AMERICAN JOURNAL OF AGRICULTURAL SCIENCE, ENGINEERING, AND TECHNOLOGY (AJASET)

ISSN: 2158-8104 (ONLINE), 2164-0920 (PRINT)

VOLUME 6 ISSUE 2 (2022)

Indexed in

PUBLISHED BY: E-PALLI, DELAWARE, USA

American Journal of Agricultural Science, Engineering, and Technology (AJASET)

Volume 6 Issue 2, Year 2022
ISSN: 2158-8104 (Online), 2164-0920 (Print)
DOI: https://doi.org/10.54536/ajaset.v6i2.472
https://journals.e-palli.com/home/index.php/ajaset

Performance Evaluation of Different Radish (*Raphanus sativus L.*) Varieties with Application of Varying Types of Biochar

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Article Information

Received: August 06, 2022

Accepted: August 09, 2022

Published: August 14, 2022

Keywords

Biochar, Growth performance, Radish, Variety, Yield

ABSTRACT

Utilization of biochar as a soil amendment is an emerging cultural management practice for increasing crop yield and productivity. Although, a number of research works have been conducted, studies on the effect of biochar as a soil ameliorant on different varieties of radish productivity is limited, hence this study was conducted. The present study was laid out in Randomized Complete Blocked Design with two factors: radish variety (four commercially available radish varieties namely, Snow White, Diwata, Improved Valiant and Speedy) and biochar (four types of biochar viz. bamboo, coconut shell, rice hull and mango with a control- no biochar), resulting in twenty treatment combinations at Tangaro, Catarman, Camiguin, Philippines from November 2015 to January 2016 in an open field condition. Results revealed that on the different varieties influenced plant height, fresh weight and diameter of tubers significantly, however no positive effect was found on the number of leaves, fresh weight of tubers, length of tubers and yield. Results also revealed that there is no positive effect that was observed regardless of the varying biochar applied. Also, there were no interaction between the interactions of the two factors. Cost and return analysis showed that T7 (V2B1-Diwata + Bamboo) obtained the highest gross income, net income, and ROI. It is therefore recommended to have further study with the use of different radish variety and varying types of biochar with an increasing amount of application. Other parameters such as soil properties, plant nutrient intake and nutrient content of radish should be to fully explore the potentiality of using biochar.

INTRODUCTION

Radish (Raphanus sativus L.) is one of the most important edible and nutritious root vegetable crops in the world. It belongs to the Brassicaceae family, which is grown in tropical and temperate region (Yu et al., 2016). Radish is grown for its young tender tuberous roots which are eaten raw as salad or cooked as a vegetable. It is relished for its pungent flavor and is considered as an appetizer (Sudhavani et al., 2015). The young leaves are also cooked as vegetable and eaten. Radish has refreshing and depurative properties. Radish is useful in liver and gall bladder troubles. In homeopathy they are used for neurologic headaches, sleeplessness (CastroTorres et al., 2014). Roots, leaves, are active against positive bacteria. The roots are useful in urinary complaints, piles and in gastrodynia. The juice of fresh leaves is used as diuretic and laxative. The primary root and hypocotyls develop into edible portion of radish root (George, 1999). In the Philippines, the volume of production is estimated at 9, 773 metric tons planted to an area of 1, 352 ha while in Camiguin it is estimated at 0.03 metrics tons (BAS, 2015). The Philippine's average productivity of radish is 7.22 t/ha (BAS, 2015).

The new trend in vegetable production is not only to obtain higher yields but also to have better quality produce, as producers are getting higher price for quality produce. There are several factors like variety, season of planting, nutrition and irrigation which plays a dominant role in yield contribution and quality production Liliane & Charles, 2020). Among these factors variety is a predominant. Several varieties of radish are available in the market having varying length, size, colour, taste, yield potential and quality parameters. Varieties like Diwata, Snow White, Valiant and Speedy are grown in different parts of the country and are also available in the markets which are having high yielding potential. In recent years, due to increased urbanization and change in food habits, the demand for salad vegetables is increasing very fast. The consumers as well as growers are demanding for the varieties having good qualities. As radish is an important salad vegetable, it is in demand throughout the year in big cities.

Appropriate variety selection and optimum nutrient supply is crucial for obtaining optimum yield from radish. Radish being a short duration and quick growing crop, the root growth should be rapid and uninterrupted. Moreover, the reason for low production of radish in farmers' field is insufficient nutrient supply and lack of knowledge on suitable varieties (Gautam & Khatiwada, 1997). Addition of biochar (a stable form of carbon produced from pyrolysis of biological materials) in the soil increases crop yields, helps to prevent fertilizer runoff and leaching, allowing the use of less fertilizer and diminishing agricultural pollution to the surrounding environment. It also retains moisture, helping plants through period of drought more easily. Most importantly, it replenishes exhausted or marginal soils with organic carbon and fosters the growth of soil microbes essential for nutrient absorption, particularly mycorrhizal fungi (Clark, 2012). The addition of biochar in the soil is one

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of the strategies in improving soil fertility (Dahal et al., 2021).

The information regarding the radish varieties suitable for Camiguin region is not available and application of biochar is limited. Farmers are asking for high yielding varieties with good quality of roots. The growth and yield performance of the radish varieties varies from place to place and region to region. Its productivity and quality is not yet tested scientifically. Hence, in order to study these aspects critically the present investigation was conducted. Generally, this study was conducted to evaluate the growth and yield of different radish varieties with the application of varying types of biochar. Specifically, the study aimed to: 1.) determine the growth performance of different radish varieties treated with varying types of biochar; 2) determine the yield and its components of radish varieties applied with varying types of biochar; and 3) evaluate the cost and return analysis of all treatments on hectare basis

MATERIALS AND METHODS

Time and Place of the Study

The study was conducted at the Crop Science laboratory area of the Institute of Agriculture, Camiguin Polytechnic State College, Tangaro, Catarman, Camiguin from November 2015 to January 2016.

Materials

The materials used in the study were plow, harrow, working animal (carabao), bolo, meter stick, weighing scale, sprinkler, record book, ruler, vernier caliper, bamboo biochar, coconut shell biochar, rice hull biochar, mango biochar, animal manure and radish seeds.

Experimental Design and Treatment

The study was laid-out following the 4 x 5 factorial in Randomized Complete Block Design (RCBD) with five (5) treatments and replicated three (3) times. Factor A were the radish varieties and Factor B were the varying types of biochar. The different treatment combinations were as follows:

Table 1: Treatment Combinations

Factor A (Radish Variety)	Factor B (Biochar)		Treatment Combination Code (VM)	Treatment Number (T)
Variety 1 Snow White	Control	B0	V1B0	T1
	Bamboo	B1	V1B1	T2
	Coconut shell	B2	V1B2	T3
	Rice hull	B3	V1B3	T4
	Mango	B4	V1B4	T5
Variety 2 Diwata	Control	B0	V2B0	T6
	Bamboo	B1	V2B1	T7
	Coconut shell	B2	V2B2	T8
	Rice hull	B3	V2B3	T9
	Mango	B4	V2B4	T10
Variety 3 Improved Valiant	Control	B0	V3B0	T11
	Bamboo	B1	V3B1	T12
	Coconut shell	B2	V3B2	T13
	Rice hull	B3	V3B3	T14
	Mango	B4	V3B4	T15
Variety 4 Speedy	Control	B0	V4B0	T16
	Bamboo	B1	V4B1	T17
	Coconut shell	B2	V4B2	T18
	Rice hull	B3	V4B3	T19
	Mango	B4	V4B4	T20

Experimental Area

An experimental area of 98 square meters (4.9 m x 20.0 m) was used in this study. There were 3 main plots with an alleyway of 0.5 m. Each main plot was composed of 20 sub-plots each measuring 1.0 m x 1.3 m. Each subplot/ treatment was planted to 32 hills with two seeds per hill.

Statistical Analysis

All data gathered was tabulated and analyzed using the analysis of variance (ANOVA) of factorial experimental in a Randomized Complete Block Design (RCBD). Difference among treatments was analyzed using the Tukey's test.

Preparation of Biochar

Dried branches of bamboo and mango was loaded into a separate kiln in a perpendicular arrangement. The lid was then placed into the kiln and the edges were sealed with clay soil. A small fireplace was created in front of the kiln using 4 bricks/concrete hollow blocks sealed with clay soil. A small fire was then lighted in front of the brick fireplace. (Wood vinegar was also collected in the process using a pipe attach to the asbestos chute). When the wood vinegar condensate becomes black, the bamboo pipe was detached, and both the kiln entrance and asbestos chute were sealed. The bricks entrance of the kiln and asbestos chute were sealed so that is completely airtight. The lack of oxygen in the kiln allowed pyrolysis to occur which resulted in the formation of charcoal. Leave it overnight, return the next day and unseal the kiln removing the bricks and clay. The dried branches of bamboo and mango in the kiln should now be charcoal – biochar. Powderized the biochar, store and can be utilized after three months.

For rice hull, biochar was produced using a rice hull carbonizer. The rice hull biochar was stored and was used after three months.

Coconut shell biochar was collected at the local coconut shell charcoal maker.

Cultural Management and Practices

Soil Sampling Analysis

Soil samples were collected from the area where the study was conducted. Collected samples were submitted to Soil Laboratory, Department of Agriculture Regional Office X, Cagayan de Oro city for laboratory analysis. The result is presented in Table 2.

Table 2: Soil Analysis result of the experimental area

Soil Data	Result
Organic Matter (%)	2.8
Phosporus (ppm)	127
Potassium (ppm)	S
pH	5.29

Source: DA-Region X, 2013

Land Preparation

The land was plowed and harrowed thoroughly with the using manual method. Each plot was measured 1 meter in long and 1.3 meters wide with 0.5 meters distance between each plot.

Planting and Thinning

Three seeds of radish per hill were sown directly with a planting distance of 20 cm between hill and 20 cm between rows and 1 cm deep. Each hill was maintained to two seedlings per hill for thinning process. This was done when seedlings bear at least three leaves.

Water Management

Water was applied to the plants with the used of sprinkler throughout the duration of the study from planting to harvesting.

Weeding and Cultivation

Weeds will compete to the growth of plants for light, nutrients, and water. The growth of weeds was controlled from time to time by pulling.

Pest and Disease Control

Prevention and control measure against insect pest and diseases was done by planting marigold and lemon grass at each corner of the plot as insect repellants.

Harvesting

Harvesting was done 45 days after planting. It was done manually by uprooting the tubers. It was done early in the morning or late in the afternoon to minimize postharvest losses.

Data Gathered

The different data gathered were the following:

Growth Parameters

1. Average Plant Height

This was measured in centimeters from the ground level to the tip of the highest stem of 10 sample random plants during harvesting.

2. Average Number of Leaves

This was taken by counting the number of leaves produce per plant from the 10 sample random plants during the termination of the study. The average was determined by dividing the number of leaves and the number of plants replication per treatment.

3. Average Fresh Weight

This was collected from the ten (10) samples of random plants in each treatment and weigh in gram during harvesting.

Yield and Its Component

4. Length of Tuber

This was taken by measuring the tubers from the tip to bottom using tape measured from the ten (10) randomly selected sample plants.

5. Diameter of Tuber

This was taken by measuring the middle of tubers from the ten (10) randomly selected plants using vernier caliper.

6. Fresh Weight of Tuber

Fresh weight of tubers was taken from ten (10) randomly selected plants.

7. Yield

This was determined by using the formula:

$$\text{Marketable Yield per hectare } \left(\frac{t}{ha}\right) = \frac{marketable\ yield\ (kg)}{harvested\ area\ (m^2} x\ 10 \ldots\ldots\ldots (1)$$

Cost and Return Analysis

The return cost analysis was based on the actual record of the cost the computed gross sale.

8. Net Income

$$Net\ Income = Gross\ Income - Total\ Expenses \ldots\ldots\ldots (2)$$

9. Return on Investment

$$ROI = \frac{Average\ Net\ Income}{Total\ Cost\ of\ Production}\ x\ 100 \ldots\ldots\ldots (3)$$

RESULTS AND DISCUSSION

Effects of different variety on the growth and yield of radish

Table 3 shows the effect of different variety on the growth and yield of radish.

Plant Height

The result showed highly significant differences between the different radish varieties with V4 and V2 exhibited taller and differs significantly in plant height as compared among different radish varieties. This implies that the variety of radish significantly influences the plant height.

Number of Leaves

Statistical analysis showed that there were no significant differences on the number of leaves of different radish varieties. However, V3 obtained the most number of leaves with 11.80, followed by V4 with 11.59, V2 with 11.35; and V1 11.17. This implies that the variety of radish has no significant influence on the number of leaves.

Fresh Weight

Statistical analysis showed significant difference on the weight of different radish varies. Among the four varieties, V4 obtained the highest fresh weight with 126.54 g; followed by V3 with 112.89 g; V2 with 111.73 g; and V1 obtained the lowest weight with 94.96 g. This implies that the fresh weight of radish is affected by the variety of radish.

Table 3: Effects of different variety on the growth and yield of radish

Treatment	Plant height (cm)	Number of leaves	Fresh weight (g)	Fresh weight of tubers (g)	Length of tubers (cm)	Diameter of tubers (mm)	Yield (ton/ha)
V1	21.11c	11.17	94.96b	66.87	15.24	25.83b	7.38
V2	23.36ab	11.35	111.73ab	76.29	15.65	28.54ab	8.72
V3	22.18bc	11.80	112.89ab	79.76	16.53	28.43ab	8.89
V4	23.72a	11.59	126.54a	85.99	16.32	29.72a	9.07
HSDα0.05	11.023**	ns	3.9557*	ns	ns	3.7354*	ns

V1= Snow White, V2= Diwata, V3= Valiant, V4= Speedy

**significant **highly significant*

Fresh Weight of Tuber

Statistical analysis showed no significant differences among treatments. This implies that different variety of radish did not influence the fresh weight. However, V4 obtained the highest fresh weight of tuber with 85.99 g; followed by V3 with 79.76 g; V2 with 76.29 g; and V1 66.87 g.

Length of Tuber

Statistical analysis revealed no significant differences on the length of tubers, however, V3 obtained the longest length with the mean of 16.53 cm; followed by V4 with 16.32 cm; V2 with 15.65 cm; and V1 with 15.24 cm. This implies that the length of tuber did not vary among different radish lines.

Diameter of Tuber

Statistical analysis showed significant differences on the diameter of tuber. This means that the diameter of tuber varied on the different radish lines with V4 obtained the largest diameter with the mean of 29.72 mm; followed by V2 with 28.54 mm; V3 with 28.43 mm; and V1 with 25.83 mm. This implies that variety significantly influence the diameter of the tuber.

Yield

Statistical analysis revealed no significant differences on the yield of radish. However, V4 obtained the highest yield with 9.07 ton/ha; followed by V3 with 8.89 ton/ha; V2 with 8.72 ton/ha; and V1 7.38 ton/ha. This implies the different variety of radish did not influence its yield. Though statistically non-significant, the yield obtained was above the Philippines average radish productivity of 7.22 tons/ha.

Effects of different biochar on the growth and yield of radish

Table 4 shows the effect of different biochar treatments on the growth and yield of radish.

Plant Height

Statistical analysis showed no significant differences among treatments. This means that the plant height was not affected by different types of biochar. B2 obtained the tallest height with 23.41cm; followed by B3 with 22.81cm; B1 with 22.60cm; B0 with 22.12cm; and B4 with 22.02cm.

Number of Leaves

Statistical analysis shows no significant differences on the number of leaves on the application of varying types of biochar. This implies that the number of leaves was not affected by different types of biochar. B2 obtained the most number of leaves with 11.82; followed by B3 with 11.75; B4 with 11.53; B1 with 11.22; and B0 with 11.08.

Fresh Weight

Table 4: Effects of different biochar treatments on the growth and yield of radish

Treatment	Plant height (cm)	Number of leaves	Fresh weight (g)	Fresh weight of tubers (g)	Length of tubers (cm)	Diameter of tubers (mm)	Yield (ton/ha)
B0	22.12a	11.08	100.57	67.65	15.20	26.80	7.19
B¬1	22.60a	11.22	113.83	80.70	16.35	27.99	9.52
B2	23.41a	11.82	115.94	81.02	15.86	28.80	8.23
B3	22.81a	11.75	120.65	85.30	16.65	29.18	9.64
B4	22.02a	11.53	106.66	71.47	15.62	27.88	7.99
HSDα0.05	ns	ns	ns	ns	ns	ns	ns

B0 = Control, B1= Bamboo, B2= Coconut Shell, B3= Rice Hull, B4= Mango

**significant **highly significant*

Statistical analysis revealed no significant differences among treatments. This means that the fresh weight of tuber was not affected by different types of biochar. Among the five treatments, B3 obtained the highest weight with 120.65 g; followed by B2 with 115.94 g; B1 with 113.83 g; B4 with 106.66 g; and B0 with 100.57 g.

Fresh Weight of Tuber

Results revealed no significant differences on the fresh weight of tuber. This means that the fresh weight of tuber was not affected by varying types of biochar. However, B3 with 85.30 g; followed by B2 with 81.02 g; B1 with 80.70g; B4 with 71.47 g; and B0 with 67.65 g.

Length of Tuber

Statistical analysis showed no significant differences on the length of tuber which implies that the length of tuber was not affected by varying types of biochar. B3 obtained the longest length with 16.65 cm; followed by B1 with 16.35 cm; B2 with 15.86 cm; B4 with 15.62 cm; and B0 with 15.20 cm.

Diameter of Tuber

Statistical analysis showed no significant differences on the diameter of tubers. This implies that the diameter of tuber was not affected by different types of biochar. B3 obtained the largest diameter with the mean of 29.18 mm; followed by B2 with 28.80 mm; B1 with 27.99mm; B4 with27.88mm; and B0 with26.80mm.

Yield

Statistical analysis revealed no significant differences on the yield of radish. This means that the yield of radish was not affected by different types of biochar. B3 obtained that highest yield with 9.64 ton/ha; followed by B1 with 9.52 ton/ha; B2 with 8.23 ton/ha; B4 with 7.99 ton/ha; and B0 with 7.19ton/ha. Though statistically non-significant, the results obtained for yield is comparable to the Philippines radish average productivity of 7.22 ton/ha.

Combined effects of variety and biochar on the growth and yield of radish

Table 5 shows the combined effects of variety and biochar treatments on the growth and yield of radish.

The interaction between varieties and types of biochar had insignificant effect on the plant height, number of leaves, fresh weight, fresh weight of tubers, length of tubers, diameter of tubers and yield. At harvest, the maximum plant height, highest fresh weight and highest tuber weight were recorded from the treatment combination V4B2, the highest number of leaves and longest length of tuber at V3B3, largest diameter at V2B3, and a maximum yield at V2B1.

Cost and Return Analysis

The cost and return analysis is presented in Table 6 which include the gross income, total expenses, net income and return on investment (ROI) for radish production in hectare basis. T7 (V2B1) obtain the highest gross sales income of P 133,300.00 while T1 (V1B0) obtained the lowest gross income P 3,500. All treatment has unequal cost of expenses and only treatment 2 (V1B1) got net loss.

Table 5: Combined effects of variety and biochar on the growth and yield of radish

Treatment	Plant height (cm)	Number of leaves	Fresh weight (g)	Fresh weight of tubers (g)	Length of tubers (cm)	Diameter of tubers (mm)	Yield (ton/ ha)
V1B0	19.95	11.03	85.33	58.40	15.19	24.37	5.35
V1B1	21.17	10.27	78.03	57.67	13.23	22.77	5.71
V1B2	23.39	12.13	115.23	86.20	17.08	29.87	11.19
V1B3	20.92	10.97	100.33	68.00	15.32	25.79	7.44
V1B4	20.10	11.47	95.87	64.07	15.41	26.35	7.22
V2B0	23.06	10.47	94.33	62.13	14.23	26.75	7.02
V2B1	24.57	11.67	139.40	98.53	17.50	30.95	13.33
V2B2	22.66	11.20	94.0	61.33	14.44	26.18	6.29
V2B3	24.22	11.80	131.07	94.60	17.43	31.90	10.0
V2B4	22.30	11.60	99.87	64.87	14.66	26.90	6.93
V3B0	21.28	11.53	104.67	71.60	15.72	27.28	8.95
V3B1	22.13	11.07	109.83	77.93	17.94	29.08	8.81
V3B2	22.22	11.86	105.27	73.47	15.05	27.48	5.97
V3B3	22.91	12.63	132.07	96.13	17.57	30.32	11.64
V3B4	22.33	11.90	112.60	79.67	16.36	27.98	9.09
V4B0	24.20	11.30	117.93	78.47	15.66	28.76	7.44
V4B1	22.53	11.87	128.07	88.67	16.72	29.17	10.21
V4B2	25.35	12.07	149.27	103.07	16.89	31.66	9.45
V4B3	23.18	11.57	119.13	82.47	16.28	28.72	9.49
V4B4	23.35	11.13	118.30	77.27	16.06	30.30	8.70
HSDα0.05	ns	ns	ns	ns	ns	ns	ns
CV (%)	6.20	9.28	22.43	27.43	9.46	11.81	35.8

V1= Snow White, V2= Diwata, V3= Valiant, V4= Speedy
B0 = Control, B1= Bamboo, B2= Coconut Shell, B3= Rice Hull, B4= Mango
**significant **highly significant*

Table 6: Cost and return analysis (Php) of radish

Treatment	Gross Income	Total Expenses	Net Income	Return on Investment (%)
T1 (V1B0)	53, 500	50,860	2,640	5.19%
T2 (V1B1)	57,100	59,260	-2,160	-3.64%

T3 (V1B2)	111,900	61,760	50,140	81.19%
T4 (V1B3)	74,400	58,260	16,140	27.70%
T5 (V1B4)	72,200	62,760	9,440	15.04%
T6 (V2B0)	70,200	41,565	28,635	68.89%
T7 (V2B1)	133,300	49,965	83,335	166.79%
T8 (V2B2)	62,900	52,465	10,435	19.89%
T9 (V2B3)	100,000	48,965	51,035	104.23%
T10 (V2B4)	69,300	53,465	15,835	29.62%
T11 (V3B0)	89,500	44,150	45,350	102.72%
T12 (V3B1)	88,100	52,550	35,550	67.65%
T13 (V3B2)	59,700	55,050	4,650	8.45%
T14 (V3B3)	116,400	51,550	64,850	125.80%
T15 (V3B4)	90,900	56,050	34,850	62.18%
T16 (V4B0)	74,400	41,565	32,835	79.00%
T17 (V4B1)	102,100	49,965	52,135	104.34%
T18 (V4B2)	94,500	52,465	42,035	80.12%
T19 (V4B3)	94,900	48,965	45,935	93.81%
T20 (V4B4)	87,000	53,465	33,535	62.72%

CONCLUSIONS

Considering the overall performance, it can be concluded that, the growth and yield of radish were affected by the different variety of radish but not on the types of biochar applied. Also, there was no interaction effects obtained in the two factors. However, Treatment V2B1 (Diwata x Bamboo Biochar) was promising in respect of yield attributes and cost and return analysis. It is therefore recommended to have further study with the use of different radish variety, varying types of biochar with an increasing amount of application and utilization of other organic fertilizers. Other parameters such as soil properties, plant nutrient intake and nutrient content of radish should be considered to fully explore the potentiality of using biochar.

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