INNSPUB

International Journal of Agronomy and Agricultural Research (IJAAR)

ISSN: 2223-7054 (Print) 2225-3610 (Online)

http://www.innspub.net

Vol. 16, No. 1, p. 16-21, 2020

RESEARCH PAPER

OPEN ACCESS

The effect of Terra preta media using pirolysis system on growth and production of corn (*Zea mays* L)

A. Sutopo*[1], Yuliyanto[2]

[1]*Departement of Production Technology of Crop Plantation, Citra Widya Edukasi Oil Palm Polytechnic Institute, Cibitung Bekasi, Indonesia*

[2]*Department of Plantation Cultivation of Oil Palm, Citra Widya Edukasi Oil Palm Polytechnic Institute, Cibitung Bekasi, Indonesia*

Article published on January 30, 2020

Key words: Terra preta, Pyrolysis, Corn

Abstract

Terra preta is a black soil found in the Amazon basin in the 15th century with the main characteristics of black and loose has the nature of resistant to leaching, able to provide and maintain nutrients in a very long time, whereas in Indonesia the availability of such land has not yet existed so it is necessary to make and apply terra preta soil with mineral soil base material mixed with charcoal, bones burned with pyrolysis combustion system and other organic materials. In enriching microorganisms, mycorrhizal fungi are added which function to increase nutrient absorption, increase plant resistance to biotic and abiotic stresses, able to maintain growth and production stability. The study aims to determine the effect of the application of terra preta planting media with pyrolysis combustion systems on the growth and production of corn plants using polybags. The results showed that the application of terra preta in general had a good effect on the growth and production of corn compared to plants that only used mineral soil or control media. Application of T1: 100% terra preta treatment on observations of plant height and stem diameter showed the best treatment. On observation of the number of leaves, of wet weight and dry weight of root, canopy, corn seed, corn cob and corn husk of T5 treatment: mineral soil + 15gr mycorrhizae + 80% terra preta showed the best treatment.

* **Corresponding Author:** A. Sutopo ✉ soetopo.ahmad13@gmail.com

Introduction

Soil conservation was carried out hundreds of years ago by residents of the American Amazon basin in the form of the addition of biochar from the burning of minimal oxygen (pyrolysis) as a soil enhancer (Adimihardja, 2008). Biochar can overcome limitations and provide additional options for land management. The result of the addition of biochar in the form of black soil called terra preta managed by the Amerindian people 500 years ago which is to maintain organic carbon content, high fertility even though abandoned thousands of years by local residents (Lehmann *et al.*, 2003). This soil is enriched with nutrient content two to three times that of the surrounding soil even without fertilization. Organic matter content and high nutrient retention are caused by very high carbon black content (Lehmann and Rondon 2006; Sohi 2009). Black carbon comes from biological biomass through combustion at temperatures of 300-5000C under limited oxygen conditions to produce aromatic organic matter with carbon concentrations of 70-80% (Lehmann *et al.*, 2006).

Terra preta in the Amazon basin is very fertile and able to multiply with a speed of 1 cm per year. However, the availability of such land in Indonesia is very small or even can be said to be non-existent. The method used to improve soil quality in Indonesia is by making terra preta with the main ingredient of mineral soil which is added by biochar with a pyrolysis system and then activated with sulfuric acid and added animal dung, urine, animal bones and mycorrhizae. The activation process aims to break the hydrocarbon bonds so that biochar undergoes changes in physical and chemical properties with a larger surface area which affects the adsorption power (Sembiring and Tuti, 2003). The composition of these materials is whether artificial black soil has physical, chemical and biological properties such as terra preta soil and what is the ideal composition of terra preta to increase plant growth and crop production. According to Gani (2009) biochar effectively retains nutrients for its availability for plants compared to other organic materials such as leaves waste, compost or manure. The addition of coconut shell charcoal can increase plant growth through its effectiveness in the availability of nutrients, especially P because it has a high cation exchange capacity (Soemeinaboedhy and Tejowulan, 2007) and serves to assist the development of Arbuscular Mycorrhizal Fungi in the roots so as to provide additional nutrients as well as a shelter for microorganisms (Soemeinaboedhy and Tejowulan, 2007). Warnock *et al.*, 2007). Therefore, to optimize the use of terra preta, roots need the help of mycorrhizal fungus hyphae to be able to absorb and reach more nutrients because the roots have different exudates from roots that are not infected with mycorrhizae because hyphae on mycorrhiza are able to help plant roots reach further and absorb elements more nutrients (Talanca, 2010). Mycorrhizal dose of 20g/plant is the best dose for growth of vanilla seeds (Tirta, 2006). Therefore it is necessary to research into the production of artificial terra preta with pyrolysis combustion systems and their application to plants that aim to find artificial terra preta, to know the effectiveness of artificial terra preta as an alternative planting medium, to know the response to growth and crop production. This research adds to the availability of fertile fertile soil that can increase plant growth and production so as to create a stable price for plant products.

Materials and methods

Research Time and Location

This study was conducted in March to July 2019. The study was conducted in Citra Widya Edukasi Oil Palm Polytechnic Institute, Cibitung Bekasi, Indonesia.

Methods and Research Implementation phase

The research was conducted in three main stages which consists of making terra preta, application of terra preta into planting media and data analysis.

Making Pyrolysis Combustion Installation.

Pyrolysis combustion installation is made from cans with a capacity of 200 liters. Modifications were made to the barrel in the form of adding a few holes to the bottom as an entrance for oxygen and a lighter. The vat is closed using a lid with a chimney pipe and a handle.

The stage of making charcoal and soil mixing

Used wood and animal bones are cut into pieces measuring 5 cm, then put into the inner barrel and then closed and carried out the combustion process for 7 hours at 5000C. After that the charcoal is activated by 2 M sulfuric acid then mixes other ingredients such as empty beds, livestock urine, goat droppings and mycorrhizal fungi because pyrolysis combustion is only hollow negative carbon. Then leave it closed for 1 month. Activated charcoal is mixed with mineral soil, then allowed to stand for one month, after which physical, chemical and biological properties are observed.

Terra Preta application

Terra preta that has been made is used as a planting medium for corn (*Zea mays* L.) using a 20cm x 30cm polybag. The study was designed using factorial randomized complete block design with 6 levels of treatment, and each treatment was repeated 3 times. The treatments tested are as follows:

T0: 100% control of mineral soil
T1: 100% terra preta
T2: mineral soil + 15gr mycorrhiza + 20% terra preta
T3: mineral soil + 15gr mycorrhiza + 40% terra preta
T4: mineral soil + 15gr mycorrhiza + 60% terra preta
T5: mineral soil + 15gr mycorrhiza + 80% terra preta

Observation Parameters

Growth parameters are observed once a week until the plants are 12 weeks old including plant height, stem diameter, the number of leaves is calculated on the leaves that have been fully opened. In 12th week onserved root wet weight, root dry weight, wet weight crown and crown dry weight. Production parameters observed at the end of the study included wet weight roots and dry weight of roots, crowns, seed, cob and cornhusk.

Data Analysis

The terra preta manufacturing data are expressed in a descriptive form while the growth and production data are analyzed using Analysis of Variants.

Results and discussion

Growth and Production Parameters

The results of data analysis of plant height showed that the treatment T1 showed the best treatment followed by treatments T3, T5, T4, T2 and the lowest in the treatment T0. The results on the diameter stem showed that the best T1 treatment at 12 weeks followed by treatments T2, T3, T4, T5, and significantly affected compared to T0 or control. The results on the number of leaves showed that the T5 treatment showed the best treatment and had a significant effect on the number of leaves of corn plants but was not significantly different from the T1, T2, and T3 treatments. The treatment of T0 showed that the corn plant had the lowest number of leaves in the 12th week. In the 1st to 12th weeks each treatment showed an increase in the number of leaves in each week and the peak in the 10th to 11th weeks subsequently decreased the number of leaves in the 12th week due to the dried leaves of the corn plant. The results on the wet weight and dry weight showed that the treatment using terra preta was better than the control of the wet weight and dry weight of corn plants. The treatment of T5 showed the best significant effect followed by the use of other terra preta, which were the parameters of the observation of wet weight and dry weight of roots, canopy, corn seed, corn cob and corn husk.

Table 1. The average height of corn (*Zea mays* L.) for terra preta application.

Treatments	Plant Height (cm) 1st to 12th weeks											
	1	2	3	4	5	6	7	8	9	10	11	12
T0	16,89	44,44	64,67 ab	89,89 a	105,00 a	120,22	127,67 ab	130,89 b	139,78	149,22 b	153,22 b	153,22 b
T1	15,17	39,89	56,44 c	81,22 bc	102,67 ab	121,44	135,33 a	141,00 a	152,44	166,33 a	171,89 a	172,56 a
T2	15,67	43,22	66,78 a	89,78 a	103,33 ab	115,56	126,22 b	132,00 ab	136,56	148,56 b	151,89 b	156,11 b
T3	15,44	40,33	60,67 abc	85,22 ab	102,11 ab	116,11	127,11ab	132,00 ab	152,00	159,78 ab	164,22 ab	167,11 ab
T4	15,22	39,67	57,56 bc	77,22 c	97,56 b	115,33	127,44 ab	133,00 ab	139,56	153,00 ab	158,22 b	158,33 ab
T5	15,67	40,00	56,89 c	81,22 bc	98,33 b	116,11	128,22 ab	136,22 ab	145,67	154,11 ab	157,44 b	162,00 ab

Note: Numbers with the same letter are not significantly different according to the DNMRT test at the 5% level.

Table 2. Average diameter stem of corn (*Zea mays* L.) for terra preta application.

Treatments	Stem Diameter (cm) 1st to 12th weeks											
	1	2	3	4	5	6	7	8	9	10	11	12
T0	0,27	0,45 b	0,65 a	0,99 a	1,24 ab	1,24 ab	1,26 b	1,24 b	1,20 d	1,32 b	1,25 b	1,26 b
T1	0,28	0,40 c	0,52 c	0,82 b	1,27 a	1,38 a	1,35 ab	1,47 a	1,50 a	1,50 a	1,36 a	1,36 a
T2	0,23	0,53 a	0,67 a	1,07 a	1,23 b	1,31 ab	1,30 ab	1,28 b	1,22 cd	1,32 b	1,29 b	1,31 ab
T3	0,26	0,42 bc	0,61 ab	0,99 a	1,25 ab	1,29 ab	1,29 ab	1,29 b	1,35 b	1,37 b	1,29 b	1,29 ab
T4	0,26	0,41 bc	0,55 bc	0,78 b	1,25 ab	1,27 ab	1,38 a	1,42 a	1,32 bc	1,35 b	1,26 b	1,29 ab
T5	0,27	0,40 bc	0,53 bc	0,80 b	1,22 b	1,22 b	1,33 ab	1,30 b	1,27 bcd	1,31 b	1,24 b	1,28 ab

Note: Numbers with the same letter are not significantly different according to the DNMRT test at the 5% level.

Table 3. Average number of leaves of corn (*Zea mays* L.) for terra preta application.

Treatments	Number of leaves (cm) 1st to 12th weeks											
	1	2	3	4	5	6	7	8	9	10	11	12
T0	3,00	5,00 a	5,78	5,22 ab	5,89 bc	5,89 b	5,67	6,44	7,00 b	7,78 b	6,89 b	6,56 c
T1	2,56	4,22 cd	5,33	5,44 a	6,22 abc	6,11 ab	6,22	6,89	9,00 a	9,11 a	8,33 a	7,78 ab
T2	2,89	4,89 ab	5,78	4,67 b	5,56 c	5,89 b	6,00	6,33	7,00 b	8,22 ab	8,00 ab	7,89 ab
T3	2,78	4,22 cd	5,33	5,56 a	5,67 c	5,89 b	6,44	6,67	8,44 ab	8,78 ab	8,00 ab	7,67 ab
T4	2,67	4,56 bc	5,33	5,56 a	6,67 a	6,44 a	6,56	7,33	9,00 a	8,89 ab	7,89 ab	7,44 bc
T5	2,44	4,11 d	5,11	5,44 a	6,56 ab	5,78 b	6,33	6,78	7,89 ab	8,78 ab	9,11 a	8,56 a

Note: Numbers with the same letter are not significantly different according to the DNMRT test at the 5% level.

Table 4. Average wet weight and dry weight of corn (*Zea mays* L.) for terra preta application.

Treatments	Wet weight (gr)					Dry weight (gr)				
	root	canopy	seed	cob	husk	root	canopy	seed	cob	husk
T0	34,85	52,44 b	12,23 ab	7,92 d	3,88 b	5,83	18,40	3,58 ab	1,90 c	1,84 b
T1	37,12	110,86 a	16,44 ab	19,72 bc	8,84 ab	4,95	26,24	4,33 ab	3,52 abc	2,64 ab
T2	34,84	89,44 a	7,53 b	11,22 cd	11,50 ab	5,65	23,57	1,01 b	1,45 c	2,68 ab
T3	37,08	83,00 ab	25,08 ab	9,47 cd	5,27 ab	7,48	20,12	7,49 a	2,79 bc	2,02 b
T4	46,48	106,83 a	13,64 ab	30,61 a	18,76 a	8,02	26,76	2,62 ab	4,93 ab	4,54 ab
T5	47,09	107,31 a	29,28 a	23,48 ab	17,60 a	9,79	26,73	6,76 ab	5,45 a	4,74 a

Note: Numbers with the same letter are not significantly different according to the DNMRT test at the 5% level.

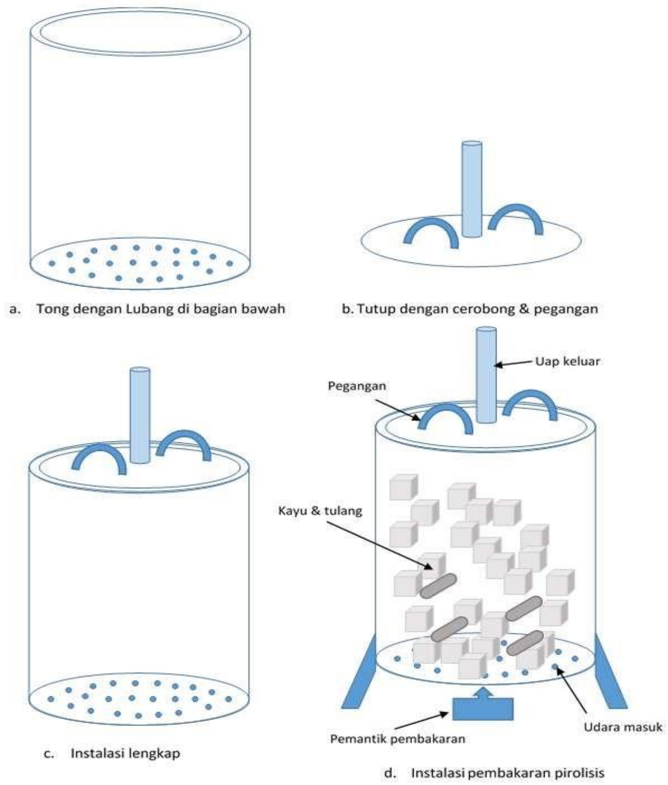

Fig. 1. Pyrolysis Combustion Installation.

Fig. 2. The process of making terra preta.

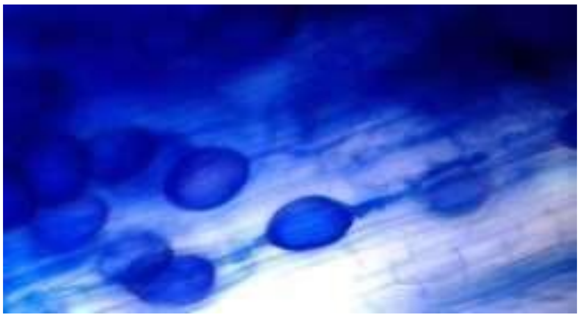

Fig. 3. Form of arbuscular mycorrhizal colonization and spores in corn root cells.

These increase on the growth and production caused by plants treated with terra preta to increase soil fertility in terms of physical, chemical and biological soil properties. This is supported by the opinion of Kuy Kendall (2008) stating that soil organic matter derived from biochar affects soil physical, chemical and biological indicators, such as aggregate stability (physical), retention, nutrient availability (chemical), nutrient cycle (biology) and are indicators of soil quality itself. In addition, soil treated with terra preta is able to be a good medium for the development of various soil miroorganisms, especially the media for the development of Arbuscular Mycorrhizal fungi in the rooting area. This is consistent with the opinion of Gani (2009) stating that biochar is effective in holding nutrients for its availability for plants compared to other organic materials such as leaves waste, compost or manure. The addition of biochar can increase plant growth through its effectiveness in providing nutrients, especially P because it has a high cation exchange capacity (Soemeinaboedhy and Tejowulan, 2007) and also functions in fostering the development of Arbuscular Mycorrhizal fungi in roots so as to provide additional nutrients and shelter for microorganisms (2007). Warnock *et al.*, 2007).

In addition, roots infected by mycorrhizal fungi are able to absorb and reach more nutrients because the roots have exudates that are different from roots that are not infected with mycorrhizae because hyphae on mycorrhizae can help plant roots reach further and absorb more nutrients (Talanca, 2010). Whereas the control treatment has a slower plant height growth this is due to the availability of fewer nutrients for plants and the lack of microorganism development.

Conclusion

The application of terra preta in general had a good effect on the growth and production of corn compared to plants that only used mineral soil or control media. Application of T1: 100% terra preta treatment on observations of plant height and stem diameter showed the best treatment. On observation of the number of leaves, of wet weight and dry weight of roots, canopy, corn seed, corn cob and corn husk of T5 treatment: mineral soil + 15gr mycorrhizae + 80% terra preta showed the best treatment.

Acknowledgement

The authors would like to acknowledge a research grant from Ministry of Research, Technology and Higher Education Republic of Indonesia (Kemenristekdikti) for the funding support of the research project.

References

Adimihardja, Abdurachman. 2008. Teknologi Dan Strategi Konservasi Tanah Dalam Kerangka Revitalisasi Pertanian. Bogor. Balai Besar Penelitian dan Pengembangan Sumberdaya Lahan Pertanian.

Gani, Anischan. 2009. Potensi Arang Hayati Biochar sebagai Komponen Teknologi Perbaikan Produktivitas Lahan Pertanian. Peneliti Balai Balai Besar Penelitian Tanaman Padi, Sukamandi 34-35.

Lehmann J, Rondon M. 2006. Biochar soil management on highly weathered soils in the humid tropics. p: 517-530 In Biological Approaches to Sustainable Soil Systems (Norman Uphoff *et al.,* Eds.). Taylor & Francis Group PO Box 409267Atlanta, GA30384-9267.

Lehmann J, da Silva Jr JP, Steiner C, Nehls T, Zech W, Glaser B. 2003. Nutrient availability and leaching in an archaeological Anthrosol and a Ferralsol of the Central Amazon basin: fertilizer, manure and charcoal amendments. Plant and Soil **249,** 343-357.

Sembiring M, Tryana, dan S Sinaga Tuti. 2003. Arang Aktif : Pengenalan dan Proses Pembuatan. Jurusan Teknik Industri Fakultas Teknik Universitas Sumatera Utara.

Soemeinaboedhy IN, Tejowulan RS. 2007. Pemanfaatan berbagai macam arang sebagai sumber unsur P dan K serta sebagai pembenah tanah. Jurnal Agroteksos **17(2),** 115-121.

Talanca H. 2010. Status Cendawan Mikoriza Vesikular-Arbuskular (MVA) pada Tanaman. Prosiding Pekan Serealia Nasional.

Tirta GI. 2006. Pengaruh Kalium dan Mikoriza terhadap Pertumbuhan Bibit Panili (Vanilla planifolia Andrew)

Warnock DD, Lehmann J, Kuyper TW, Rillig MC. 2007. Mycorrhizal responses to biochar in soil - concepts and mechanism. Plant and Soil **300,** 9-20.