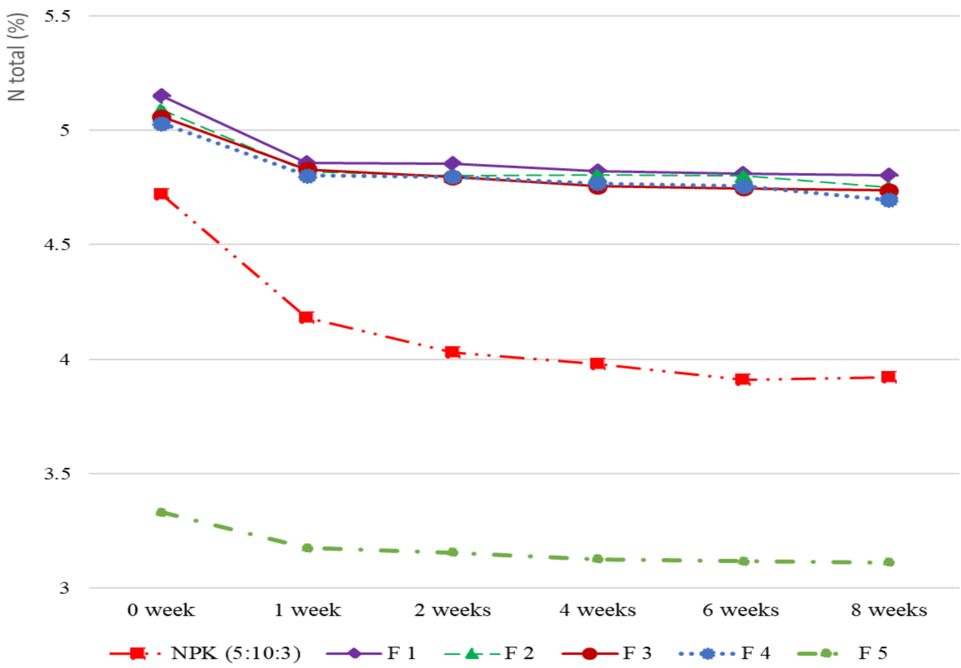

Figure-2. The content of total N remaining of the formulas after the experiment time.

The results of Table-7 show that the nitrogen loss ratio during the largest storage process is NPK mixed fertilizer (16.95%), while 5 formulas mixed with biochar have a much lower rate of nitrogen loss (6.72%) (Table-7). Comparing the nitrogen loss ratio of 5 formulas mixed with biochar shows that there is a difference between the formulas. After 8 weeks, the rate of nitrogen loss in descending order was F1, F2, F4, F5 and F3 respectively 6.72%, 6.67%, 6.65%, 6.59% and 6.36%. All 5 formulas follow the rule that in the first week, the total N amount will decrease the most (4.52-5.69%), the following weeks will gradually decrease compared to the first week (Table-7).

The amount of nitrogen lost here due to evaporation and not following the biochar increase rule will reduce the possibility of nitrogen loss and vice versa. The reason for combining biochar into a NPK mixture on the one hand reduces the possibility of Ammonium losses due to the fixation of biochar, on the one hand because the pH of high biochar has led to an increase in the pH of the mixture. NPK, leading to nitrogen loss due to evaporation. Research results of Esfandbod *et al*. [39] also showed that, pH is low (5), increasing pH instead of adsorption capacity, due to supplementation of biochar, causing greater nitrogen loss through evaporation from bauxite -processing residue sand.

Table-7. The rate of nitrogen loss during the experiment time.

Time (week)	The rate of nitrogen loss during the experiment time (% compared to original value)						CV (%)	LSD (5%)
	NPK (5:10:3)	F1	F2	F3	F4	F5		
0	0.00	0.00	0.00	0.00	0.00	0.00	-	-
1	11.44	5.69	5.31	4.54	4.52	4.64	3.14	1.985
2	14.62	5.75	5.64	5.24	4.64	5.24	4.57	0.873
4	15.68	6.37	5.58	6.01	5.18	6.11	4.61	0.925
6	17.16	6.58	5.65	6.19	5.45	6.39	4.39	0.511
8	16.95	6.72	6.67	6.36	6.65	6.59	5.08	0.479

Research results show that, when storing fertilizer can be wasted a large amount of nitrogen, if using NPK fertilizer combined with biochar can reduce the amount of nitrogen lost in the process of preserving fertilizer.

3.2.3 Nutrient retention ability in soil

To assess nutrient retention in soil of fertilizer formulas, mix fertilizer formulas with soil to get N, P_2O_5, K_2O in 1kg of soil with 50g N, 100g P_2O_5 and 30g K_2O. Then spray water into the mixture to allow moisture to

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reach about 60% and incubate at room temperature for 4 weeks

Sampling before incubation (0 week), after incubation period 1, 2, 3 and 4 weeks for analyzing N, P and K available. The analytical results indicated that the application of NPK (5:10:3) mixture into the soil during the first week provided the highest available N, P, and K levels. In the following weeks, N, P and K available contents in the soil decreased, except for the ability to supply available potassium in soil of formula F1. The release of potassium was the smallest in the first week, then increased in the following weeks (Table-8).

Experimental results showed that, immediately after mixing with soil, there was a change in the ability to release N, P_2O5 and K_2O available from fertilizer to soil. The content of N and P_2O_5 is available to release the soil gradually reduced according to the amount of biochar used, the higher the biochar content, the lower the content of N and P_2O_5 available release the soil, the highest is the mixed formula NPK (5:10:3) and the lowest is the 30% biochar mixing formula (formula F5). Meanwhile, the K_2O available released the soil at the lowest level in the control formula with NPK (5:10:3), while the formulas are added with biochar, the formula F3 released the lowest K_2O available (1,036.1 mg / 100 g), the formula with the highest release K_2O available content was formula F5 (1, 268.7 mg / 100 g) and formula F1 (1,263.3 mg / 100 g).

After 1 week, the content of N, P_2O5 and K_2O available in the soil is the highest. In particular, the N available in formula F1 (10% biochar) was highest (813.3 mg / 100 g), then the control formula NPK (5: 10: 3) with the amount of N available was 743.3 mg / 100 g, N available in formula F4 (25% biochar) was lowest (351.3 mg / 100 g). Similar to the P_2O_5 available content, the highest in F1 formula (10% biochar) is 2, 625, 0 mg / 100 g, then the NPK (5: 10: 3) formula with a value of 2,581, 7 mg / 100 g, the lowest in the formula F4 (25% biochar) with a value of 2, 090, 0 mg/100 g. For content of K_2O available, the value in control formula NPK (5: 10: 3) is the highest, in formulas added biochar there is no difference of terms statistical.

The following weeks, the content of N, P_2O_5 and K_2O available in the soil decreases with time. In particular, the content of N available decreased most rapidly, then the content of P_2O_5 available and the slowest reduction of K_2O available content.

After four weeks monitoring the N available content of soil decreased significantly compared to the first week (Table-8). In which, the control formula NPK (5: 10: 3) with the highest N available content in soil was 366.7 mg / 100g, then the formula F1 (10% biochar) was 350, 0 mg / 100 g soil and F2 formula (15% biochar) was 326.6 mg / 100 g. The remaining formulas had similar N available content (from 260.0 - 266.7 mg / 100 g). The content of P_2O_5 available in soil after incubation for 4 weeks in the formula is equivalent, the value varies from 2, 145, 0 - 2,351.7 mg / 100 g. For K_2O content, after four weeks of incubation the content of the control formula NPK (5: 10: 3) was highest with a value of 1.565.0 mg/100 g and the lowest in F1 formula with a value of 1,183, 3 mg/100 g, slightly higher in the F2 formula was 1,243.3 mg/100 g. The remaining formulas have similar K_2O available content in the soil (from 1,324.8 to 1,366.3 mg/100 g).

Table-8. Results of nutrient analysis in soil during testing time.

Fertilizers	Nutrients (mg/100g)	Time				
		0 week	1 week	2 weeks	3 weeks	4 weeks
NPK (5:10:3)	N available	326.7	743.3	343.3	356.7	366.7
F 1: 10% Biochar		366.7	843.3	346.7	350.0	350.0
F 2: 15% Biochar		298.5	665.9	299.2	315.8	326.6
F 3: 20% Biochar		283.3	446.7	253.3	256.7	266.7
F 4: 25% Biochar		269.0	351.3	240.8	252.6	261.0
F 5: 30% Biochar		260.0	413.4	238.0	246.3	260.0
LSD (5%)		31.22	37.97	46.35	38.86	30.15
CV (%)		5.8	3.9	8.1	7.4	5.8
NPK (5:10:3)	P_2O_5 available	1,430.0	2,581.7	2,130.0	2,180.0	2,231.7
F 1: 10% Biochar		1,193.3	2,625.0	2,110.0	2,148.3	2,351.7
F 2: 15% Biochar		820.0	2,390.0	1,895.0	1,957.0	2,145.0
F 3: 20% Biochar		671.5	2,178.1	1,662.3	1,722.5	2,213.5
F 4: 25% Biochar		670.0	2,090.0	1,565.0	1,685.1	2,219.0
F 5: 30% Biochar		667.3	1,990.0	1,495.0	1,785.0	2,215.0
LSD (5%)		62.42	97.16	139.41	125.90	82.42
CV (%)		3.8	2.6	4.7	3.9	4.7
NPK (5:10:3)	K_2O available	926.7	1,580.0	1,583.3	1,570.0	1,565.0
F 1: 10% Biochar		1,263.3	1,216.7	1,180.0	1,186.7	1,183.3
F 2: 15% Biochar		1,173.3	1,263.3	1,260.0	1,250.0	1,243.3
F 3: 20% Biochar		1,036.1	1,271.8	1,326.0	1,325.1	1,324.8
F 4: 25% Biochar		1,186.7	1,172.6	1,367.3	1,367.0	1,366.3
F 5: 30% Biochar		1,268.7	1,176.7	1,373.3	1,370.0	1,363.3
LSD (5%)		57,16	62,80	61,08	56,67	48,05
CV (%)		4,9	5,3	4,6	3,9	4,3

The above results show that, when put into the soil, the higher the formula of fertilizer with biochar content, the higher the nutrient retention capacity in the soil. However, with the mixing ratio of 20% biochar, the nutrient retention capacity of the fertilizer increases slowly. NPK fertilizer combines biochar with the best effect on nitrogen retention and release gradually in the soil, thus significantly saving the amount of chemical nitrogen used.

4. CONCLUSIONS

When producing NPK fertilizer combining biochar, increasing biochar content will increase the price of fertilizer. In contrast, increasing biochar content reduces the possibility of nitrogen loss during storage and helps reduce the possibility of losing nitrogen when applied to the soil.

In fertilizers with different biochar ratio, NPK (5: 10: 3) is added with 20% biochar best suited for mass production due to ensuring organic minerals fertilizer requirements, reduce the possibility of losing nitrogen when stored, be able to keep and release N gradually into the soil.

ACKNOWLEDGMENTS

This work was supported by the program “Science and Technology to respond to Climate change, Natural Resources and Environmental Management in the period of 2016-2020” under subject code BDKH.03/16–20.

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