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Effect of Soil Amandements on Nutrient Absorbtion, Growth, and Yield of Soybean and Sweetcorn in Podzolic Soil by Different Cropping System

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Abstract:
The purpose of this study was to investigate the effect of different soil amendments on the nutrient absorption, growth, and yields of soybean and sweet corn cultivated in podzolic soil. The study was conducted at Jantho, Aceh Besar District from July 2016 to January 2017. Soil amendments used were NPK 400 kg ha^{-1} (A_0), biochar 10 ton ha-1 (A_1), cow dung 10 ton ha $^{-1}$ (A_2) biochar 10 ton ha^{-1} + NPK 400 kg ha^{-1} (A_3), cow dung 10 ton ha^{-1} + NPK 400 kg ha^{-1} (A_4). Whereas, the cropping system consists of soybean monoculture (S_1), sweet corn monoculture (S_2), and soybean-sweet corn intercropping (S_3). The results showed that the application of biochar 10 ton ha^{-1} affected significantly N absorption in the monoculture system (153,66 mg/plant). The highest yields of soybean and sweet corn were found by application of soil amendment cow dung + NPK with monoculture system that reached yield potential 1.16 and 21, 08 ton ha^{-1} respectively.
***Key Word**: Soil amendment, biochar, cropping pattern, intercropping.*

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I. Introduction

Podzolic soil is one of the soil types in Indonesia that has the widest distribution from unused agricultural dry land, reaching approximately 45,794,000 ha or about 25% of the total land of Indonesia (Subagyo *et al*., 2004). Dryland is a potential zone that is not optimally used for planting development in many regions in Indonesia. This land has many obstacles to achieve optimum growth and harvesting yields such as low soil fertility, low availability of N, P, K, Ca, Mg, S, and Mo, and relatively high toxic element such as Al, Fe, and Mn (Berek *et al*., 1995). Besides, to have low carbon and nitrogen, podzolic soil land in Jantho of Aceh Besar Regency has also low soil porosity (36.5 to 41.8%) and poor soil structure with aggregate stability index ranges from 34.1 to 36.5%. Podzolic soil has low sensitivity to erosion, percolation, and infiltration, low soil pH, low organic materials, and nutrients (Harjoso, 2002). Efforts to improve the fertility of this soil can be done through the application of soil amendment.

Materials that can be used as soil amendments are cow dung, green fertilizers, biochar, and others. Biochar and cow dung are used as an amendment to improve podzolic soil productivity. Soil amendments are primarily used to repair the physical, chemical, and/or biological properties of soil so that the productivity of the soil becomes optimum (Dariah *et al.*, 2015).

Based on the main forming compounds or elements soil amendments are categorized into organic, biological, and mineral. The use of biological soil amendment should become the main priority not only because of its effectiveness in repairing both soil quality and productivity, but also its renewable property, *in situ* availability and affordability, as well as its potential to support conserved soil carbon (Dariah *et al.*, 2015).

Another strategy that might be used to improve the productivity of podzolic dry land is the use of an appropriate cropping system. Implementation suitable cropping system is an effort to do cropping at a soil plot by arranging layouts and plant order for a certain time period, including the land processing and implanting. Three cropping patterns generally used are monoculture, plant rotation, and polyculture (Anwar, 2012). Monoculture agriculture is agriculture with a similar type of plant. Intercropping is the simultaneous cropping of more than one plant type in the same land for a certain time of the cropping period (Thahir, 1999). Soybean and sweet corn are cropped by monoculture and intercropping systems to evaluate the response and yield in podzolic soils by application of different kinds of soil amendments and cropping systems. Podzolic soil can be found at different reliefs, range from flat to mountainous regions.

In addition to the use of soil amendment, the cropping system is also a factor that might potentially improve the yield of plants. According to Warsana (2009), intercropping is a cropping system where two or more plants are simultaneously in a relatively similar or different time period by alternating planting and regular

planting spacing at the same plot of land. Intercropping land processing might improve the intensity of land use. The higher intensity of land use has a positive impact on farmer income where the higher the intensity of land use, the better farmer's income.

Based on the aforementioned explanation, a detailed analysis about the appropriateness of the application of soil amendments and cropping system in the dry podzolic soil is required to obtain better plant productivity that finally might give a positive impact on the improvement of people's economy. This study aimed to investigate nutrient absorption, growth, yields of soybean and sweet corn planted at dry land of podzolic soil for maintaining crop productivity in this land by application of different soil amendments and cropping systems.

II. Material And Methods

Plants Materials and Soil Amandments

Research materials used in this study were Dena 1 soybean seeds and Bonanza sweet corn seeds. Soil amendments used were biochar rice husks, cow dung, and NPK fertilizers. Fertilization given is inorganic NPK fertilizer type Phonska 15:15:15, the fertilizer dose is 400 kg ha-1 equivalent to 294 g / plot. NPK Fertilizer is given through an array. This study was carried out at Kota Jantho Subdistrict, Aceh Besar Regency, Aceh, Indonesia from June 2016 to January 2017.

Soil Chemical Properties Analysis

Initial analysis on chemical soil properties was conducted to analyze pH (H_2O) by using electrometric, N-total using the Kjeldahl method, P-available with Bray 2, K-dd by NH_4COOCH_3 method at pH 7, and C-organic by Walkley and Black method.

Plot Preparation, Planting Use

The study was conducted in the podzolic soil of Teureubeh Village, Kota Jantho Subdistrict, Aceh Besar Regency. Two factors of treatments will be evaluated, the first factor was soil amendment and the second factor was the cropping system. Soil amendments consist of five treatments as follows: 10 ton/ha of biochar rice husks (with and without the combination of 400 kg/ha of NPK), 10 ton/ha cow dung (with and without the combination of 400 kg/ha of NPK), and 400 kg/ha of NPK (15:15:15) fertilizer as control. Biochar had a pH of 7.5 and contained organic carbon (C-org) of 35%, total nitrogen of 0.53%, and P-available of 0.02%. Cow dung had a pH of 9.40 and contained C-org of 28.5%, total N of 2.8%, and P_2O_5 of 2.59%. Whereas to analyze the effect of cropping system, soybean and sweet corn were planted by three configurations of planting system as follows: S_1 = soybean monoculture with planting spacing of 30 x 30 cm, S_2 = sweet corn monoculture with planting spacing of 70 x 30 cm and S_3 = soybean and sweet corn intercropping (soybean was planted between sweet corn row plants). There were 45 experimental plots, each with a size of 3.5 x 2.1 m. Sweet corn was planted 21 days after soybean plantation for both monoculture and intercropping systems. The population of soybean in monoculture and intercropping was 84 and 28 planting holes per plot, respectively. Whereas the sweet corn population for both monoculture and intercropping were 35 planting holes per plot. For analyzing the data a factorial randomized block design (RBD) with 3 replications was used in this study.

III. Result and Discussion

Soil Chemical Properties of the Experimental Site

Initial soil samples were collected before performing of soil analysis. Soil analysis indicated that podzolic soil in the study location had normal soil pH, very low C-organic, low total N, low P-available, low Ca, Mg, K, Na, and had medium cation exchanged capacity (CEC), with low alkaline saturation (AS). Chemical properties presented above are thought to become the limitation on the growth and production of plants. Chemical properties of analyzed soils and their evaluation according to evaluation criteria issued by the Soil Research Agency (2009) are presented in Table 1.

Tabel 1. Soil chemical properties before the implementation of soil amendment in a podzolic soil

Soil Properties	Score	Criteria
Soil pH (H_2O)	6.80	Neutral
Organic C (%)	0.67	Very low
Total N (%)	0.16	Low
Available P (ppm)	1.40	Very low
Ca-dd (me/100g)	3.40	Low
Mg-dd (me/100g)	0.68	Low

K-dd (me/100g)	0.15	Low
Na-dd (me/100g)	0.10	Low
Cation exchange capacity (CEC) (me/100g)	16.933	Medium
Alkaline saturation (%)	23.73	Low

Note : Results of analysis at the Laboratory of Soil and Plant Research, Faculty of Agriculture, University of Syiah Kuala

Effects of Soil Amendments on Nutrient Absorption of Soybean and Sweet Corn

Nutrient absorption in podzolic soil effected by soil amendment were analyzed for three important nutrients; nitrogen (N), phosphor (P), and potassium (K). The research results of nutrient absorption by different soil amendments and cropping systems both for soybean and sweet corn monoculture or intercropping systems are presented in Table 2.

Table 2 showed that basically soil amendment did not have a significant difference on N, P, and K absorption in soybean both by cropping system monoculture and intercropping. N absorption ranges from 80.27-129,5 mg plant^{-1} in monoculture and from 97.8-175,6 mg plant^{-1} in intercropping system. P absorption ranges from 7,9-12,8 mg plant^{-1} in monoculture and from 9.4-17,4 mg plant^{-1} in the intercropping system, whereas K absorption ranges from 57,11-94.47 mg plant^{-1} in monoculture and from 74.8-141.5 mg plant^{-1} in the intercropping system. However, soil amendments have a significant difference in N absorption in sweet corn. The largest N absorption (72.69 mg plant $^{-1}$) was found in soil amendment with Biochar rice husk + NPK. P absorption in sweet corn almost similar both in monoculture and intercropping system with the ranges from 2.69-8.23 mg plant^{-1}, whereas K absorption in sweet corn both in monoculture and the intercropping system had the ranges from 12.47-38.25 mg plant^{-1}. According to Miller and Donahue (1990), N is the main nutrient required for the growth of sweet corn and is generally used for the formation and growth of vegetative parts of the plant such as leaves, stems, and roots. Phosphor (P) is available in the forms of phytic, nucleic, and phosphatides whereas potassium is not the element directly required for the formation of organic compounds.

Table 2. Nutrient absorption of soybean (45 DAP) and sweet corn (65 DAP) by different soil amendments and cropping system in podzolic soil

Treatment	**Nutrient absorption mg/plant**						**Nutrient absorption mg/plant**					
	Monoculture (S1 / S2)						**Intercropping (S3)**					
Soil Amendment (A)	**N**		**p**		**K**		**N**		**p**		**K**	
	Soybean	Sweet corn	Soybean	Sweet corn	Soybean	Sweet corn	Soybean	Sweet corn	Soybean	Sweet corn	Soybean	Sweet corn
NPK	88.56	61.66	8.34	6.89	71.11	32.34	175.63	43.32	17.38	4.81	141.54	22.62
Biochar rice husks	129.54	61.98	12.84	6.95	94.47	32.37	154.12	23.94	14.81	2.69	115.90	12.47
Cow dung	101.05	68.76	9.92	7.74	72.02	36.08	97.77	45.85	9.36	5.20	77.48	24.10
Biochar rice husks + NPK	122.82	72.69	12.37	8.23	92.63	38.25	155.64	36.42	15.45	4.09	123.61	19.05
Cow dung + NPK	80.27	57.15	7.89	6.37	57.11	29.82	102.90	50.78	10.34	5.66	74.75	26.47
Significant Level	ns	**	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Note : SL=sign. level, ns=non sign. **= sign. level at P=0.01, *= sign. level at P=0.05

Effects of Soil Amendment and Cropping Pattern on the Plant Growth and Yield

The growth of soybean in monoculture and the intercropping system was significantly different by application of soil amendments as shown in Table 3. The table showed that the highest soybean and sweet corn height at the generative stage in monoculture were found in the treatment with soil amendment cow dung + NPK with their height 79.32 and 221.1 cm respectively. Whereas, the lowest height of soybean or sweet corn was found in soil amendment by using biochar rice husks.

Table 3. . Effects of soil amendment on the height of soybean and sweet corn at the generative stage by different cropping system

Treatment	Soybean-Sweet corn Height (cm)			
	Monoculture (S)		Intercropping (S)	
Soil Amendment (A)	Soybean 77 DAP	Sweet corn 49 DAP	Soybean 77 DAP	Sweet corn 49 DAP
NPK	74.66 a	217.36 b	73.68 c	175.82 b
Biochar rice husks	73.64 a	206.37 a	68.15 a	140.30 a
Cow dung	77.19 b	209.91 a	69.51 b	173.98 b
Biochar rice husks + NPK	74.55 a	211.51 ab	68.68 a	180.21 b
Cow dung + NPK	79.32 c	221.10 b	66.35a	184.35 b

Note: Number with different superscript letter in the same column showed significant difference at probability level of 0.05.

Table 3 also showed that the highest soybean and sweet corn height at the generative stage in the intercropping system were found in the treatment with soil amendment cow dung + NPK with their height 68,7 and 180,2 cm respectively. Based on these data, it showed that the height of soybean and sweet corn at the generative stage by monoculture system is better than that of sweet corn by the intercropping system.

Table 4. Effect of Soil Amendment on The Yield of Soybean and Sweet Corn in Different Cropping System

Soil amendment	**Monoculture (S1 / S2)**					
	Soybean			**Sweet corn**		
	Weight 1000 seeds	**Seed weight/plot (kg)**	**Yield potential (ton ha^{-1})**	**Weight of Corn cob/plot (kg)**	**Weight of Corn without cob/plot (kg)**	**Weight of Corncob (kg ha^{-1})**
NPK	18,55	0,86	1,17	13.33	10.05	18.14
Biochar rice husks	18,44	0,86	1,16	12.12	10.18	16.49
Cow dung	18,37	1,00	1,36	11.08	9.62	15.07
Biochar rice husks + NPK	21,44	0,94	1,27	12.87	10.20	17.51
Cow dung + NPK	22,14	0,85	1,16	15.55	12.70	21.08
Significant Level	ns	ns	ns	ns	ns	ns
Intercropping (S3)						
Soil amendment	**Soybean**			**Sweet Corn**		
	Weight 1000 seeds	**Seed weight/plot (kg)**	**Yield potential (ton ha^{-1})**	**Weight of Corn cob/plot (kg)**	**Weight of Corn without cob/plot (kg)**	**Weight of Corncob (kg ha^{-1})**
NPK	17.10	0.45	1.85	12.23	8.60	16.65
Biochar rice husks	17.37	0.41	1.68	7.77	5.60	12.23
Cow dung	16.23	0.49	2.01	9.23	7.73	7.77
Biochar rice husks + NPK	23.50	0.59	2.40	13.07	10.13	9.23
Cow dung + NPK	19.55	0.38	1.57	13.10	10.40	13.07
Significant Level	ns	ns	**	**	**	**

Note: SL=sign. level, ns=non sign. **= sign. level at P=0.01, *= sign. level at P=0.05

The data in Table 4 shows that the yield parameters of soybean and sweet corn by monoculture were not significantly affected by soil amendment. However, by application soil amendment cow dung + NPK caused a slight increase in yield parameter both for soybean and sweet corn. The potential yield of soybean and sweet corn were 1.16 and 21.08 ton ha^{-1}.

Table 4 also shows that soil amendment affected the yield potential of soybean and all of the yield parameters in sweet corn. The best yield potential of soybean reached 2,40 tons by application soil amendment Biochar rice husk + NPK. In Sweet corn, however, the application of soil amendment cow dung + NPK increased yield parameter significantly compare to other soil amendment treatment. The weight of corncob by this soil amendment treatment reached 13.07 ton ha-1. The yield parameter of soybean cultivated with the monoculture cropping system is better than the intercropping system.

In this study, the effect of monoculture and intercropping systems on the growth and yield of soybeans and sweet corn cultivated on podzolic land was to improve soil quality by providing different soil amendments. The use of soil amendment is to improve the chemical properties of podzolic soils which are deficient in organic nutrients and have lower pH. Li et al. (2003) suggested that soil acidity, C-organic content, and balance of N, P,

and K were key factors that significantly influenced microbial and enzyme activity in the soil, including podsolic soil quality. Intercropping, on the other hand, is a polyculture effort that can reduce production on some agricultural lands, especially non-competitive crops.

IV. Conclusion

The application of NPK, Biochar, cow dung, NPK-Biochar, and NPK-cow dung soil amendments did not influence nutrient absorption of podzolic soils cultivated with soybean and sweet corn by monoculture and intercropping cropping system. The application of soybean-sweet corn intercropping system to dry podzolic soil amended with NPK, Biochar, cow dung, NPK-Biochar, and NPK-cow dung soil amendments resulted in lower sweet corn growth compared to the monoculture cropping system.

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