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Evaluation of Phosphorus Leaching in an Agricultural Soil under Different Soil Amendments

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Abstract

The transport of Phosphorus (P) from agricultural soils to surface waters sensitive to eutrophication has long been a world-wide environmental concern. The intensive agricultural activity in the upper Shkodra fields, combined with others point source pollution, probably, intensify eutrophication of the Shkodra Lake. These Clay Loamy soils (calcaric Regosols) are characterized by low organic matter, N and P, with a high water percolation. An experiment was conducted at Greenhouse Research Station, Agriculture University of Tirana, Albania to evaluate Total P (TP) concentration in leaching and runoff waters. A three-month cultivation period of ryegrass (*Lolium multiflorum*) was studied in fourfold replication, while three successive harvests were accomplished under greenhouse conditions. Treatments comprised control soils (without amendment), soil with NPK fertilizer and soils amended with Straw and Biochar. Results of TP leaching tests showed continuous releases of P from fertilizer treatments (NPK without amendments treatment), while on the treatments with organic amendments (Biochar and Wheat Straw) were found to have had a weakened role on TP retention.

Keywords: Total phosphor, biochar, leaching, Clay Loamy soil, NPK fertilizer.

1. Introduction

The intensive agricultural activity in the upper Shkodra fields which include the use of mineral fertilizers, combined with the large amount of solid waste and urban wastewater that end up to the lake have negatively influenced and intensified the eutrophication of the Shkodra Lake [3]. Soils in this area affect the quality of water in the lake, while it hosts a diverse biodiversity and numerous sensitive habitats with important economic value [13]. Chemicals used in agriculture activities (fertilizers and pesticides) on the east side of the lake and municipal wastes are considered as the main sources that affecting the water quality in the Albanian side of the Shkodra Lake. The trophic state of this lake is reported as oligotrophic [13].

Several of incoming surface water streams are situated in this part (Rrjolli, Banushi and Vraka creeks and more than 46 wellsprings), which discharge water and other materials - due to erosion and other human activities – to the lake. Land fragmentation with numerous small private property areas with individual farming activities complicate the control of agrochemicals usage, which in turn increase the value of nutrients (especially phosphate ions) at the East side of the lake, as compared to the Western part [31]. Thus, the control of nonpoint sources of P is a major issue to protecting freshwaters from accelerated eutrophication [42, 40, 47]. The transport of Phosphorus (P) from agricultural soils to surface waters sensitive to eutrophication has long been a world-wide environmental concern. Phosphorus from over-fertilized soil has become an extended environmental issue that contributes to water eutrophication [1]. Sources of P in agricultural runoff include commercial fertilizers and manure. While soluble P concentrations of 0.2 mg/L are required for normal plant growth, currently the increase of fertilizers use in soil contributed to the rapid increase of P, which was measured in soil solution at 8 mg/L, compared to fertilized soil that range from <0.01 to 1 mg /L [38]. Single applications of mineral or organic fertilizers may also cause a direct risk of P loss,

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especially in cases of fertilizers application of large amounts and/or during conditions with high risk of surface runoff or leaching. This risk is mainly related to soil texture and structure, thus in soils with dominance of macropores is reported a rapid transport of nutrients in soil solutions and particles [23]. Generally, the concentration of P in percolating water through the soil profile is low due to P fixation in sub-soil horizons due to their P deficiency. But P leaching through the soil profile is higher in sandy, acid organic or peaty soils with low P fixation or holding capacities and in soils where the preferential flow of water can occur rapidly through macro pores and earthworm holes [41, 5]. Glæsner et al., [18] compared the surface application and injection of dairy slurry and concluded that P leaching from irrigated topsoil columns of clay loam and loam decreased by about half when the slurry was injected. Shoot growth significantly increased by using biochar rate and P fertilizer application under leaching conditions. Plant P uptake increased significantly with organic supplements and biochars because of higher P content in wheat biochar at about 2%. The increase in plant growth and P uptake can be attributed to the ability of organic amendments and wheat biochar to increase mycorrhizal colonisation, water and P retention in soil and supply to the growing plants [37].

2. Materials and Methods

The study area

The soil samples were collected in the eastern part of Shkodra Lake (Figure 1), which is the largest natural, shallow (mean depth 5m), and fresh water lake of tectonic-karst origin in the Balkan region [37]. Based on FAO Soil Classification [22] and Soil Atlas of Europe [17], soil types found in this area are the Regosols (subtype B - Calcaric Regosol). Regosol soils in the region are about 12,000 ha and situated between the mountainous massif and the Lake’s coast. Regosols are formed by deluvions which came from surrounding mountains and are considered as young soils, non-well altered, placed on skeletal and stony materials.

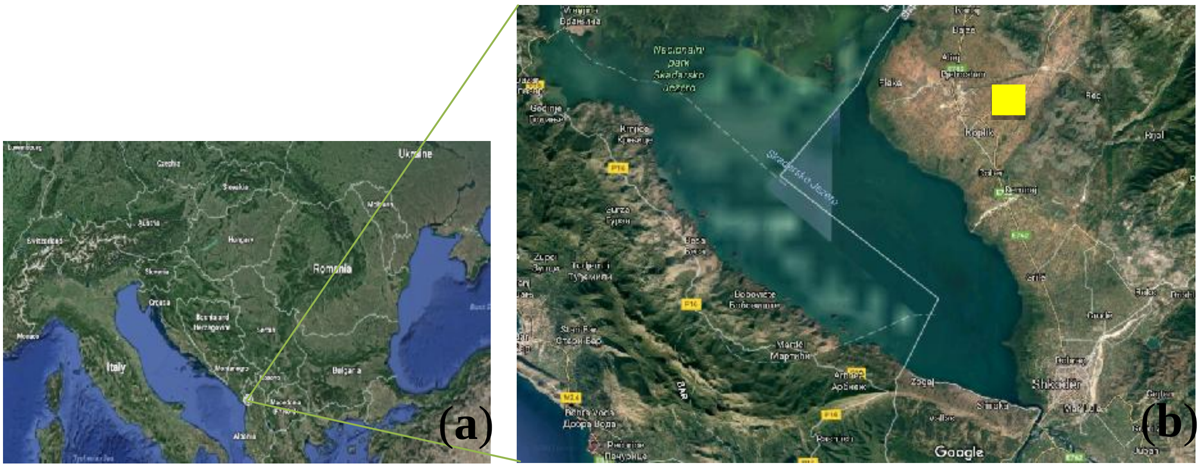

Figure 1. Map of Shkodra Lake (a) and used plot for soil sampling in Gruemira Vilage with yellow color (b).

These soils are characterized by low organic matter, N and P, with a high rate of water percolation. The mineral fraction is dominated by silt and loam fractions, low capacity of cationic exchange (CCE) and adsorption capacity. The special construction of the profile which intensifies the runoff and erosion activities, is further exacerbated due to intensive rains as Shkodra region has an irregular distribution of rainfalls with high intensity [17]. Besides the intensive agricultural activity in the upper Shkodra fields based on the use of artificial fertilizers, the large amount of solid waste and wastewater discharged to the lake which negatively affect and intensify the eutrophication processes in the Lake [11]. Serving as an agricultural field, this part of the lake is the most ecologically sensible and economically important area [14]. To evaluate the effect of organic substrates such as wheat straw by-product and biochar in the retention of soluble mineral forms of P, an experiment was performed in vegetation pots under controlled conditions. This study was conducted in order to evaluate whether straw and biochar – produced from agricultural residues – could release P in the water, as well as study its potential effect on plant growth and P uptake.

Soil sampling and analysis

Soil samples, were collected in Gruemira village, part of the Koplik municipality in Malesia e Madhe District. A representative soil sample (1kg) from this soil was used to determine physical and chemical parameters. Before set up the experiment, the main soil properties were determined. Thus, the soil texture was determined by Bouyoucos hydrometer method, Total N were determined after digestion with $H_2SO_4^{cc}$ and $H_2O_2^{cc}$ of Kjeldahl and Total P were analyzed according to the ascorbic acid molybdenum blue method on Spectrophotometer [12, 36]**.** The Mehlich III extraction method was used for the determination of available P in soil [32]. $N\text{-}NO_3^-$ determination was conducted based on KCl 2M extraction [6] within 24 hours. The result of Organic Carbon was taken after oxidation of organic matter by potassium bicarbonate ($K_2Cr_2O_7$) in mixture with $H_2SO_4^{cc}$ followed by oxidation of ammonium ferrous sulphate ($Fe\ (NH_4)_2\ (SO_4)_2 \times 6H_2O$) based on Walkley, A. and I. A. Black, 1934 [46]. The micronutrients as Mg, Fe, K, Ca were determined with microwave digestion method [33] and then analysed with a Flame Atomic Absorption Spectrometer type AA350. The obtained results on soil properties are presented in the Table 2.

Experimental design

The experiment was conducted in four replicates and different treatments at Greenhouse Research Station, Agriculture University of Tirana, Albania. In the Table 1 are presented all six treatments and experimental design.

Table 1. The Pots experiment design

	Treatments					
Replication	**BARE SOIL** T1 S	**SOIL Lolium** T2 SL	**SOIL STRAW** T3 SS	**SOIL NPK Lolium** T4 SFL	**SOIL STRAW NPK Lolium** T5 SSFL	**SOIL BIOCHAR NPK Lolium** T6
R1	**S1**^{1r}	**SL2**^{1r}	**SS3**^{1r}	**SFL4**^{1r}	**SSFL5**^{1r}	**SBFL6**^{1r}
R2	**S1**^{2r}	**SL2**^{2r}	**SS3**^{2r}	**SFL4**^{2r}	**SSFL5**^{2r}	**SBFL6**^{2r}
R3	**S1**^{3r}	**SL2**^{3r}	**SS3**^{3r}	**SFL4**^{3r}	**SSFL5**^{3r}	**SBFL6**^{3r}
R4	**S1**^{4r}	**SL2**^{4r}	**SS3**^{4r}	**SFL4**^{4r}	**SSFL5**^{4r}	**SBFL6**^{4r}

The Abbreviation of the above table represent Treatments (**T**) and Replications [*n=4*] (R); **T1** =[Bare Soil (7kg) **(S); T2** =[Soil (7kg) + *Lolium multiflorum* **(SL); T3** =[Soil (7kg) + Straw **(SS); T4** =[Soil (7kg) + NPK **(F)** + *Lolium multiflorum* **(L); T5** =[Soil (7kg) + Straw **(SS)** + NPK **(F)** + *Lolium multiflorum* **(L); T6** =[Soil (2kg) + Biochar from Wheat Straw**(B)** + NPK **(F)** + *Lolium multiflorum* **(L).**

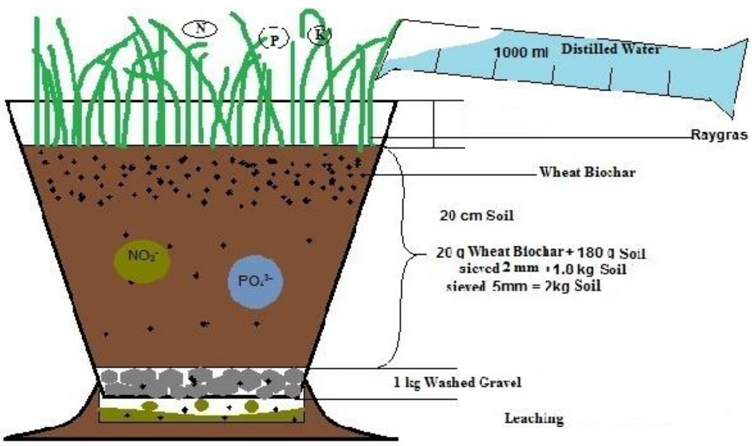

Figure 2. Pot experiment design and leaching sampling.

From the bulk soil samples, stones and plant tissues were removed, and the samples were homogenized, air dried, crushed, and passed through a 5 mm sieve. Plastic pots with dimension (22 x 24 cm) were used in the experiment Figure 2.

The pots, bottom packed with washed gravel 1kg/pot (with a diameter of 1cm), prepared in 6

Treatments with four replicates. Three (3) gram of *Lolium multiflorum* seeds were planted in thoroughly mixed with soil in T_2, T_4, T_5, and two gram for T_6 in May 2015.

NPK inorganic fertilizer (15%N**:**15% $\mathbf{P_2O_5}$**:**15%K_2O) with dose of 300 kg ha^{-1} was divided into three doses (3.9 g/pot/dose) in T_4, T_5 and 1.11g/pot/dose for T_6 (pots with 2kg of soil). The first fertilization was done at 2/3 leaf stage or in other words 2 weeks after sowing. The second fertilization with the same amount of fertilizer was 1 week after first harvest which was 1 month after planting and the same principle was followed for the third dose of fertilization. The pots were held at 75% Moisture Field Capacity based on the method WFC [2], adding water based on gravimetric method as WFC was calculated in advance. Soil pots were checked daily and water loss was replenished by bringing the pots back to weight.

Organic material such as **Wheat Straw** of <0.1cm minced faction with dose 10 $Mgha^{-1}$, practically 40g/pot for T_3, T_5 was used as amendment. Organic fertilizers contain high levels of specific nutrients and they generally have a high organic matter content with a variety of micronutrients [24]. Studies have shown that crop straw is rich in organic material and soil nutrients [31, 45] the addition of crop residues to cultivated soils helps to improve the soil quality and productivity via its favourable effects on soil properties [35]. P concentration in wheat straw is reported about 0.027% or 0.27gkg^{-1} [4].

Biochar from wheat as organic material was used with dose 10 $Mgha^{-1}$ in T_7, from which 20g was mixed with 100 g of this soil, previously sieved 2 mm and then was mixed with 1900g soil sieved 5mm. Biochar was the pyrolysis product of wheat straw biomass. As a soil amendment, biochar can greatly influence various soil properties and processes [25]. The presence of biochar in the soil can improve soil chemical (e.g. pH, CEC) [37] and physical properties (e.g. soil water retention, hydraulic conductivity) [30]. Total P concentration on biochar was 1.1 gkg^1 as previously analyzed.

Plant sampling and analysis

One month after planting, the plants were cut by using laboratory scissors to 2-3 cm from the surface and were encoded taking the wet weight for each crop and the same procedure was performed in the three harvests. Plant samples (*Lolium multiflorum*) collected from the pot experiment were washed uniformly with distilled water to eliminate other materials. Plant samples were placed by spreading on a clean paper sheet, air-dried in an isolated place, dried in an oven at 60^0C till constant weight, ground in a Wiley mill, and analyzed for Total P based on ammonium molibdate method [29] at Laboratory of the Agro-Environment and Ecology Department, AU of Tirana.

Soil sampling and analysis

The soil samples were taken with a sterile syringe prepared as probe by plunging in pot 0 – 10 cm, after one month during three harvest process, the syringe was carefully applied to avoid disturbing the soil structure in the pot and the blanks were substituted with clean plastic pipes to maintain precisely this structure. Total P in soil were measured according to the ascorbic acid molybdenum blue method on Spectrophotometer [15]. The syringes with soil samples were labeled by placing the code corresponding to the same treatments and replication.

Water leaching sampling and analysis

The last water leachate samples were collected from each treatments, by filling the pots with 1000 ml of distilled water in a slow leaching process. From six first treatments respectively T_1, T_2, T_3, T_4, T_5 were taken an average 450 ml leach while in T_6 it was drowned with 700 ml of distilled water and was taken an average of 250 ml leaching *Figure 2*. The percolate (leaching) was stored in dark plastic bottles in the refrigerator at a temperature of 4°C and the Total P was analyzed according to the colorimetric methods issued by the International Standard Organization (ISO 15681–12003) within 24 hours [21]. The same procedure was followed for two other harvests during the three months long experiment.

Statistical analysis

Data collected in three harvests were statistically analysed with the EXEL 2010. The statistically significant differences between groups were tested using the nonparametric Kruskal Wallis test ($p < 0.05$).

3. Results and Discussion

The result of physical analysis showed that **Clay Loamy Soil (CLS)** with 38.1% of Silt was used for this experiment. The chemical analysis showed higher amount of macro and micro elements in LCS composition.

Table 2. Physical and Chemical characteristics of the soil.

Soil type	Physical characteristics				Chemical characteristics								
					mg*kg^{-1} DW	**g*kg^{-1} DW**							
	(%)												
	pH	**Sandy**	**Silt**	**Clay**	**NO_3^-**	**N total**	**P-total**	**P available**	**C organic**	**Mg**	**Fe**	**K**	**Ca**
CLS	**8**	**25,3**	**38,1**	**36,6**	**166.16**	**1.56**	**0.673**	**0.047**	**19.474**	**17.292**	**15.648**	**4.685**	**0.797**

Leachability of phosphorus

The results of total phosphorus (TP) leached, taken after 3 successive extractions, are provided at the Table 3. Data indicated the differences between fertilizer and non-fertilizer treatments, thus, providing that the TP leached originates mainly from the fertilizers applied.

Table 3. The mean values and standard deviation for concentration of Total P (TP) on four replications of six treatments in Leaching samples.

Clay Loamy Soil		1st cut	2nd cut	3rd cut	Amount TP
Treatments		LEACHING Average mgL^{-1}			
T1	**S**	0.016 ± 0.011 [a*]	0.009 ± 0.004 [a]	0.034 ± 0.009 [a]	0.059 ± 0.0078 [a]
T2	**SL**	0.043 ± 0.016 [b]	0.093 ± 0.071 [b]	0.075 ± 0.004 [b]	0.211 ± 0.0301 [b]
T3	**SS**	0.038 ± 0.019 [b]	0.029 ± 0.010 [c]	0.056 ± 0.010 [ab]	0.123 ± 0.0131 [ab]
T4	**SFL**	0.036 ± 0.011[b]	**0.171 ± 0.113 [d]**	0.052 ± 0.015 [ab]	**0.259 ± 0.0463 [c]**
T5	**SSFL**	**0.07 ± 0.048 [c]**	0.003 ± 0.002 [a]	0.067 ± 0.010 [ab]	0.14 ± 0.0199 [ab]
T6	**SBFL**	0.039 ± 0.006 [b]	0.036 ± 0.005 [c]	**0.119 ± 0.024 [c]**	0.194 ± 0.0115 [b]

[*]Means ± standard deviation, Small letters (a, b and c) indicate significant differences within each table column (α=0.05; n=4)

It was found that the average TP value leached in T_4 was higher compared with all other treatments (Figure 3). The results obtained in T_5 and T_6 are significantly lower compared with T_4 due to the addition of the Straw and Biochar amendments. The differences between the T_5 and T_6 were observed in the second and third harvests. In the second harvest the TP amount in leaching was higher in those treatments where straw was added, likely a result of the rapid effect of Biochar compared to Straw amendments. In the third harvest a weakened role of the Biochar in TP retention accompanied with an enhanced role of Straw were observed in the process. The results of both treatments T_5 and T_6 indicated that the Biochar had a short-time effect in TP retention compared to Straw but in total the use of organic amendments decreased TP leached from the soil.

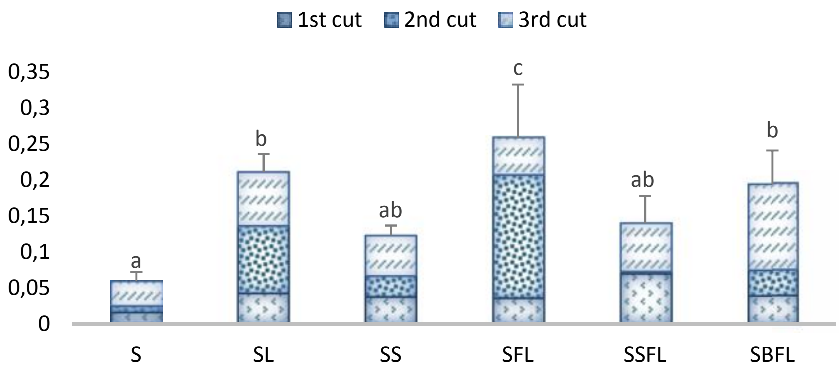

Figure 3. TP accumulated in three successive Leaching process on 3-Cuts (1, 2 and 3rd cut) in mgL^{-1}. Small letters (a, b and c) indicate significant differences within each graph column (α=0.05; n=4).

According to Water Quality Standard the TP should be lower than 5-10μgL^{-1} in lake water but in the agriculture water discharges (leaching) in three cuts the values were beyond the limit. The order from the highest to the lowest concentration of P released in relation to the total P was: SFL>SL>SBFL>SSFL>SS>S.

Phosphorus leaching is reported to be strongly correlated to soil texture [26]. Thus, in Clay Loamy soil was found up to 1.50 mg L^{-1} Total P concentration after applying mineral P fertilizer, as reported by Liu et al., [28]. The amendement of biochar to alkaline soils is likely to increase absorption and decrease availability of P [9] since the presence of alkaline metals would only exacerbate Ca-driven P limitations. Biochar contains a large amount of P and may therefore directly release soluble P and enhance its availability, especially for short-term uses [8]. Biochar may also alter P availability through sorption of chelating organic molecules like phenolic acids, amino acids and complex proteins or carbohydrates [10].

Impact of Straw and Biochar on total P in soil

Table 4. The mean values found in treatments for Total Phosphor in soil samples.

Treatments		1^{st} cut	2^{nd} cut	3^{rd} cut	Average TP of three Cuts
			SOIL Average mgkg^{-1}		
T1	**S**			849.33 ± 9.81	849.33 ± 9.81
T2	**SL**	711.44 ± 146.94	957.43 ± 151.21	927.88 ± 60.83	865.58 ± 119.66
T3	**SS**	532.71± 40.74	962.13 ± 69.77	967.06 ± 61.52	820.63 ± 57.34
T4	**SFL**	593.70 ± 17.58	1031.38 ± 84.12	1021.34 ± 5.60	882.14 ± 35.77
T5	**SSFL**	592.01 ± 21.36	1007.29 ± 62.67	1052.50 ± 55.20	883.93 ± 46.41
T6	**SBFL**	878.10 ± 31.11	1037.76 ± 56.06	998.46 ± 74.65	971.44 ± 53.94

The result of Table 4 did not show a difference between T_4 and T_5 during three cuts, but a different behaviour of biochar was noted from the first to the third cut. In general, lower value of TP were observed in the first cut for T_3, T_4, T_5, as compared to T_6 and T_2. There was a difference between the first and the second cut, likely as a consequence of the addition of NPK as fertilizer (T_3-T_5). Concentrations of P in biochars were several times higher than in unpyrolyzed organic materials rendering biochar a potential P soil amendment [7]. Many studies reported on biochar itself being a potential P source [43, 20, 44, 9, 48].

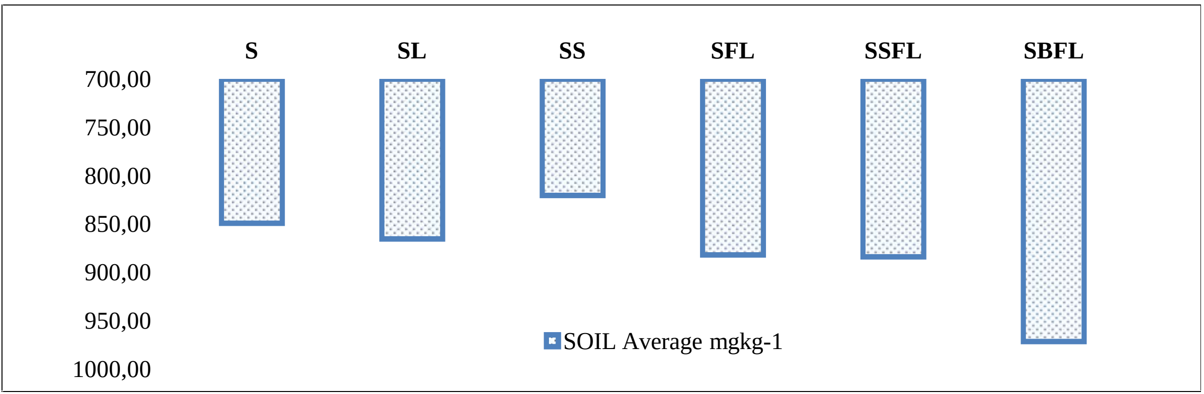

Figure 4. Average Total P values found in plant tissues of each treatments, expressed as average mg kg^{-1}Soil

The results given in Figure 4 express the average value of the TP measured by the analysis made in each harvest, from which it becomes clear that the biochar (SBFL treatment) has played an important role in the TP retention. Contrariwise, the wheat straw (SSFL treatment) has not affect the impacting TP value, by having almost equal value to treatment where only NPK were used (SFL treatment). The difference was obvious in SS treatment were the TP values, in terms of average, were lower compared to the control, explaining the active role of microorganisms over decomposition process of organic matter and TP consumption for their metabolism needs.

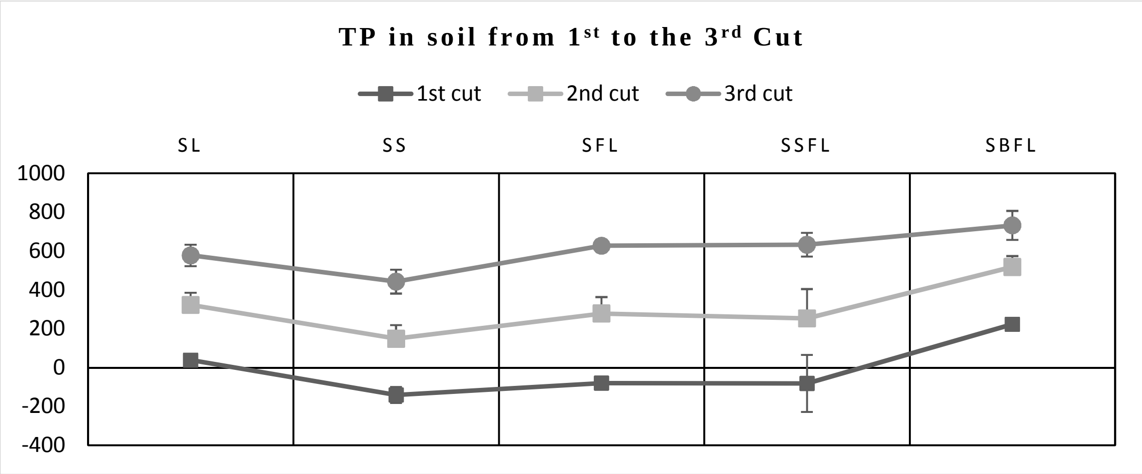

Figure 5. Average TP concentration in soil as difference value between treatments and control one. From five treatments the TP value of control was removed.

To evaluate the added TP value from the firs harvest in the third one, a comparison was made between different treatments value as average and the TP value (serving as control) found on soil at the beginning of the experiment (Figure 5). During the first cut in all the treatments the TP were added or fixed to the soil expected here the SBFL treatment. This trend were observed during the three harvests with the highest amount of TP accumulated in biochar treatment.

Straw and Biochar effect on P uptake

Phosphorus uptake by *Lolium multiflorum* is the product of the plant yield and the P concentration in *Lolium multiflorum*, which are depicted at Table 5 provided below. Plant yields (Shoot + Root) derived from the 3 harvests are shown in Table 5 as well. In first and second harvest, biochar applications demonstrated positive significant difference ($P < 0.05$), compared to the control. However, in the third harvests both SFL and SSFL treatments showed positive significant difference ($P < 0.05$), compared to the SL control.

Table 5. Amount of TP plant content and plant uptake in different treatments.

Treatments		Yield 1st Cut	Yield 2nd Cut	Yield 3rd Cut	Biomass yield (gkg^{-1} Soil) *	Total P shoot Uptake 3 Cuts†	Total P root Uptake	Total P plant Uptake ‡
		gkg^{-1} Soil				TP $mgkg^{-1}$Soil		
T2	**SL**	0.464	0.264	0.337	1.358	2.00	0.556	2.56
T4	**SFL**	0.437	0.357	0.500	1.588	2.51	0.698	3.21
T5	**SSFL**	0.488	0.370	0.534	1.755	2.69	0.747	3.43
T6	**SBFL**	0.540	0.563	0.351	1.830	2.85	0.791	3.64

∗Biomass yield is amount of Shoot part in 3 Cuts; †Amount of Replications [n=4] Mean value in 3 Cuts (1st Cut + 2nd Cut + 3rd Cut); ‡ Amount of TP content in Shoot part and Roots part of the plant.

The results of Total Phosphorus absorption by plant showed that were higher in T_5 and T_6. The TP uptake, from the *Lolium multiflorum* were influenced by the organic matter. No fundamental changes were observed between the treatment with wheat straw SSFL and the treatment with biochar SBFL in shoot part of the plant and remained the same in the root too Figure 6.

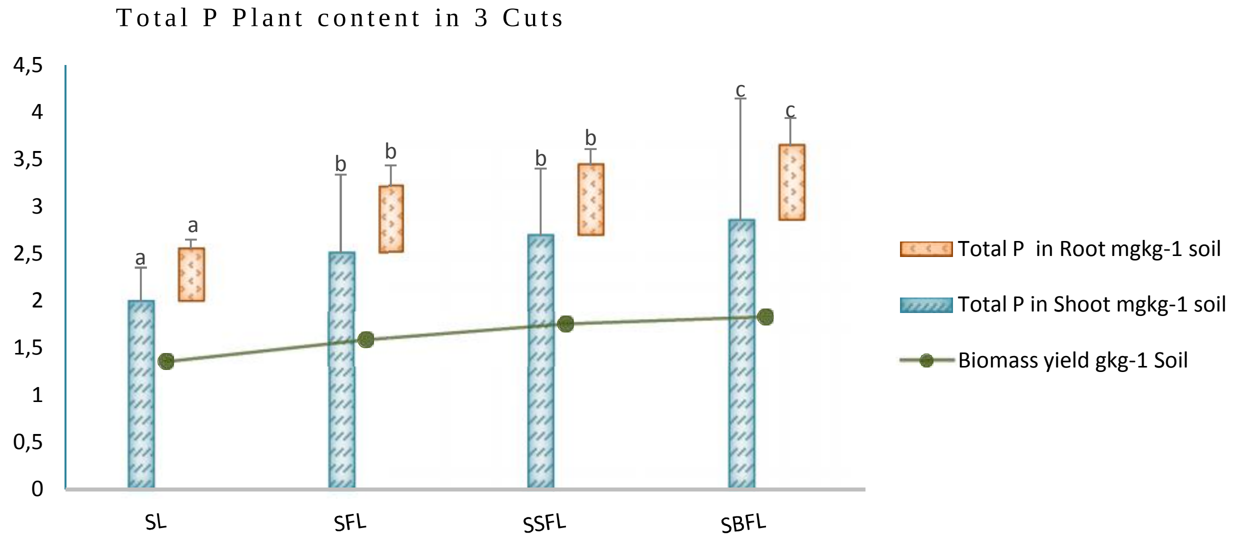

Figure 6. The trend biomass yield and TP shoot uptake compare to the root uptake. Small letters (a and b) indicate significant differences within each graph column (α=0.05; n=4).

4. Conclusions

Intensive agriculture generates large quantities of nutrient-rich agricultural wastes that could be applied to soils enhancing crop production and reducing the amount of needed chemical fertilizers. The results from this study suggest that biochars derived from wheat straw as pyrolyzed agricultural residues, had the potential to release phosphorus into the water phase continuously and gradually compared with raw biomass like wheat straw. The addition of NPK together with different amendments showed positive effects on plant yield, although statistically positive significant differences were observed in treatments with straw and biochar amendments. Arguable effects with plant yield were observed for P leached from soil, where positive significant differences were detected in different harvests. The highest amount of TP leached in three successive leaching processes was found in SFL (T_4) treatment. Despite the fact that leaching tests and pot experiments were a good starting point for assessing biochar-soil-plant systems under natural conditions, the most reliable data could be obtained by experiments under field conditions with different type of soils and plants.

5. References

1. Academic Press 2012, "**Significance of Phosphorius for the Agriculture and Environment**", in *Advances in Agronomy*, 1st ed., Donald Sparks, Ed. USA: Elsevier, 2012, vol. 114, pp. 96-97.
2. American Society of Agronomy Methods of Soil Analysis, "**Physical and Mineralogical Methods**" in *Methods of Soil Analysis*. Wisconsin: Soil Science Society of America, 1986, vol. II.
3. Bekteshi Dh., A. & Rakaj, M. Dhora, "**Consideration on the eutrophication in the Lake of Shkodra**" in *Challenges of sustainable Tourism Developement*, Shkoder, 2012.
4. Bilal Khan et al., "**Effect of Phosphatic Fertilizers on Chemical Composition and Total Phosphorus Uptake by Wheat (Triticum aestivum L.)**", *International Journal of Agricultural Science, Research and Technology*, vol. II, no. 1, pp. 37-42, July 2012.
5. **Breeuwsma, A., and S. Silva., "Phosphorus fertilization and environmental effects in The Netherlands and the Po region (Italy)"**, Agricultural Research Department, The Winand Staring Centre for Integrated Land, Soil and Water Research, Wageningen, The Netherlands., 1992.
6. Bremner and Keeney, "**Chemical and Microbilogical Properties, Extraction of exchangeable ammonium, nitrate and nitrite**" in *Methods of Soil Analysis*, 2nd ed., A.L. Page, Ed. Athens, Wisconsin 53711, USA: Agronomy, 1996, vol. 9, ch. 33, pp. 36-37.
7. Brewer, C. E., Schmidt-Rohr, K., Satrio, J. A. & Brown, R. C., "**Characterization of biochar**

from fast pyrolysis and gasification systems". *Environmental Progress and Sustainable Energy*, vol. 29, pp. 386-396, 2009.

8. Chan K Y, Van Zwieten L, Meszaros I, Downie A, Joseph S., "**Agronomic values of greenwaste biochar as a soil amendment**". *Soil Res*, vol. 45, pp. 629–634, 2007.
9. Chintala R, Mollinedo J, Schumacher T E, Malo D D, Julson J L., "**Efect of biochars on chemical properties of acidic soil**". *Arch Agron Soil Sci*, vol. 60, pp. 393–404, 2013.
10. Cole M A. Stevenson F J., John Wiley and Sons, Ed. New York: Inc., 1999.
11. Dhora Dh., Bekteshi, A. Rakaj, M., "**Consideration on the eutrophication in the Lake of Shkodra in Challenges of sustainable Tourism Developement**". Shkoder, 2012.
12. DIN EN 16169. "**Sludge, treated biowaste and soil - Determination of Kjeldahl nitrogen**", 2011-2012.
13. Dizdari Anila Mesi. "**Toxicity Bio-Monitoring of Shkodra Lake Surface Water Using a Higher Plant Assay**". *Academic Journal of Interdisciplinary Studies*, vol. 2, no. 8, 2013, Doi:10.5901/ajis.2013.v2n8p133.
14. Dizdari Anila Mesi. "**Toxicity Bio-Monitoring of Shkodra Lake Surface Water Using a Higher Plant Assay**". *Academic Journal of Interdisciplinary Studies*, vol. 2, no. 8, p. 133, 2013.
15. EN 14672. "**Characterization Of Sludges - Determination Of Total Phosphorus**" 2005.
16. **Energy, Water and Enviroment Institute of GeoSciences**. (2015-2016, September 2015-January 2016; December, January 1990-2015) IGEWE. [online: http://geo.edu.al].
17. **European Commission**. *Soil Atlas of Europe*, Luca Montanarella and Robert Jones Arwyn Jones, Ed. L-2995 Luxembourg: Office for Official Publications of the European Communities, 2005.
18. Glæsner N, Kjaergaard C, Rubæk GH, Magid J. "**Interactions between soil texture and placement of dairy slurry application**: II, Leaching of phosphorus forms". *J Environ Qual*, vol. 40, pp. 344–351, 2011.
19. Hale, S.E., Alling, V., Martinsen, V., Mulder, J., Breedveld, G.D., Cornellisen, G. "**The sorption and desorption of phosphate-P, ammonium-N and nitrate-N in cacao shell and corn cob biochars**. *Chemosphere* , vol. 91, pp. 1612-1619, 2013.
20. Harris X., W., Cao, "**Properties of dairy-manure-derived biochar pertinent to its potential use in remediation**. *Bioresour. Technol.*, vol. 101, pp. 5222-5228, 2010.
21. ISO 15681–1. "**Water quality - Determination of phosphate and total phosphorus by flow analysis**". International Standard Organization, (CFA and FIA), Geneva, Switzerland, 2003.
22. IUSS Working Group WRB, "**International soil classification system for naming soils and creating legends for soil maps**" FAO, ROME, World Soil Resources Reports No. 106 E-ISBN 978-92-5-108370-3, Updated,2015.
23. Jarvis Nj. "**A review of non-equilibrium water flow and solute transport in soil macropores: principles, controlling factors and consequences for water quality**". *Eur J Soil Sci*, vol. 58, pp. 523–546, 2007.
24. Lee J., "**Effect of application methods of organic fertilizer on growth, soil chemical properties and microbial densities in organic bulb onion production**". *Scientia Horticulturae*, vol. 124, no. 3, pp. 299–305, 2010.
25. Lehmann, J., Joseph, S., "**Biochar for environmental management: an introduction**". *Biocharfor Environmental Management*, pp. 1-12, 2009.
26. Leinweber, P., R. Meissner, K.U. Eckhardt, and J. Seeger., "**Management effects on forms of phosphorus in soil and leaching losses**". *Eur. J. Soil Sci.*, vol. 59, pp. 413–424, 1999.
27. Liang, B., Lehmann, J., Solomon, D., Kinyangi, J., Grossman, J., O'Neill, B., Skjemstad, J.O., Thies, J., Luiza, F.J., Petersen, J., Neves, E.G., "**Black carbon increases cation exchange capacityin soils**". *Soil Science Society of America Journal*, vol. 70, pp. 1719-1730, August 2006.
28. Liu et al., "**Phosphorus leaching from loamy sand and clay loam topsoils after application of pig slurry**". *SpringerPlus*, vol. 1, p. 53, 2012.
29. LLC Taylor & Francis Group. **Reference Methods for Plant Analysis**. Yash P. Kalra, Ed. Boca Raton, Boston, London, New York, Washington, D.C.: CRC Press, 1998.

30. Major, J., Lehmann, J., Rondon, M., Goodale, C. "**Fate of soil-applied black carbon: downwardmigration, leaching and soil respiration**". *Global Change Biology*, vol. 16, pp. 1366-1379, August 2009.
31. Malollari I., Bacu A., Bekteshi A., Babani F., Uku S. "**Nutrition Factors of the Shkodra Lake Waters and Their Distribution**". *Journal of Environmental Protection and Ecology*, vol. 13, no. 2, p. 532, 2012.
32. Mehlich A. "**Mehlich-3 soil test extractant: A modification of Mehlich-2 extractant**" in *Commun. Soil Sci. Plant Anal.*, 1984, vol. 15, ch. 12, pp. 1409-1416.
33. METHOD 3051A. "**Microwave Assisted Acid Digestion of Sediments, Sludges, Soils, and Oils**" 2007.
34. Mijović S. R., et al., "**A Pan-European Classification of the Skadar Lake According to Environmental Standards**". *FACTA UNIVERSITATIS,Physics, Chemistry and Technology*, vol. IV, no. 1, pp. 35 - 43, 2006.
35. Mulumba L, Lal R., "**Mulching effects on selected soil physical properties**". *Soil & Tillage Research*, vol. 98, no. 1, pp. 106–111, 2008.
36. Murphy, J., Riley, J.P., "**A modified single solution method for the determination of phosphate in natural waters**". *Anal. Chim.*, vol. Acta 27, pp. 31-36, March 1962.
37. Obed F. Madiba, Zakaria M. Solaiman, Jennifer K. Carson & Daniel V. Murphy, "**Biochar increases availability and uptake of phosphorus to wheat under leaching conditions**". *Biol Fertil Soils*, February 2016.
38. Pierzynski, Gary M., "**Soil Phosphorus and environmental quality**". in *Soil and Environmental Quality*, 2nd ed. London, New York, Washington D.C.: CRC Press LLC, 2000, ch. 5, p. 164.
39. Saroa G, Lal R., "**Land Degradation & Development**". *Soil restorative effects of mulching on aggregation and carbon sequestration in a Miamian soil in central Ohio*, vol. 14, no. 5, pp. 481–493, 2003.
40. Sharpley, A.N., and H. Tunney, "**Phosphorus research strategies to meet agricultural and environmental challenges of the 21st century**". *Journal of Environmental Quality*, vol. 29, pp. 176–181, 2000.
41. Sharpley, A.N., and J.K. Syers, "**Loss of nitrogen and phosphorus in tile drainage as influenced by urea application and grazing animals**". *Journal of Agricultural Research*, vol. 22, pp. 127–131, 1979.
42. Sharpley, A.N., T.C. Daniel, J.T. Sims, "**Agricultural phosphorus and eutrophication**". USDA-ARS, U.S. Government, Washington, DC, 1999.
43. Silber, A., Levkovitch, I., Graber,E.R., "**PH-dependent mineral release and surface properties of cornstraw biochar: agronomic implications**". *Environ. Sci.Technol.*, vol. 44, pp. 9318-9323, 2010.
44. Sohi T.E., S.P., Angst, "**Establishing release dynamics for plant nutrients from biochar**". *Glob. Change Biol. Bioenergy*, vol. 2, pp. 221-226, 2013.
45. Tan D, Jin J, Huang S, Li S, He P., "**Effect of long-term application of K fertilizer and wheat straw to soil on crop yield and soil K under different planting systems**". *Agricultural Sciences in China*, vol. 6, no. 2, pp. 200–207, 2007.
46. Walkley, A. and I. A. Black, "**An examination of Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method**" 1934.
47. Withers, P.J.A., I.A. Davidson, and R.H. Foy, "**Prospects for controlling diffuse phosphorus loss to water**". *Journal of Environmental Quality*, vol. 29, pp. 167–175, 2000.
48. Zimmerman A., A.R., Mukherjee, "**Organic carbon and nutrient release from a range of laboratory-produced biochars and biochar-soil mixtures**". *Geoderma*, pp. 193-194, 122-130, 2013.