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Growth and production responses of local sweet potatoes (*Ipomoea batatas* L.) genotypes on paddy straw biochar application in the paddy fields

To cite this article: M Y Andika *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **260** 012152

Growth and production responses of local sweet potatoes (*Ipomoea batatas* L.) genotypes on paddy straw biochar application in the paddy fields

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Abstrak. Biochar application as an organic soil conditioner can increase plant growth and production, especially on suboptimal lands. This research aimed to determine the response of growth and production in some local sweet potato genotypes (Accession of Cengkeh Turi with yellow tuber flesh, Accession of Cengkeh Turi with orange tuber flesh, and Accession of Tanah Seribu with orange tuber flesh) on various doses application of paddy straw biochar (0, 5, 10, 15 tons/ha) in paddy fields. A field experiment was conducted from April to August 2018 in the paddy fields of Tandem Hilir I Village, Deli Serdang. The results of this research indicated that the local sweet potato genotype had a good growth and production response in paddy field cultivation. Accession of Tanah Seribu with orange tuber flesh had a significant effect on vine length, tuber weight per sample, and harvest index, while Accession of Cengkeh Turi with orange tuber flesh significantly affects the number of tubers per sample. Paddy straw biochar application had a significant effect on the length of vine, and tuber weight per sample. The best dose of paddy straw biochar in the paddy fields is 10 tons/ha.

1. Introduction

Sweet potatoes are used as the main carbohydrate source that acts as food, industrial raw materials and animal feed [1]. Efforts to increase sweet potato production can be done by using superior and local varieties and the use of paddy fields. The used of paddy fields were carried out during dry season which aimed to cut the cycle of pests and diseases of paddy plants [2].

The provision of nutrients in the form of paddy straw in the paddy fields is useful to keep nutrients availability in the soil [3]. Straw compost application has a significant effect on plant length, biomass weight, tuber weight, tuber length and harvest index [4].

The use of organic materials as natural soil conditioner is usually temporary. Currently, biochar has been used as an alternative soil conditioner. Biochar is a carbon-rich solid material that is formed through the combustion process of organic materials without or little oxygen at temperatures of 250-500 ºC [5].

Biochar applications are useful for improving the quality of degraded soil, increasing soil porosity and water retention capability, increasing pH and soil CEC, increasing the efficiency of chemical fertilizer utilization and increasing crop productivity [6,7,8].

This research aimed to determine the response of growth and production in some local sweet potato (*Ipomoea batatas* L.) genotypes (Accession of Cengkeh Turi with yellow tuber flesh, Accession of Cengkeh Turi with orange tuber flesh, and Accession of Tanah Seribu with orange tuber flesh) on various doses application of paddy straw biochar (0, 5, 10, 15 tons/ha) in paddy fields.

2. Materials and Methods

Field experiment was conducted from April to August 2018 in the paddy fields of Tandem Hilir I Village, Deli Serdang. This research used a randomized block design with two factors, the first factor was the local sweet potato genotypes (Accession of Cengkeh Turi with yellow tuber flesh, Accession of Cengkeh Turi with orange tuber flesh, and Accession of Tanah Seribu with orange tuber flesh) and the second factor is the dose of paddy straw biochar (0, 5, 10, 15 tons/ha) with three replicates per each treatment with sampling. This research started from land preparation, biochar application, planting, maintenance, fertilization, and morphological parameter analysis which includes vine length, fresh weight, number of tubers per sample, tuber weight per sample and harvest index.

The application of biochar was carried out 1 week before planting by immersing it into the soil and mixed to be evenly distributed using a hoe. The biochar application is adjusted to the experimental plot. Biochar is not given on control treatment.

Morphological character data retrieval, i.e. the length of vines was carried out when the plants are 10 weeks after planting (WAP). Observation of fresh weight, number of tubers per sample, tuber weight per sample and harvest index were observed when the plants were 16 WAP.

Data were analysed statistically by F test and continued by Duncan Multiple Range Test (DMRT) at α 5%.

3. Results and Discussion

The data presented in Table 1 showed that the genotype had a significant effect on the vine length parameter. Tanah Seribu Accession (orange tuber flesh), the increased vine length was the highest compared to other genotypes. This is due to the ability of each genetic variation to adapt in the growing environment. Differences in vegetative growth, namely the vines length and fresh weight from various genotypes, are genetic responses to the environment. Chipungu et al., [9] reported that environmental factors strongly influence the vegetative growth of sweet potatoes when compared to genotypes and interactions between genotypic and environmental.

Table 1. Effect of local sweet potato genotypes on vine length and fresh weight in paddy fields

Genotypes	Vine length (cm)	Fresh weight (g)
Cengkeh Turi Accession (yellow tuber flesh)	144.37 b	1017.98
Cengkeh Turi Accession (orange tuber flesh)	155.81 b	1205.27
Tanah Seribu Accession (orange tuber flesh)	183.75 a	1129.81

Note: Mean values by the same letter in same column do not significantly differ based on DMRT at 5% level

The application of various doses of paddy straw biochar significantly increased the vine length parameter (Table 2). Treatment of 10 tons/ha of paddy straw biochar dose increased the highest vine length compared to other treatments. It has been reported by Chan et al., [10] that biochar amendments were able to increase N available to plants. N is needed by plants in the process of growing vegetative organs such as stem elongation, number of leaves, development of tubers and in the process of photosynthesis. Generally, N in biochar is in low concentrations depends on the biochar raw materials. However, when combined with chemical fertilizers, biochar can prevent N nutrient leaching and also the absorption of nutrients N, P, K, Ca, Mg and S. Walter and Rao [11] also reported that the application of biochar was able to improve the efficiency of chemical fertilizer fertilization which was characterized by an increase in tuber yields by 100% and biomass by 75% when compared to biochar without fertilizer only increased tuber yields by 20%.

Table 2. Vine length and fresh weight on various doses of paddy straw biochar in paddy fields

Doses of paddy straw biochar (tons/ha)	Vine length (cm)	Fresh weight (g)
0	142.16 b	934.64
5	166.39 a	1111.72
10	176.44 a	1227.81
15	160.25 ab	1196.58

Note: Mean values by the same letter in same column do not significantly differ based on DMRT at 5% level

The data in Table 3 showed that genotypes had a significant effect on the number of tubers and tuber weight per sample. Cengkeh Turi Accession (orange tuber flesh) produced the highest number of tubers per sample compared to other genotypes while the Tanah Seribu Accession (orange tuber flesh) obtained the highest tuber weight per sample compared to other genotypes. Paddy straw biochar application significantly affected tuber weight parameters per sample (Table 4). The dose of 10 tons/ha of paddy straw biochar produced the highest tuber weight per sample compared to other treatments, although the dose of paddy straw biochar had no significant effect on the parameters of the tubers number per sample. Biochar can improve soil structure to increase the productivity of sweet potatoes in Ultisol soil [12]. Paddy straw biochar also contains high potassium nutrients. Potassium plays a role in the plant structures formatting, related to protein synthesis, carbohydrate metabolism, and enzyme activity. Physiological processes that depend on Potassium are such as stomata and photosynthetic regulation. In drought conditions, K regulates stomata opening and helps plants adapt to water deficits [13]. Dou et al. [14] also reported that biochar can increase soil pH and EC (Exchangeable Cation), concentrations of K, Mg, and NO_3^- in the Field Science Center (FS Center) in Japan and increase tuber yield, sugar content and the quality of sweet potato display.

Table 3. Effect of local sweet potato genotypes on number of tuber and tuber weight per sample in paddy fields

Genotypes	Number of tuber per sample	Tuber weight per sample (g)
Cengkeh Turi Accession (yellow tuber flesh)	3.77 b	1605.25 ab
Cengkeh Turi Accession (orange tuber flesh)	5.08 a	1446.71 b
Tanah Seribu Accession (orange tuber flesh)	4.38 ab	1749.77 a

Note: Mean values by the same letter in same column do not significantly differ based on DMRT at 5% level

The observation of harvest index in some local sweet potato genotypes has a significant effect (Table 5). Tanah Seribu Accession (orange tuber flesh) and Cengkeh Turi Accession (yellow tuber flesh) produced the highest harvest index when compared to Cengkeh Turi Accession (orange tuber flesh). This is presumably because the harvest index is a carbon distribution [15]. The high harvest index value illustrates that the distribution of assimilation results is greater to tuber enlargement while the low harvest index value is an indication of the high yield of biomass and lack of distribution of assimilates to tubers [15]. Bhagsari and Ashley [16] reported that the harvest index affects tuber yields. The relationship between harvest index and tuber dry matter indicates that the potential yield of a genotype can be predicted when the plant is 80 days after planting. Bahgsari [17] also supported that the harvest index and sink strength of the tubers greatly affect tuber yield when compared to photosynthetic efficiency. Harvest index shows that the effect is not significant in each treatment of paddy straw biochar dose (Table 6). However, treatment without biochar application increased the harvest index compared to other treatments. This is in accordance with the previous researches, it was reported that the control treatment of the IRA1112 variety harvest index increased significantly compared to the treatment of PM (Poultry Manure) and GM (Green Manure) fertilizers that were applied singly [18].

Table 4. Number of tuber and tuber weight per sample on various doses of paddy straw biochar in paddy fields

Doses of paddy straw biochar (tons/ha)	Number of tuber per sample	Tuber weight per sample (g)
0	4.64	1516.33 b
5	4.11	1395.78 b
10	4.19	1901.47 a
15	4.69	1588.72 b

Note: Mean values by the same letter in same column do not significantly differ based on DMRT at 5% level

Table 5. Effect of local sweet potato genotypes on harvest index in paddy fields

Genotypes	Harvest index
Cengkeh Turi Accession (yellow tuber flesh)	0.61 a
Cengkeh Turi Accession (orange tuber flesh)	0.55 b
Tanah Seribu Accession (orange tuber flesh)	0.61 a

Note: Mean values by the same letter in same column do not significantly differ based on DMRT at 5% level

Table 6. Harvest index on various doses of paddy straw biochar in paddy fields

Doses of paddy straw biochar (tons/ha)	Harvest index
0	0.63
5	0.55
10	0.61
15	0.57

4. Conclusions

Morphological parameter evaluation on some local sweet potato genotypes had a significant effect in increasing the growth and production of local sweet potato genotypes in paddy fields. Accession of Tanah Seribu with orange tuber flesh are local genotype with the highest growth rate, tuber yield and harvest index. The biochar application had a significant effect in increasing the vine length, and tuber weight per sample on the local genotype of sweet potato in the paddy field. The best dose of paddy straw biochar in paddy field is 10 tons/ha.

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